INTERNATIONAL MONETARY FUND

FISCAL AFFAIRS; MONETARY AND CAPITAL MARKETS; STRATEGY, POLICY, AND REVIEW DEPARTMENTS

Resilience amid Structural Transformations: Are Macro Policy Frameworks Fit for Purpose?

Prepared by Diala Al Masri, Ivailo Arsov, Yongquan Cao, Sonali Das, Julia Faltermeier, Anna Ilyina, Benjamin Kett, Jesper Lindé, Jeta Menkulasi, Mico Mrkaic, Anh D.M. Nguyen, Julia Otten, and Jerome Vandenbussche

2026

DEPARTMENTAL PAPER

INTERNATIONAL MONETARY FUND

FISCAL AFFAIRS; MONETARY AND
CAPITAL MARKETS; STRATEGY, POLICY,
AND REVIEW DEPARTMENTS

DEPARTMENTAL PAPER

Resilience amid Structural Transformations: Are Macro Policy Frameworks Fit for Purpose?

Prepared by Diala Al Masri, Ivailo Arsov, Yongquan Cao, Sonali Das, Julia Faltermeier, Anna Ilyina, Benjamin Kett, Jesper Lindé, Jeta Menkulasi, Mico Mrkaic, Anh D.M. Nguyen, Julia Otten, and Jerome Vandenbussche under the guidance of Era Dabla-Norris, Christopher Erceg, and Daria Zakharova

Cataloging-in-Publication Data
IMF Library

Names: Al Masri, Diala, author. | Arsov, Ivailo, author. | Cao, Yongquan, author. | Das, Sonali, author. | Faltermeier, Julia, author. | Ilyina, Anna, author. | Kett, Benjamin, author. | Lindé, Jesper, author. | Mrkaić, Mićo, author. | Menkulasi, Jeta, author. | Nguyen, Anh D. M., author. | Otten, Julia, author. | Vandenbussche, Jérôme, author. | International Monetary Fund, publisher.
Title: Resilience amid structural transformations: are macro policy frameworks fit for purpose? / Prepared by Diala Al Masri, Ivailo Arsov, Yongquan Cao, Sonali Das, Julia Faltermeier, Anna Ilyina, Benjamin Kett, Jesper Linde, Mico Mrkaic, Jeta Menkulasi, Anh D.M. Nguyen, Julia Otten, Jerome Vandenbussche.
Other titles: Departmental Paper. | International Monetary Fund. Fisal Affairs Department. | International Monetary Fund. Monetary and Capital Markets Department. | International Monetary Fund. Strategy, Policy, and Review Department.
Description: Washington, DC : International Monetary Fund, 2026. | Includes bibliographical references.
Identifiers: ISBN:

9798229042925	(paper)
9798229049108	(ePub)
9798229049061	(webPDF)

Subjects: LCSH: Economic policy. | Macroeconomics.
Classification: LCC HD87.A46 2026

This Departmental Paper was prepared by a team from the IMF's Strategy, Policy, and Review Department, Fiscal Affairs Department, and Monetary and Capital Markets Department under the guidance of Daria Zakharova, Era Dabla-Norris, and Christopher Erceg. The team was led by Anna Ilyina (lead), Sonali Das (co-lead), Benjamin Kett (co-lead), Jeta Menkulasi (co-lead), Jerome Vandenbussche (co-lead) and comprised of Diala Al Masri, Ivailo Arsov, Yongquan Cao, Julia Faltermeier, Jesper Lindé, Mico Mrkaic, Anh D.M. Nguyen, and Julia Otten. With contributions from Hassan Adan, Sybi Hida, Marcin Kolasa, Raphael Lam, Ruy Lama and Yunhui Zhao and excellent research assistance provided by Muneeb Naseem.

Publication orders may be placed online or through the mail:
International Monetary Fund, Publication Services
P.O. Box 92780, Washington, DC 20090, USA
T. +(1) 202.623.7430
publications@IMF.org
elibrary.IMF.org

Contents

BOXES

FIGURES

TABLES

Executive Summary

The steady expansion of global economic integration, accompanied by relatively stable growth and inflation experienced by advanced economies from the mid-1980s to 2007—known as the "Great Moderation"—was interrupted by the global financial crisis. Following a sluggish and uneven postcrisis recovery, the world entered a very different environment, characterized by structural shifts, frequent geopolitical and supply shocks, and volatile trade and capital flows—a period increasingly referred to as the "Great Turbulence." Accelerating structural transformations, including the demographic transition, climate change, geoeconomic fragmentation, and artificial intelligence, have brought about risks, opportunities, and unprecedented uncertainty. Furthermore, many countries have entered this period with historically high public debt levels, in part because of the COVID-19 pandemic, and hence, with less capacity to support economic stability and adaptation to structural shifts. The question addressed in this paper is whether current macro policy frameworks are fit for purpose in this "new normal." To explore this question, this paper discusses the macroeconomic implications of these four key structural transformations, outlines the new challenges they pose, and proposes ways in which policy frameworks could be adjusted to remain effective in maintaining domestic and external stability.

Taken together, these structural transformations are expected to weigh on medium- and long-term growth prospects, though with significant heterogeneity across countries. Although there is considerable uncertainty around these estimates, negative climate and geoeconomic fragmentation effects are expected to combine with unfavorable demographic trends in many countries, with only a partial offset from the growth-enhancing effects of artificial intelligence expected so far. Under a moderate-impact scenario, the sum of the effects of individual trends could lead average annual per capita GDP growth to decline by about 0.4 percentage points (not including acute climate effects) for advanced economies over the next decade (0.7 with acute effects). For emerging markets, the average decline (not including acute climate effects) would be 0.1 percentage points (0.5 with acute effects), whereas for low-income countries, there could be an average gain of 0.3 percentage points if the demographic dividend is effectively exploited. This compares with global average per capita growth (not including acute climate effects) of roughly 2 percent in 2023–24. The effect could be much larger because of negative effects generated by interactions between megatrends, alongside more frequent and persistent supply shocks. Other key macro variables will be affected as well. Although estimates suggest that natural rates are likely to remain low in advanced economies and decline further in emerging markets, heightened uncertainty and rising public debt could put upward pressure on term prema, partially offsetting the benefits of low neutral rates.

With limited policy space and acute trade-offs, macro stabilization policies become more challenging:

(1) **Fiscal policy frameworks**: Slower growth, rising spending pressures, and potentially higher borrowing costs point to a further deterioration in debt dynamics, underscoring the need to prioritize debt stabilization. Transformation-related spending needs could average 3–4 percent of GDP annually over the next decade. At the same time, maximum sustainable debt levels are likely to be lower because of weaker growth prospects, higher risk premia, and persistent spending pressures. Model-based simulations presented in this paper show that for countries near their tax capacity—the highest level of tax revenue a country could realistically mobilize—fiscal space will remain highly constrained unless spending is reprioritized or entitlement programs are reformed; for others, sustained revenue mobilization will be critical to preserve—or expand—fiscal space.

(2) **Monetary policy frameworks**: A more shock-prone environment will sharpen inflation–output trade-offs and reduce the effectiveness of relying on a single baseline forecast. Inflation-targeting central banks may need to reassess when to "look through" supply shocks and make more systematic use of

alternative scenarios. The use of some unconventional monetary policy tools will require clearly defined escape clauses. Safeguarding central bank independence will be essential to ward off fiscal dominance pressures, even as interactions between fiscal and monetary policy become more important.

(3) **External sector policy frameworks**: Greater trade and capital flow volatility and deeper financial frictions driven by geoeconomic fragmentation and climate shocks will test external policy frameworks. In this "new normal," monetary and fiscal policies may have to be complemented with additional tools—such as foreign exchange interventions and macroprudential measures—more often, underscoring the importance of clear principles guiding their use, rethinking adequacy of reserve buffers, and maintaining strong institutional capacity.

(4) **Policy interactions**: The structural transformations are exacerbating the trade-offs between monetary, fiscal, and external sector policies. Constrained fiscal space can weaken monetary transmission and amplify inflationary pressures, whereas tighter monetary policy raises debt servicing costs, limiting fiscal support. External constraints and financial stability risks can further restrict both policies, forcing simultaneous tightening even in adverse conditions. The model-based simulations presented in this paper show that careful consideration of interactions between different policy levers can help ensure more effective use of available policy space and achieve better growth and inflation outcomes. For example, any fiscal stimulus to support the economy facing adverse supply shocks must be carefully calibrated not to contribute to additional inflationary pressures and thus force an offset with tighter monetary policy by the central bank.

To remain fit for purpose in this emerging "new normal," macro policy frameworks must balance credibility and flexibility, be more risk based, and better integrated. Possible adjustments to the current fiscal, monetary, and external sector policy frameworks highlighted in the tables below follow these directions. Several cross-cutting themes emerge from the analysis presented in this paper:

- *First*, reduced policy space and more frequent supply shocks raise the premium on ex ante *robustness of policy frameworks*. Stronger buffers, robust prudential safeguards, and credible institutions are essential for preserving room to maneuver when shocks hit.
- *Second*, more limited scope for countercyclical policies and acute policy trade-offs require greater focus on *effective policy interactions*, while mandates remain distinct, and on *coherent policy mixes*, rather than on any single policy instrument. Even under the optimal policy mix, limited policy space may mean deeper and longer recessions are at times unavoidable.
- *Third*, persistently high uncertainty strengthens the case for *risk-based frameworks* and *state-contingent policy design*, including greater reliance on risk scenarios alongside baseline point forecasts for formulation and calibration of policy responses, as well as improving the real-time identification of shocks.
- *Fourth*, the paper highlights the limits of what can be achieved through macro policies alone and the need for structural policies to boost economic resilience through greater diversification, and more robust adjustment mechanisms to help economies withstand and rebound from shocks. Without such measures, macro policies will face an ever-narrowing set of options to preserve stability.

In sum, this paper encourages a more holistic consideration of ongoing structural transformations, their interactions, related shocks, and implications for individual countries. It aims to stimulate a discussion about possible adjustments to macro policy frameworks to make them more robust for the period of Great Turbulence, however long it might last. Finally, it also provides some guiding lines for a more granular assessment of framework adjustments for individual countries, given their exposures to megatrends as well as their structural and institutional characteristics.

Fiscal Policy Frameworks

Challenges	Possible Adjustments
Continued elevated debt and higher borrowing costs	Prioritize containing debt vulnerabilities
Long-term spending pressures	Recalibrate fiscal rules to account for ongoing structural transformations Reform entitlement programs where unsustainable
More frequent supply shocks. Higher uncertainty about the nature and transmission of shocks	Recalibrate targeted fiscal support toolkits and automatic stabilizers Reduce spending rigidity Pay greater attention to effective fiscal and monetary interactions
Structural shifts in the tax base	Redesign tax systems and upgrade social safety nets

Source: IMF staff.

Monetary Policy: Inflation-Targeting Frameworks

Challenges	Possible Adjustments
More frequent supply shocks	React more decisively to large supply shocks and establish conditions when "looking through" remains appropriate Analyze how megatrends affect the inflation-output trade-off
Higher uncertainty about the nature and transmission of shocks	Make greater use of risk scenarios to formulate and communicate uncertainty and the central bank reaction function
Fiscal dominance risk	Preserve/strengthen central bank independence Pay greater attention to effective fiscal and monetary policy interactions
Effective lower bound risk	Consider more use of negative interest rates, forward guidance with escape clauses, cautious use of QE, tolerate small inflation undershooting

Source: IMF staff.
Note: QE = quantitative easing.

External Sector Policy Frameworks

Challenges	Possible Adjustments
Higher volatility of trade and capital flows	More systematic application of the Integrated Policy Framework
Higher uncertainty about the nature and transmission of shocks	Improve real-time shock identification Develop effective modalities of FXI, MPM, and CFMs (magnitude and instruments)
Deepening financial frictions under structural transformations	Prioritize developing domestic financial markets, incl. adaptation to ongoing structural transformations
Possibly lower effectiveness of CFMs. More fragmented GFSN	Establish conditions for using FXI under more frequent shocks and higher uncertainty, upgrade reserve adequacy metrics

Source: IMF staff.
Note: CFMs = capital flow management measures; FXI = foreign exchange intervention; GFSN = global financial safety net; MPM = macroprudential policy measure.

Abbreviations

CFM	capital flow management measure
ELB	effective lower bound
FFL	funding for lending
FG	forward guidance
FXI	foreign exchange intervention
GEF	geoeconomic fragmentation
IPF	Integrated Policy Framework
IT	inflation targeting
MPM	macroprudential policy measure
MSD	maximum sustainable debt
QE	quantitative easing
TFP	total factor productivity
UMP	unconventional monetary policy

1. Introduction

The global economy is being reshaped by major structural transformations, including demographic shifts, climate change, geoeconomic fragmentation, and artificial intelligence (AI).[1] These transformations and their interactions will pose new challenges for policymakers by altering growth dynamics, amplifying uncertainty, and changing the nature of shocks. This paper aims to shed light on *whether existing macro policy frameworks remain effective in the environment shaped by these transformations and related shocks*. It does this by first discussing how these transformations affect key economic variables in advanced economies (AEs), emerging markets (EMs), and low-income countries (LICs) over the next decade, before examining the implications for fiscal, monetary, and external sector policy frameworks, identifying emerging challenges, and proposing possible adjustments.

A. Structural Transformations

In the coming decade, these transformative forces and their interactions are expected not only to affect growth and fiscal spending but also lead to more frequent and persistent supply shocks, and higher growth and inflation volatility. Some of the key channels are highlighted below:

- *Demographics*. Fertility rates have declined globally, dropping below the replacement level in many countries, while longevity has increased. Although the total global population is projected to increase until the 2080s, there is a significant variation across countries (Figure 1, panel 1).[2] For aging countries, the implications range from pressures on fiscal sustainability and social cohesion to weaker growth due to declining labor force and total factor productivity (TFP) growth given a higher share of older workers. In contrast, many LICs could benefit from the demographic dividend but will need to foster opportunities for their youth and avoid capital shallowing.
- *Climate change*. Although the full effect of rising global temperatures on growth is uncertain, countries are already grappling with the effects of record-breaking extreme weather events (Figure 1, panel 2). Natural disasters can both disrupt output in the short term, as the workforce is prevented from working or a harvest is destroyed, and in the medium term, as physical capital is destroyed and needs to be rebuilt. Meanwhile, how and when the green transition will unfold poses significant challenges to firms, households, and policymakers, including in (but not limited to) fossil fuel exporters. Stranded assets and climate-related vulnerabilities may also increase financial stability risks.
- *Geoeconomic fragmentation*. Geoeconomic fragmentation, defined as a policy-driven reversal of economic integration guided by countries' strategic considerations, is deepening with a rising number of cross-border restrictions on trade and investment flows (Figure 1, panel 3). As countries continue reshaping their trade, foreign direct investment (FDI), and financial linkages to reduce exposures to geopolitical risks, gains from international trade and international risk sharing may be eroded, leading to weaker growth and higher volatility (Aiyar and others 2023; Bolhuis, Chen, and Kett 2023; IMF 2023b, 2023g, 2023f, 2024c, 2024d; Okuda and Tsuruga 2024). The recent intensification of trade tensions and geopolitical conflicts will likely further increase calls for greater energy security and self-sufficiency, strengthening incentives for inward-looking policies and further deepening fragmentation.

