Q-CRAFT Explorer Companion Guide

Understanding Climate-Aware Fiscal Projections

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Preface

This guide accompanies **Q-CRAFT Explorer**, an open-source Python reimplementation of the IMF's Quantitative Climate Risk Assessment Fiscal Tool. It is written for economists at ministries of finance, IMF staff working on capacity development, and development practitioners who use fiscal projection tools in their work.

Q-CRAFT Explorer is developed by Teal Insights and NatureFinance. The code is open source (MIT license).

The guide has three parts:

1. **Policy Relevance and How Q-CRAFT Works**: the economic methodology, the debt dynamics equation, and the seven-module pipeline, explained for practitioners who want to understand what the tool computes and why
2. **Using the Explorer**: parameter-by-parameter guidance for running your own projections. Start with the Quick Start checklist if you need results now.
3. **Co-Design and the SovTech Vision**: what we built, what we learned, and how to shape the next version

A Glossary defines key terms and a References section provides annotated pointers to the primary sources underlying the methodology.

This is an educational companion, not a replacement for the IMF's User Guide (Tim and Rahman, 2024), which remains the authoritative methodology reference. Where this guide explains a concept, it cites the relevant User Guide section so you can go deeper.

> **This is an initial version**
>
> Q-CRAFT Explorer is a starting point, not a finished product. We want to co-design the next version with you. See Part 3 for how to get involved.

> **Try the App**
>
> **Open Q-CRAFT Explorer** to follow along as you read. The source code is on GitHub.

Chapter 1

Policy Relevance and How Q-CRAFT Works

What you need to know:

- Q-CRAFT projects how climate change affects a country's debt trajectory through 2099
- The tool connects seven modules (from demography to climate scenarios) through a single debt dynamics equation
- Q-CRAFT Explorer reimplements the IMF's Excel-based tool as an open-source web application, with parity tested against the original for Uganda (the golden master country)

1.1 Why a new platform for an existing tool

The IMF's Fiscal Affairs Department built Q-CRAFT as an Excel workbook. That decision made sense. Excel is universal. Every Ministry of Finance has it. Every economist knows how to use it. The Q-CRAFT workbook is well-structured, clearly documented, and covers 197 economies. The team that built it made a tool that works.

The challenge is what happens next.

A fiscal economist in a low-income country's Ministry of Finance opens the workbook. It has 19 sheets. The macroeconomic data is pre-loaded from the IMF's World Economic Outlook, but the WEO vintage may be a year old. The productivity growth assumption needs to reflect the country's structural outlook, but the workbook shows one default (1.2%) for all countries. Was that default used in last year's C-PIMA assessment, or did the visiting IMF team change it? The workbook doesn't record that history.

A year later, the next analyst opens the same file. There is no way to tell which assumptions were deliberate choices and which were left at defaults. There is no audit trail, no version history, no automated checks.

These are not failures of Excel. They are limitations of a format that was designed for calculation, not for workflow management, reproducibility, or collaborative analysis across institutions and time.

The practical cost is measured in capacity development budgets. Countries need technical assistance to set up and interpret these projections. The IMF sends economists to work alongside ministry staff, valuable work, but expensive to scale. If practitioners could start from a higher base, with a tool that guides them through parameter selection and records their analytical choices, that capacity development investment would stretch further.

Q-CRAFT Explorer puts the same proven economics on a modern platform. The calculation engine is a standalone Python package with extensive automated testing. The web interface loads bundled macroeconomic data (currently WEO October 2024 vintage) automatically, provides guidance at point of need, and exposes the key projection parameters in an interactive sidebar. The code is open source (MIT license): anyone can examine, verify, and extend it.

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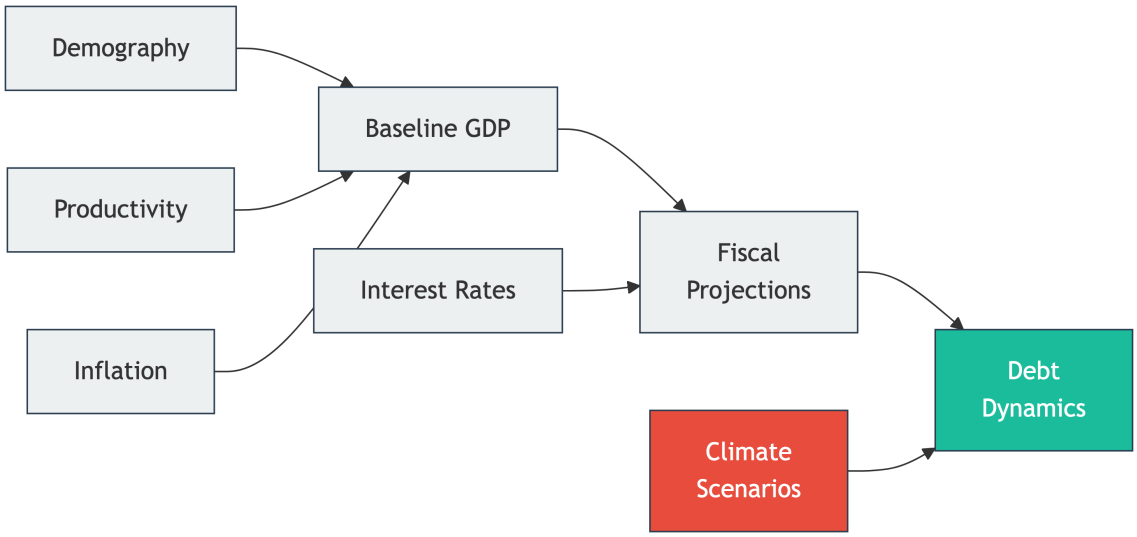
1.2 What Q-CRAFT computes

