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Are debt sustainability frameworks compatible with climate and nature action?

Findings from a new dataset of the IMF's Debt Sustainability Analyses

Christina Laskaridis and Angela Zha

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About the authors

Christina Laskaridis is Senior Lecturer (Associate Professor) in Economics at The Open University, a Visiting Senior Fellow at CETEx, leading work on sovereign debt and debt sustainability and affiliated to St Edmund Hall at the University of Oxford.

Angela Zha is a PhD candidate at Saïd Business School and Stipendiary Lecturer at Corpus Christi College, both at the University of Oxford.

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Summary

Debt sustainability analyses (DSAs) face numerous challenges. Highly technical methodologically, their outcomes bear enormous political significance as not only do they govern the operational lending of the World Bank-International Monetary Fund (IMF) grant-loan mix for low-income countries (LICs) but they also affect the risk perception of the private sector. In the context of heightened debt vulnerability, which a growing proportion of countries currently face, DSAs indicate the susceptibility of debt levels to various types of shocks and how different policy scenarios impact debt sustainability. Importantly, these assessments determine distributional impacts of the cost of a debt crisis – and whether and what size of debt restructuring is needed to bring a country's debt back to sustainable levels. They provide the envelope for negotiations regarding the amount of debt relief the borrower will seek to negotiate with its creditors. The macro-critical impacts of climate change and nature loss represent key additional concerns on top of the longstanding challenges inherent to these exercises.

Only during the 2021 review of the Sovereign Risk Debt Sustainability Framework (SRDSF) for Market Access Countries (MACs) by the IMF did the impact of climate change on debt sustainability become acknowledged, and the framework was subsequently updated. Yet, room for improvement and the growing fiscal impacts of climate change have provoked a heightened need for commitments at the global policy level. This is being recognised at gatherings such as the 2025 Financing for Development Conference in Seville, where policymakers committed to the need for debt sustainability assessments to integrate climate risks and better account for sustainable development spending in relation to climate and nature.

We provide a comprehensive evaluation of the MAC SRDSF and its efforts to include the impact of climate change in advanced economies. Our empirical analysis documents, uniquely and comprehensively, the underlying and pre-existing weaknesses in DSAs as well as the way that the climate module has been rolled out. Our main finding from advanced economies is that simply 'bolting on' climate change without adequately addressing pre-existing debt weaknesses will result in a weaker policy tool. Given the definition and specification of the climate module, we make several proposals for its improvement.

Our contributions are threefold:

- **First, we create a novel dataset using all the debt sustainability analyses published by the IMF for advanced economies.** Our new dataset is an unbalanced panel for 37 countries, covering the period between 2008 and 2024, and is based on a total of 421 individual DSAs. This report is part of a broader effort underway by the authors to create a unique database of all DSAs for market access countries.
- **Second, we evaluate how successful the framework is in adequately projecting debt sustainability within each IMF Article IV report in the case of surveillance and within each programme review in the case of countries that have been part of an IMF lending programme.** This is a foundational step to subsequently investigating how successful the integration of climate into sustainability assessments has been.

- **Third, we examine the different elements that constitute the inclusion of climate change in DSAs:** namely, short- to medium-run stress testing, a long-term risk module, and aspects of the narrative context that frame the analysis. The effectiveness of introducing climate change is evaluated according to several criteria, focusing on comprehension and consistency, appropriate scale of stress tests, and long-term risk assumptions.

Key findings

1. There are large errors – up to 30 percentage points of GDP – in projecting public debt-to-GDP ratios in advanced economies.
2. Errors in projections increase with the forecast horizon.
3. The source and direction of error differs according to type of country and projection horizon.[1]

For all countries:

Across all horizons	Residual (positive error) and real GDP growth (positive error)
1-year horizon	Primary deficit (negative) and residual (positive)
3-year horizon	Residual (positive) and real GDP growth (positive)
5-year horizon	Real GDP growth (positive) and real interest rate (negative)

For programme and non-programme countries:

	Programme countries	Non-programme countries
Across all horizons	Residual (positive error) and real interest rate (negative error)	Primary deficit (positive error) and real GDP growth (positive error)
1-year horizon	Primary deficit (negative) and residual (negative)	Primary deficit (negative) and residual (positive)
3-year horizon	Residual (positive) and primary deficit (negative)	Primary deficit (positive) and real GDP growth (positive)
5-year horizon	Residual (positive) and real interest rate (negative)	Primary deficit (positive) and real GDP growth (positive)

4. Natural disaster stress testing is rolled out unevenly and inconsistently across advanced economies. This type of stress testing is currently triggered for countries that fit narrowly-defined eligibility criteria. Given the far-reaching impacts of climate change, this should be applied across all countries.
5. Over time, climate change affects underlying baseline macroeconomic performance. Climate change has not been incorporated at all into the underlying macro framework.

Thus, errors in the size and frequency of climate impacts and climate costs will only exacerbate overall errors in projecting debt sustainability, and hence undermine the potential for policymakers to

[1] Positive error refers to an outcome that was greater than projected, while a negative error indicates that the outcome was less than projected.

use these assessments effectively. Shocks to the economy will only be confounded and remain disaggregated unless more attention is paid to the underlying errors in debt dynamics.

Recommendations for policymakers at the IMF to enhance DSAs

1. First and foremost, address underlying weaknesses that lead to large forecast errors in DSAs, to improve macroeconomic projections.
2. Do more to identify and tackle the underlying causes of persistent forecast errors in constituent components in the public debt-to-GDP ratio, notably the residual term.
3. Publish macroeconomic forecast errors in debt dynamics routinely in IMF staff reports to avoid the exacerbation of additional errors due to erroneous climate estimates. This could form an additional robust 'realism tool' alongside other realism tools introduced in previous reviews. It would be useful to separate climate errors from baseline macroeconomic errors, to avoid confounding the sources of errors.
4. Customise the natural disaster stress test using available country-based or natural-disaster-specific studies. This would counteract the lack of realism in designing a stress test by assuming a similar and small-sized shock will affect all countries in a similar way.
5. Increase the diversity of stress tests and scenarios to recognise the effect of climate shocks on the uncertainty of projection risks. This entails creating more ambitious scenarios for meeting climate and development goals and associated financing pathways. In contrast, introducing climate as an add-on leads to the proliferation of more 'black-boxes' within the DSA, weakening policymakers' ability to draw firm conclusions.
6. Acknowledge ecosystem collapse and widespread nature loss scenarios and integrate these into specific medium- and long-term risk scenarios.

Overall, integrating climate and nature into DSAs must first and foremost address underlying macro framework challenges. A thorough integration rather than a superficial one could enable a far more ambitious financial planning tool for varied levels of climate- and nature-resilient investments and help assess the implications of climate and nature impacts on debt sustainability.

1. Introduction

Climate change and nature degradation pose existential threats to people and the planet's wellbeing. Extreme weather events are taking their financial, economic, social as well as environmental toll. Ecosystem services – the benefits that humans derive from ecosystems – are being depleted and degraded, harming livelihoods.

It is indisputable that addressing climate change and nature degradation requires financial investment. But several regions across the world are experiencing ever-narrowing fiscal space and are highly vulnerable to debt, inhibiting their ability to cope with climate-related emergencies. This report focuses on the degree to which assessments of debt sustainability are compatible with ambitious climate and nature action.

Addressing the climate and nature crises should not be secondary to dealing with the economic, financial, political or geopolitical shocks that exacerbate pressures on policy space. There is increasing need to better acknowledge and account for the macro-financial criticality of climate change and nature degradation, and to do this before further shocks destabilise and exacerbate pressures on policy space.

In this report we focus on evaluating the International Monetary Fund (IMF)'s debt sustainability analysis (DSA) for Market Access Countries (MACs), now called the Sovereign Risk and Debt Sustainability Framework for Market Access Countries (SRDSF MAC), and the ways in which climate change has been integrated into this framework.[2] The IMF has included climate change in several examples of its surveillance, lending and technical capacity-building work. Calls have been increasingly issued to incorporate the effects of climate change into assessments of debt sustainability (Expert Review on Debt, Nature and Climate, 2025; Kraemer and Volz, 2022).

At the global policy level, there has been some agreement over the need to examine debt sustainability assessments. For example, at the 2025 Financing for Development Conference in Seville, it was concluded that these assessments need to "better account for sustainable development priorities and spending needs, including in relation to climate and nature actions; consider multidimensional vulnerabilities; better account for spillover effects from monetary policies; account for investments (for example, in resilience, nature protection and productive capacity) and their impact on long-term growth and sustainable development" (Fourth International Conference on Financing for Development, 2025).

At the national level, the Organisation for Economic Co-Operation and Development (OECD) has called on Ministries of Finance to integrate climate risks into macro-fiscal frameworks by revising debt sustainability assessments to include climate shocks in medium-term expenditure frameworks (OECD, 2025).

[2] The World Bank and IMF have developed and routinely use debt sustainability assessment exercises in their work. This began in 2002, when the IMF introduced a DSA into all country reports as part of Article IV or programme reviews. This was introduced initially for countries predominantly reliant on international capital markets for financing (i.e. Market Access Countries/MACs) (IMF, 2002) and was followed by a low-income country (LIC) framework in 2005.

This report aims to show why assessments of debt sustainability need to be made compatible with ambitious climate and nature action, points out existing obstacles and provides clear guidance on how to overcome them.

We create a new, unique dataset of advanced economies' DSAs and conduct a comprehensive evaluation of their performance:

- First, we investigate how successful DSAs are at projecting the evolution of public debt-to-GDP ratios in advanced economies. We investigate the extent to which forecasts of debt sustainability are accurate and where persistent biases may arise from. We find that persistent large errors in capturing how debt dynamics will develop in the short-to-medium run are frequently the result of overoptimism in the underlying macro framework. We examine in detail the size and origin of such errors.

- Second, we examine comprehensively, across all advanced economies, how climate modules have been rolled out and integrated into DSAs. We find that climate modules are too simple, and that integration across countries is inconsistent.

We demonstrate that while well-intended efforts are underway to reconfigure DSAs, so long as longstanding weaknesses remain unaddressed, the effort to integrate climate and nature will be hampered. We examine the challenges of including climate and nature in assessments of debt sustainability, though without addressing underlying methodological challenges regarding routine errors in how debt sustainability is assessed. Concrete steps for policymakers are provided to support their development of a rigorous and well-integrated approach to climate and nature degradation.

Our main conclusion is that current DSAs are not yet compatible with bold climate and nature action because adding climate variables into the DSA on top of underlying forecast errors will cause assessments to lose credibility and weaken their value.