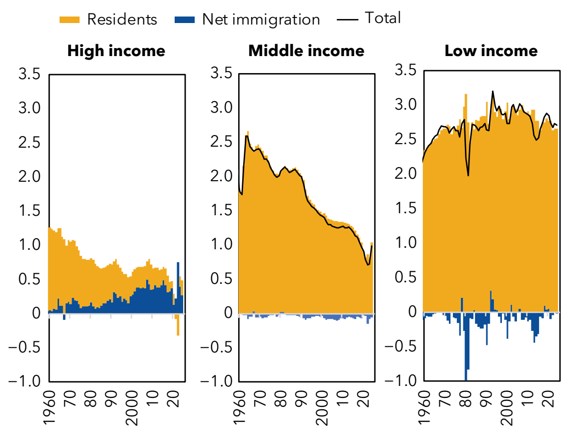
[1] These four megatrends were flagged as key transformative forces that will be shaping global economic landscape in the next 5–10 years by the country authorities in their responses to the survey conducted in the context of the IMF's Comprehensive Surveillance Review (2026).

[2] For example, at one extreme, Korea's population is projected to decrease by almost 60 percent by 2100, whereas the population of low-income countries (LICs) is projected to increase by 187 percent in the same period.

- *AI*. Recent advances in AI could trigger the next wave of automation and profoundly change the structure of economies. The resulting gains in productivity promise to boost growth, especially in AEs where sectoral exposure to AI and digital preparedness are higher. However, the magnitude of these gains and the horizon over which they might materialize are highly uncertain. At the same time, large increases in AI investment along with rapid AI adoption (Figure 1, panel 4) could pose challenges for effective regulation, raise energy prices, and increase cybersecurity and financial stability risks (IMF 2024b; Bogmans and others 2025). AI could also affect income and wealth inequality within countries, for instance through displacement of jobs—including those previously shielded from automation—and greater market concentration and power (Cazzaniga and others 2024; Cerutti and others 2025).

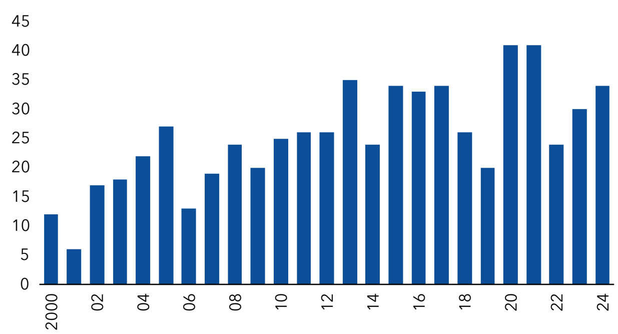
Figure 1. The Four Major Structural Transformations

1. Contributions of Residents and Migrants to Population Growth—by Income Group
(Annual percentage change)



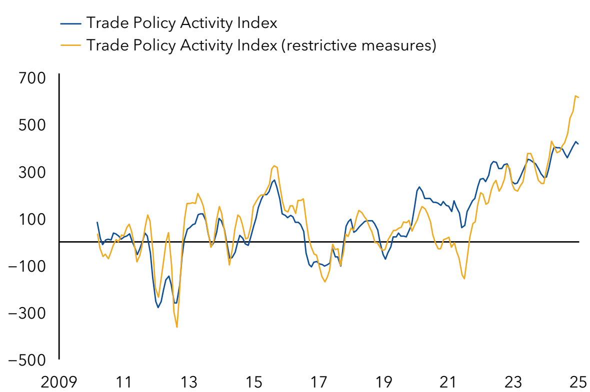
Source: United Nations Population Division.
Note: Grouped by country income groups.

2. Extreme Disasters Globally
(Count of disasters with damages more than US$1 billion)



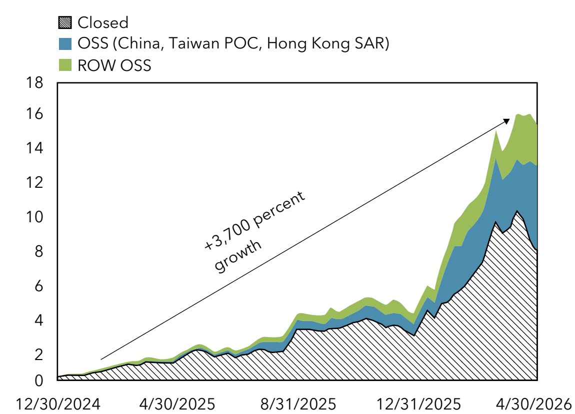
Source: EM-DAT.
Note: Count of disasters with damages more than US$1 billion, excluding earthquakes and volcanic eruptions.

3. Increase in Trade Restrictiveness
(Index, Jan. 2010–Dec. 2011 = 0)



Source: Centorrino, Diakantoni, and others (2025).
Note: The Index is a composite indicator derived from a dynamic factor model estimation synthesizing a broad set of trade-related policy measures normalized to a reference period.

4. AI Token Usage by Source Type
(Weekly token volume in trillions)



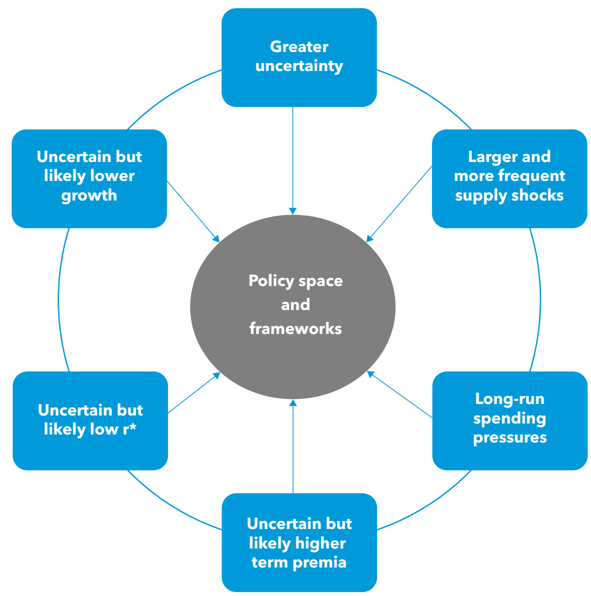
Sources: Data provided by OpenRouter, Inc. used under license; and IMF staff calculations.
Note: Token volume refers to the sum of prompt and completion token based on metadata collected from the OpenRouter platform, a unified AI inference layer. "Closed" refers to proprietary models accessibly through restricted API. "OSS" refers to open-source models with publicly available weights. Rest of the world (ROW) covers North America, Europe, and other regions. Also see Aubakirova and others (2025). AI = artificial intelligence; API = application programming interface.

Overall, the net effect of these structural transformations on growth is estimated to be negative on average and for most economies. Although there is significant uncertainty around these estimates, negative climate and geoeconomic fragmentation effects are shown to combine with unfavorable demographic trends in a wide range of economies, with only a partial offset from the growth-enhancing effects of AI.

B. Macroeconomic Policy Frameworks

In a more uncertain and shock-prone environment, existing policy frameworks may need to be adapted to remain effective in safeguarding domestic and external stability (Figure 2). Policy frameworks refer to the institutional arrangements, rules, and policy instruments that guide short-to-medium-term economic stabilization and anchor inflation and debt sustainability expectations. They encompass fiscal policy, monetary policy, macroprudential policy measures (MPMs), foreign exchange intervention (FXI), and capital flow management measures (CFMs), which can form part of an integrated policy mix (see IMF 2020, 2022, 2023c, 2023d). Many frameworks currently in place were originally developed during the Great Moderation and, while these frameworks have been adapted since the global financial crisis and COVID-19, they may nonetheless require further adjustments if heightened uncertainty as well as larger and more frequent supply shocks become the new normal. This paper focuses on macro policy frameworks and does not address financial regulation or the role of broader structural reforms in mitigating shocks or facilitating adaptation to structural transformations.

Figure 2. Key Effects of Structural Transformations and Their Interactions on Macro Policy Frameworks and Policy Space



Source: IMF staff.

Macro policy frameworks will likely face multiple pressures:

- *Fiscal policy.* With public debt and deficits already elevated, fiscal policy will confront sharper trade-offs between preserving fiscal space and output stabilization. These pressures will intensify if growth slows (for example, if the potential productivity boost from AI fails to offset the drag from the other transformations) and spending rises because of the demographic transition, climate change, the climate transition, and geoeconomic fragmentation. Fiscal policy frameworks—rules, anchors, and reaction functions—may need to be recalibrated to maintain fiscal space and contain the macroeconomic and financial stability risks associated with higher debt levels.
- *Monetary policy.* The likely more frequent and persistent supply shocks will complicate inflation–output stabilization trade-offs. Although the long-term effects of structural transformations on natural interest rates remain uncertain, they are generally expected to remain low, suggesting that monetary policy frameworks may again be challenged by the effective lower bound (ELB), as in the pre-COVID-19 period.
- *External sector policies.* Increased capital flow and trade flow volatility may lead to greater use of policy tools such as FXI, CFMs, and MPMs, calling greater attention to the integrated use of policy tools, as guided by the IMF's Integrated Policy Framework (IPF), and highlighting the need to revisit foreign exchange (FX) reserve adequacy frameworks and strengthen the global financial safety net (GFSN).

Calibrating the optimal policy mix could become more challenging. Structural transformations may exert conflicting pressures on monetary, fiscal, and external sector policies, amplifying trade-offs and increasing the importance of a more holistic approach to managing available policy space. Against this backdrop, the paper addresses **three sets of questions**:

(1) How will structural transformations and their interactions affect long-run growth?

(2) How will these structural transformations influence the nature of shocks/risks economies face, the associated transmission channels, and other key macroeconomic variables?

(3) What are the implications for macroeconomic policymaking? What adjustments are needed to ensure that fiscal, monetary, and external sector policy frameworks remain effective in maintaining domestic and external stability?

2. Economic Effects of Structural Transformations

A. Long-Run Growth Impacts

Although there is broad agreement on the importance of the four megatrends in shaping future economic outcomes, there is considerable uncertainty about the magnitude of impacts. This section presents estimates of the potential effect of each structural transformation *on average GDP per capita growth over the next decade (2026–35)* for 143 economies. For each transformation, the estimated impact is defined as the difference between the annual real GDP per capita growth under the transformation and a *hypothetical baseline* that does not include the transformation going forward.[3] This exercise differs from baseline long-run growth forecasts: Here we isolate the effects of moderate-impact scenarios for each structural transformation without taking a stance on likelihoods, whereas baseline forecasts focus on the most likely scenarios incorporating country-specific factors and judgment. Furthermore, these estimates should not be viewed as simple add-ons to the latest baseline projections, as some of these effects may have already been internalized by economic forecasters.

Figure 3 presents estimates for a **moderate-impact scenario** for each of the structural transformations. These estimates are based on a parsimonious approach applied to a large sample of economies, with ranges of uncertainty provided where possible. Although the specific methodologies differ by megatrend, these are standard approaches for each particular structural transformation that can be applied to any number of countries in a consistent way. In contrast, a structural model that has the capacity to simultaneously consider the macro effects of more than one megatrend would typically limit the number of countries and economic sectors (as, for example G-Cubed dynamic general equilibrium model application in McKibbin and Liu 2025). The goal is to have a common starting point for assessing the extent of economies' exposures to these transformations and for quantifying possible implications for policy space and policy constraints (discussed next).

Specifically,

- *Demographics:* Estimates are based on staff calculations using a Cobb-Douglas production function with population projections from the UN's World Population Prospects Dataset 2024 vintage and incorporating a reduction of TFP in economies with larger shares of older workers (as in Aiyar and Ebeke 2016).[4] The moderate scenario uses the median UN population projections by five-year age-groups to track the total and working-age population in each country. We assume that GDP depends on the dynamics of the labor force (population aged 15–65) and we do not make any additional assumptions on offsets through later retirement or more healthy aging—in part because these are country-specific, and often politically challenging (see IMF 2025g). The uncertainty around population projections over the forecasting horizon primarily affects the total population, while the working-age population is largely predetermined for time horizons shorter than 15 years. For this reason, the uncertainty of GDP per capita growth related to demographics comes from changes in the number of dependents, with deviations from the moderate scenario

[3] For example, for climate transition, this means that future temperatures remain the same as the 2025 level. For demographics, the hypothetical baseline assumes constant population at the 2025 level. This approach is consistent with the literature.

[4] Slower total factor productivity (TFP) growth in older populations reflects a combination of factors—reduced physical and cognitive abilities as workers age, in addition to slower creation of new technologies (see Aksoy and others 2015). Similar effects are found by Feyrer (2007) and Poplawski-Ribeiro (2020), whereas 2025 *World Economic Outlook* chapter on "silver economy" (IMF 2025g) not only argues that "healthy aging" could reduce the effect of aging on productivity but also notes that the effect is small for workers above 60.

of about +0.2 and −0.2 percentage points per year for low- and high-fertility scenarios, respectively, while the total GDP remains unchanged over the period (see Annex I for more information). Finally, migration flows, considerable for some economies, are taken at their baseline projected values.

- *Climate change:* Figure 3 presents estimates based on IMF staff's assessment of slow-moving (chronic) climate effects across economies.[5] This analysis uses a panel econometric model to estimate the effects of temperature increases on macroeconomic variables. The moderate scenario focuses on a *world of incremental progress*, where current policy trends broadly continue and emissions fall only slowly. As a result, global temperatures keep rising and the overall temperature outcome moves well beyond what is consistent with the goals of the Paris Accord. The additional losses from extreme weather shocks ("acute" effects) are available only for 49 AEs and EMs (as discussed in Box 1). To provide a comparison, the global average level effect of chronic damages by 2100 is estimated at a moderate 8 percent using this approach, whereas the literature provides a range for total effects from 1 percent to 25 percent depending on the modeling approach (all for the "current policies" scenario). Box 1 provides a more in-depth discussion of the uncertainty around these estimates.
- *Geoeconomic fragmentation*: Effects are based on a standard quantitative multicountry multisector general equilibrium trade model, where barriers between economies are introduced through iceberg trade costs. Scenarios are adapted from Bolhuis, Chen, and Kett (2023), taking into account ongoing developments in global trade policies. These estimates do not account for the negative effects of fragmentation of FDI and financial flows.[6] With an average long-term global impact of negative 2.1 percent of GDP, these estimates are in line with the Aiyar and others (2023), which reports model-based estimates of losses ranging from about 0.2 percent in mild fragmentation scenarios to roughly 7 percent in severe cases, with country-level losses potentially higher (up to ~8–12 percent) when technological decoupling is included. The iceberg trade cost increases are also within the ranges observed during the peak periods of the 20th century (see Jacks, Meissner, and Novy 2008). Estimates are based on adapting to long-run outcomes over a 10-year period.
- *Artificial Intelligence*: The growth impact estimates are derived by extending Acemoglu's (2024) task-based framework across economies. Occupation-specific AI exposure is weighted by country-specific wage bill shares to gauge potential productivity gains. Since the profitability of automation depends on relative labor costs, the gains from AI are adjusted for cross-country differences in wages, with stronger incentives to adopt AI in AEs already facing adverse demographics. Lower AI preparedness, including digital infrastructure, human capital, and regulatory capacity, slows AI adoption leading to lower productivity gains.[7] Finally, over the medium term, capital is expected to adjust in line with the productivity gains. Our estimate for the United States is somewhat larger than Acemoglu (2024), reflecting more optimistic assumptions on productivity gains, and in line with recent IMF scenarios, though toward the lower end of estimates discussed in the literature (see Annex 1 and Box 2 for more details). Significant upside risk could come from innovation spillovers though these are unlikely to materially affect GDP over the horizon considered in this paper.

Figure 3 shows that there is a large variation in the expected effects across AEs, EMs, and LICs:

- *Growth in AEs,* on average, will be negatively affected by demographic shifts (−0.5 percentage points); climate change (−0.3 percentage points, including both chronic and acute effects);[8,9] and geoeconomic fragmentation (−0.2 percentage points), with demographics being the main drag on growth. The positive estimates of the effect of AI (+0.3 percentage points) suggest that the upside may not be large enough to offset the

[5] Further information can be found in Centorrino, Massetti, and others (2025).