Q-CRAFT projects long-term fiscal outcomes under different climate scenarios. It is a partial-equilibrium tool: it does not model feedback effects from fiscal policy changes on GDP growth or interest rates (User Guide, p. 5). It connects seven analytical modules, each feeding into a central debt dynamics equation.



Q-CRAFT's seven modules flow into the debt dynamics equation

1.2.1 The debt dynamics equation

The core of Q-CRAFT is the debt accumulation equation. In plain terms: next year's debt equals this year's debt, adjusted for interest payments and economic growth, minus the primary balance (revenue minus non-interest spending).

$$d_t = d_{t-1} \times \frac{1 + r_t}{1 + g_t} - pb_t$$

Where:

Symbol	Meaning
d_t	Debt-to-GDP ratio in year t
r_t	Effective nominal interest rate on government debt
g_t	Nominal GDP growth rate
pb_t	Primary balance as a share of GDP (revenue minus non-interest spending)

The intuition: when interest rates exceed growth ($r > g$), the debt ratio rises automatically: the government must run a primary surplus just to keep debt stable. When growth exceeds interest rates ($g > r$), debt dynamics are favorable and the ratio declines even with modest deficits. Climate change worsens debt dynamics through two indirect channels: it reduces GDP growth (g), and, when expenditure is rigid, it worsens the primary balance (pb) as revenue falls with GDP while spending stays elevated. There is no separate climate term in the equation; the climate impact is embedded in g and pb.

> **Debt floor asymmetry**
>
> The baseline scenario applies a floor of zero to the debt-to-GDP ratio: if the equation produces a negative value, debt is set to zero. Climate scenarios do not apply this floor, allowing debt to go negative (representing net asset positions). This asymmetry is intentional; it avoids masking the full range of climate-scenario outcomes.

Every module in Q-CRAFT exists to produce an input to this equation.

1.2.2 How each module feeds the equation

Demography projects population by age group (children, working age, elderly) using UN World Population Prospects data in three variants: medium, high, and low. Working-age population growth (ages 15-64) drives employment growth after the WEO forecast horizon, which in turn drives potential GDP. Countries with shrinking working-age populations face slower growth and more challenging debt dynamics.

Productivity measures GDP per employed person using World Bank data. Users set a starting growth rate and a long-run convergence rate. Q-CRAFT transitions between them using a logistic function: growth shifts gradually, not abruptly. The productivity-relative-to-OECD trajectory serves as a realism check: assumptions that imply a low-income country surpassing OECD productivity by 2099 warrant scrutiny.

Inflation follows the same logistic convergence pattern. Users set starting and ending rates based on the central bank's inflation target. The starting rate should reflect the WEO projection for the final forecast year; the ending rate should reflect the long-run target (typically 2-3% for advanced economies, 3-6% for emerging and developing economies).

Baseline GDP combines the previous three modules. Nominal GDP growth is decomposed into employment growth, productivity growth, and inflation. During the WEO forecast period (through 2029), Q-CRAFT uses the IMF's own projections. Beyond that horizon, the model takes over using the assumptions set in the dashboard.

Interest rates determine the cost of carrying debt. Q-CRAFT offers three approaches: constant nominal rate, constant interest-growth differential, or constant real rate. Country expertise matters here: the choice should reflect concessional lending terms, sovereign risk premia, and the maturity structure of domestic financial markets.

Fiscal projections compute revenue, expenditure, and the primary balance. Revenue grows with nominal GDP (maintaining a constant revenue-to-GDP ratio). Primary expenditure, the component excluding interest payments, grows multiplicatively with productivity, inflation, and total population (that is, (1+productivity growth) × (1+inflation) × (1+population growth)) plus any fiscal rule adjustment. When enabled, a fiscal rule adjusts spending to steer debt toward a target ratio.

Climate scenarios apply empirical estimates of how temperature changes affect GDP. Q-CRAFT uses the FADCP Climate Dataset (Centorrino, Massetti, and Tagklis, 2024), building on the Kahn et al. (2021) methodology for long-term macroeconomic effects of climate change. Six scenarios span the range from Paris-aligned (below 2°C warming) to hot-unadapted (high warming with slow policy response). Climate scenario impacts begin in 2030; before that year, all scenarios match the baseline (User Guide, p. 19). Climate impacts flow through the productivity channel: reduced GDP growth means lower revenue, higher expenditure-to-GDP ratios, and accelerating debt.