2. Why does overoptimism matter?

As long as assessments of debt sustainability remain blind to the economic impacts of climate change and nature degradation on key macro variables, it is impossible to calculate the impact that the additional spending needed to address these issues would have on debt sustainability. Countries adapt to different types of climate shocks in different ways, and hence it is necessary to ascertain the specific vulnerability of a particular country's debt-to-GDP to negative climate shocks. Failure to ensure there is adequate finance for meeting climate goals, or adequate preparation against threats from climate shocks, has resulted in climate shocks worsening debt dynamics and spending on debt service far exceeding the amounts countries spend on climate change or other core social and development goals. While the need to integrate climate change and nature degradation into DSAs is ever more pressing, efforts to do so currently rely on policy frameworks that contain significant sources of error, leading to increased scope for amplified errors and further weakening the usefulness of DSAs.

The starting point for the DSA is the underling macroeconomic baseline scenario and the projections of debt dynamics. The accuracy of these projections has long been criticised as being biased and overoptimistic (de Resende, 2014; Genberg and Martinez, 2014; Guzman and Heymann, 2015; Schavey and Beach, 1999; Wyplosz, 2007).

Assumptions about how future variables may evolve are important, as we explain further below. Errors in those assumptions lead to several negative outcomes. Efforts to introduce climate variables must first address these underlying sources of error and their implications.

A burgeoning literature on the optimism of IMF forecasts has drawn several conclusions about why this matters. The most significant reasons are:

Consequences for lenders:

1. Overoptimism in forecasts undermines the design of realistic macroeconomic policies.
2. Overoptimism may lead to poor programme design with much larger adjustments imposed on countries than necessary.
3. Overoptimism is associated with longer restructuring periods and larger creditor losses, via dilution of recovery value for market participants (Horn et al., 2024).
4. In low-income countries, biases lead to misguided lending decisions by creditors, with adverse economic effects (Lang and Presbitero, 2018).
5. The gap between mechanical outcomes of DSAs and the use of judgement introduces significant sources of biased decision-making (Erce, 2024).
6. Overoptimism may lead to severe dents in the IMF's credibility – recall the IMF's 2012 *mea culpa* regarding fiscal multipliers.[3]

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[3] In the October 2012 vintage of the World Economic Outlook (WEO), the IMF conceded that it had underestimated short-term fiscal multipliers, resulting in errors in growth forecasts (IMF, 2012).

7. IMF credibility is further weakened in the face of concerns around analytical and politically-driven biases in DSAs (Gelpern, 2016; Guzmán and Stiglitz, 2024).

Consequences for the country:

1. Overoptimism underestimates the risk of debt distress (Guzman and Heymann, 2015), and the pace of recovery is overestimated. This often occurs due to political preferences to avoid debt restructuring (Rehbein, 2020).
2. Overoptimism undermines the need for debt relief, focusing on adjustment while failing to appropriately reduce the debt burden (Laskaridis, 2021).
3. Where overoptimism creates a sense of complacency, it could create a false signal for further private and public debt accumulation (Beaudry and Willems, 2022). This could lead to default and financial crises (Debrun et al., 2019).
4. Overoptimism in programme countries leads to an overestimation of structural reform payoffs (IMF, 2019).

Overoptimism does not only matter with respect to forecasting debt dynamics. It is also crucial in order to uncover the multifaceted relationship between climate change and sovereign debt. Given the abundant evidence for the variety of channels through which climate change has fiscal impacts, climate change would also affect the underlying macroeconomic baseline.

Government finances are strongly affected by the cost of borrowing to invest in climate change adaptation and mitigation. Higher costs constrain fiscal space more broadly, thus crowding out investments in other critical areas of needed investment. Kling et al. (2018) find evidence that climate vulnerability positively impacts on the cost of sovereign debt, and this constitutes one of the additional costs that climate-vulnerable countries face.

The world's first climate-adjusted sovereign credit rating, launched in 2021 for 108 countries by researchers at the Bennett Institute for Public Policy, Cambridge, indicated that sovereign downgrades and terms of borrowing will increase as climate change intensifies, where we would see a direct impact on annual interest payments on sovereign debt (Klusak et al., 2021). Similarly, Cevik and Jalles (2022) find that countries that are more climate resilient have lower bond yields and bond spreads relative to those with greater climate vulnerability. Thus, the cost of sovereign borrowing at the global level is driven by both vulnerability and resilience to climate risk (Beirne et al., 2021).

While these channels of impact impinge directly on public finances, there are additional issues to consider when capturing the varied impacts of climate change and nature degradation on the economy. First, the economic impacts of climate change are heterogeneous, as countries have varying abilities to cope with and adapt to climate change. There is no one-size-fits-all set of adaptation measures. Second, natural disasters vary significantly in size and severity and therefore also present varying economic impacts. Third, the size and frequency of climate and nature catastrophes are increasingly volatile and hard to predict, and may occur in close proximity.

3. Data and methodology

This section describes the novel dataset we have created using all the debt sustainability analyses published by the IMF for advanced economies, extracting key tables from public and external DSAs.

New unique database of all DSAs in advanced economies

Our new dataset is an unbalanced panel for 37 advanced economies,[4] covering the period 2008 to 2024, and is based on a total of 421 individual DSAs.[5] In advanced economies, the most common DSA published is the public DSA and our analysis in this report relies on public DSAs.

DSAs are published routinely as part of IMF Surveillance within Article IV reports, or with each programme review. We define programme countries as those that have experienced at least one IMF lending programme during our sample period. Despite official guidance to produce a DSA each year, over the 16-year period 2008 to 2024, the median number of DSAs produced per country for non-programme countries was 11. Unsurprisingly, the number was much higher for programme countries, with a median number of 33.

Our first aim is to evaluate forecast errors within the IMF's DSA contained within each Article IV report in the case of surveillance and within each programme review in the case of programme countries. In order to examine projection biases in each individual effort of constructing a DSA, we include each DSA irrespective of whether some countries have a comparatively larger number of DSAs over a particular period. In advanced economies, Ireland has the most DSAs (38) and Macao the least (5).

Using our DSA database, we reconstruct projected and actual time series. We compare these with the data in the October 2024 edition of the IMF's World Economic Outlook (WEO) – our other main source of data.[6] The WEO data provides a reference point to compare actuals and projected variables, as reconstructed from our DSA dataset. As highlighted in Gaudin et al. (2024), important discrepancies between actual and projected values occur irrespective of optimism/pessimism bias. Such discrepancies may result due to frequent data revisions, changes in precise debt coverage, and revisions in underlying variables, notably GDP. Regular revisions of national statistics lead to divergences in actual and projected data that do not arise directly from overoptimism bias. We adjust the size of errors in DSAs for such discrepancies. We calculate the adjusted difference of forecast errors, which we call Forecast Error 2, as in Mooney and De Soyres (2017). This contrasts with a simple forecast error (Forecast Error 1), which looks at the simple difference between what was projected for a given year and what actually materialised. We adjust Forecast Error 1 for changes in actuals as

[4] Unbalanced panel means data points do not exist for all countries across all years in the sample.

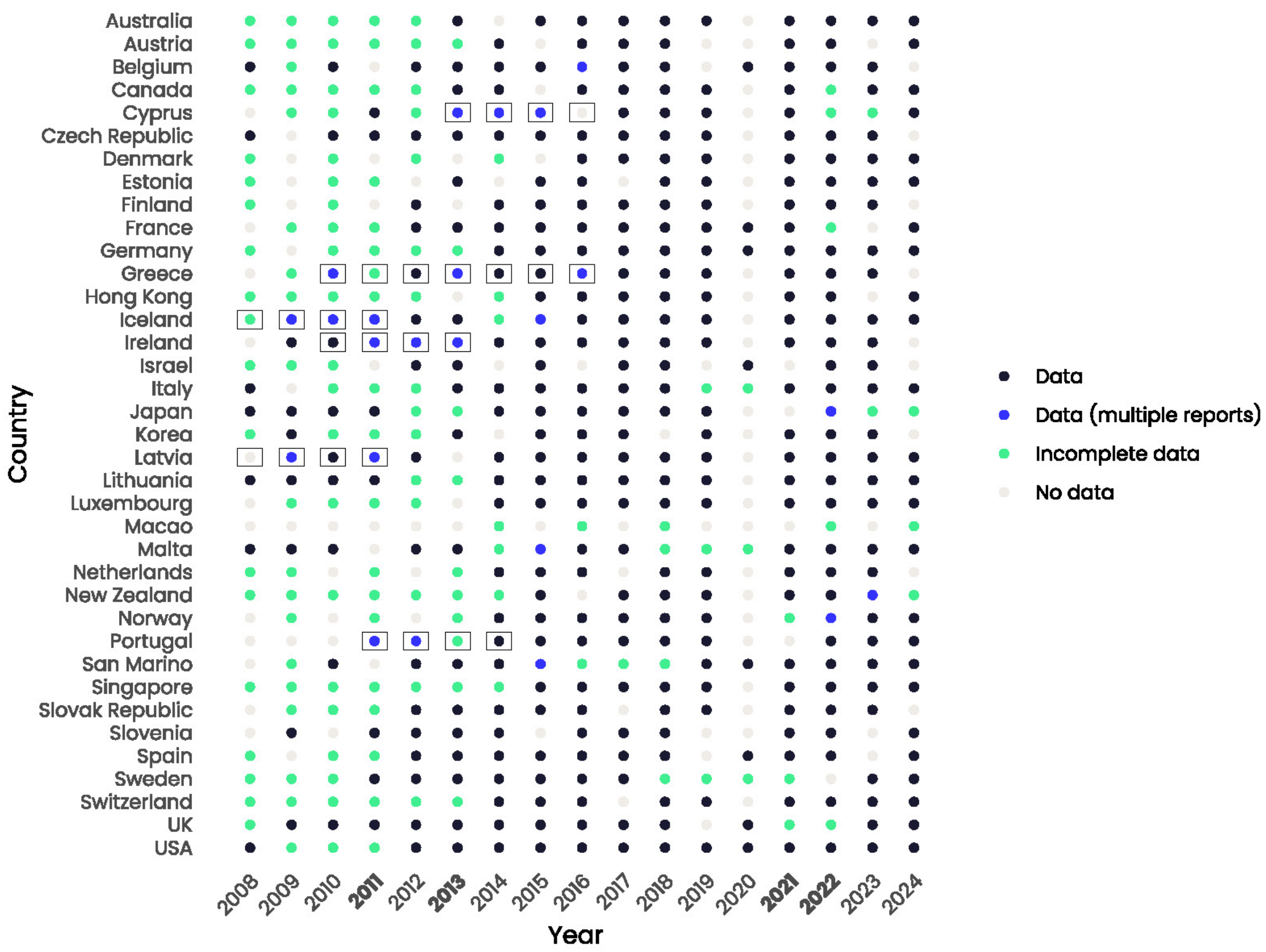
[5] Although introduced in early 2002, it was not until later in the 2000s that there was consistent publication of DSAs during programmes and surveillance. Our choice to focus on advanced economies shows that even in countries with high quality reporting and data, there exist significant forecasting errors for key macroeconomic variables and inconsistent application of the debt sustainability template. This work is part of our broader effort, close to completion, to create a unique database of all DSAs for MACs.