[6] The estimates focus on trade-specific fragmentation costs, but it is important to note that additional losses are also likely to occur because of barriers to capital flows, in particular foreign direct investment (FDI), and knowledge spillovers (IMF 2023b, 2023g).

[7] The analysis assumes that, conditional on access to the technology, countries are ultimately able to adopt AI and realize productivity gains, even if diffusion is slower initially. In this sense, preparedness affects the timing rather than the long-term feasibility of artificial intelligence (AI)-related gains.

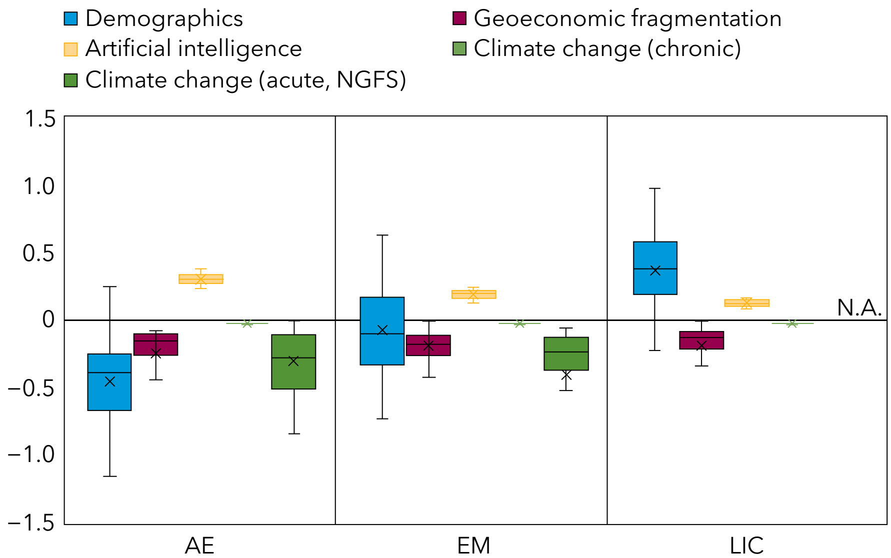
[8] Chronic effects are available for all 143 economies (34 advanced economies [AEs] and 68 emerging markets [EMs]). Acute effects are only available for a subsample of 32 AEs and 17 EMs. The combined effect adds together the average effect of chronic and acute effects for the available samples by income group.

[9] Although acute losses appear to be larger for AEs than EMs, this is in part because of the larger sample of AEs. The simple average for EMs is −0.4 relative to −0.3 for AEs, highlighting the heterogeneity between countries within income groups.

negative effects stemming from other transformations. AI would need to add around 1 percentage point to annual growth for the average AE to offset the effects of other transformations—a tall order requiring fast and widespread adoption, viewed as unlikely by many researchers, at least for the next decade (see Box 2). The estimated total impact on an average AE (−0.7 percentage points, including both chronic and acute climate effects) is significant when compared with the average annual per capita growth of 1.6 percent during 2015–24.

Figure 3. Estimated GDP Impacts from Structural Transformations, Moderate Scenario, 2026–35

(Average yearly effect on GDP per capita growth per country, percentage points; for each megatrend, the chart shows interquartile ranges for economies in the AE, EM, and LIC income groups based on the sample of 143 economies)



Sources: Demographics, staff calculations based on UN population projections with Cobb-Douglas production function; climate change, chronic effects sourced from Centorrino, Massetti, and others (2025), acute effects from NGFS (n.d.); GEF, based on staff calculations using Caliendo and Parro (2015) long-run GE trade model; AI, based on staff calculations following Acemoglu (2024), incorporating labor market exposure from Cazzaniga and others (2024); and IMF staff calculations.

Note: All effects are relative to hypothetical baseline without the trend. Full sample covers 34 AEs, 68 EMs, and 41 LICs (acute climate effects available for subsample of 32 AEs and 17 EMs). Detailed description of methodologies can be found in Annex I. Chronic and acute climate effects may not be fully additive. AEs = advanced economies; EMs = emerging markets; LICs = low-income countries.

- *Growth in EMs,* on average, will be adversely affected by geoeconomic fragmentation (−0.2 percentage points) and climate change (−0.4 percentage points, including both chronic and acute effects). Demographic trends will have heterogeneous effects: Some economies may potentially benefit from a demographic dividend, whereas others will face aging-related headwinds. On average, the effect of demographics is negative (−0.1 percentage points). Gains from AI would only reach 0.2 percentage points per year for an average EM, not enough to offset the effects of other megatrends. The estimated total effect on an average EM (−0.5 percentage points, including both chronic and acute climate effects) is fairly large compared with the average annual per capita growth of 2.4 percent during 2015–24.
- *Growth in LICs,* on average, is projected to face headwinds from both geoeconomic fragmentation (−0.2 percentage points) and climate change (with acute effects likely significant but difficult to ascertain in the absence of reliable estimates). In contrast, demographic dynamics could provide a strong tailwind (+0.4 percentage points), but the magnitude of the positive effect will depend critically on the ability of these economies to productively employ their rapidly expanding labor forces and avoid capital shallowing.[10]

[10] The question is whether LICs are capable of matching their population growth with enough investments to prevent the dilution of capital per worker. Based on historical data, capital dilution because of rapid population growth does not seem to be a problem for LICs. We also do not find a long-term systematic connection between the rates of population growth and unemployment. That said, geoeconomic fragmentation may potentially reduce technology diffusion and availability of external financing for LICs, which would affect the pace of capital deepening.

Given limited AI preparedness, high employment shares in sectors with low AI exposure and relatively low labor costs, productivity gains from AI adoption in LICs could be modest in the medium term. On balance, it is unclear whether the average annual per capita growth in LICs of 2.3 percent during 2015–24 can be lifted or sustained going forward.

Overall, estimates in Figure 3 are broadly in line with the literature.[11] However, given uncertainty about the magnitude of the effects of the four structural transformations, and the range of channels through which they affect growth, these estimates should be considered as illustrative. Annex 1 provides more details.

So far, the megatrends have been analyzed separately but as most economies are simultaneously exposed to multiple structural transformations, *their combined effect on growth may be larger than the sum of the individual effects* (see Annex Table 1.1). In some cases, interactions may reinforce each other; in others, they may partially offset. For example, geoeconomic fragmentation could restrict migration, exacerbating demographic pressures by preventing workers from moving to aging economies while trapping excess labor in economies with younger populations. Fragmentation can also weaken international knowledge transfer, slowing the diffusion of AI technologies and dampening associated productivity gains. Geopolitical tensions could lead to disruptions in the supply of fuel and other critical commodities that could slow advancement and diffusion of AI. Conversely, rapid advances in AI may heighten strategic competition, prompting additional export controls and trade barriers as economies seek technological dominance or autonomy—further intensifying fragmentation.

A full modeling of these interaction channels is beyond the scope of this paper. However, indicative estimates of effects through selected channels—related to higher barriers to trade and migration, and slower AI diffusion—could shave off an additional 0.4 percentage points of annual per capita growth on average in the moderate scenario. *This would bring the total average effect of the combined megatrends (not including acute climate effects) to over half a percentage point* (see Annex 1 for details).

The bottom line is that the effect of ongoing structural transformations on future GDP growth is highly uncertain but likely very significant. To better understand possible magnitudes and relevant transmission channels for individual economies, there is a need for more holistic consideration of ongoing structural transformations, including their complex interactions with each other and the country-specific structural and institutional features.

[11] McKibbin and Liu (2025) summarize a range of studies of long-term GDP growth projections and provide their own projections that explicitly account for demographics, potential AI adoption, and climate change. The latter suggest for AEs an average effect on 2026–35 GDP per capita from demographics of −0.5 percent, from AI +0.6 percent, and from climate change −0.7 percent. For EMs, the average effects are −0.2 percent (demographics), 0.3 percent (AI), and −1 percent (climate change). For LICs, the average effects are +0.4 percent (demographics), 0.2 (AI), and −0.9 (climate change). These projections point to significant downshift in GDP per capita growth, concentrated in AEs and EMs, and are broadly similar to the projections of the moderate scenario in this paper for demographics, somewhat more positive for AI, and somewhat more pessimistic for climate change.

Box 1. Potential Effect of Climate Change on GDP: What We Know So Far

Currently, there is no consensus on how severely temperature increases affect GDP. For the same assumed global warming trajectory, different modeling strategies yield markedly different estimates of long-run GDP losses. Traditional integrated assessment models, computable general equilibrium models, and empirical approaches that link temperature increases to GDP levels, typically imply relatively modest damages—often a few percent of GDP by 2100. By contrast, empirical approaches that relate temperature to GDP growth (possibly nonlinearly) and incorporate broader transmission channels (for example, climate variability and natural disasters) suggest substantially larger effects. A recent comparison of alternative damage functions under the "current policies" scenarios of Network for the Greening of the Financial System by Aerts, Stracca, and Trzcińska (2024) (see Box Table 1.1) finds that projected global GDP losses by 2100 range from about 2 to 44 percent, depending on the specification. This wide range reflects uncertainty in how temperature increases translate into economic damages, rather than differences in climate scenarios.

Box Table 1.1. Various Estimates of Climate Effect

(Percentage points)

Study	Type of Damage Function	Projected Effect of 1°C Incremental Global Temperature Increase	Projected Global GDP Loss by 2100 under Current Policies in the Absence of Further Climate Action
Nordhaus and Boyer (2000)	Enumeration	1 percent	2 percent
Weitzman (2012)	Enumeration	1 percent	3 percent
Tol (2014)	Meta-analysis	1 percent	2 percent
Nordhaus (2014)	Enumeration	1 percent	2 percent
Dietz and Stern (2015)	Enumeration	3 percent	13 percent
Burke, Hsiang, and Miguel (2015)	Econometric	10 percent	14 percent
Howard and Sterner (2017)	Meta-analysis	4 percent	8 percent
Kompas, Pham, and Che (2018)	CGE	1 percent	2 percent
Kalkuhl and Wenz (2020)	Econometric	3 percent	5 percent
Howard and Sylvan (2020)	Survey	4 percent	8 percent
Kahn and others (2021)	Econometric	4 percent	7–13 percent
Waidelich and others (2024)	Econometric	5 percent	8 percent
Bilal and Känzig (2024)	Econometric	25 percent	44 percent

Source: Economic losses from climate change are probably larger than you think: New NGFS scenarios, Aerts, Stracca, and Trzcińska (2024), VoxEU.
Note: CGE = computable general equilibrium.

Many studies estimate chronic effects only, whereas some also consider acute damages. Chronic (driven by gradual temperature changes) effects of climate change are slow-moving, persistent effects that accumulate over time and affect economic output. Acute effects of climate change represent the average effect of sudden, high-impact events that cause immediate economic and physical damage.

Chronic effects are better understood than acute effects though estimates still vary widely. The chronic damage estimates used in this paper are based on the IMF How-To Note (Centorrino, Massetti, and others 2025) that follows Kahn and others (2021) and uses panel regressions linking persistent temperature increases to output (see Box Table 1.1). Under current policies, this approach implies limited near-term GDP effects—generally below 2 percent by 2030—but rising losses over time to around 3–6 percent by 2050 and about 7–10 percent by 2100. These estimates are accompanied by 95 percent confidence intervals that widen with the horizon, spanning roughly 0–10 percent of GDP losses by mid-century and about 1–20 percent by 2100, reflecting parameter uncertainty and different adaptation speeds.

Acute damages are even harder to quantify. Uncertainty is even greater for extreme weather (acute) effects, which are inherently nonlinear and more difficult to quantify. Network for the Greening of the Financial System Phase IV estimates suggest that acute damages alone could result in GDP losses of up to around 8 percent by 2050 for the 49 economies covered in Figure 3. These estimates show much larger effects for acute damages than chronic damages, with the average effects being larger for emerging markets than for advanced economies (AEs). There are no well-established estimates of acute damages for low-income countries, with some studies suggesting larger damages because of lack of preparedness, whereas others pointing to lower capital losses from extreme events than in advanced economies or emerging markets.

Estimates are subject to scenario dependence and structural uncertainty. Estimates depend on emissions paths, adaptation, and technological change. Empirical relationships may not hold under higher warming, and many models omit tipping points, financial spillovers, and interactions with structural shifts. Focusing on near-term realized damages also understates lock-in risks—the macroeconomic consequences of being committed to a high-warming path (tragedy of the horizon). Taken together, climate-related GDP losses are likely to increase over time and may become substantial by mid-to late century, but their magnitude remains highly uncertain and skewed toward adverse outcomes.

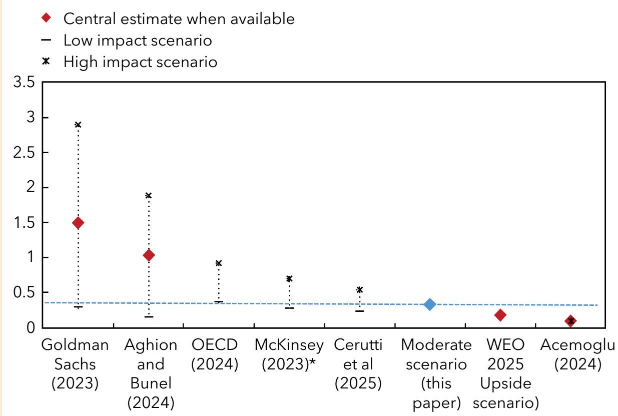
Box 2. Potential Impact of Artificial Intelligence (AI) Adoption on Growth: What We Know So Far

Estimates of the growth impact of AI differ widely. Early estimates by Goldman Sachs (Briggs and Kodani 2023) projected labor productivity gains from AI of around 1.5 percentage points per year on average over the next 10 years for the United States, but after considering additional factors, those gains only translated to 0.4 percentage points additional medium-term GDP growth. Aghion and Bunel (2024) arrive at a similarly optimistic boost of around 1.0 percentage point per year to labor productivity over the same horizon. On the other end of the spectrum, Acemoglu (2024) expects no more than 0.1 percentage points of annual labor productivity growth due to AI in the next 10 years (see Box Figure 2.1). This paper's moderate scenario follows Acemoglu (2024) framework but estimates somewhat larger gains—around 0.3 percentage points per year for the United States, between the high total factor productivity scenario in Cerutti and others (2025) and the upside scenario explored in the 2025 October *World Economic Outlook* (IMF 2025h).

Although most analysts recognize the powerful capabilities of AI, there is considerable disagreement about the scale of potential macroeconomic gains. The text chart compares estimates from different studies for the United States. Although most papers employ a similar task-based framework to aggregate micro data on occupations and productivity gains, differing views about the potential speed and scale of AI adoption lead to vastly different estimates. Acemoglu (2024) based on Eloundou and others (2023) and Svanberg and others (2024) estimates that AI would be capable of performing tasks accounting for about 20 percent of the aggregate US wage bill today. However, given the high cost of AI, Acemoglu assumes that only 23 percent of tasks exposed to AI can be *profitably* automated in the next decade, limiting aggregate GDP gains to a magnitude comparable to those observed from earlier waves of automation. Others believe AI adoption will be much broader—up to two-thirds of jobs exposed, of which up to 80 percent could see productivity gains from AI adoption—explaining most of the differences in estimates.

Box Figure 2.1. Estimates of AI Effect in the United States across the Literature

(Annual labor productivity growth in percentage points)



Source: IMF staff calculations, other sources presented in chart.
Note: For ease of comparison, when a paper only presents TFP estimates, the labor share is used for conversion to labor productivity. Assuming constant capital-to-labor ratios, GDP grows at same rate. AI = artificial intelligence; TFP = total factor productivity.
* McKinsey estimate only includes generative AI, total estimate including all automation is substantially larger.