ℹ The six climate scenarios

Scenario	Warming (wrt present)	Based on	Description
Paris-Aligned (1.5°C)	+0.7°C	SSP1-2.6	International commitments met; significant emission cuts
Moderate (2°C)	+1.6°C	SSP2-4.5	Current trends continue; no new aggressive mitigation
High (4°C+)	+2.5°C	SSP3-7.0	Countries scale back mitigation; fragmented response
Hot (3°C)	+3.5°C	SSP3-7.0 (90th pctile)	Same emissions as High but using the 90th percentile of temperature increases

Hot + Adapted	+3.5°C	SSP3-7.0 (90th pctile)	Same temperatures as Hot; countries adapt more quickly
Hot + Unadapted	+3.5°C	SSP3-7.0 (90th pctile)	Same temperatures as Hot; countries adapt very slowly

Warming values are IPCC best estimates for 2081-2100 relative to present (User Guide Table 1). Adding ~1.1°C for present-to-pre-industrial warming gives the more familiar above-pre-industrial framing: Paris <2°C, Moderate ~2.7°C, High ~3.6°C, Hot ~4.6°C.
These scenarios are conservative. They do not account for climate-induced natural disasters, sea-level rise, tipping points, non-market damages (morbidity, mortality, conflict, food insecurity), or spillover effects. The model also does not capture the fiscal cost of adaptation spending: even the Hot Adapted scenario reflects faster economic adjustment, not the public expenditure required to achieve it (User Guide, p. 6). Actual fiscal impacts are likely larger.

1.3 How the Explorer works

Try it now. The steps below describe what you will see.

Select a country from the dropdown. Q-CRAFT Explorer loads macroeconomic data from the IMF World Economic Outlook (October 2024 vintage) and UN population projections (2022 revision) automatically. No manual data entry needed.

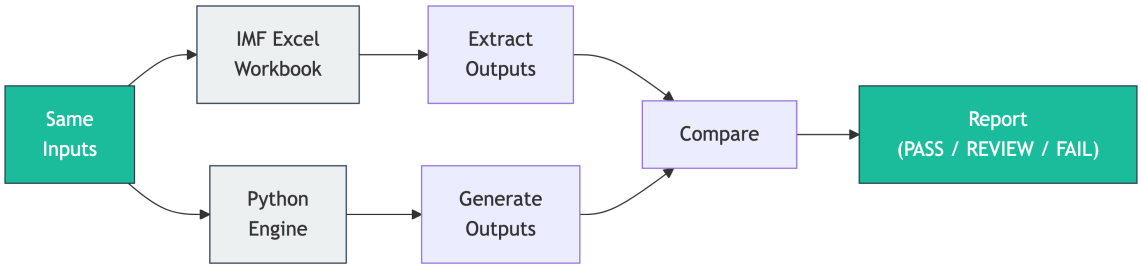
Set a few parameters in the sidebar. V1 exposes five controls: demography variant (medium, high, or low population projection), debt target, fiscal rule (on or off), and expenditure rigidity. Productivity, inflation, and interest rate assumptions use defaults matched to the original Excel tool; future versions will expose these as user-adjustable parameters. Each parameter includes guidance linking to this companion guide.

The engine runs the seven-module projection and displays results across interactive tabs. The Baseline tab shows the no-climate-change scenario. The Climate tab shows how GDP is affected under each warming scenario. The Analysis tab overlays all scenarios on a single chart: the spread between trajectories is your country's climate-fiscal risk.

Everything is open source. The calculation engine is a standalone Python package (MIT license) with automated tests verifying every module. The web interface and engine are separate: the same engine could power a desktop application, a Jupyter notebook analysis, or a country-specific dashboard. Anyone can examine the code, verify the calculations, or build on top of it.

1.4 Verification against the IMF Excel tool

We reimplemented the IMF's Q-CRAFT methodology in Python and are testing parity against the original Excel workbook across a diverse set of countries.



The verification pipeline: same inputs, two engines, automated comparison

We run identical inputs through both the original Excel workbook and the Python engine, then compare every output cell for every projection year. Think of it like an auditor reconciling two copies of the same ledger: if a single number differs, the test fails and we investigate. We test debt-to-GDP, revenue, primary balance, and primary expenditure as shares of GDP, with a target tolerance of 0.1 percentage points.

Verification status

We are building a comprehensive, public, automated testing pipeline to ensure parity with the Excel model. So far we have tested well over 140 countries on baseline fiscal metrics across a variety of parameter combinations. Results have been strong: 0.0 percentage-point difference across the board. We continue to expand and improve the test suite.

This matters for two reasons. First, getting the implementation right: the Python engine must reproduce the Excel workbook's outputs exactly before we can build anything on top of it. Second, building public confidence: anyone can run the test suite and verify the results for themselves. For the LIC-DSF, where results inform lending decisions worth billions, this kind of transparent, automated testing is essential.

This section will be updated as verification progresses.

Our goal is not to replace Excel but to complement it, adding automatic data updates, interactive visualization, extensive testing, and the ability to build different interfaces for different users. The Excel workbook remains the authoritative reference implementation. Parity with it is the foundation on which everything else is built.