[6] WEO forecasts are published twice a year. As discussed in de Resende (2014), WEO forecasts result from several economic models, combined with staff judgements and other sources. They are comprehensive, covering all IMF member states, and, according to Beaudry and Willems (2022), command a great degree of consensus, use and agreement on their importance by country authorities.

derived from the latest version of the WEO, to obtain Forecast Error 2. This is the method followed in the remainder of the report (see the Appendix for further details).

Figure 3.1 provides an overview of our novel database and depicts the DSAs published per country per year. Within our sample period, six countries had IMF programmes, four of which were Exceptional Access programmes.

Figure 3.1. Overview of DSA data availability



Notes: 'Data' means that data exists and is extracted; 'Data (multiple reports)' means multiple data points exist for a single year; 'Incomplete data' means country report exist but DSA information is not reported or that such information is reported for a different year; 'No data' means no country report exists. A box around the data point means that the country was in an IMF programme in that year. A year in bold on the horizontal axis indicates the year that the DSA framework was revised. [7]
Source: Authors' DSA database from IMF DSAs.

[7] We find that revisions of the DSA template did not have significant effects on forecast errors.

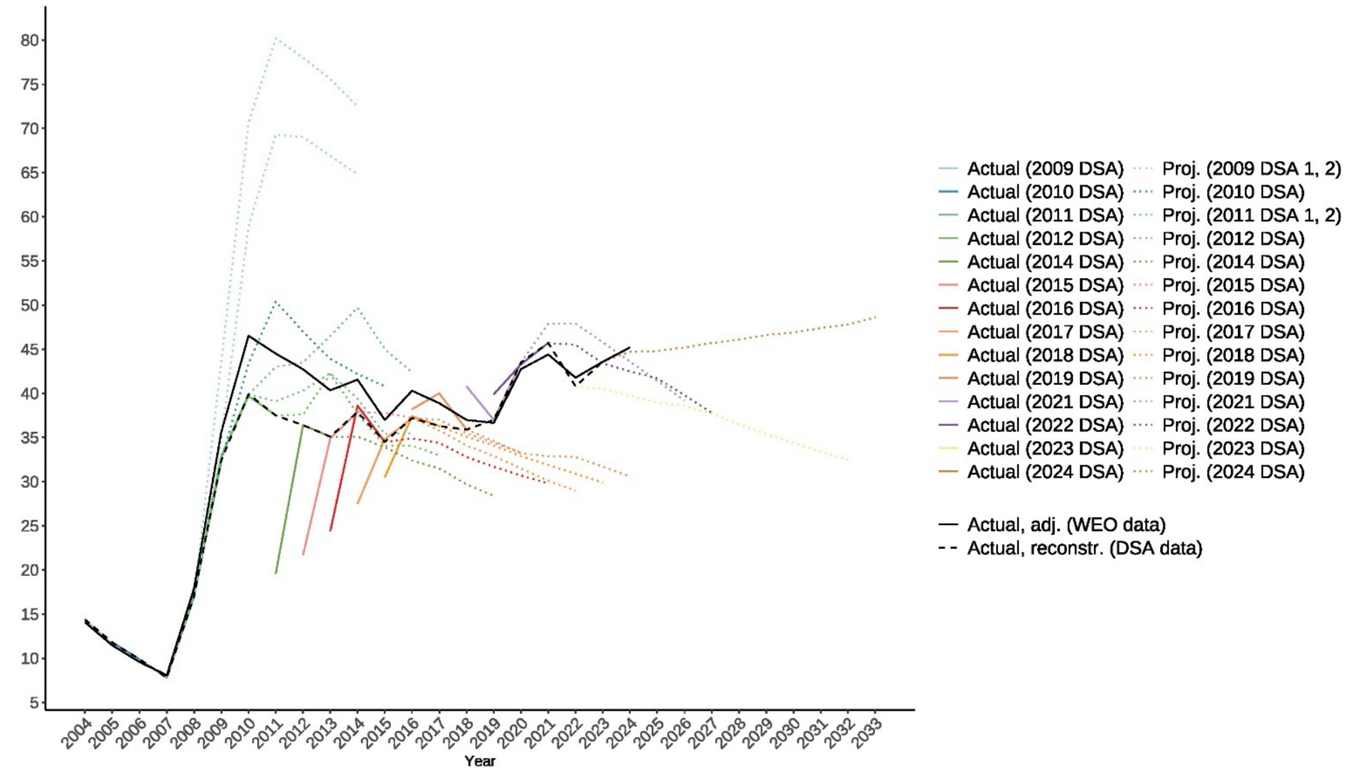
4. Projecting public debt dynamics: a difficult exercise

How accurately does each debt sustainability analysis present actual and projected debt-to-GDP data? To illustrate the discrepancies, in this section we plot two examples, from Latvia and Greece, that illustrate respectively an underestimation and overestimation of projected debt dynamics.

Large forecast errors in both directions

DSAs, at times, assume a higher debt-to-GDP ratio than goes on to materialise. For example, in Latvia, as shown in Figure 4.1, prior to 2012 projections foresaw debt-to-GDP would skyrocket to a far greater extent than it eventually did (where the coloured dotted lines lie above the black lines indicates where pessimism was observed). After 2012, Latvia illustrates optimism in forecasts (where the coloured dotted lines lie beneath the black lines).

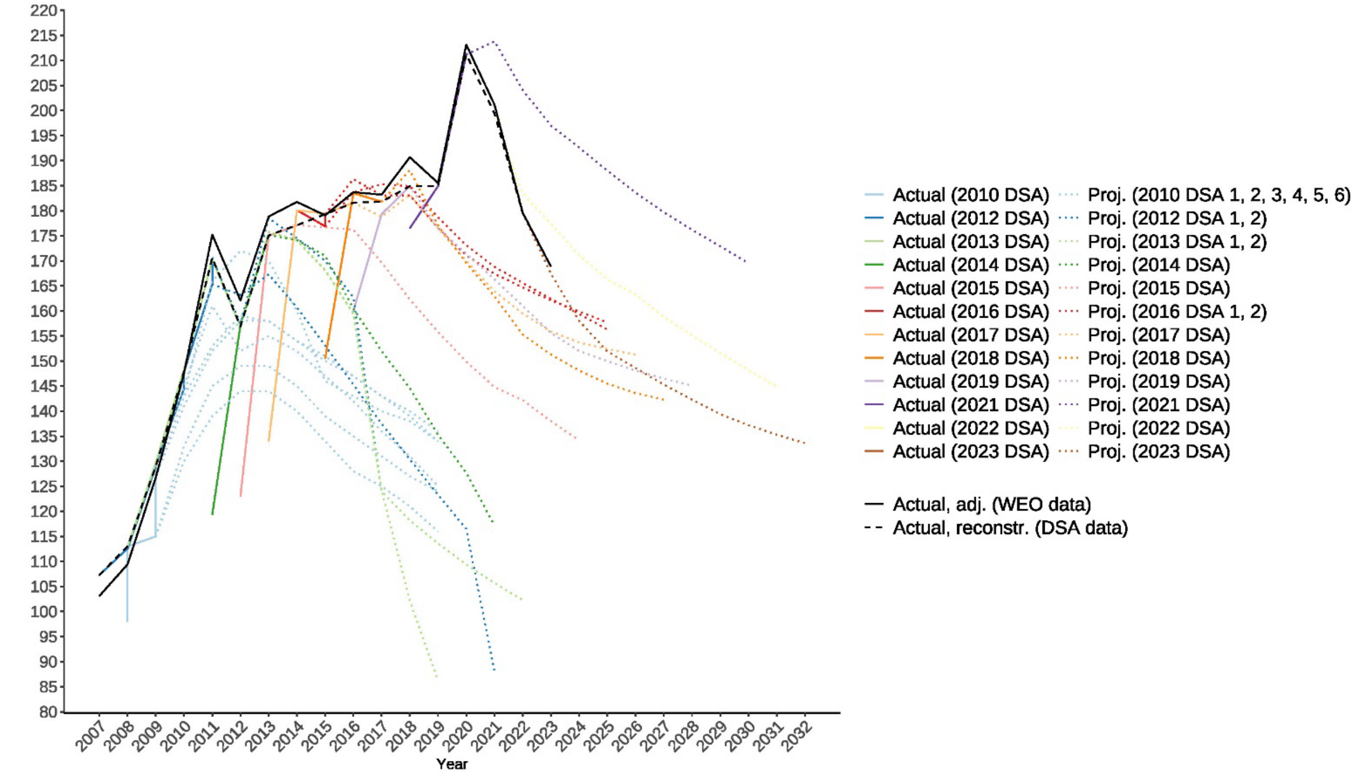
Figure 4.1. Actual versus projected public debt-to-GDP, Latvia



Notes: Solid coloured lines show actual public debt-to-GDP values while dotted coloured lines show projections from each DSA report. Where a year has multiple DSAs, multiple projections are shown. The dotted black line is the reconstructed actual public debt-to-GDP series using our DSA data, while the solid black line is the actual realised public debt-to-GDP ratio using the October 2024 WEO data.
Source: Authors' calculations from IMF DSA (multiple years) and WEO (2024) data

Persistent forecast optimism is apparent in Figure 4.2, for Greece, where debt forecasts undershot realised debt values across most of the sample period (where the coloured lines lie beneath the black lines).