Additional uncertainty stems from the still limited information on the likely productivity gains, sectoral reallocation and distributional effects, and the pace of innovation. So far only a handful of case studies based on early experience with AI adoption give a sense of the potential productivity gains from using AI in the workplace. More research is needed to measure gains for a broader set of occupations. It is also hard to predict how fast labor and capital can be reallocated to AI-exposed sectors. Filippucci, Gal, and Schief (2024) model frictions to factor reallocation, which may lower the gains, especially if productivity gains remain concentrated in a few sectors. Income inequality may also rise, especially for entry-level jobs with low complementarity to AI (Cazzaniga and others 2024), dampening aggregate demand. On the other hand, upside risks from new job creation or even faster innovation through increased research and development productivity could be substantial. Baily, Brynjolfsson, and Korinek (2023) argue that under this scenario, US GDP could double in 20 years.

Emerging and low-income economies may see fewer benefits of AI, especially initially. Many emerging markets (EMs) have a sectoral composition skewed toward less AI-exposed sectors, which lowers potential productivity gains (Cazzaniga and others 2024). Accounting for lower AI exposure and preparedness, because of a lack of digital infrastructure, access to AI and gaps in legal and regulatory frameworks, Cerutti and others (2025) find that low-income countries will only see half the gains of advanced economies. We add varying labor costs as another factor—cheap labor in many economies may make automation with AI less profitable, whereas aging economies with scarce labor may benefit more. Over the next 10 years, we find the additional growth in EMs (low-income countries) from AI is likely to be only about half (one-third) of the effect in the United States. Even under optimistic assumptions, AI seems unlikely to fully offset the negative effect from other megatrends, especially in economies with adverse demographics: For the average advanced economy (EM) in the moderate scenario shown in Figure 3, this would require gains from AI to be close to 1.0 (0.7) percentage point per year. Many LICs, especially in Africa, still benefit from the demographic dividend but for those with less favorable dynamics, AI equally seems to be an insufficient remedy.

B. Shocks and Uncertainty

The four structural transformations and their interactions are also likely to influence the nature, frequency, and dynamics of shocks.[12] For several megatrends, changes in the incidence or severity of particular shocks are already foreseeable as the underlying transformations unfold. For example, the frequency and intensity of extreme climate events tend to increase with rising global temperatures. Table 1 illustrates the types of shocks associated with each of the four structural transformations, as well as those that may emerge from their interactions.

Table 1. Structural Transformations Affect the Economy through Trend Shifts and Shocks

Transformation	Trend Impacts	Shocks and Uncertainty
Demographics	Decline in working-age population Higher dependency ratio	Migration shocks (for example, from climate-induced natural disasters, fragmentation-induced policy shifts, and conflicts)
Geoeconomic fragmentation	Reduced allocative efficiency due to trade and financial barriers Reduced knowledge spillovers Reduced international risk sharing	Sharp changes in cross-border barriers Increased uncertainty over future barriers Regional conflicts and supply disruptions
Artificial intelligence	Increased TFP, gradual structural transformation Higher investment in AI infrastructure	Rapid displacement of specific employment types Sharp policy shifts (for example, regulatory, taxation, IP) Greater risk of cyber threats Additional upward pressure on energy prices
Climate change	Impact on output and inflation from temperature increases, adaptation, and green transition More stranded assets Higher investment in green technology	More frequent and more intense natural disasters Sharp policy shifts (for example, regulatory, taxation, IP)

Source: IMF staff
Note: AI = artificial intelligence; TFP = total factor productivity; IP = industrial policy

Although the precise timing of shocks is unpredictable, identifying how each megatrend maps into different types of shocks is essential for assessing whether existing macro policy frameworks are sufficiently robust to handle future disruptions. For monetary policy, distinguishing between demand and supply shocks, along with identifying persistence and second-round effects, remains central to the calibration of the policy stance. Differentiating between fundamental and nonfundamental shocks is similarly critical for formulating appropriate policy advice.[13] Several developments associated with the structural transformations are particularly relevant for policymakers:

- More frequent, severe, and/or persistent *aggregate supply shocks* stemming from disruptive geopolitical events, trade barriers, restrictions on migration, or extreme climate events.[14]

[12] It is also possible that increased uncertainty could depress growth as discussed in Bianchi, Kung, and Tirskikh (2023). Such feedback effects are not reflected in the effects of the megatrends on trend growth.

[13] In the context of the IMF's Integrated Policy Framework (IPF), fundamental shocks are those that require macroeconomic adjustments to restore stability, irrespective of whether financial frictions exist. Fundamental shocks include unexpected movements in remittances, tourism flows, supply of agricultural output, commodity prices, or FDI flows (particularly if driven by changes in anticipated productivity) as well as shocks to fiscal sustainability.

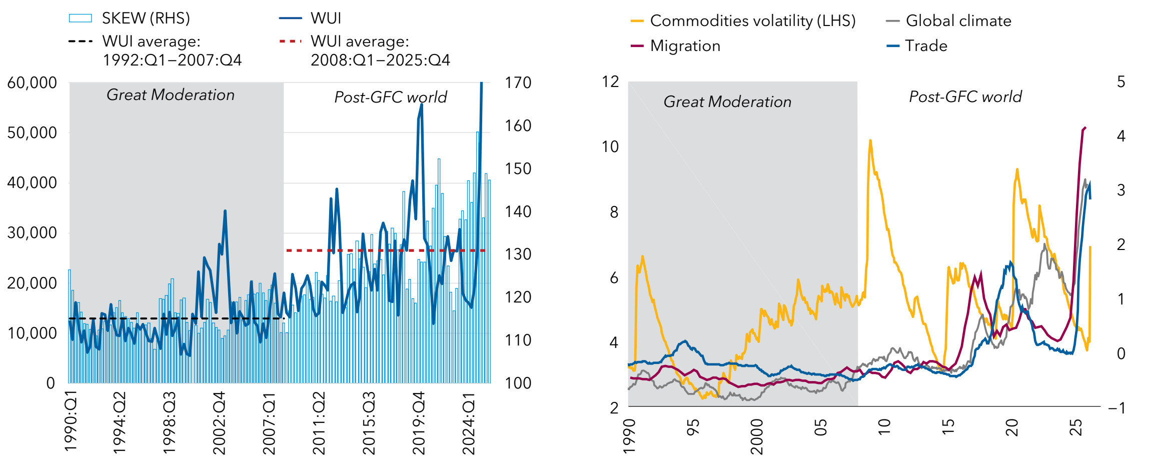
[14] Such events can manifest as both supply and demand shocks. They can manifest as supply shocks for some countries, for example, those that raise import tariffs, and demand shocks for other countries, for example, those that are subject to higher tariffs (also see section 4 on monetary policy frameworks).

- More frequent and widespread *policy-induced sectoral supply shocks* arising as economies pursue policies to achieve national/economic security objectives or gain strategic advantage in targeted sectors (for example, high tech, critical minerals, and so on).
- More frequent *risk-off shocks* with bouts of market volatility and disruptions in cross-border flows.
- *Uncertainty spikes* that act as demand shocks by depressing consumption and investment.

Figure 4. Economic Policy Uncertainty and US Equity Market Expected Volatility

1. World Uncertainty Index and Cboe SKEW Index

2. Economic Policy Uncertainty and Commodity Price Volatility
(Percent, LHS; number of standard deviations, RHS)



Sources: Cboe Global Markets; www.policyuncertainty.com; EUROPACE AG/Haver Analytics; and World Bank.
Note: Panel 1 shows the World Uncertainty Index and Cboe SKEW Index. The World Uncertainty Index determines uncertainty using the word "uncertainty" in the quarterly Economist Intelligence Unit country reports, and the index is GDP weighted. The Cboe SKEW index measures the market's perceived "tail risk"—the probability of extreme market moves—in the S&P 500, over a 30-day horizon, a higher SKEW means that investors are paying more to hedge against "tail risk," this series is averaged quarterly for this chart. Panel 2 shows a 12-month moving average of *z*-scores of economic policy uncertainty indices (count frequency of policy area-specific uncertainty terms in news reports) with mean and standard deviation since 1993 and exponentially weighted average volatility of monthly commodity price returns. Migration uncertainty is PPP-GDP weighted for large advanced economies' quarterly data. Trade uncertainty is the simple average of US and China trade uncertainty indices.

As the effects of ongoing structural transformations become more apparent, both economic and policy uncertainties rise as well, increasing demand for insurance and hedging against extreme downside risks (Figure 4). Overall, these developments signal an emerging regime shift toward a more volatile and supply-shock-prone environment, which is very different from the Great Moderation.

C. Natural Interest Rates and Term Premia

The four structural transformations are also likely to affect (real) natural interest rates and term premia. Although many factors shape the natural rate, longer-term potential growth prospects and the balance between supply and demand for savings are the primary drivers.[15] Across AEs, a range of estimates indicate

[15] The natural rate is the short-term (policy) real rate that brings inflation to target and output to potential. The well-known Laubach and Williams (2003) model directly ties the natural rate to potential growth following standard economic theory describing intertemporal optimizing behavior allowing for a persistent unobserved additional component. In such models, the natural rate is closely tied to potential growth, and the drivers of potential growth affect the natural rate typically one to one. Others, including Rachel and Summers (2019) and IMF (2023g), take a savings-investment balance perspective to allow for additional factors to influence the natural rate and help better explain the potential growth and additional unobserved component; these factors include demographic factors such as population growth and longevity, productivity growth, and the supply of and demand for safe assets.

that natural rates, after declining for several decades, stabilized and rose somewhat following the COVID-19 pandemic but still remain close to the low levels observed in the late 2010s (see Box 3).

Projecting future natural rates is even more complex than estimating their historical or current levels. Conceptually, future natural rates will depend on trajectories of population growth, longevity, productivity, and related structural forces. IMF (2023h) provides a comprehensive set of natural rate projections, based on scenarios aligned with structural transformations related to demographics, geoeconomic fragmentation, and climate change, covering both AEs and EMs over several decades, while the effects of AI are projected in this paper using a similar framework (see Figure 5, panel 1).[16] Because natural rates are shaped by slow-moving forces, the 2023 projections remain broadly relevant, albeit with some caveats:

- *Most factors point toward natural rates remaining low in AEs and declining in EMs* (IMF 2023h). In AEs, population aging is already advanced, implying that its future drag on natural rates will be more limited. At the same time, higher public debt and geoeconomic fragmentation could push natural rates upward—for example, if fragmentation reduces capital inflows from China and other EMs. In EMs, slowing productivity growth and aging populations are expected to bring natural rates down toward AE levels, albeit with significant differences in the projected decline across EMs, with larger declines in economies facing more adverse population dynamics. The decline in EM natural rates could be amplified by a redirection of China's outward capital flows toward domestic investments.[17,18] Furthermore, if population growth surprises on the downside, both potential growth and natural rates could fall further than current projections.
- *There is, however, a possibility that natural rates could be higher in the future*. Natural rates could rise if widespread AI adoption substantially boosts productivity growth or if the associated investment build-out generates strong investment demand. If future AI-related productivity growth aligns with the moderate scenario (Figure 3), this would have some positive effect on natural rates in both AEs and EMs, with AI's positive effects through higher productivity growth offset to some extent by increased inequality if AI's gains flow disproportionately to the upper levels of the income and wealth distributions. However, a larger productivity acceleration boost, or a more significant surge in AI-related investment, or more equitable distribution of AI's gains, could increase natural rates more substantially.[19] In addition, fiscal pressures and the increased supply of government bonds could raise natural rates in some economies by reducing convenience yields (Schnabel 2025). To date, there is no evidence that the recent, larger-than-expected fiscal deficits are exerting upward pressure on short-term rates. However, the effects of higher sovereign bond supply could instead appear in higher term premia; a point discussed further below.

[16] AI's effect on the natural rate is projected by applying elasticities of the natural rate to TFP growth and inequality (share of income of the top 10 percent of the income distribution who are assumed to capture all the AI gains from higher TFP growth), with the elasticities implied from Platzer and Peruffo (2022) which is the paper that informed the *World Economic Outlook* April 2023 projections for the other megatrends.

[17] IMF 2023 April *World Economic Outlook* estimates suggest that global r^* will decline from 1 percent in 2022 to 0.5 percent by 2030, based on r^* projections from a sample of large AEs and EMs. In plausible alternative scenarios, while factors such as higher government debt, erosion of the convenience yield, or higher labor shares in AEs could raise natural rates, natural rates are still expected to remain relatively low. The green transition may further lower natural rates, and geoeconomic fragmentation would have heterogeneous effects across regions. The reallocation of China's outward capital flows away from AEs is a significant driver of the decline in China's natural rate and may have a mixed effect on natural rates in other EMs, depending on how much of the flows are redirected to other EMs.

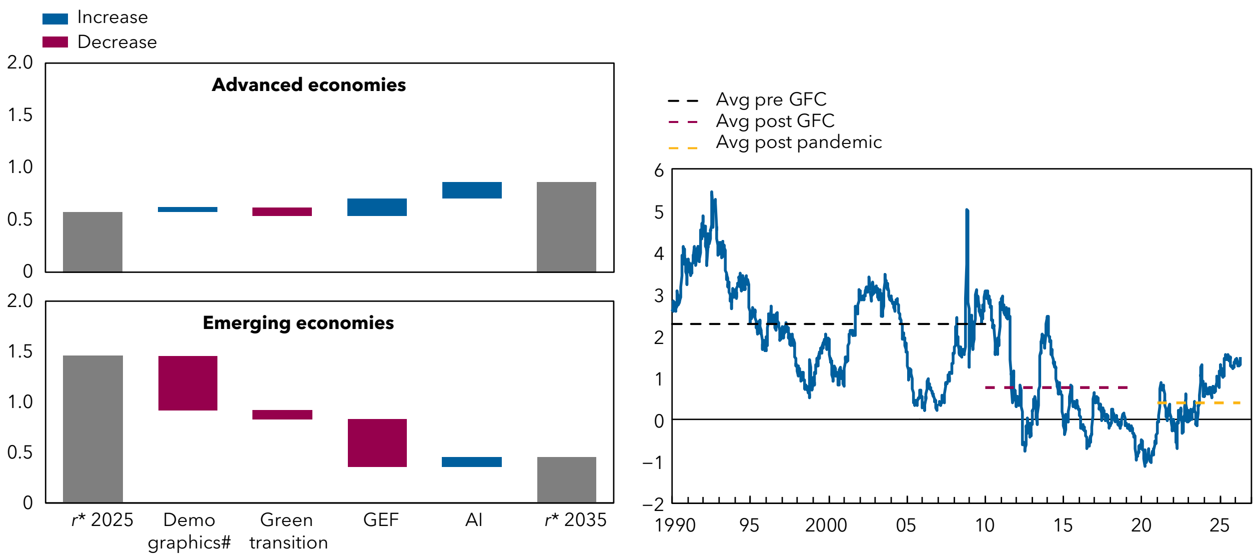
[18] Gopinath (2022) notes two more factors that could continue to depress r^*, rising inequality and savings, especially in safe assets.

[19] Melina and Villa (2025) argue that under a strong AI-led investment surge, broadly consistent with the information and communications technology investment boom in the United States in the late 1990s, natural rates can rise by 0.7 percentage points, which would result in a US natural rate that is double the baseline natural rate in AEs.

Figure 5. Natural Rates and Term Premia

1. Natural Rate of Interest and Effects of Transformations in Selected Economies
(Percent)

2. US Five-Year-Forward Term Premia
(Percent)



Sources: IMF *World Economic Outlook* April 2023; and IMF staff estimates.