Chapter 2

Using the Explorer

What you need to know:

- This section walks through every parameter in Q-CRAFT Explorer and how to interpret the results
- Each parameter includes guidance on how to set it, with references to the IMF User Guide for detailed methodology
- If you have the app open alongside this guide, you can follow along step by step

2.1 Quick Start

Zero to Analysis in 5 Minutes

Open Q-CRAFT Explorer and follow these steps:

1. **Select your country** from the sidebar dropdown: WEO macroeconomic data and UN population projections load automatically
2. **Check the Baseline tab**: does the debt-to-GDP trajectory look plausible given what you know about the country?
3. **Switch to the Climate tab**: how do different warming scenarios affect GDP?
4. **Open the Analysis tab**: compare baseline and climate debt trajectories side by side
5. **Export your data** from the Data tab: CSV files for your own analysis

If you are reading this because you need to run the tool now, follow the checklist above. The rest of this chapter explains what each parameter means, how to think about setting it, and how to read the results.

2.2 Setting the Parameters

Q-CRAFT Explorer has five user-facing parameters. The first (country selection) loads the data. The remaining four shape the projection. Each parameter is explained below with guidance on how

to set it and what it does to the debt trajectory.

2.2.1 Country selection

What it is. A dropdown menu listing countries for which Q-CRAFT Explorer has complete data coverage across all required input datasets. Selecting a country loads macroeconomic data from the IMF's World Economic Outlook (currently October 2024 vintage) and population projections from the UN World Population Prospects (2022 revision).

Why it matters. The country selection determines all historical data and WEO forecast-period projections. No manual data entry is needed: the tool loads real GDP, nominal GDP, revenue, expenditure, debt, interest rates, and demographic projections automatically.

How to set it. Choose the country you are analyzing. The sidebar displays key context after selection: the latest WEO debt-to-GDP ratio and total population. Use these as a quick sanity check: if these numbers do not match your understanding, investigate before proceeding.

> **Country coverage**
>
> Q-CRAFT Explorer currently covers 197 countries. Coverage is expanding as verification progresses. If your country is not listed, it may be added in a future update. See the IMF User Guide (Tim and Rahman, 2024), Section II.B for details on what data is loaded for each country.

2.2.2 Demography variant

What it is. The UN publishes population projections in three variants (Medium, High, and Low) reflecting different fertility assumptions. This parameter selects which variant Q-CRAFT uses for population and labor force projections through 2100.

Why it matters. Working-age population growth (ages 15-64) drives employment growth in Q-CRAFT's production function after the WEO forecast horizon. Higher population growth means a larger labor force, higher potential GDP, and, all else equal, more favorable debt dynamics. Countries facing demographic decline see slower growth and more challenging fiscal trajectories. Total population growth also affects expenditure projections, since primary spending grows with total population (see Part 1 for the expenditure growth formula).

How to set it:

- **Medium** is the standard assumption for most policy analysis. Use it unless you have a specific reason to explore demographic scenarios.
- **High** and **Low** bracket uncertainty. They are useful for countries where fertility trends are uncertain or where demographic policy changes are anticipated.
- For countries experiencing rapid demographic transition (declining working-age population), compare Medium and Low to understand the fiscal sensitivity to demographic outcomes.

For detailed methodology, see the IMF User Guide, pp. 10-12 and Section IV.A on demography and employment.

> **See the effect**
>
> Switch between Medium and High in the sidebar. Watch the Baseline tab's debt trajectory. In countries with young, growing populations (many Sub-Saharan African economies), the difference between variants is small. In countries facing demographic decline (Japan, many European economies), the gap widens significantly: slower working-age population growth means lower GDP growth and rising expenditure-to-GDP ratios.

2.2.3 Debt target (% of GDP)

What it is. The debt-to-GDP ratio that the fiscal rule aims to converge toward over time. Range: 0-200% of GDP.

Why it matters. This parameter only has an effect when the fiscal rule is enabled (see below). It determines how aggressively government spending adjusts: a lower target relative to current debt means more consolidation is needed, which reduces primary expenditure. A higher target means less adjustment.

How to set it:

Start from the country's actual fiscal framework. Many countries have explicit fiscal rules with legislated debt targets: use those where they exist. Where no formal target exists, the debt-stabilizing primary balance, a standard DSA metric (see the IMF User Guide, Section IV.A), provides a useful benchmark.

As rough starting points (not authoritative IMF guidance):

- **Low-income countries (LICs):** 40-50% of GDP is a common range in practice, broadly consistent with IMF-World Bank Debt Sustainability Framework thresholds.
- **Emerging markets (EMs):** 50-70% of GDP, depending on the country's market access, institutional quality, and fiscal track record.
- **Advanced economies (AEs):** Can sustain higher ratios (60-100%+), though the appropriate target depends on growth prospects and market confidence.

For detailed methodology, see the IMF User Guide, pp. 15-18 on fiscal rule assumptions and the baseline scenario.

> **See the effect**
>
> With the fiscal rule enabled, try setting the debt target to 40% and then to 80%. Watch how primary expenditure adjusts in the Baseline tab. A lower target forces faster consolidation: expenditure is cut more aggressively to bring debt down. A higher target allows more spending room. The adjustment is gradual, not immediate: it works through the fiscal gap mechanism over multiple years.