Figure 4.2. Actual versus projected public debt-to-GDP, Greece

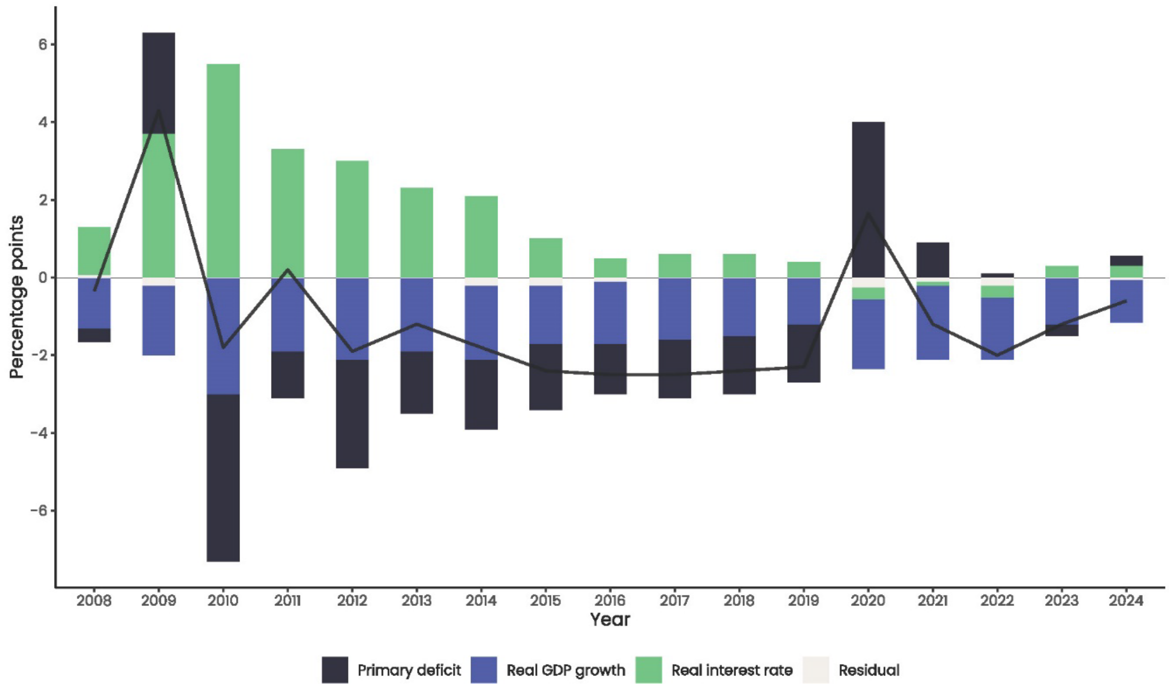


Notes: Solid coloured lines show actual public debt-to-GDP values while dotted coloured lines show projections from each DSA report. Where a year has multiple DSAs, multiple projections are shown. The dotted black line is the reconstructed actual public debt-to-GDP series using our DSA data, while the solid black line is the actual realised public debt-to-GDP ratio using the October 2024 WEO data.
Source: Authors' calculations from IMF DSA (multiple years) and WEO (2024) data

For both countries, at times, there is a divergence between actual realised debt-to-GDP values from the WEO and the actuals as reconstructed from our DSA dataset (the difference between the black solid and black dotted lines). This relates to subsequent data revisions in GDP due to a combination of data updates, structural shifts and significant policy responses, and justifies our decision to use Forecast Error 2, which accounts for such changes.

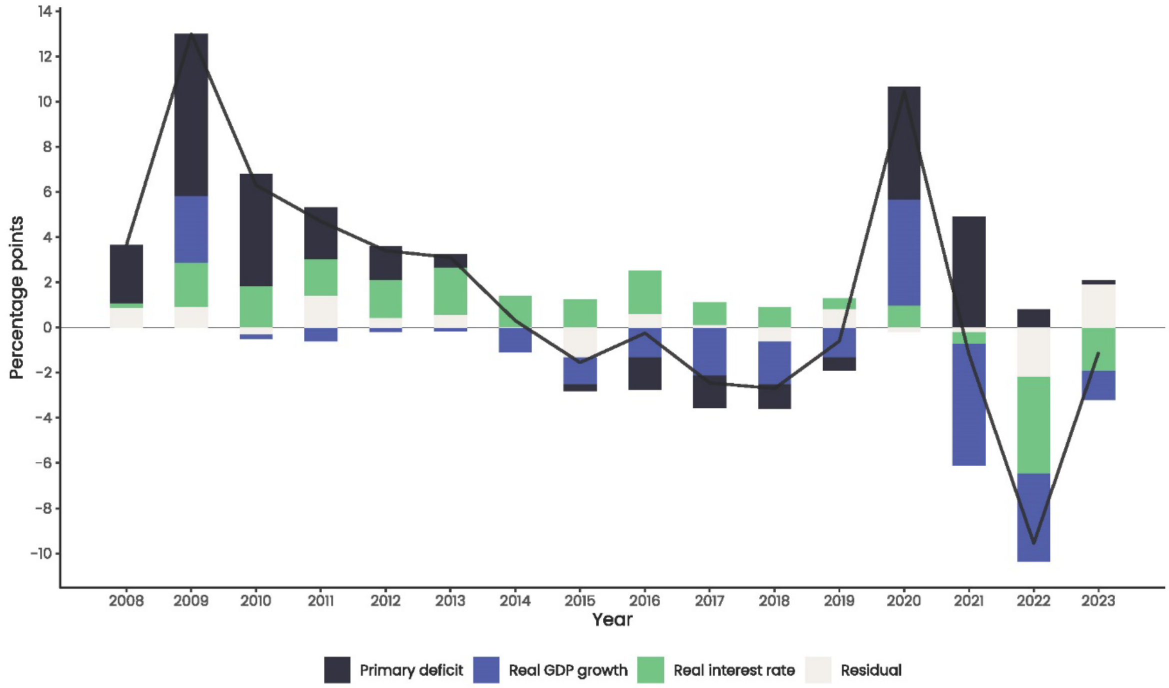
To see what is driving the errors we need to examine the constituent parts of debt dynamics, explained in full in Appendix A.2. Figure 4.3 illustrates projected values of changes in public debt-to-GDP and decomposes this into its constituent parts. In these projections, the residual plays a minimal role, whereas forecasters expected fluctuations in the debt-to-GDP ratio to arise mainly from changes in real GDP growth (higher growth is expected to contribute to a lower public debt-to-GDP ratio) and the real interest rate (higher interest rates are expected to contribute to a higher public debt servicing burden). During the Eurozone debt crisis, forecasters projected that fiscal austerity measures undertaken to reduce the primary deficit would contribute to the reduction of debt-to-GDP, while the onset of the COVID-19 pandemic led forecasters to believe the primary deficit would be associated with a rise in public debt, due to the size of fiscal stimulus packages in advanced economies required to support the economy.

Figure 4.3. Decomposition of projected change in public debt-to-GDP over time, median across all countries



Notes: The black line shows change in public debt-to-GDP. The coloured bars show contributions from constituent variables. The y-axis shows the size of projected change in the public debt-to-GDP ratio, in percentage points.
Source: Authors' calculations from IMF DSA (multiple years) data

Figure 4.4. Decomposition of actual change in public debt-to-GDP over time, median across all countries



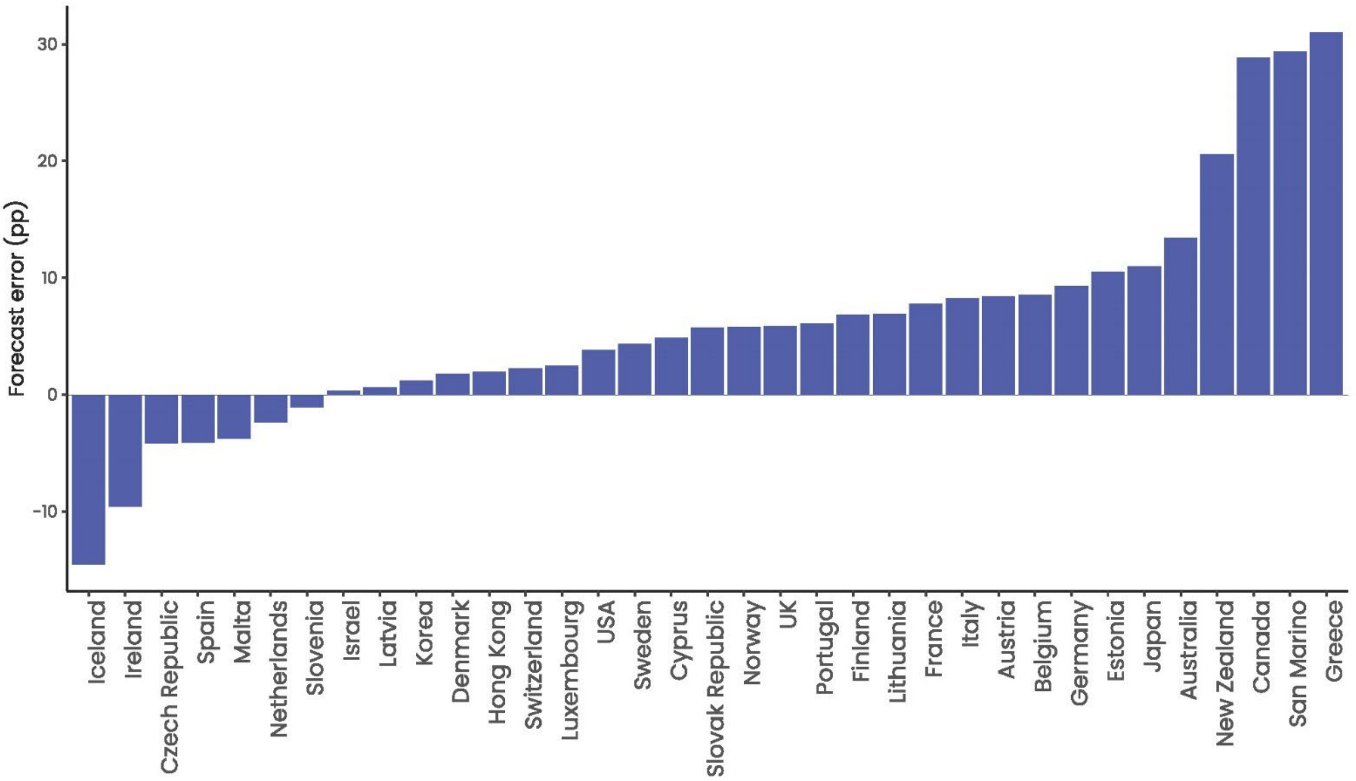
Notes: Black line shows change in public debt-to-GDP. Coloured bars show contributions from constituent variables. The y-axis shows the size of actual change in the public debt-to-GDP ratio, in percentage points.
Source: Authors' calculations from IMF DSA (multiple years) data

When compared with the decomposition of actual debt evolution as shown in Figure 4.4, we see that the actual drivers of debt-to-GDP were different from those projected in Figure 4.3. The primary deficit contributed significantly to changes in public debt-to-GDP. The residual plays a much more substantive role than was assumed, showing that factors that are not even considered exerted influence over debt dynamics. The real interest rate contributed both positively and negatively to public debt dynamics across different years. The size of changes in public debt-to-GDP from year to year were much larger than projected, especially during crisis episodes, as can be seen from the differing scales of the y-axes between Figures 4.3 and 4.4.

Significant positive and negative errors in programme countries

To accurately capture the scale of errors between the IMF DSA projections and what eventually materialised, we calculate the size of forecast errors (as defined in detail in Appendix A.1). The median size of error at the five-year time horizon for all countries can be seen in Figure 4.5. For countries furthest to the right-hand side of the x-axis, debt-to-GDP errors as large as 20 or 30 percentage points of GDP may be present in IMF assessments. Conversely, actual debt-to-GDP may have turned out to be a lot smaller than projected (countries to the left) by over 10 percentage points of GDP.