Note: In panel 1, (the real) natural rate in 2025 blends estimates in early 2025 and *World Economic Outlook* April 2023 estimates. Other than for AI, the projections of the effects of the transformation on the natural rate are based on *World Economic Outlook* April 2023. # refers to *World Economic Outlook* baseline scenario that is largely driven by demographics and also includes effects of higher debt and productivity convergence across economies. AI's projected effect on the natural rate is based on projected AI effect on TFP growth and inequality, assuming that all AI benefits are captured by the top 10 percent of income distribution, using elasticities implied from Platzer and Peruffo (2022). AEs (United States, Germany, France, Japan, United Kingdom) and EMs (China, India, Brazil). In panel 2, term premia are the average from the Adrian, Crump, and Moench (2013) and Christensen and Rudebusch (2012) models. AEs = advanced economies; AI = artificial intelligence; EMs = emerging markets; GEF = geoeconomic fragmentation; TFP = total factor productivity.

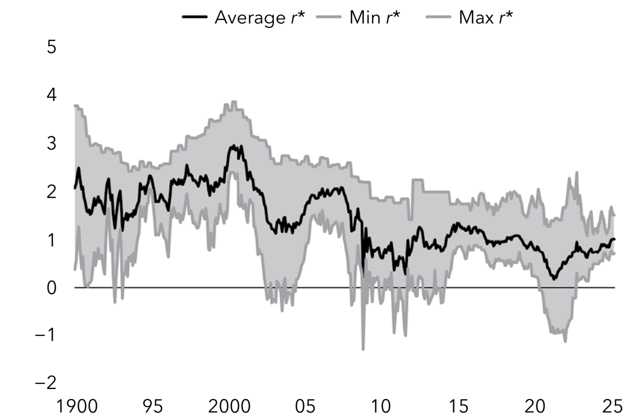
Since the global financial crisis, term premia have remained at historically low levels, but there are signs of a potential reversal. Term premia have risen somewhat alongside the steepening of yield curves since early 2025 (Figure 5, panel 2). A normalization of term premia to pre-global financial crisis levels could offset much of the benefit from low natural rates, thereby increasing borrowing costs for both sovereigns and the private sector. Several factors could push term premia higher. Heightened macroeconomic uncertainty and volatility may lead investors to demand greater compensation for holding longer-term securities. In addition, rising sovereign debt issuance—reflecting expanding fiscal spending needs (see next section)—could also push term premia higher by intensifying concerns about debt sustainability.

Box 3. Recent Natural Rate Developments in Select Economies

Given the inherent difficulty in estimating the natural rate, especially in real time, economists use a range of approaches. This box briefly discusses recent natural rate estimates for several advanced economies (AEs) for which estimates are available, with the fullest range of approaches available for the United States (Box Figure 3.1.). The estimates suggest that natural rates in AEs have increased somewhat since the COVID-19 pandemic but only to around prepandemic levels, which were considered historically low at the time. This is in line with recent research findings such as Cacciatore, Feunou, and Ozhan (2024) for the United States and Canada, Brand, Lisack and Mazelis (2024) and Beyer and Brandão-Marques (2025) for the euro area, and Nakano, Sugioka, and Yamamoto (2024) for Japan.

Box Figure 3.1. Natural Rate Estimates for the United States

(Percent)



Sources: Authors' calculations; Consensus Economics; FRB; FRBNY; and FRBSF.

The most commonly used approach for estimating the natural rate is an econometric model, such as the semistructural model of Holston, Laubach, and Williams 2017, which typically infers the unobserved natural rate from a system of equations including observed economic variables such as inflation and GDP growth. Although intuitive, these models produce estimates with wide uncertainty bands. These models point to natural rates in the United States, Canada, and the euro area currently being at around prepandemic low levels.[1]

Another approach relies on publicly available views from the central banks. Although the US Fed does not have an official view on the natural rate, it can be inferred from the Summary of Economic Projections, which contains the FOMC's reported long-term federal funds rate and inflation projections.[2] They imply that, after declining for an extended period, the US natural rate has increased somewhat since 2024, but only to a low level similar to that prevailing just before the pandemic. The Bank of Canada's annual update in 2025 shows the Canadian neutral rate returning to its 2019 level.[3]

Views of private sector economists about future values of short-term interest rates and inflation can also inform an estimate of the natural rate. Economists' 5- to-10-year-ahead forecasts are typically examined to see through near-term cyclical influences. These long-term aggregate forecasts published by Consensus Economics suggest a similar pattern of implied natural rates increasing since 2022 but only to around the low levels just before the pandemic.

Finally, financial market prices, especially those of government bonds and related instruments, embed views about the natural rate. In addition to considering forward rates on government bonds for future periods after the cyclical influences have subsided (typically horizons 5–10 years in the future), this approach requires that forward rates are adjusted for term premia. Several methods are available for this adjustment from Adrian, Crump, and Moench (2013) and Christensen and Rudebusch (2012).

Overall, the range of approaches applied to the United States suggests that, after a persistent decline over several decades, the natural rate bottomed out during the pandemic, and increased after that, but only to around the low levels prevailing just before 2020. A similar picture is observed in other AEs.

[1] Up-to-date estimates are produced by the Federal Reserve Bank of New York, available at https://www.newyorkfed.org/research/policy/rstar.

[2] For the December 2025 Summary of Economic projections, see https://www.federalreserve.gov/monetarypolicy/files/fomcprojtabl20251210.pdf.

[3] For Bank of Canada's 2025 natural rate update, see https://www.bankofcanada.ca/2025/06/staff-analytical-note-2025-16/.

3. Fiscal Policy Frameworks

Sovereign debt pressures are likely to intensify as spending needs are expected to rise, while interest-growth differentials could widen in some economies, reflecting weaker growth prospects (Figure 6).[20] Effectively managing these challenges may require a reevaluation of fiscal policy frameworks, including fiscal rules, anchors, and supporting institutional structures.

A. Challenges

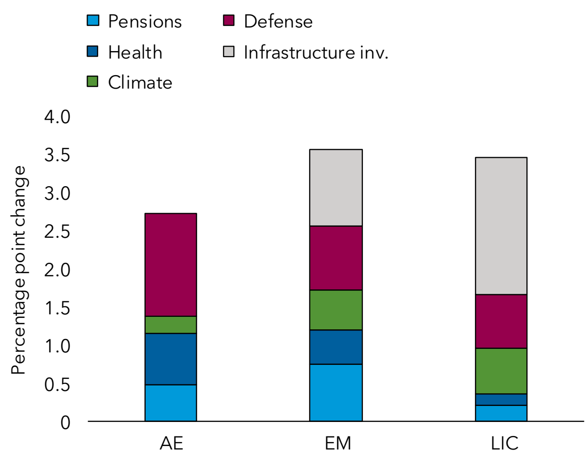
Fiscal policy management will face several challenges:

(1) **Transformation-related fiscal spending will increase.** *Expenditure pressures* reflect additional outlays linked to preexisting commitments to accommodate ongoing structural transformations, such as higher age-related health and pension spending and rising adaptation costs amid more frequent and severe climate shocks. *Expenditure needs* reflect discretionary policy choices in response to structural transformations, including higher defense spending linked to fragmentation or investments in human capital and infrastructure to support economic development. Together, these demands could amount to *3–4 percent of GDP annually over the next decade*. The expenditure needs may turn out to be higher as social safety nets may have to be redesigned and expanded to ensure that they remain effective in the face of AI-related labor market disruptions.[21]

(2) **Fiscal space could shrink significantly.** *Fiscal space*—defined as the difference between the *maximum sustainable debt (MSD)* and the actual debt—will likely be negatively affected by the ongoing structural transformations. The MSD refers to the highest level of public debt that a government is willing and able to service without

Figure 6. Additional Fiscal Spending Driven by the Four Structural Transformations

(Average additional spending 2025–35, percentage points of GDP, simple average)



Source: IMF staff estimates.

Note: The figure shows estimated additional spending linked to the four megatrends for AEs, EMs, and LICs (194 economies). Estimates show the simple mean across years and economies, per income group, of the annual increases in spending/GDP during 2025-35 relative to 2024. Climate reflects adaptation-related investment needs, and infrastructure reflects spending toward closing gaps to sustainable development goals and is adjusted to reflect absorption capacity constraints for some economies. Defense spending relies on most recent data (Classification of the Functions of Government, COFOG 2022) and reflects the gap needed to reach the NATO targets. AE = advanced economy; EM = emerging market; LIC = low-income country; NATO = North Atlantic Treaty Organization.

[20] The paper uses average estimates of the 10-year spending needs related to the four structural transformations. Data come from the April 2024 *Fiscal Monitor*, IMF COFOG, Carapella and others (2023), and the Finance for Development staff paper (2025). These estimates are lower compared with other assessments, reflecting absorptive capacity constraints, a more modest pace of spending accelerations and, for infrastructure and human capital, some progress toward the objectives of sustainable development goal (SDG) rather than full attainment. The estimates include spending on defense, climate adaptation, health and pensions, infrastructure, and human capital. For AEs, we assume zero additional spending on human capital or infrastructure, which may underestimate costs related to maintenance and renovation of aging infrastructure. The defense spending is limited in country coverage, and in line with the new North Atlantic Treaty Organization (NATO) targets (an immediate jump to 2 percent and then a gradual increase to 3.5 percent). There is no spending specific to the AI transformation, and it is assumed to be part of infrastructure spending. See Annex 2 for details.

[21] These estimates are somewhat lower than other reported estimates. For example, IMF's Europe's *Regional Economic Outlook* estimates spending pressures of approximately 5 percent of GDP (relative to 2025) in 2040, whereas Eble and others (2025) estimate 8 percent of GDP per year in 2050 in Central, Eastern, and Southeast Europe and 5.75 percent for AEs.

default, given its fiscal capacity and macrofinancial conditions.[22] Going forward, the MSD levels will likely decline because of higher risk premia, lower convenience yields, and potentially weaker growth (and hence lower tax base). Moreover, permanent increases in age-related, defense, and infrastructure spending imply lower sustainable primary balances unless accompanied by permanently higher tax revenues. With the MSD levels declining and actual debt levels already elevated, fiscal space will be increasingly constrained.

(3) **Changing shock characteristics will complicate management of fiscal buffers.** Frequent and severe supply shocks—such as commodity market dislocations, supply-chain disruptions, and climate-related destruction of capital—may require repeated discretionary fiscal responses while reducing the time available to rebuild buffers. Persistent sectoral shocks may also require adjustments to medium-term fiscal frameworks (MTFFs) and fiscal rules. In an environment of persistently high uncertainty, countries will need to recalibrate buffer levels to maintain resilience.

(4) **Trade-offs between fiscal commitment to not overspend and flexibility will become more acute.** Large shocks may lead to repeated suspension of fiscal rules, undermining their credibility. Evidence points to large deviations from existing rules and shortcomings in supporting fiscal institutions, which weaken credibility and make current fiscal rules less robust to shocks and spending pressures (Acalin and others 2025). Going forward, fiscal frameworks may come under greater strain.

To illustrate the effect of structural transformations on the *MSD levels*, the paper estimates their potential effects for 128 economies, using the growth impact estimates from Figure 3 (not including acute climate effects), and the methodology of Jiang and others (2024) and Cao and others (2025). Results (see Figure 7) reveal not only significant heterogeneity across economies but also some common patterns:[23]

- *In AEs, the MSD levels are expected to decline significantly*. Many AEs are already operating near their maximum tax capacity, that is, the highest level of tax revenue a country could realistically mobilize, given its economic structure, endowments, policies, and institutions. The proximity to the maximum tax capacity limits AEs' ability to offset higher spending through higher revenues.[24] Increased expenditure requirements combined with weaker potential growth driven by demographics and fragmentation reduce the maximum sustainable primary balance and, consequently, the MSD (Figure 7, panels 1 and 2). This erosion is primarily driven by geoeconomic fragmentation and demographic pressures, which contribute to weaker potential growth and higher government expenditure—particularly on defense, pensions, and health care. Given that AI adoption only modestly supports growth in the moderate-impact growth scenario, its contribution to

[22] This follows Jiang and others (2024), where the MSD is determined at the point where the marginal cost of servicing debt—the economic burden of raising taxes to repay debt—equals the benefit of preserving the debt and avoiding default costs. In the model, the maximum sustainable debt (MSD) threshold has a simple closed-form expression (Annex 3), which highlights two forces. First, countries can sustain higher debt when their willingness and ability to raise taxes are high relative to government spending. Second, the MSD is higher when borrowing costs, comprising the risk-free rate, risk premiums, and convenience yields, are low relative to growth, since a smaller interest-growth differential reduces the resources needed to stabilize debt. Although our estimates are derived from a specific p-theory framework, the underlying intuition is robust across models, including fiscal limit approaches such as Leeper (2013).

[23] The parameters on spending and growth are average estimates over the next 10 years to reflect a steady state measure, and so the MSD is also the average MSD estimated over the next 10 years.

[24] Tax gap is defined as the difference between the model-implied optimal taxation backed out from the p-theory framework (Cao and others 2025) and the tax capacity calibrated in the model. Although AEs on average are near tax capacity, several AEs have room to increase their revenue to accommodate additional expenditure, but for consistency with other AEs, simulations assume no further room to raise tax revenue. The maximum sustainable primary balance is therefore the difference between "optimal taxation" and "equilibrium spending ratios to GDP."

generating additional fiscal space is limited.[25] Nonetheless, there is considerable heterogeneity across AEs, reflecting differences in revenue-raising capacity or ability to reallocate spending.

- *In EMs and LICs, the MSD levels could increase, subject to economies' ability to mobilize untapped tax revenue and realize growth potential.* First, many EMs and LICs operate well below their maximum tax capacity (Benitez and others 2023; Baer, Barra, and Benitez 2025), offering scope to raise revenues and preserve—or in some cases raise—the maximum sustainable primary balance (Figure 7, panels 1 and 2). Second, demographic trends in many LICs point to labor force expansion and higher potential growth relative to AEs and EMs, while projected declines in natural interest rates (Figure 5) further improve "r–g" dynamics.[26] Although geoeconomic fragmentation and the climate transition will weigh on growth, their effects on the MSD levels may be muted because of the larger scope to mobilize additional revenue.[27] For instance, closing up to half of the tax gap in EMs and one-quarter in LICs—corresponding to median revenue gains of 2.6 percent and 2 percent of GDP annually, respectively—could preserve fiscal space of approximately 23 percent of GDP over the next decade, on average (Figure 7, panel 1).[28] This said, sustaining such revenue increases may be politically challenging. For LICs, concessional and blended financing from development partners could help to meet large transformational needs without excessive reliance on domestic tax increases.[29]

Although the MSD is a critical concept in determining fiscal space, it refers to *gross* public debt and does not account for governments' assets. In particular, sizable financial assets—such as deposits, public pension assets, or holdings in sovereign wealth funds—can provide an important buffer against shocks by supporting market confidence and financing needs during stress. In the country-specific context, assessing fiscal space would therefore benefit from a broader balance sheet perspective that considers net debt or public sector net worth alongside the gross debt indicators.

[25] Shifts in MSD can be substantial—on the order of 50 percent of GDP over a 10-year period for some countries. This is because of two factors: (1) AEs tend to have high baseline model-based MSD levels (prior to the inclusion of the effects of structural transformations) and (2) the model only constrains MSD from falling below zero, without imposing a practical lower bound default threshold. As a result, estimated declines can be large, though in practice, countries could default long before reaching such levels.

[26] Realizing the benefits of demographic dividend will also require complementary investments in infrastructure and human capital, implying additional fiscal outlays captured in the model through higher spending. The annex shows the sensitivity of the MSD estimates to various spending needs assumptions. For example, when human capital spending is also taken into account in the calculation of the MSD, the demographic dividend gains and the increase in fiscal space in LICs are reduced (see Annex 3).

[27] Defense spending, unless mainly channeled into productivity-enhancing investment, is unlikely to permanently raise potential growth, while any short-term demand stimulus may be partially offset by an endogenous interest rate response, further attenuating the net growth effect.