2.2.4 Fiscal rule (Yes / No)

What it is. When enabled, the fiscal rule adjusts primary expenditure to steer debt toward the target ratio. When disabled, spending follows baseline trends regardless of the debt level.

Why it matters. Without a fiscal rule, debt dynamics are purely mechanical: they depend on the interest-growth differential and the primary balance that results from revenue and expenditure trends. With the fiscal rule, the model simulates active fiscal policy: the government responds to rising debt by cutting spending or responds to fiscal space by allowing more spending.

How to set it:

- **Start with the fiscal rule off** to see the "no policy change" baseline. This reveals the underlying fiscal trajectory: is debt stable, rising, or falling under current trends?
- **Turn the fiscal rule on** to see how active fiscal policy changes the picture. This answers: "How much consolidation would be needed to reach the debt target?"
- Most countries in practice have some form of fiscal anchor, though enforcement varies. The IMF User Guide notes that Q-CRAFT's fiscal rule is a partial-equilibrium approximation: it does not model the GDP effects of fiscal consolidation (User Guide, p. 17, footnote 11).

The adjustment is applied after the multiplicative growth factors and is additive in levels: it modifies the level of primary expenditure, not the growth rate. The adjustment depends on the prior year's state, which is why Q-CRAFT computes this recursively year by year.

> **i** See the effect
>
> Run the same country with the fiscal rule on and off. With the rule off and unfavorable debt dynamics (interest rate exceeding growth), you may see debt-to-GDP rising without bound. Turn the rule on and watch debt converge toward your target: the primary expenditure chart will show the spending cuts required to achieve that convergence. The gap between the two scenarios is the fiscal effort required.

2.2.5 Expenditure rigidity (0.0 - 1.0)

What it is. The degree to which government spending resists downward adjustment when climate shocks reduce GDP. This parameter only affects climate scenarios, not the baseline.

Why it matters. This is the key parameter for understanding climate-fiscal risk. When climate change reduces GDP, government revenue falls (since revenue tracks nominal GDP). What happens to spending determines how much of the climate cost shows up as additional debt.

- **1.0 (fully rigid, worst case):** Spending stays at its baseline level in local currency terms, even as GDP falls. Revenue declines but expenditure does not adjust. The entire climate impact passes through to the primary balance and onto the debt ratio. This represents a government that cannot or will not cut spending in response to slower growth, due to large civil service wage bills, entitlement programs, or political constraints on adjustment.
- **0.0 (fully flexible):** Spending adjusts proportionally with GDP decline, maintaining the same expenditure-to-GDP ratio as in the baseline. The debt impact of climate change is smaller because the government absorbs the shock by reducing real spending per capita.
- **Values between 0 and 1** represent partial adjustment. Most countries fall somewhere in between: some spending categories (wages, pensions, debt service) are rigid, while others (capital investment, discretionary programs) can adjust.

How to set it:

- Countries with large public sector wage bills, universal social programs, or rigid entitlement commitments: lean toward 0.7-1.0.
- Countries with more fiscal flexibility, smaller governments, or well-established expenditure review processes: 0.3-0.6.
- The default of 1.0 is deliberately conservative: it shows the worst-case scenario where all climate damage translates into additional borrowing.

For detailed methodology, see the IMF User Guide, pp. 20 and 35-36 on the expenditure rigidity parameter and fiscal effects of climate change.

> **See the effect**
>
> On the Analysis tab, compare the climate scenario debt trajectories at rigidity = 1.0 versus rigidity = 0.0. At 1.0, the fan of climate scenarios spreads wide: the gap between Paris-aligned and Hot Unadapted is large because all climate damage accumulates as debt. At 0.0, the scenarios compress: the government absorbs shocks through spending adjustment, so debt trajectories stay closer to the baseline. The difference between these extremes is your country's fiscal exposure to expenditure rigidity.

2.3 Interpreting the Results

Q-CRAFT Explorer displays results across four analytical tabs. Each answers a different question about the country's fiscal outlook.

2.3.1 Baseline tab

The Baseline tab shows the no-climate-change scenario: the country's fiscal trajectory under current trends and the assumptions you have set.

Three charts to read:

Debt-to-GDP trajectory (top). The headline chart. Follow the trajectory from the historical period (shaded, through 2029) into the projection period. Is debt rising, stable, or falling? If the fiscal rule is on, debt should converge toward your target. If it is off, the trajectory reveals the underlying fiscal dynamics: favorable (growth exceeds interest rates) or unfavorable (interest rates exceed growth).

Revenue and Expenditure (% of GDP) (bottom left). Revenue-to-GDP stays constant by assumption: it grows with nominal GDP. Primary expenditure-to-GDP may diverge because expenditure grows with total population and productivity, while revenue grows with working-age population. In countries where working-age population grows faster than total population (demographic dividend), expenditure-to-GDP falls and fiscal space opens. In aging countries, expenditure-to-GDP rises, a structural fiscal pressure independent of any policy choice.

Fiscal Balances (bottom right). The primary balance (revenue minus non-interest expenditure) and overall balance (including interest payments). The zero line is the key reference: a primary

surplus means the government is generating enough non-interest revenue to cover non-interest spending. The gap between primary and overall balance reflects the interest burden on existing debt.