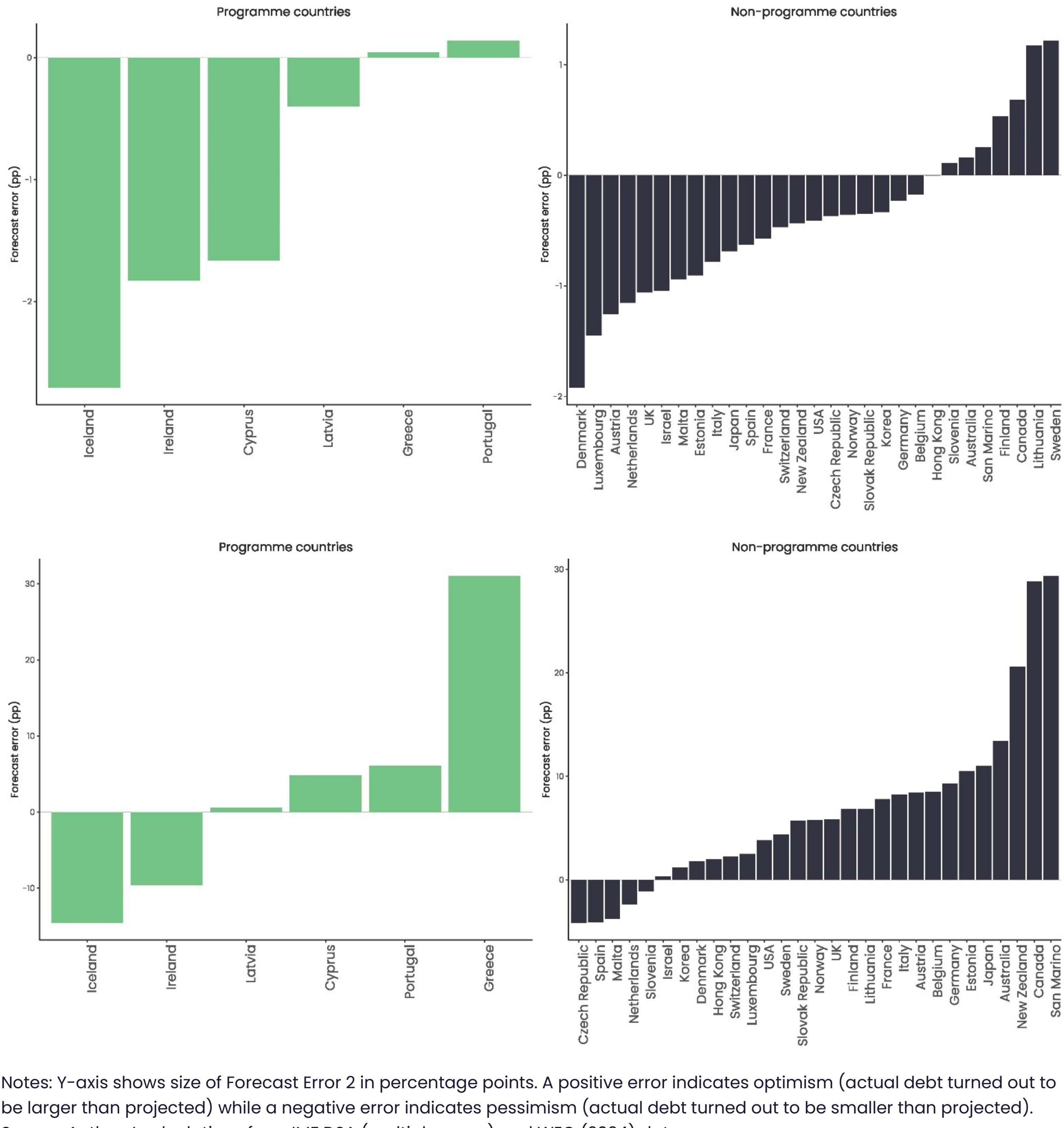
Figure 4.5. Median five-year Forecast Error 2 for public debt-to-GDP, all countries



Notes: Y-axis shows size of Forecast Error 2 in percentage points. A positive error indicates optimism (actual debt turned out to be larger than projected) while a negative error indicates pessimism (actual debt turned out to be smaller than projected).
Source: Authors' calculations from IMF DSA (multiple years) and WEO (2024) data

A more detailed examination of the errors can be seen in Figure 4.6. The top panel examines the size of errors in projecting debt-to-GDP one year on from the year the projection is made. The bottom panel examines the size of errors in projecting debt-to-GDP five years from the year the projection is made. The left-hand side of each panel examines the size of error for advanced economies that had a programme and the right-hand side examines the size of error for all other advanced economies.

Figure 4.6. Median one- (top panel) and five-year (lower panel) horizon Forecast Error 2 for public debt-to-GDP, programme and non-programme countries



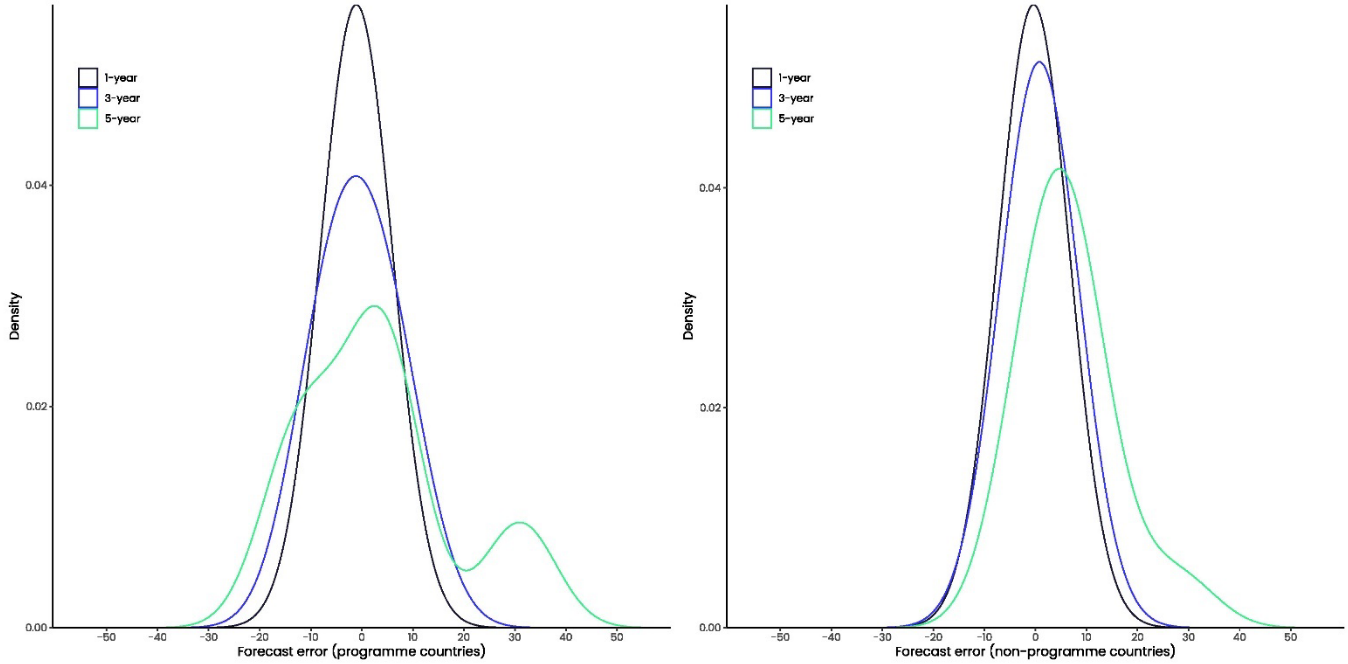
Notes: Y-axis shows size of Forecast Error 2 in percentage points. A positive error indicates optimism (actual debt turned out to be larger than projected) while a negative error indicates pessimism (actual debt turned out to be smaller than projected).
Source: Authors' calculations from IMF DSA (multiple years) and WEO (2024) data

As the projection horizon increases, the magnitude of errors increases (see the vertical axes), and errors show greater optimism. We see that DSA projections demonstrated pessimism at the 1-year horizon but greater optimism for the longer-term horizon. This phenomenon is more pronounced for programme countries, where the magnitude of errors in either direction is larger.

Large errors, even over short horizons

Figure 4.7 presents the distribution of median forecast errors for the public debt-to-GDP ratio based on various projection horizons (one, three and five years) across programme and non-programme countries. Errors are centred around 0 at the one-year horizon but can reach up to 30 percentage points. As the forecast horizon increases, errors become larger (tails are fatter), less concentrated around 0, and more right-skewed (with the overall level of skewness in the data being 1.28). The distribution shifting to the right as projection horizons grow reflects greater optimism as projection horizons lengthen.[8] Comparing programme and non-programme countries, Figure 4.7 shows that as the forecast horizon increases, positive skewness among programme countries increases by more, losing the shape of a normal single-peaked distribution.