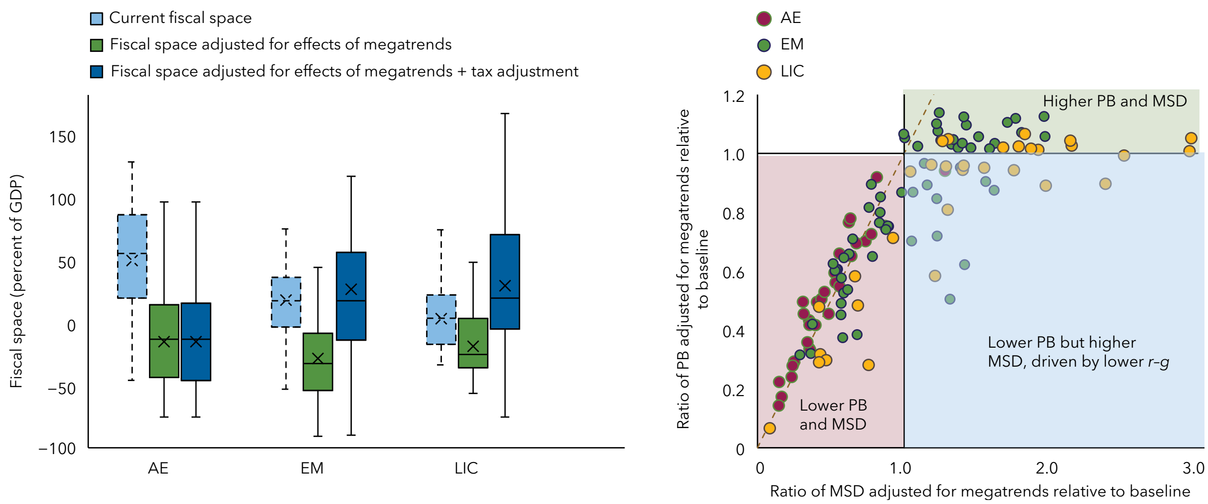
[28] This does not include human capital investments. The tax rate increases are a portion of the remaining tax gap between tax capacity and the optimal tax backed out from the model at current forecast. They are calibrated such that, on average, they remain within what is assumed in Gaspar, Mansour, and Vellutini (2023). When running the simulations, the optimal tax rate for EMs and LICs is lower than the reported averages here, and there is large heterogeneity across countries, see Annex 3.

[29] For fossil fuel importers, especially those with limited scope for further tax increases, energy subsidy reform can be a key instrument to rebuild fiscal space.

Figure 7. The Effect of Structural Transformations on Maximum Sustainable Debt Levels
(Percentage points)

1. Model-Based Fiscal Space with and without Tax Adjustment
(Fiscal space, percent of GDP, interquartile ranges for countries in AE, EM, and LIC income groups)

2. PB and MSD Level
(Ratio of PB or MSD, adjusted for effects of megatrends, to their respective baseline forecasts)



Source: IMF staff estimates.

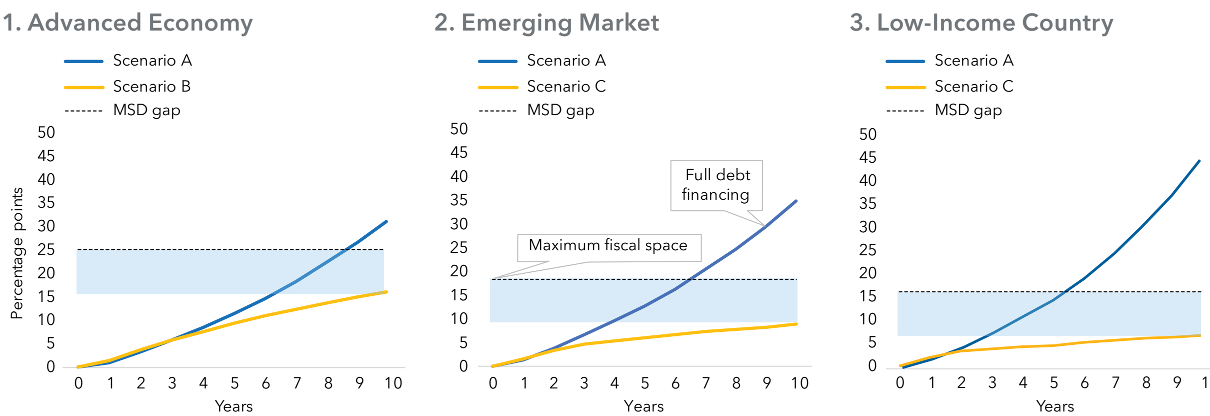
Note: MSD refers to the maximum sustainable debt level without default (Jiang and others 2024; Cao and others 2025). Panel 1 compares 2024 debt levels with MSD at baseline and after transformations under two scenarios: (1) no tax increases and (2) optimal tax adjustment. MSD is bounded at zero. Optimal tax increases are capped relative to current forecast, up to half of the tax gap in EMs and one-quarter in LICs, corresponding to median revenue gains of 2.6 percent and 2 percent of GDP annually, moving closer to tax capacity, whereas AEs are assumed to not be able to increase revenues. Panel 2 shows the ratios of primary balance and MSD (adjusted for the effects of megatrends, not including acute climate effects) relative to the current projections across income groups after 10 years. Missing spending data are treated as zero. Defense spending is based on 3.5 percent target for NATO countries. The sample includes 128 economies. AE = advanced economy; EMs = emerging markets; LIC = low-income country; MSD = maximum sustainable debt; NATO = North Atlantic Treaty Organization; PB = primary balance.

There are other factors—not fully captured in the model-based estimates—that may also influence MSD levels. Political and social constraints can limit revenue mobilization. Structural transformations may reshape the tax base: Digitization and AI may improve value-added tax and personal income tax compliance, whereas the energy transition could decrease carbon-related revenues. Conversely, aging, automation, climate shocks, and fragmentation may erode revenues from labor taxes, corporate profits, and customs duties. Generative AI could significantly disrupt tax systems by eroding the labor income tax base through job displacement and wage pressures, while simultaneously increasing the importance of taxing capital income, especially profits linked to data, algorithms, and other intangible assets.[30] To safeguard revenues and address rising inequality, there could be a need to strengthen progressive tax systems and modernize corporate tax rules that can effectively capture AI-related rents and market power (Brollo and others 2024). These developments would affect the sustainable primary balance, and thus the MSD—more stable or expanding revenue sources would increase the MSD, whereas declining or more volatile revenues would reduce it.

[30] In the MSD analysis, AI's effect occurs only through *r–g* as accounting accurately for other channels such as AI's effect on the relative importance of labor versus capital tax bases and labor displacement shifts toward income taxes goes beyond the scope of the paper. Public spending on the AI ecosystem is not modeled explicitly. As a result, the AI megatrend's effect on MSD excludes any additional direct spending effects. Only the indirect contribution of infrastructure investment—such as roads and electricity—that enables the AI ecosystem is captured.

Next, the paper examines the pace at which economies can scale up their spending without breaching the MSD, while still preserving adequate fiscal buffers. This is illustrated using a general equilibrium model developed by Nguyen, Lam, and Sher (2025), which extends the frameworks of Mian, Straub, and Sufi (2025) and Bi and Traum (2012). The model features a rich fiscal block, with both public investment and public consumption, as well as multiple tax instruments. Government debt dynamics are subject to an endogenous risk of debt distress that increases nonlinearly with the debt-to-GDP ratio, allowing the model to capture the disproportionate increases in sovereign borrowing costs as debt accumulates, and the associated spillovers to private sector activity. This would in turn affect the multiplier of government consumption and investment (including defense, human, and climate spending), featuring the link between financing options and the multiplier (see also Acalin and others 2025). The model is calibrated to reflect the structural characteristics of a representative AE, EM, and LIC country.[31] Based on these characteristics, the analysis considers three scenarios: (1) *scenario A*, in which all new spending is financed through borrowing, (2) *scenario B*, in which all new spending is financed by adjusting government consumption, and (3) *scenario C*, in which financing comes from expanding tax capacity (see Figure 8).[32] Scenario B is considered only for AEs given that they are close to their tax capacity and scenario C is considered for both EMs and LICs, given their potential for revenue mobilization.

Figure 8. The Effect of Structural Transformations on Maximum Sustainable Debt Levels and Fiscal Space
(Percentage points)



Source: IMF staff estimates.

Note: (1) Advanced economy, scenario A: full financing through borrowing. Scenario B: adjusting government consumption by reducing other components of government expenditure to accommodate baseline spending, that is, resulting in an increase of 1.2 percentage points of GDP out of 2.7 percent in baseline per year on average. (2) Emerging market, scenario A: full financing through borrowing. Scenario C: increasing tax capacity: resulting in a total revenue increase of 2.4 percent of GDP per year on average over the next decade. (3) Low-income country, scenario A: full financing through borrowing. Scenario C: increasing tax capacity: resulting in a total revenue increase by 2.8 percent of GDP per year on average over the next decade, with 80 percent of increases coming from lump-sum tax and 20 percent from consumption tax. MSD = maximum sustainable debt.

The simulation results are as follows:

- *For a stylized AE, the projected spending over the next decade cannot be financed only through borrowing without markedly increasing the risk of debt distress* (Figure 8).[33] If the additional spending associated with the four structural transformations—amounting to roughly 3 percent of GDP per year as presented in

[31] A representative AE is proxied by the GDP-weighted average across AEs, excluding the United States. Given large outliers in EMs and LICs these groups are represented by the median country within each category.

[32] Spending efficiency is a mitigating channel, but unless efficiency gains are large and accompanied by an uplift in growth projects (not just lower effective spending path), MSD deterioration is dampened but not drastically overturned. As for the model simulations, they assume relatively efficient public investment with an efficiency of 0.85 (or 0.15 efficiency gap) across all country groups. Lower spending efficiency would lead to a higher debt increase because of smaller effects on GDP for each dollar spent.

[33] There is of course some heterogeneity within the group. Countries with low debt and significant fiscal space can accommodate such expenditure without cutting other expenditure (see Acalin and others (2025) for a detailed discussion).

Figure 6—is fully debt financed (scenario A), public debt would exceed the MSD threshold (scenario A).[34] Given that most AEs already operate close to their tax capacity, accommodating new spending will require a reallocation of existing expenditures toward high-impact, growth-enhancing areas (scenario B), such as public investment, health, and innovation, and away from lower-impact consumption outlays and rigid spending components (IMF 2025h). Entitlement reforms may also be necessary to contain rising pressures from pension and health care expenditures (IMF 2025g). Strengthening fiscal governance ex ante—by preventing the emergence of fiscal imbalances—would facilitate achieving these objectives and help mitigate adverse debt-interest rate feedback loops, thereby reducing the scale of required adjustment.

- *For a stylized EM or LIC in Figure 8, the additional expenditure pressures can be absorbed through a combination of debt financing and purposeful domestic revenue mobilization.* Relying solely on debt financing would risk setting off a cycle of rising debt and escalating interest costs. By contrast, sustained improvements in tax capacity can significantly strengthen debt dynamics. Many EMs and LICs operate with tax-to-GDP ratios persistently below 15 percent (Baer and others 2025)—a level often viewed as a critical minimum to finance basic state functions and growth-enhancing public services—indicating ample room for revenue mobilization. As illustrated in *scenario C*, increasing tax revenues by an average of about 2.8 percent of GDP in LICs and 2.4 percent of GDP in EMs per year over the next decade enables these economies to finance additional spending while keeping debt comfortably below their MSD thresholds and maintaining adequate fiscal buffers.[35] This highlights the key role of tax policy and revenue administration reforms—such as broadening tax bases, improving indirect taxes, rationalizing tax incentives, diversifying revenue sources, improving compliance, and modernizing tax administration—in enabling higher and more sustainable public spending without undermining debt sustainability.

B. Possible Adjustments

Elevated debt levels, shrinking buffers, and more frequent supply shocks constrain traditional policy choices and exacerbate trade-offs between output stabilization and fiscal sustainability. What can be done to ensure that fiscal policy frameworks remain robust to the challenges outlined earlier?

Prioritize Debt Sustainability

Policymakers face a difficult trade-off between supporting macroeconomic stabilization and ensuring long-term debt sustainability as structural transformations unfold in the context of already high public debt levels and reduced fiscal buffers. These pressures suggest that fiscal priorities need to pivot toward mitigating sovereign risks—making the establishment of credible MTFFs more critical than ever, as many countries still lack a fully operational framework to anchor policy, strengthen credibility, and guide adjustment. This shift does not imply abandoning stabilization but rather making it more targeted and state contingent, while preserving credible paths back to fiscal anchors to safeguard the capacity to respond to future shocks. For countries with established MTFFs, this pivot requires reassessing fiscal anchors and adopting a risk-based approach centered on a medium-term debt anchor and explicit safety margins to keep debt below critical limits with high probability.[36] When facing major structural shifts, policymakers would have to recalibrate their anchors and buffers to reflect new spending pressures and the changing nature of shocks.[37] To preserve

[34] The buffer is estimated based on Eyraud and others (2018) using the 1981–2025 sample so that debt is kept under threshold with a high probability (90 percent), subject to shocks.

[35] The buffers of a representative EM and LIC are estimated based on Eyraud and others (2018) with the 2000–25 sample. For LIC, given the prevalence of concessional financing and the role of financial repression, we cross check with the average stock-flow adjustment, that is, unidentified debts, which is an important driver of debt in this group. The average stock-flow adjustment over 2000–25 is about 1–1.5 percent of GDP per year on average (IMF 2024a), so a buffer of 10 percent of GDP is in this range.

[36] Although fiscal anchors can vary, they need to be observable, easily communicated and relate to debt sustainability risks. Examples of medium-term anchors include debt anchors, budget balance, sovereign spreads, and interest expense.

[37] Typically, in such a framework, the debt limits are often set exogenously, whereas estimating the risk surrounding debt outlook is often based on regression relationships estimated based on historical shocks that may not account for future expectations.

credibility, risk-based anchors should be reviewed only intermittently—every four to five years. Consideration could also be given to other approaches that capture a broad range of relevant risks.[38] Finally, given high uncertainty surrounding megatrends, incorporating robust control principles into fiscal framework design can help ensure that fiscal rules and strategies remain effective across a wide range of environments, including those characterized by shifts in underlying economic relationships.[39] The ultimate goal is to help ensure that fiscal buffers are maintained at levels consistent with a country's debt risk profile (Acalin and others 2025). Such adjustments to existing fiscal frameworks could effectively imply a *tighter fiscal stance, on average*, particularly for countries facing declining MSD and rising fiscal risks.

Recalibrate Fiscal Rules to Account for Structural Transformations and Reform Unsustainable Entitlement Programs

- *Fiscal rules should be transparent, comprehensive, and sufficiently robust to remain binding under stress.* Expenditures linked to structural changes should remain within the scope of fiscal rules, as exclusions—whether for investment or through repeated use of escape clauses—can weaken transparency over the debt path, and undermine credibility. Regular stress testing of fiscal frameworks against adverse scenarios, including prolonged low growth, higher interest rates, or the materialization of contingent liabilities, is critical to assess whether rules remain credible under strained conditions. As greater flexibility is introduced, strong and well-designed error-correction mechanisms become critical to guide policy back to the fiscal anchor and rebuild buffers. Effective correction mechanisms require clear triggers, well-specified timelines, and adjustment paths calibrated to debt sustainability and macroeconomic conditions, balancing the need for decisiveness when risks are elevated with gradualism after large shocks to avoid procyclicality (Acalin and others 2025).
- *Rising age-related health and pension spending underscore the need for comprehensive long-term fiscal sustainability analysis* (as is done, for example, in Canada, Australia, and New Zealand) and timely entitlement reforms. These assessments can quantify the implications of maintaining current policies and support informed debate about the necessary reforms, including adjustments to entitlement programs, to effectively address long-term pressures (Flores and others 2024). Yet these reforms have proven to be difficult. Aging societies tilt the political economy of fiscal policy toward the status quo, as rising pension and health care costs borne by a shrinking workforce collide with strong electoral resistance to benefit cuts or tax increases, especially from older voters, biasing governments toward debt accumulation and postponement of adjustment.