> **Baseline Sanity Check**
>
> Before interpreting climate results, verify the baseline makes sense:
>
> - ☐ Does the initial debt level match your country's actual current debt-to-GDP ratio?
> - ☐ Is the revenue-to-GDP ratio plausible given WEO forecasts?
> - ☐ Does the expenditure path reflect realistic spending trends?
> - ☐ If the fiscal rule is on, does debt converge toward your target?
> - ☐ Do the primary and overall balance paths make economic sense given the country's fiscal history?

2.3.2 Climate tab

The Climate tab shows how climate change affects real GDP under six warming scenarios, using empirical estimates from the FADCP Climate Dataset (Centorrino, Massetti, and Tagklis, 2024), building on Kahn et al. (2021).

What to look for. Two charts show absolute GDP levels and a GDP index (2029 = 100). The six scenarios span from Paris-aligned (below 2°C warming by 2100) to Hot Unadapted (high warming with slow adaptation). Climate impacts begin in 2030; before that year, all scenarios match the baseline. The gap between scenarios represents the range of GDP outcomes across different climate futures.

Countries closer to the equator generally show larger GDP losses. The empirical estimates reflect historical relationships between temperature deviations and economic output: countries already in warm climates experience more severe productivity impacts from additional warming.

A country showing a large gap between Paris and Hot Unadapted scenarios faces high climate-fiscal vulnerability. A small gap suggests lower direct climate exposure in the model, though this does not account for indirect effects (natural disasters, sea-level rise, trade disruptions) that Q-CRAFT's conservative methodology does not capture (User Guide, p. 5).

2.3.3 Analysis tab

The Analysis tab is the comparison view: it overlays baseline and all climate scenario debt trajectories on a single chart.

The climate-fiscal risk premium. The spread between the baseline debt trajectory and the climate scenario trajectories is the country's climate-fiscal risk premium: the additional debt burden attributable to climate change. This spread depends on three factors:

1. **Climate exposure:** How much GDP the country loses under each scenario (from the Climate tab).
2. **Expenditure rigidity:** How much of the GDP loss passes through to the primary balance and debt. Higher rigidity means a wider spread.

3. **Starting fiscal position:** Countries with unfavorable baseline debt dynamics (interest exceeding growth) see climate shocks amplified through the debt accumulation equation.

Reading the chart. If the baseline shows stable or declining debt but the Hot Unadapted scenario shows rapidly rising debt, climate change has the potential to destabilize an otherwise sustainable fiscal position. This is the core finding Q-CRAFT is designed to surface: it answers the question, "Even if our fiscal policy is sound today, could climate change make it unsustainable?"

The scenarios are conservative. They capture slow-moving productivity effects of temperature change but do not include natural disasters, sea-level rise, ecosystem tipping points, non-market damages, or spillover effects. Actual fiscal impacts are likely larger than the model suggests (User Guide, p. 5).

2.3.4 Data tab

The Data tab provides an interactive data grid and CSV export functionality. Two download options are available:

- **Download Baseline CSV:** The baseline fiscal projection (no climate scenarios). Useful for incorporating Q-CRAFT projections into your own fiscal framework or DSA.
- **Download All Scenarios CSV:** Baseline plus all six climate scenarios, stacked with a scenario identifier column. Use this for custom analysis, cross-country comparison, or integration with other tools.

All values are in billions of local currency units (except ratios, which are percentages of GDP). The data covers the full projection period from 2009 through 2099.

2.4 What the Numbers Mean, and What They Do Not

Q-CRAFT Explorer produces stylized long-term projections. The results are useful for understanding the direction and magnitude of climate-fiscal risks, comparing scenarios, and identifying the fiscal parameters that matter most for a given country.

The results are not forecasts. Projections to 2099 depend on assumptions about productivity, inflation, interest rates, and climate that involve deep uncertainty. The value is in the comparison across scenarios and the sensitivity to assumptions, not in any single projected number.

Q-CRAFT is designed to complement, not replace, existing fiscal analysis. The IMF User Guide positions it as "a starting point for climate change fiscal risk analysis" that supplements country macroeconomic models (User Guide, pp. 5-6). Use Q-CRAFT to identify which climate-fiscal channels matter most for your country, then investigate those channels with more detailed models and country-specific data.

Chapter 3

From Q-CRAFT to the LIC-DSF

What you need to know:

- Q-CRAFT is a proof of concept for a larger goal: making the LIC-DSF more usable through human-centered design
- The biggest barrier to effective fiscal projection tools is ergonomics, not economics
- We are looking for co-design partners, not endorsements

3.1 The real barrier: ergonomics, not economics

The biggest barrier to effective use of fiscal projection tools is not the economics. It is the ergonomics. Smart people struggle not because the methodology is too complex, but because the tools do not guide them through the decisions they need to make.

This observation has emerged from years of conversations with MoF economists, central bank staff, and IFI economists. It has inspired a more organized human-centered design approach: structured design sprints and organized discussions with practitioners who use these tools in their daily work.

3.2 What we built and what we proved

Q-CRAFT Explorer reimplements the IMF's Q-CRAFT Excel workbook as an open-source Python web application. The calculation engine is a standalone package with automated parity tests against the original Excel tool.