Figure 4.7. Distribution of median Forecast Error 2 for public debt-to-GDP, programme versus non-programme countries



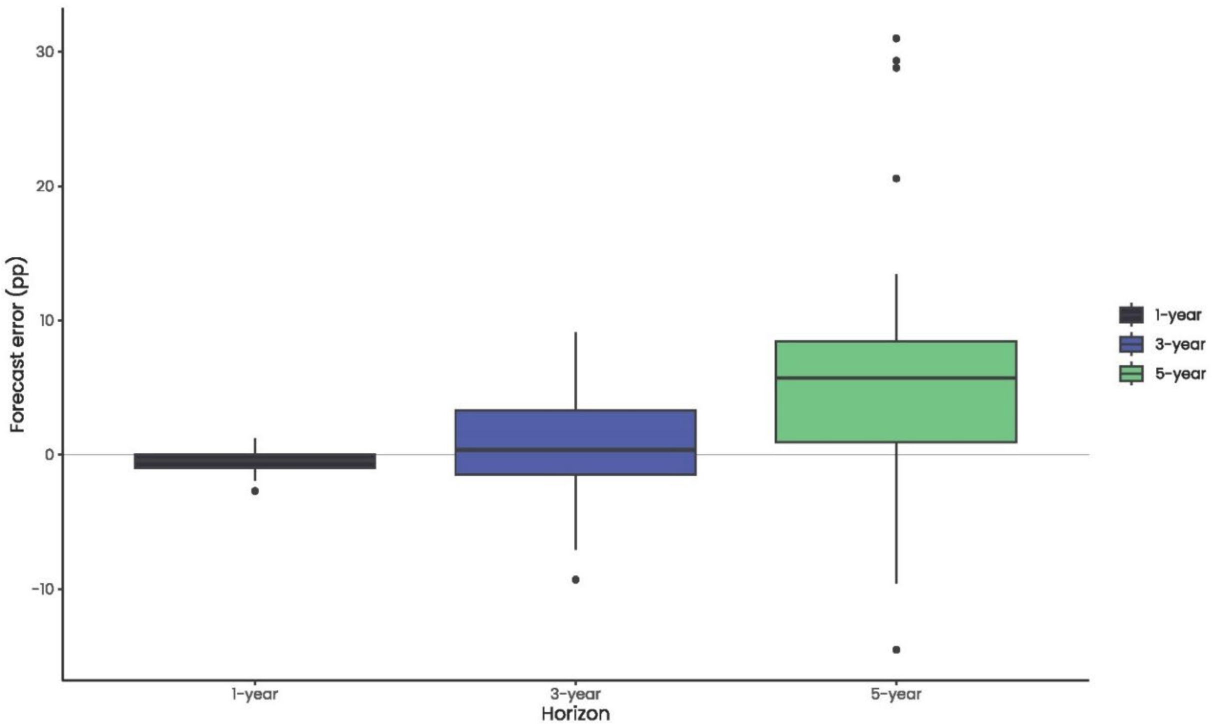
Source: Authors' calculations from IMF DSA (multiple years) and WEO (2024) data

Figure 4.8 illustrates Forecast Error 2 in a box-and-whisker plot. As the forecast horizon increases, errors increase in magnitude and become more positively-skewed, echoing results seen in Figure 4.7. Outliers also become larger. In our sample of advanced economies, the largest outlier countries at the five-year horizon are Greece, Iceland, Canada, New Zealand and San Marino.

Large divergence over horizons can be seen in Figure 4.9, which displays the median Forecast Error 2 for all countries' public debt-to-GDP ratios at each forecast horizon for countries with and without a programme.

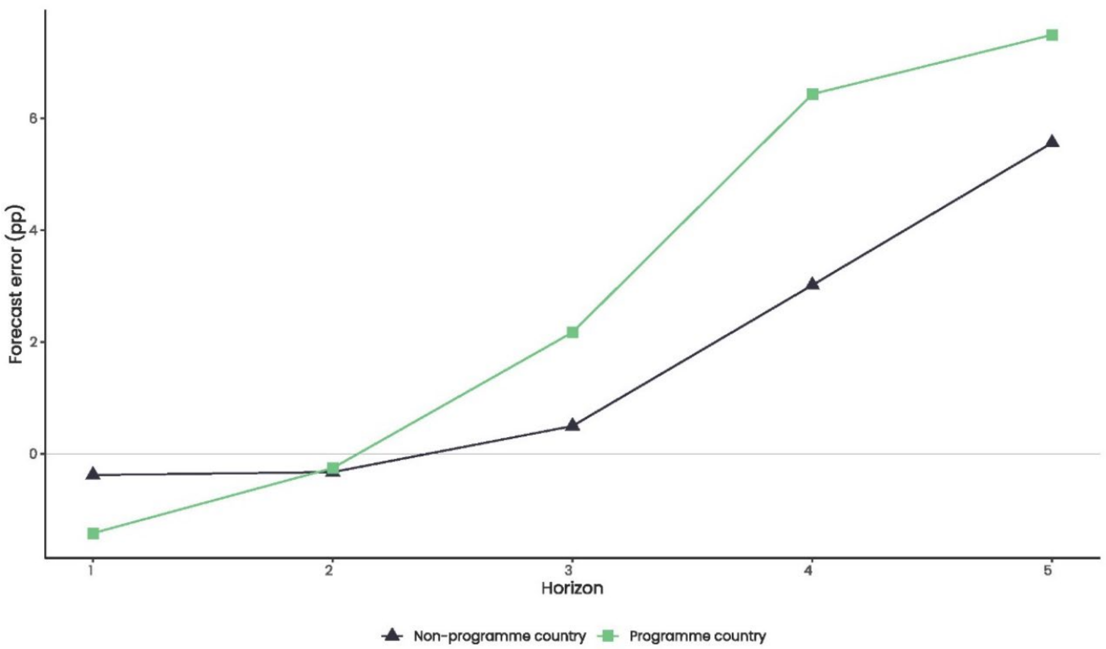
[8] At the 1-year horizon, the magnitude of error is 7.5 density units. This measures the width of the tail around the peak. At the 3- and 5-year horizons, this increases to 18 and 77 density units respectively.

Figure 4.8. Box-and-whisker plot of Forecast Error 2 for public debt-to-GDP, median across all countries



Notes: The box shows the interquartile range. The vertical lines show data points that are 1.5 times the interquartile range, and the dots show outliers outside 1.5 times the interquartile range. The y-axis shows size of Forecast Error 2 in percentage points. A positive error indicates optimism (projected debt is smaller than the actual) while a negative error indicates pessimism.
Source: Authors' calculations from IMF DSA (multiple years) and WEO (2024) data

Figure 4.9. Evolution of Forecast Error 2 for public debt-to-GDP, median across all countries



Notes: Y-axis shows the size of Forecast Error 2 in percentage points. A positive error indicates optimism (actual debt turned out to be greater than projected) while a negative error indicates pessimism (actual debt turned out to be smaller than projected).
Source: Authors' calculations from IMF DSA (multiple years) and WEO (2024) data

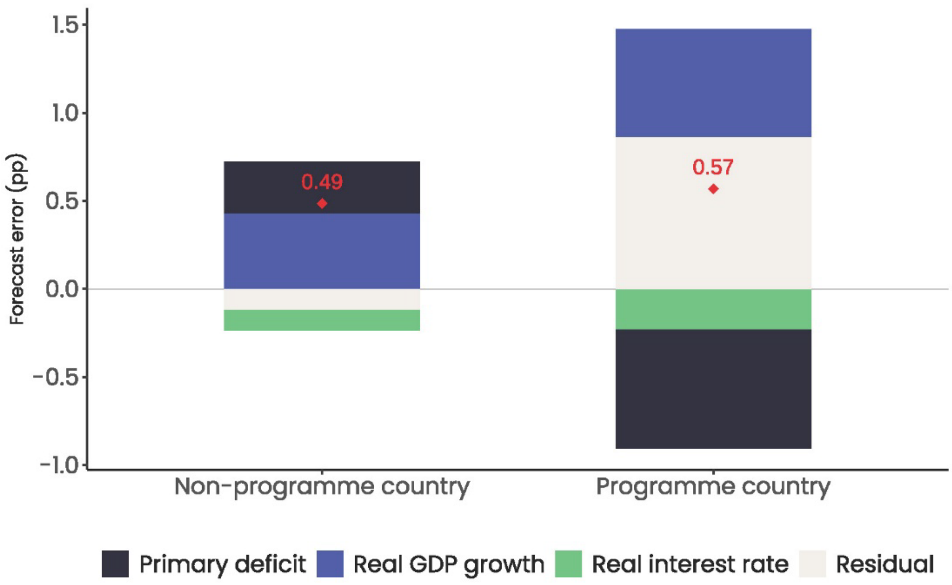
The drivers behind forecast errors

Large errors, even at the one-year horizon, pose multiple problems for policymaking, as examined in Section 2. The question remains: where do the errors come from? To investigate the contributing factors to overall forecast errors, we follow methods adopted by Gaudin et al. (2024) and Mooney and De Soyres (2017) and describe the calculation in detail in Appendix A.2.

The change in the public debt-to-GDP ratio over time can be decomposed into contributions from the primary deficit, automatic debt dynamics (the interest rate/growth differential) and the residual (see Equation 3 in Appendix A.2). The residual arises due to stock-flow reconciliation, driven primarily by balance sheet effects and contingent liabilities (Campos et al., 2006). Balance sheet effects also include a valuation component for foreign exchange movements.

Figure 4.10 shows the decomposition of the three-year forecast error in the *change* in the public debt-to-GDP ratio (note the distinction with the Figures in the previous subsection, which focused on forecast errors in the level of public debt-to-GDP), taking the median across all countries for all years. Median forecast errors are positive, indicating actual debt exceeds projected debt values. For both country groupings, the real interest rate has a negative overall error while real GDP growth has a positive error. For countries that received an IMF programme, the total error is larger than for non-programme countries and the magnitude of errors in all constituent drivers is also larger. For programme countries, the residual has the largest positive error while the primary deficit has the largest negative error. For non-programme countries, real GDP growth has the largest positive error whereas the real interest rate has the largest negative error. The fact that the error from the residual is non-trivial in both cases is plausible given that projections for contingent liabilities and other effects are usually 0 unless there are exceptional transactions, given the unpredictable nature of when and how these line items arise.

Figure 4.10. Decomposition of the median 3-year Forecast Error 2 for the change in public debt-to-GDP for programme and non-programme countries, in advanced economies, 2008-2024

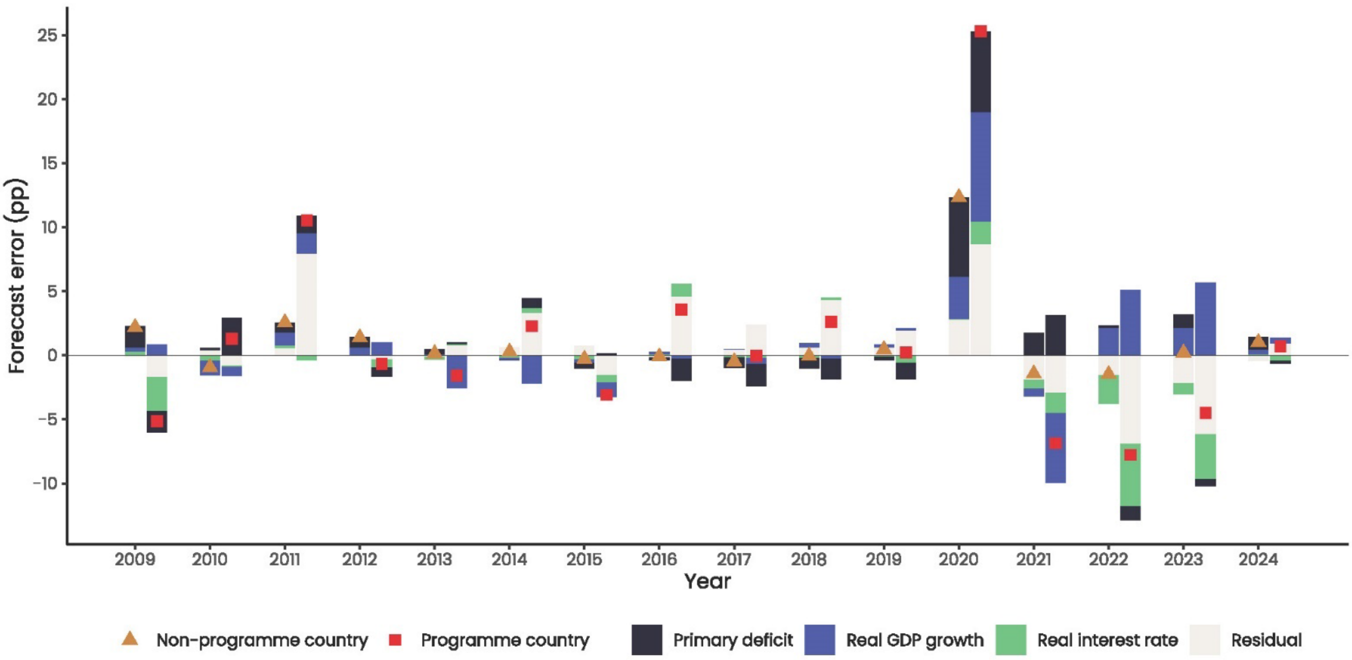


Notes: Total errors in the change in public debt-to-GDP are represented on the figure. The y-axis shows the size of Forecast Error 2 in percentage points. A positive error indicates optimism (actual debt turned out to be larger than projected) while a negative error indicates pessimism (actual debt turned out to be smaller than projected).
Source: Authors' calculations from IMF DSA (multiple years) and WEO (2024) data