Strengthen Fiscal Management by Reducing Spending Rigidities, Improving Spending Efficiency, and Strengthening Fiscal Institutions

- Rigidities—stemming from legally mandated expenditures, entrenched entitlement programs, or inflexible budget processes—limit governments' ability to reallocate resources in response to evolving needs.[40] Systematic reviews, embedded in medium-term budget frameworks, can help identify and address these rigidities to better align expenditure patterns with spending needs linked to structural transformations.
- Improving spending efficiency—through transparent procurement, and robust public investment management—not only ensures that every unit of public expenditure delivers maximum value but also amplifies the growth dividends from reallocating expenditures (Acalin and others 2025).

[38] One such example is the IMF debt-at-risk framework, which has an advantage of estimating the full distribution of debt outlook up to five years head, based on current debt and a broad set of variables including sovereign spreads, political conditions, and other macro variables (Furceri and others 2025).

[39] Robust control approaches explicitly account for model uncertainty by designing policies that perform reasonably well even when economic conditions, parameters, or behavioral responses differ from those assumed, thereby reducing the risk of policy failure under adverse or unexpected scenarios.

[40] Public spending rigidity stems from budget-process rules, structural factors, and political economy constraints. It is higher in AEs—about one-third of outlays are hard to shift—where health, education, and social protection are most rigid; in EMs, rigidity is concentrated in public investment and defense/public order (October 2025 *Fiscal Monitor*).

- Strengthening fiscal institutions, particularly fiscal councils, can help improve compliance and transparency and foster political consensus around sound fiscal policies. This requires both strong communication and operational independence. Fiscal councils should have direct and transparent communication channels with the public and media to disseminate their views on fiscal risks and policy costs. Their operational independence must be safeguarded through clear statutory mandates, adequate resources, and protection from political pressures.

Redesign Fiscal Instruments to Future-Proof Revenues and Upgrade Social Safety Nets

Structural transformations are likely to reshape labor markets, tax bases, and spending needs in ways not captured in standard fiscal frameworks:

- *To adapt to the demographic transition*, fiscal systems will need to adjust to longer working lives and slower labor force growth by supporting lifelong learning and reskilling, encouraging age-friendly workplaces and flexible work arrangements, and removing age-based disincentives embedded in tax and benefit systems that discourage continued labor market participation.
- *For AI-driven transformations*, the potential erosion of the labor tax base and increased concentration of capital income may require a rebalancing of the tax system away from labor and toward capital and corporate income, alongside a redesign of automatic stabilizers and social safety nets, which are currently built for cyclical unemployment rather than structural labor market displacement.[41] Social protection systems in particular will need to be upgraded along several dimensions: coverage (as AI reshapes employment), duration, interaction with reskilling programs, and potentially new instruments such as wage insurance, which can cushion income losses for workers reemployed at lower wages, and supporting adjustment to AI-driven disruptions (Brollo and others 2024).
- *Climate change and energy transition* will require a redesign of fiscal frameworks for fossil fuel exporters to manage declining hydrocarbon revenues and address stranded assets and fiscal risks associated with state-owned enterprises in carbon-intensive sectors.

Pay Greater Attention to Fiscal–Monetary Policy Interactions

Fiscal policy as a demand management tool is not well placed to deal with large supply shocks, particularly when debt is high. Broad fiscal expansions to counteract negative supply shocks can be inflationary and can also exacerbate debt vulnerabilities when monetary policy has to shift into tighter stance (see section 7, Figure 15). This implies a limited stabilization role for fiscal policy and a greater focus on temporary and targeted interventions. An important challenge is that the distinction between supply and demand shocks, while conceptually clear, is difficult to make in real time. A shock originating as a supply disruption can rapidly lead to second-round effects with demand-side characteristics such as tighter financial conditions and falling confidence thereby broadening the contractionary impulse. This underscores the need for careful shock identification and close attention to fiscal–monetary policy interactions to avoid conflicts between different policy levers.

Adopt More Proactive Financing Strategies Given High Uncertainty

In a more shock-prone world, fiscal frameworks would benefit from greater integration with debt-workout mechanisms and state-contingent instruments, including with disaster clauses, to enhance risk sharing and smooth debt service in adverse states. Particularly for EMs and LICs, strengthening public debt management

[41] The shift toward capital taxation reflects the need to protect the revenue base and address inequality as AI could lower the labor share and concentrate capital income. Strengthening capital taxation can thus support both redistribution and financing of expanded social protection. The 2024 Staff Discussion Note on "Broadening the Gains from Generative AI: The Role of Fiscal Policies"; June 2024; SDN/2024/002 (https://www.imf.org/-/media/files/publications/sdn/2024/english/sdnea2024002.pdf) highlights four priorities: reinforcing the corporate income tax, taxing excess profits from rents, improving enforcement (for example, automatic exchange of information), and enhancing capital gains taxation.

and domestic debt market development—through resilient debt structures, stronger DMO institutions, debt transparency, active investor relations, and local-currency bond issuance—can reduce rollover risks and FX mismatches, raise absorption capacity, and help increase the MSD (also see section 5). These elements are particularly important for LICs that are facing declining concessional financing. For economies with sustainable but vulnerable debt positions, especially emerging markets and developing economies (EMDEs) near tax capacity, fiscal frameworks could explicitly embed the *IMF–World Bank three-pillar approach*—a sequenced strategy that envisages domestic reforms first, followed by external financing support, and complemented by measures to reduce effective debt service burdens and mobilize private capital.

Figure 9 presents a summary of challenges and possible adjustments.

Figure 9. Fiscal Frameworks: Challenges and Possible Adjustments

Challenges	Possible Adjustments
Continued elevated debt and higher borrowing costs	Prioritize containing debt vulnerabilities
Long-term spending pressures	Recalibrate fiscal rules to account for ongoing structural transformations Reform entitlements programs where unsustainable
More frequent supply shocks Higher uncertainty about the nature and transmission of shocks	Recalibrate targeted fiscal support toolkits and automatic stabilizers Reduce spending rigidity Pay greater attention to effective fiscal and monetary interactions
Structural shifts in the tax base	Redesign tax systems and upgrade social safety nets

Source: IMF staff.

4. Monetary Policy Frameworks

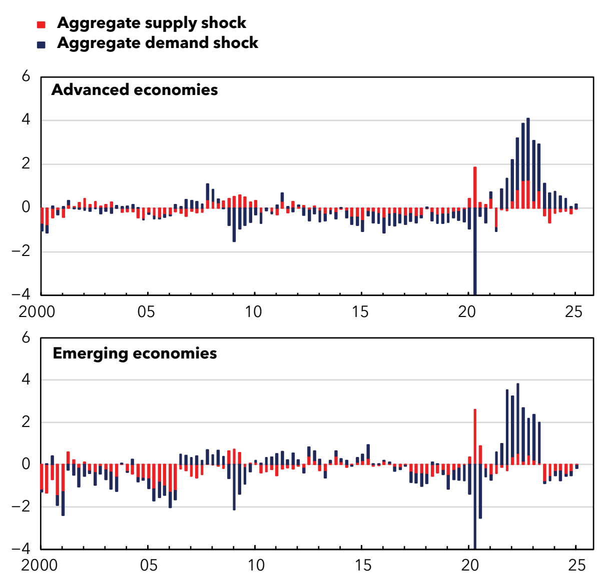
Structural transformations that affect potential GDP growth, the natural rate of interest, and the nature of shocks, including those that may intensify inflationary pressures, raise the question of whether existing monetary policy frameworks will remain fit for purpose. This section focuses on inflation-targeting (IT) frameworks, as their clearly defined objectives and targets make them more amenable to systematic review and adaptation; some implications for non-IT countries are discussed later in the paper. Detailed considerations regarding the choice of monetary policy regime and related exchange rate regime are outside the scope of this paper.[42]

A. Challenges

Supply shocks have had a larger effect on inflation in recent years. A decomposition of core inflation shows that the scale of contributions of demand and supply shocks during the postpandemic recovery and following the outbreak of the war in Ukraine differ markedly from patterns observed in the previous two decades. Figure 10 shows a standard decomposition of the contribution to inflation from supply and demand shocks based on sign-restricted vector autoregression. It indicates that both supply and demand shocks contributed significantly to inflation in this period, with the contribution of supply shocks particularly elevated across AEs and some EMs. The effect was especially large in energy-importing European economies affected by the war in Ukraine and associated sanctions.[43,44] This highlights the rising risk that larger and more frequent supply-side shocks will pose to price stability in the future.

Figure 10. Relative Contributions of Supply and Demand Shocks to Core Inflation

(Percent, quarter-on-quarter annualized)



Sources: Authors' calculations; and EUROPACE AG/Haver Analytics.

Note: Supply and demand shocks estimated with sign-restricted VAR on the cyclical components of GDP and core CPI inflation, with these components estimated with stiff HP filters. Data shown are annualized quarter-on-quarter inflation. CPI = consumer price index; VAR = vector autoregression.

[42] A wide range of country-specific factors shapes both the choice of monetary policy framework and the selection of an exchange rate regime. These factors fall broadly into two categories: (1) those reflecting characteristics of the economy, including trade and political integration, financial development, trade openness, the strength of the monetary transmission mechanism, the types of shocks to the economy, and the concentration of trading partners, and (2) those related to institutional capacity—such as central bank credibility and the ability to conduct forward-looking policy. For a detailed discussion of considerations relevant to exchange rate regime choice, see Casiraghi, Habermeier and Harjes (2022).

[43] The sign-restricted vector autoregression identifies supply and demand shocks through the signs of the residuals, with supply shocks having opposite signs on the GDP growth and inflation residuals, whereas demand shocks have the same signs. The decomposition used here is based on Davoodi, Hamid, A. Nguyen, M. Poplawski-Ribeiro 2023, Fiscal and Non-fiscal Drivers of Inflation. A decomposition Analysis, Fiscal Affairs Department Note, which uses a commonly used approach such as in Canova and Del Nicoló (2002) and others. Although widely used, this methodology has some shortcomings when mark-up supply-side shocks predominate because, as explained in Erceg and others (2024), with such shocks output and inflation could move positively and this framework could confuse them for demand shocks. Nonetheless, the result presented here aligns closely with the supply-demand composition of inflation shocks from alternative methods for the United States such as Shapiro (2022).

[44] See Blanchard and Bernanke (2023) and Arce and others (2023) for discussion of causes of inflation surge in the United States and the euro area.

IT regimes will face five main challenges stemming from the changing nature of shocks and other aspects of structural transformations:

(1) **More frequent supply shocks and sharper inflation–output trade-off.** Negative supply shocks raise inflation while suppressing output, forcing central banks to manage a more difficult policy trade-off than under demand-driven fluctuations, which typically move inflation and output in the same direction.[45] As supply shocks become more frequent, severe, or persistent, policymakers will need to reassess the adequacy of their policy toolkit for navigating these trade-offs.

(2) **Greater uncertainty.** Rising uncertainty—stemming from the increased frequency and severity of shocks or from changes in how economies respond to them—poses challenges for monetary policy formulation and communication. Reliance on a single baseline forecast may become less effective when uncertainty increases, complicating policy formulation and communication and undermining credibility.

(3) **Increased risk of fiscal dominance.** High fiscal vulnerabilities discussed in the previous section may constrain the scope for monetary tightening to achieve inflation objectives. In some cases, the central bank's ability to raise policy rates as much as needed to meet its inflation target may be limited by political pressures. It is well known that fiscal dominance can significantly erode purchasing power and lead to financial repression, resulting in suboptimal and destabilizing macroeconomic outcomes (Leeper 2023; Reis 2026).[46] Recent research finds that fiscal policy events can influence inflation expectations (Coibion, Gorodnichenko, and Weber 2021; Brandão-Marques and others 2023), which could further test central banks' ability to control inflation. Challenges for monetary policymaking will be even greater where financial vulnerabilities are elevated, and there is a tight sovereign-financial sector nexus.

(4) **Continued ELB risk.** Low natural rates limit the ability of conventional monetary policy to respond to disinflationary shocks. Although the outlook for natural rates is uncertain, baseline estimates suggest they are likely to remain low, implying that some central banks may again confront the ELB, constraining their ability to support demand through conventional tools.

(5) **Changes in monetary policy transmission mechanisms.** The demographic transition, climate change, and geoeconomic fragmentation are expected to weaken monetary policy transmission, while the effect of AI is uncertain. Population *aging* may reduce the economy's interest rate sensitivity and blunt the effectiveness of monetary policy by increasing reliance on nonlabor income, raising holdings of interest-insensitive short-term assets, and reducing investment demand.[47] *Climate change* could weaken bank balance sheets by lowering collateral values and increasing exposure to climate shocks, reducing risk taking, and dampening credit and asset price channels.[48] *Geoeconomic fragmentation* may weaken policy transmission further by impairing international risk sharing, reducing risk taking, and eroding collateral values. In contrast, the potential effects of widespread AI adoption are complex, and the net effect is unclear.[49] For example, AI could enhance price flexibility, including through changes in labor markets and wage-setting behavior, or it could reduce the economy's interest rate sensitivity, by

[45] Climate change may also shift relative prices—especially for food, energy, and carbon-intensive goods—with stronger effects in LICs because of larger consumer price index weights, higher climate exposure, and stronger second-round effects.

[46] Leeper (2023) points out increasing risks of fiscal dominance and potential negative consequences, while Reis (2026) highlights increasing risks of financial repression and potential consequences. Extensive empirical evidence establishes a link between fiscal dominance and undesirably high inflation, including well-known episodes of hyperinflation (see Sargent 1982; Blanchard 2005; Nachega 2005).

[47] Recent research suggests that population aging will likely reduce the effectiveness of monetary policy through the interest rate channel (see, for example, Imam 2013; Wong 2019).

[48] NGFS (2020) and Altavilla and others (2024) discuss the potential effects of climate change on monetary policy transmission channels.

[49] For more detailed discussion of possible effects on the monetary policy transmission mechanism, see BIS (2025), Hartmann and Maver (2025), and ECB (2024).

increasing market concentration and deepening income inequality, thus altering the inflation response to monetary policy. AI-related changes in the financial sector, such as a more widespread use of algorithmic trading, could also affect the transmission mechanism.

B. Possible Adjustments

How can IT frameworks be adapted to remain robust to the challenges outlined earlier?[50] Experience over the past two decades—including the post–global financial crisis period, when several AE central banks faced the ELB, and the post-COVID-19 inflation surge—suggests that IT frameworks have been relatively resilient. This points to the need for incremental adjustments rather than wholesale redesign. However, these episodes may foreshadow the economic environment ahead and provide lessons for refining existing frameworks.

Building on recent experience, the following discussion considers specific refinements to IT frameworks and associated policy tools, outlining their benefits and costs. Although recent policy discussions covered a broad range of adjustments, several such options involve significant trade-offs, practical implementation challenges, and significant credibility risks (Gnan and Holzmann 2023; Macklem 2025). For example, raising the inflation target level (unless the current level of the target is very low, that is, below 2 percent) could undermine credibility. Shifting from a fixed target horizon to a more flexible horizon may help central banks navigate sharper inflation–output trade-offs in a shock-prone environment, but such flexibility may entail risks if credibility is not firmly established. Likewise, reviewing the width of tolerance bands may be appropriate, but should be approached with caution. Given these concerns, the remainder of this section focuses on refinements where expected benefits clearly outweigh the risks, and Annex 5 (Annex Table 5.1) lays out the pros and cons of other potential adjustments.