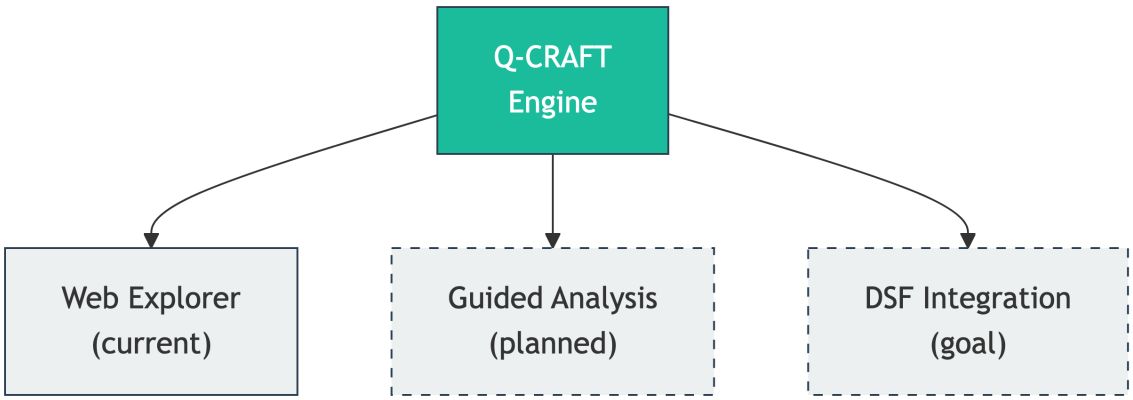
We are building a comprehensive, public, automated testing pipeline to ensure parity with the Excel model. So far we have tested well over 140 countries on baseline fiscal metrics across a variety of parameter combinations. Results have been strong: 0.0 percentage-point difference across the board. We continue to expand the test suite. This kind of transparent, automated verification is essential for tools where the stakes are higher.

3.3 Q-CRAFT is the proof of concept

Q-CRAFT is deliberately small: five user-facing parameters, one core equation. We chose it because it demonstrates the approach in miniature.

The real goal is the LIC-DSF, the Low-Income Country Debt Sustainability Framework. The LIC-DSF modeling chain (Q-CRAFT, DIGNAD, LIC-DSF) is far more complex, far more consequential, and used for every low-income country. We are already working with end-users of the LIC-DSF, and we want to work with its designers too.

3.4 A modular engine, multiple interfaces



One engine, multiple interfaces

The same engine powers different front-ends for different needs:

1. **Web Explorer (current).** Interactive charts for quick country analysis. Select a country, adjust parameters, compare scenarios.
2. **Guided Analysis Tool (planned).** AI-assisted reasoning through input assumptions. Always available, cheaper than a technical assistance mission. Helps users understand what to enter and why.
3. **DSF Integration (the goal).** Q-CRAFT and DIGNAD feeding into LIC-DSF assumptions, with the same ergonomic layer applied to a far more consequential tool.

The current process makes it hard to do things the right way. Documentation is separated from implementation. If you do not know what to enter for a parameter, you search the user guide and hope it is there (and often it is not). The goal is design that makes it easy to do the right thing and hard to do the wrong thing.

3.5 The co-design invitation

We built V1. Here are specific areas where practitioner input shapes V2.

1. **Parameter guidance.** How should we help users choose productivity growth, expenditure rigidity, and debt target values? What heuristics do experienced practitioners use?
2. **Default assumptions.** What are sensible defaults by country type? Should defaults vary by region?
3. **Capacity development integration.** How would this tool fit into an actual CD workshop or IMF mission?
4. **Validation priorities.** Which countries and scenarios should we prioritize for verification?
5. **Missing features.** What is the first thing you would want that is not here?

What we are asking for: a few hours from a few people for design feedback, continued communication so we build credibly, and feedback on whether we are making something useful.

What we are NOT asking for: official endorsement (we understand institutional constraints), access to confidential information (we work with publicly available materials), or money (this is grant-funded, MIT-licensed open source).

3.6 Why start here

Two reasons to start with Q-CRAFT:

1. **Immediate value.** A co-designed Q-CRAFT tool could be in use within weeks. It costs nothing and requires minimal commitment to evaluate. It complements, not replaces, the Excel workbook.
2. **Pioneer the approach.** Success with Q-CRAFT builds trust and methodology for the LIC-DSF. We prove the design process works on a small tool before applying it to the one that matters most.

3.7 The SovTech vision

Central banks have been applying technology to supervisory functions for years. The BIS documented "SupTech generations" as a framework for technology-driven supervisory and regulatory solutions. The question is no longer whether such tools belong in public financial institutions. The question is when sovereign debt management will catch up.

We call this **SovTech**: the application of SupTech principles to sovereign debt analysis. Three principles guide this work:

Modularity that respects how people work. Same engine, different interfaces. Components like building blocks: swap one module without rebuilding everything.

Open source as institutional infrastructure. Transparency means anyone can examine how analysis is done. MIT license, no barriers to adoption. The calculation engine and the interface are separate concerns, developed and tested independently.