To examine how errors evolve over time, we illustrate how the sources of error vary at different moments. In Figure 4.11, programme countries have much larger contributing drivers to their overall forecast error. The real interest rate, residual and real GDP growth have the largest negative errors.

The primary deficit, real GDP growth and residual have the largest positive errors. During the Eurozone debt crisis, the residual played a large role in raising debt-to-GDP. The size of errors in the residual during the COVID-19 pandemic was similar to that of the previous crisis, but notably the primary deficit and real GDP growth also displayed large positive errors. During 2022-23, unexpected and persistent inflationary pressures meant the real interest rate turned out to be smaller than predicted, generating negative errors in this constituent part of debt dynamics.

Figure 4.11. Decomposition of median Forecast Error 2 for change in public debt-to-GDP for IMF programme and non-programme countries, over time



Notes: Total errors in the change in public debt-to-GDP are represented on the figure. The y-axis shows the size of Forecast Error 2 in percentage points. A positive error indicates optimism (actual debt turned out to be greater than projected) while a negative error indicates pessimism (actual debt turned out to be smaller than projected).
Source: Authors' calculations from IMF DSA (multiple years) and WEO (2024) data

5. Integrating climate into debt sustainability analyses

The previous section has illustrated the underlying and longstanding difficulties in producing accurate assessments of how debt-to-GDP will develop in one, three and five years from the time of projection. The IMF framework for debt sustainability was revised in 2021 (IMF, 2021) and the subsequent staff guidance note proposed a new methodology for assessing countries' debt sustainability that incorporates triggered stress tests and long-term risk modules regarding climate change and natural disasters (IMF, 2022). The new template for assessing debt sustainability, the Sovereign Risk and Debt Sustainability Analysis (SRDSA), brought about the integration of climate modules for advanced and emerging market economies. Meanwhile, nature-related loss and degradation or ecosystem degradation has not yet been integrated into the policy framework. There are two main ways in which climate is introduced into the IMF's debt sustainability template: the medium-term stress test and the long-term climate module, as discussed in this section.

Medium-term stress test

The triggered stress tests form part of medium-term analyses which cover up to five years ahead and are designed to capture risks associated with one-off events. Natural disasters form one of the five specific vulnerabilities included in stress testing. The natural disaster stress test is triggered for countries that experience, in a three-year window:

1. Two natural disaster events
2. Cumulative economic losses of at least 5% of GDP caused by the natural disaster during the window period (IMF, 2021)

The standard calibration consists of a direct impact of 4.5 percentage points to the public debt-to-GDP ratio, and an interaction effect that lowers real GDP growth by 1.3 percentage points, both to be introduced in the second year of the projection period. The most impacted quintile would see a one-off shock increase the public debt-to-GDP ratio by 7% and lower real GDP growth by 5 percentage points. After the shocks are determined, the stress testing tool will automatically simulate paths for the debt-to-GDP and public financing needs-to-GDP ratios over a five-year horizon.

However, there is insufficient evidence that the size and frequency of stress testing is appropriate or realistic. With climate change intensifying the frequency of climate damages occurring (World Meteorological Association, 2021) and heightening disaster-related costs (Network for Greening the Financial System, 2024), it is likely that a one-shock event in the horizon period is unrealistically infrequent. The direct economic cost of natural disasters was US$70–80 billion per year during the period 1970–2000, but rose substantially to US$180–200 billion per year during the period 2001–2020 and now exceeds US$2.3 trillion (United Nations Office for Disaster Risk Reduction, 2025). In addition, the IMF assumes a one-size-fits-all shock, where is no heterogeneity in the profiles of different natural disasters, and all are assumed to produce similar-sized outcomes for all countries. Yet, for North America, US$69.57 billion was incurred in direct losses in 2023, accounting for only 0.23% of GDP, while for Micronesia, US$4.3 billion in losses accounted for 46% of GDP in 2023 (ibid.). This implies that the shock used in DSAs is not specific enough to capture the adaptive capacity of different countries and the impacts of different types of natural disasters. While users can customise the parameters of the shock to better capture the impact of natural disaster events on public finances and GDP growth, as well as to manually trigger the natural disaster stress test, customisation has not been applied.

Furthermore, a GDP channel is insufficient to capture the all-round economic impacts that a large-scale disaster may have. Increasing evidence points to the effects on prices (Beirne et al., 2024; Parker, 2018), exports (Osberghaus, 2019) and financial stability (Noth and Schüwer, 2023) that natural disasters may have. This underestimation in the size of climate impacts on debt dynamics will only exacerbate the pre-existing errors described in Section 4.

Policymakers thus need to incorporate into stress tests a range of better-calibrated climate- and nature-related factors that affect debt dynamics. This could include a wider range of issues, such as stranded assets and a variety of ecosystem collapse scenarios. Policymakers can rely on recent developments in modelling climate and nature-related risks in order to provide a more thorough assessment of which problems are macro-critical. The costing of those risks and the economic benefits of their mitigation needs to be more coherently examined.

Long-term climate module

The long-term climate module covers risks to debt that could materialise after five years. It includes projections up to 30 years out for debt and gross financing needs, and four optional modules. One of the latter captures mitigation and adaptation investments to combat climate change, given both of these pose significant needs for public investment and create debt-related risks arising from policy commitments to address climate change. Under the baseline, the fiscal costs of adaptation and mitigation measures would be added as a deterministic shock from $t + 6$ onwards, with t as the reference year. Under customised scenarios, it would be possible to adjust the financing terms of climate-related investments, underlying primary balance assumptions and the long-term GDP growth path depending on country-specific circumstances. The output contains substantial uncertainty surrounding the future evolution of climate change.

The adaptation sub-module is compulsory for countries highly exposed to natural disasters. This includes:

- Countries for which the natural disaster stress test is triggered
- Countries at high risk from climate change impacts, identified as those in the top quartile of an Adaptation Ranking Index calculated by the IMF (IMF, 2021)

To run the module, inputs needed are estimates of expected capital expenditures and long-run assumptions of key debt drivers. The standard scenarios are pre-populated with IMF adaptation cost estimates and by extrapolating the $t + 5$ values of debt drivers over the remainder of the 30-year horizon. It assumes that the benefits of adaptation investment offset the negative long-term impacts of climate change on economic growth.

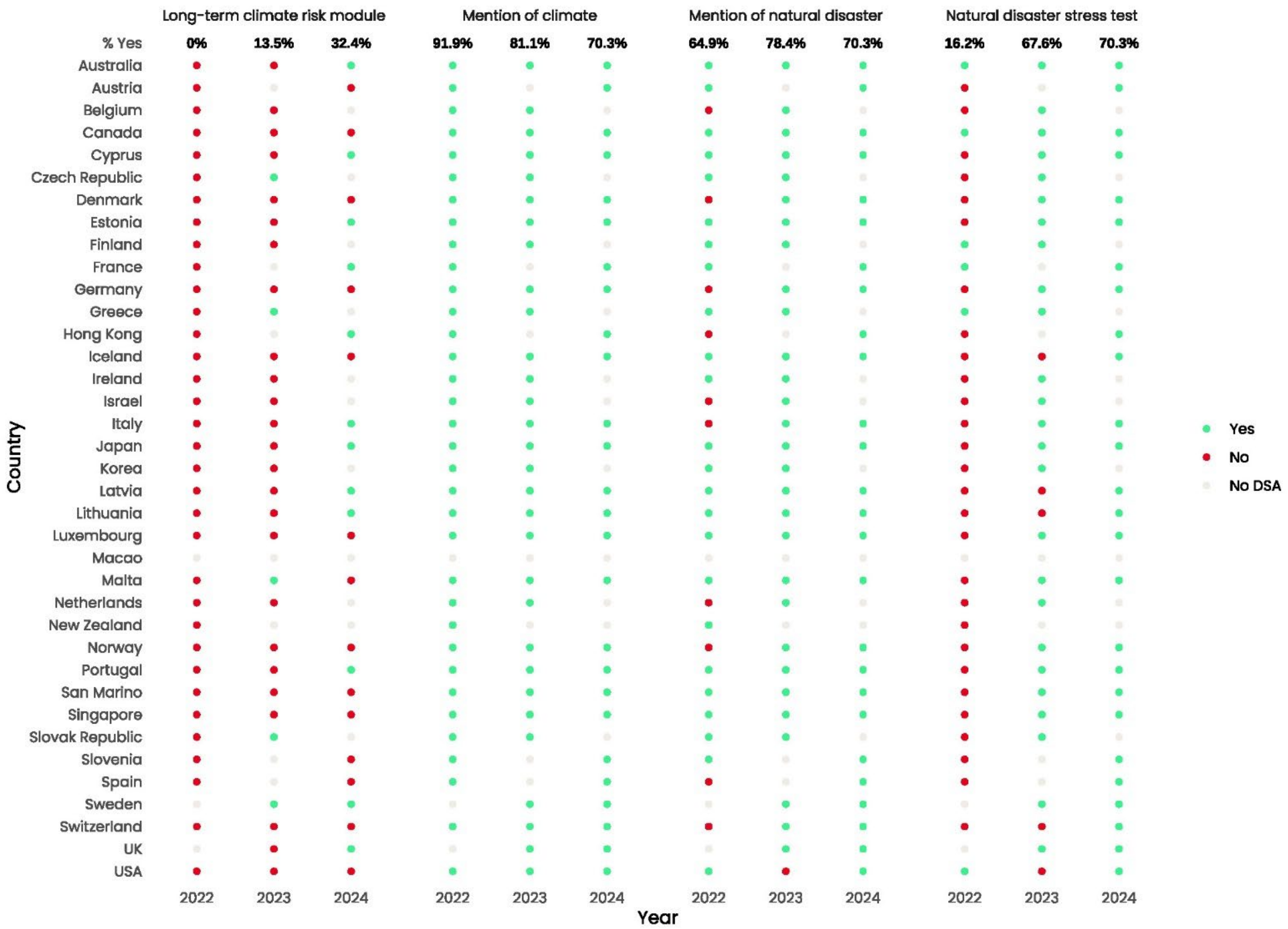
The mitigation sub-module captures the impact of upfront investment to ensure a transition to a low-carbon economy on debt sustainability, over a 30-year horizon. This is required for countries with an ambitious net zero carbon emission target and the 25 largest CO_2 emitters per unit of output.