AI as enabler, with a trust layer. The cost of building analytical software has dropped dramatically. But sovereign debt analysis serves policy decisions worth billions of dollars. Verification pipelines, automated testing, and human-in-the-loop governance are requirements, not optional features. This is why we built the parity verification pipeline described in Part 1.

Q-CRAFT Explorer is our attempt to show what this looks like. The source code is on GitHub. We welcome your input.

Glossary

Climate scenarios Six warming pathways used in Q-CRAFT, based on IPCC Shared Socioeconomic Pathways (SSPs). Range from Paris-aligned (below 2°C warming by 2100, SSP1-2.6) to Hot Unadapted (high warming with slow adaptation, SSP3-7.0 at the 90th percentile). Climate impacts on GDP are derived from the FADCP Climate Dataset (Centorrino, Massetti, and Tagklis, 2024), building on the empirical estimates of Kahn et al. (2021). See the IMF User Guide, Section IV.B for detailed methodology.

C-PIMA (Climate Public Investment Management Assessment) An IMF framework for evaluating how well a country's public investment management institutions account for climate change. C-PIMA assessments include an annex that uses Q-CRAFT to model the fiscal impacts of climate scenarios for the assessed country. See the C-PIMA Handbook (IMF, 2025) for the full framework.

DSA (Debt Sustainability Analysis) A framework used by the IMF and World Bank to assess whether a country's debt is sustainable (that is, whether the government can meet its current and future debt obligations without requiring debt relief or accumulating arrears). Q-CRAFT projections can complement DSA analysis by providing long-term climate-adjusted fiscal trajectories.

Debt dynamics equation The core equation in Q-CRAFT: $d_t = d_{t-1} \times \frac{1+r_t}{1+g_t} - pb_t$. Next year's debt-to-GDP ratio equals the current ratio, adjusted for the interest-growth differential, minus the primary balance. When interest rates exceed growth ($r > g$), debt rises automatically: the government must run a primary surplus just to keep debt stable. See the IMF User Guide, Section IV.A on debt dynamics for detailed derivation and corollaries.

Debt-to-GDP ratio Total government debt expressed as a percentage of nominal GDP. The standard measure of a country's debt burden, since it scales debt relative to the economy's ability to service it. Q-CRAFT projects this ratio through 2099 under baseline and climate scenarios.

Expenditure rigidity The degree to which government spending resists downward adjustment when climate shocks reduce GDP. Measured on a 0-1 scale. A value of 1.0 means spending is fully sticky: it stays at the baseline level in local currency terms even as GDP falls, representing the worst case for debt accumulation. A value of 0.0 means spending adjusts fully with GDP, maintaining the baseline expenditure-to-GDP ratio. This parameter only affects climate scenarios, not the baseline. See the IMF User Guide, pp. 20 and 35-36.

Fiscal rule A mechanism in Q-CRAFT that adjusts primary expenditure to steer debt toward a target ratio. When enabled, the model computes the debt-stabilizing primary balance and adjusts spending by the fiscal gap (the difference between the actual and debt-stabilizing primary balance). The adjustment is additive in levels (not a rate) and depends on the prior year's state, requiring recursive year-by-year computation. See the IMF User Guide, pp. 15-18.

DIGNAD (Debt, Investment, Growth, and Natural Disasters) An IMF dynamic general equilibrium model for analyzing the macroeconomic effects of natural disasters and public investment in developing countries. More complex than Q-CRAFT, with substantially more parameters. Referenced in Part 3 as an example of a tool that could benefit from the SovTech approach.

Golden master In software verification, a reference output used to detect unintended changes. Q-CRAFT's golden master tests compare the Python engine's outputs against values extracted from the IMF's Excel workbook for the same country and parameter inputs. Parity with the Excel tool (not any independent calculation) is the acceptance criterion.

LIC-DSF (Low-Income Country Debt Sustainability Framework) The IMF-World Bank framework for assessing debt sustainability in low-income countries. Uses country-specific debt burden thresholds based on a composite indicator of institutional quality and macroeconomic fundamentals. Referenced in Part 3 as a more complex tool that could benefit from the SovTech approach.

Interest-growth differential The difference between the nominal interest rate on government debt (r) and nominal GDP growth (g), expressed as $(r - g)/(1 + g)$. When positive ($r > g$), debt dynamics are unfavorable: the debt ratio rises automatically. When negative ($g > r$), debt dynamics are favorable. This single variable determines whether debt is self-stabilizing or self-reinforcing.

Primary balance Government revenue minus non-interest expenditure (primary expenditure), expressed as a share of GDP. The primary balance is the fiscal variable that a government can control in the near to medium term through fiscal policy. A primary surplus means the government generates enough revenue to cover its non-interest spending; a primary deficit means it does not.

WEO (World Economic Outlook) The IMF's flagship publication providing analysis and projections of the global economy. Q-CRAFT uses the WEO database (currently October 2024 vintage) as the source for macroeconomic and fiscal data through the medium-term forecast horizon (currently through 2029). Beyond this horizon, Q-CRAFT's own projection methodology takes over.

SovTech The application of SupTech (supervisory technology) principles (modularity, open source, human-centered design) to sovereign debt analysis and public financial management tools. Q-CRAFT Explorer is a proof of concept for this approach.

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