It is important to note the caveats: scenarios do little to integrate the costs of inaction and non-investment by governments, beyond the direct fiscal burdens involved. This has significant consequences for the underlying macroeconomic baseline of the economy. Furthermore, just as considering a GDP channel only is insufficient for medium-run natural disaster stress tests, for the long-term risk module policymakers should also consider the slow-moving impacts of climate change on economic growth and exports (Hsiang and Jina, 2014) that would develop over the 30-year horizon period, beyond the pure impacts on GDP growth.

Climate integration is underway but patchy

We comprehensively examined the implementation of climate modules introduced in the 2021 IMF review of the MAC DSA framework. Our findings are summarised in Figure 5.1. The column 'Long-term climate risk module' shows that, by and large, this has rarely been considered. The column on the right-hand side, 'Natural disaster stress test', shows that this is more widely considered than the long-term adaptation and mitigation modules. In 2024, application of the stress test was considered across the sample countries, but the eligibility criteria for it to be triggered and used was only present in one instance: Latvia. The two central columns examine mentions of either 'climate' or 'natural disaster' within country reports. Our findings of the actual technical investigation of the impact of climate change on debt do not mirror the ubiquitous mention of and concern for climate change in country reports that we find. Inclusion of climate modules in the SRDSA contrasts with the actual narrative framing of the IMF's analysis, which refers more closely to the impacts of climate change on the economy given the large number of climate-related keyword mentions.

Figure 5.1. Rolling out the climate modules



Notes: 'Mention of' refers to when the word 'climate' or the phrase 'natural disaster' appeared in the staff report for that given country and year.
Source: Authors' DSA database from IMF DSAs

In 2024, natural disaster stress-testing was discussed in all cases where the DSA was published, but there were no DSAs published for 11 countries – approximately 30% of cases. Even fewer countries have introduced long-term assessments of climate risks to debt sustainability.

In summary, we find:

- The stress test is increasingly discussed but seldom used.
- The eligibility criteria for the natural disaster stress test to be triggered and used were present in only one instance in 2024: Latvia.
- The long-term risk module is both infrequently mentioned and applied.
- The conditions integrating the long-term risk module were only present for it to be used in France and Sweden in 2024.

6. Conclusion and recommendations

This report has comprehensively examined the performance of debt sustainability analyses in advanced economies, and the integration of climate change modules following the 2021 review by the IMF. We have used our novel dataset of all the debt sustainability analyses published by the IMF for advanced economies between 2008 and 2024 to evaluate the performance of the framework along different time horizons.

Key findings

1. There are large forecast errors (which can reach up to 30 percentage points) in projecting debt sustainability within a short- to medium-run horizon, both within Article IV reports in the case of surveillance, and within each programme review in the case of programme countries.
2. Errors increase in magnitude with the forecast horizon.
3. The residual and primary deficit components are the largest components of forecast errors in the change in public debt-to-GDP.
4. Natural disaster stress tests and long-term climate risk modules are insufficiently rolled-out and at times inconsistent with the narrative context framing of the analysis. Furthermore, the size and scope of stress tests and long-term scenarios are too small and ill-conceived to form credible assessments of the impact of climate change and nature loss on debt dynamics. In reality, each country would be impacted by climate events differently and the size and frequency of climate events would not affect each country in the same way.
5. Errors in the size and frequency of climate impacts and climate costs will exacerbate overall macroeconomic errors in the baseline. Shocks to the economy will be confounded and remain disaggregated unless more attention is paid to the underlying errors in debt dynamics. This weakens the credibility of introducing climate into debt sustainability assessments.

We conclude that although assessing debt sustainability is essential to ascertaining the fiscal health of a country, and despite these assessments being crucial in distributing the costs between creditors and debtors during a debt crisis, the impact of climate change and nature degradation have not been sufficiently addressed. DSAs need to incorporate nature-related losses, as well as fiscal and debt dynamics of climate change, into underlying macroeconomic baseline modelling. The positive macroeconomic benefit of protecting against nature loss is currently invisible and could be made clearer through improved and individualised country-level modelling. The introduction of climate stress testing and long-term mitigation and adaptation scenarios have been welcome, but as yet remain limited.

Our conclusions lead us to make the recommendations detailed below, aimed at policymakers at the IMF.

Recommendations

1. **Improve underlying methodological weaknesses in projecting macroeconomic variables.** This is the primary issue to be addressed in order to successfully and credibly integrate climate and nature into DSAs. Mitigating underlying forecast errors in the macro framework is a necessary first step.
2. **Further investigation of the underlying causes of persistent and large errors, especially in the residuals.**
3. **Overhaul and open up the black-box of underlying macro projections and the macro-framework.** Macroeconomic forecast errors in debt dynamics should be routinely published.

4. **Enable the separation of errors in macro forecasts and errors in the impacts of climate change.** This would mitigate black-boxes and improve policymakers' ability to draw firm conclusions.
5. **Increase the diversity of both stress tests and scenarios, including more ambitious scenarios to meet climate and development targets and the financing pathways associated with them.** Stress tests that are customisable and account for country-level and disaster-type differences would elevate the effectiveness of climate modules in DSAs.
6. **Include ecosystem collapse and widespread nature loss scenarios into specific long-term risk scenarios to capture realistic outcomes.** Given that current DSAs only consider climate and natural disasters, this would increase their usefulness as a policy tool.

Appendix

A.1. Estimating forecast errors

Our report follows the forecast error calculations covered in Gaudin et al. (2024) and Mooney and De Soyres (2017). As discussed therein, there are three different ways to estimate the forecast error. The first is the simple difference between actual and projected values, which has been used in previous studies such as Martins and Correia (2016), Baduel and Price (2012), and Estefania-Flores et al. (2023).

For a given variable y, the forecast error of country i at horizon h is

$$FE_1^{r,i}(y_{t+h}) = A^{r+h,i}(y_{t+h}) - P^{r,i}(y_{t+h}) \quad (1)$$

where

- FE_1 denotes this is the first method of calculating forecast errors, following Mooney and De Soyres (2017)
- the r superscript denotes the DSA report publication year (for example, the DSA for Australia published in 2022)
- the t subscript denotes the reference year (the last year with actually realised values of the variable). This is usually $r - 1$, but occasionally equals r
- $A^{r+h,i}(y_{t+h})$ is the actual value of variable y realised at time $t + h$, as found within a subsequent DSA report, for example in report $r + h$
- $P(y_{t+h})$ is the projected value of variable y made at time t, given in report r

The estimation of simple forecast errors faces several methodological challenges. As highlighted in Gaudin et al. (2024), simple forecast errors may mask important discrepancies between actual and projected values that occur irrespective to optimism or pessimism bias. Such discrepancies may result due to standard frequent data revisions, changes in precise debt coverage, and revisions in underlying variables, notably GDP. Regular revisions in national statistics lead to divergences in actual and projected data that do not arise from optimism bias.

These challenges can be mitigated by applying the second method of calculating forecast errors, the adjusted difference in Mooney and De Soyres (2017). In this case, the simple forecast error, FE_1, is adjusted for changes in actuals as derived from the latest version (i.e. October 2024) of the World Economic Outlook (WEO).[9]

Consider a DSA for a given country i in a given report r. The forecast error for a given variable y at horizon h is by:

$$FE_2^{r,i}(y_{t+h}) = \left[A^i(y_{t+h}) - A^i(y_t)\right] - \left[P^{r,i}(y_{t+h}) - P^{r,i}(y_t)\right] \quad (2)$$

where

- FE_2 follows the second measure of forecast error in Mooney and De Soyres (2017) and Gaudin et al. (2024)

[9] Latest version at the time the authors conducted their calculations.

- $A^i(y_{t+h})$ is the actual realised value of the variable at time $t + h$, obtained from the latest version of the WEO dataset

- $A^i(y_t)$ is the actual realised value of the variable in reference year t obtained from the latest version of the WEO dataset

- $P^{r,i}(y_{t+h})$ is the projected value of the variable for $t + h$, given in DSA report r

- $P^{r,i}(y_t)$ is the actual realised value of the variable at reference year t given in DSA report r

This adjustment ensures that discrepancies between actual and projected values incorporate data revisions that may occur between actual data for a given year as reported in two different years. Whereas the simple difference is the most accurate measure absent data revisions, the adjusted difference takes into account revisions that were made at each date of projection.

A.2. Reviewing public debt dynamics

To ascertain the drivers of forecast errors over time, we use the standard debt dynamics equation that drives the DSA, as outlined in IMF (2022):

$$\begin{aligned}\Delta d_t &= PB_t + ADD_t + RES_t \\ &= PB_t + [contribution(r_t) + contribution(g_t)] + RES_t \\ &= PB_t + \Bigg[\underbrace{\frac{r_t}{1+g_t}}_{\substack{\text{contribution} \\ \text{from } r_t}} - \underbrace{\frac{g_t}{1+g_t}}_{\substack{\text{contribution} \\ \text{from } g_t}}\Bigg] d_{t-1} + RES_t \qquad (3)\end{aligned}$$

where

- $\Delta d_t \equiv d_t - d_{t-1}$ is the annual change in public debt-to-GDP

- PB_t is the primary balance, calculated as difference between primary expenditures and primary revenues

- ADD_t is the automatic debt dynamics, equal to the interest rate/growth differential

- RES_t is the residual, which contains other debt flows

- $r_t \equiv i_t^e - \pi_t$ is the real interest rate, obtained by subtracting inflation from the effective (nominal) interest rate

- g_t is real GDP growth, in per cent

- π_t is inflation, GDP deflator, in per cent

We use this relationship to decompose the drivers of forecast errors in the change in public debt-to GDP.

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