Structural and institutional features of AEs and EMDEs may affect the effectiveness of monetary policy frameworks as well. Compared with AEs, EMDEs tend to face more volatile macroeconomic conditions and more volatile inflation driven by larger food and energy consumer price index weights, stronger shock amplification, and weaker anchoring of inflation expectations. Thus, EMDEs' greater exposure to supply and global risk-off shocks may intensify trade-offs between price stability and other policy objectives, whereas weaker institutional safeguards and shorter IT track records put a premium on the central bank credibility considerations.[51]

Possible adjustments to IT frameworks should center on four key priorities: (1) determining conditions under which policymakers can "look through" supply shocks; (2) making more systematic use of alternative scenarios; (3) safeguarding central bank independence to mitigate the risk of fiscal dominance; and (4) reviewing the policy toolkit at the ELB.

Determine Conditions for "Looking through" Supply Shocks

Traditionally, many AE IT central banks have "looked through" supply shocks, particularly when such shocks were viewed as transient and unlikely to affect medium-term inflation expectations (in most EM and LIC IT countries, "looking through" is generally limited by concerns about credibility). Under these conditions, policy could concentrate on underlying, persistent inflation dynamics (Freedman and Laxton 2009). However, with supply shocks becoming larger, more frequent, and more persistent, this approach may not always be appropriate. Recent research shows that when supply shocks are large and persistent, monetary policy may need to respond more forcefully to prevent the shocks from becoming embedded in inflation expectations (Erceg, Lindé, and Trabandt 2024).

[50] The term "framework" is used broadly here to encompass all aspects of monetary policymaking.

[51] Recent research shows that monetary transmission in EM inflation targeters is not substantially weaker than in AEs (Emeksiz and others 2026; Gornicka and others, forthcoming), but the challenges discussed earlier are typically more acute.

The appropriate response also depends on the state of the economy, the level of inflation, and the degree of central bank credibility. When inflation is already elevated, "looking through" shocks may increase the risk that inflation expectations become de-anchored, as firms may be more willing to raise prices and workers more likely to demand wage increases (see Box 4). The cyclical position matters as well: If shocks hit when the economy is running above or close to potential, firms can more easily pass through cost increases, and workers are less inclined to accept real wage reductions, thereby amplifying inflationary pressures (Harding, Lindé, and Trabandt 2023). Credibility is also crucial; when credibility is weaker—as is more often the case in EMDEs—the central bank's ability to respond flexibly to supply shocks without jeopardizing the medium-term inflation objective is more limited.[52]

Looking ahead, further work is needed to clarify the circumstances under which "looking through" supply shocks would remain appropriate, and when a more active response is warranted to safeguard inflation expectations. This will require a better understanding of how the nature, persistence, and transmission of shocks interact with the state of the economy and the degree of monetary policy credibility.[53] In addition, it will be important to assess how ongoing structural transformations may alter the interest sensitivity of aggregate demand as well as the shape and stability of the Phillips curve, potentially changing the inflationary effect of supply shocks and the optimal policy response.

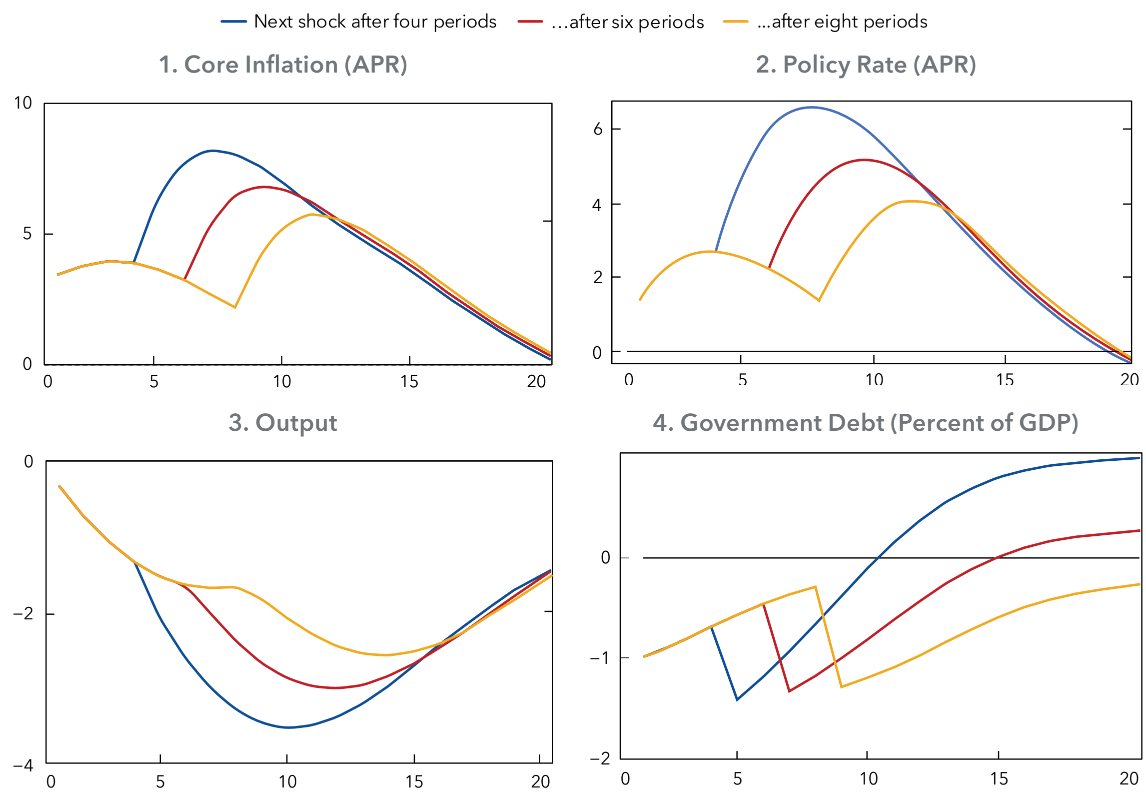
[52] A synchronized monetary policy response across central banks during periods of severe global supply shocks could also help mitigate the growth-inflation trade-off (Guerrieri, Lorenzoni, and Werning 2025).

[53] Laxton, Igityan, and Mkhatrishvili (2025) develop a theoretical framework featuring endogenous credibility. Beaudry, Carter, and Lahiri (2023) analyze the optimal monetary policy response to a supply shock under alternative assumptions about expectations formation.

Box 4. Monetary Policy Implications of Elevated Shock Uncertainty

This Box presents simulation results based on the *IMF's Quantitative Integrated Policy Framework (QIPF)* model augmented with endogenous wage indexation. In such an environment, a more pronounced adverse inflation cycle can emerge from an adverse supply shock when inflation is more elevated to begin with (see Annex 6 for further details). To illustrate this dynamic, Box Figure 4.1 shows an initial *global cost-push supply shock* at time t = 1, followed by a second identical shock hitting before the economy returns to equilibrium. The blue, red, and yellow lines correspond to the second shock hitting at 4, 6, or 8 quarters after the initial shock, so that the baseline level of inflation varies. Focusing on the blue line (second shock at 4 quarters), the inflation response is only marginally larger than the response to the first shock (panel 1). However, to achieve this, the policy rate hike from t = 4 onward has to be significantly larger than the rate increase following the first shock at t = 1 (panel 2).

Box Figure 4.1. Monetary Policy Responses in the Face of Repeated Shocks
(Percentage points)



Source: IMF staff calculations.

Note: Impulse response functions based on the IMF's QIPF model. QIPF = Quantitative Integrated Policy Framework. APR = Annualized Percentage Rate.

This simulation shows that counteracting inflation risks from already elevated wage indexation, even if the second shock is identical to the first one, requires a much larger monetary policy response, with significant additional output costs (panel 3). The red and yellow lines depict a similar effect when the second shock hits later, although the risks recede as inflation gets closer to target before the realization of the second shock. These results highlight the potential risks of allowing inflation to rise in response to global supply shocks in a more shock-prone world, as repeated shocks may give rise to nonlinearities that increase the risk of inflation de-anchoring if authorities do not tighten monetary policy sufficiently and in a timely manner. Panel 4 shows how surprise inflation may improve the government debt position in the near term although output and tax revenues fall.

Make More Systematic Use of Alternative Scenarios under Increased Uncertainty

Even as techniques for real-time shock identification improve, nontrivial challenges related to the diagnosis of the nature, persistence, and transmission of shocks and model uncertainty will likely remain. Although most central banks already acknowledge uncertainty in their monetary policy processes, there is scope *for more systematic use of alternative scenarios* alongside the baseline forecast. This could involve routinely exploring a set of internally consistent narratives and stress-testing policy choices in these scenarios (Bank of England 2024). This set should remain small, as attempting to game out and insure against an excessive number of contingencies would risk overcomplicating deliberations. A structured approach to scenario analysis would support a risk-management approach to monetary policy, allowing decisions to reflect insurance considerations where warranted. In particular, it would help policymakers assess the robustness of decisions under different assumptions about exogenous variables (such as energy prices) or the structure of the economy (Orphanides and Williams 2002; Levin and others 2005; Brandão-Marques, Meeks, and Nguyen 2024), highlight potential nonlinearities and tail risks, and clarify how policy trade-offs might shift in alternative states of the world. Scenario-based analysis can also support a more gradual and flexible policy approach, helping policymakers adjust their stance as new information becomes available, while reducing the risk of large policy missteps during periods of elevated uncertainty.

Future work on real-time shock identification should focus on improving the capacity to distinguish between transitory and persistent shocks. Another priority is to strengthen scenario design including developing frameworks for constructing alternative narratives and conveying their policy implications. Recent research offers additional useful directions: Adrian, Giannone, and others (2025) show how combining statistical models with judgment-based scenarios can help integrate diverse risks into policy forecasts, whereas Cairó and others (2025) propose a probabilistic weighting approach that updates the likelihood of the baseline and a limited set of alternative scenarios as new information arrives. Nonetheless, turning scenario analysis into concrete policy guidance will likely remain challenging, especially when models yield conflicting signals or when shocks fall outside historical experience.

Communicating uncertainty through scenario analysis could similarly become a regular part of the central bank's communication framework. Presenting alternative paths under different assumptions can help the public gain a clearer understanding of salient risks to the outlook and the central bank's reaction function. This transparency would reduce the risk that unavoidable deviations from previously published baseline forecasts or policy paths are interpreted as policy errors or shifts in objectives, thereby reinforcing credibility. Scenarios would need to be carefully selected and designed, as excessively detailed scenario presentations could overwhelm the public and obscure the key messages.

Regarding scenario communication, clear principles for selecting, summarizing, and presenting scenarios—such as establishing a hierarchy of scenarios, standardizing key metrics, and offering concise explanations of underlying assumptions—would help convey uncertainty effectively without sacrificing nuance or clarity.

Strengthen Central Bank Independence and Mitigate the Risk of Fiscal Dominance

Mitigating the risk of fiscal dominance ultimately hinges on reducing fiscal vulnerabilities. That said, preserving or strengthening central bank independence is equally essential.[54] This includes safeguarding operational autonomy by ensuring full control over monetary policy instruments and prohibiting monetary financing. Institutional and personal independence should be reinforced through transparent appointments, fixed and staggered terms, and narrowly defined conditions for dismissal.[55] Financial independence—supported by

[54] See Adrian, Khan, and Menand (2024) for a new measure of central bank independence based on its most important dimensions.

[55] See Bolhuis, Rui, and Thorell (forthcoming) for evidence relating politically motivated central bank governor transitions and inflation outcomes.

adequate capitalization, predictable recapitalization arrangements, and autonomous budgeting (Adrian, Khan, and Menands 2024; IMF Safeguards Assessment)—is also critical. Strong accountability and transparency frameworks, including adherence to the IMF's Central Bank Transparency Code, further help sustain this independence (IMF 2020).[56]

In some IT regimes, more commonly in EMDEs, there may also be scope to strengthen the inflation target as the nominal anchor. Reinforcing commitment to exchange rate flexibility can help reduce inconsistent policy signals and enhance credibility (Ötker-Robe and Vavra 2007). Introducing a medium-term review cycle for the inflation target—such as the five-year review cycle adopted by some central banks—could also reinforce commitment to the target by limiting the scope for ad hoc adjustments and supporting more firmly anchored expectations (Carter, Kamber, and Otten 2026).

Review the Policy Toolkit at the ELB

As real interest rates are expected to stay low on average—reflecting persistently low natural rates in AEs and a likely gradual convergence toward lower natural rates in EMs—albeit with occasional supply-driven inflation and rate surges, the risk of exhausting conventional monetary policy space remains in AEs and may emerge in EMs. This concern is most acute in the context of negative demand shocks, which would require substantial policy easing. Policymakers need to review and prepare the unconventional monetary policy (UMP) toolkit:

- *Negative interest rate policy* may play a greater role. The pre–global financial crisis consensus held that policy rates could not be reduced below zero, but subsequent experience has demonstrated that the ELB lies lower—Switzerland lowered its policy rate to −0.75 percent—and that negative rates can provide meaningful stimulus (Brandão-Marques and others 2024; Kolasa, Lassen, and Lindé 2025).[57]
- *Quantitative easing (QE)* is another important instrument in the UMP toolkit, though its use should typically be reserved for prolonged liquidity traps and governed by clearly defined exit clauses (Adrian, Erceg, and others 2025).[58,59] QE can boost private demand in major economies and provide additional stimulus in open economies through the exchange rate channel. Even so, QE carries risks, particularly in countries with weaker institutions where distinctions between QE and monetary financing may blur (Hofman and Kamber 2020), and large balance sheets can generate losses that complicate fiscal–monetary relations (Adrian, Erceg, and others 2024). These considerations reinforce the need for strong safeguards and transparent communication around activation and unwinding of QE. Given the convexity of the Phillips curve, the likely greater frequency of large supply shocks, and the challenges associated with unwinding QE, a greater tolerance for modest inflation undershooting may be warranted in some circumstances, provided that long-term inflation expectations remain well anchored.
- *Funding-for-lending (FFL) programs* can strengthen monetary transmission by lowering bank funding costs and encouraging credit expansion when rate cuts lose traction. These schemes were used extensively during the early stages of the COVID-19 pandemic, and in earlier years, by the Bank of England and the European Central Bank. FFL schemes entail risks such as potential credit misallocation, financial stability pressures, and challenging exit dynamics. Their net benefits are generally viewed as positive in stressed environments but diminish as policy rates normalize (BIS 2023).

---

[56] When the central bank is independent, monetary and fiscal policies operate independently in pursuit of their respective objectives. Awareness of their interactions is essential but does not equate to explicit coordination.

[57] Structural features of some financial systems—such as the relatively large size of the money market fund sector—may still make some policymakers reluctant to deploy negative policy rates in the future.

[58] Here, QE refers to purchases undertaken for macroeconomic stimulus rather than for financial stability purposes.

[59] As argued by Adrian, Erceg, and others (2025), QE may also be considered in a "shallow" liquidity trap of shorter duration in which the monetary policy stance is less constrained, but the appropriateness of relying on QE in such a situation depends on the availability of other unconventional tools like negative short-term policy rates and state-contingent forward guidance. Of course, any unconventional monetary actions should depend on the gains and perceived distribution of risks attributed to these tools.

- *Forward guidance* can also play an important role at the ELB by shaping expectations about the future policy path and thereby influence longer-term interest rates. Its effectiveness depends critically on credibility and clarity regarding how policy may evolve under different economic conditions. Forward guidance also carries the risk of locking in suboptimal policies, particularly when combined with other UMP measures (Adrian, Erceg, and others 2025). Accordingly, its deployment should always be accompanied by well-designed escape clauses.
- *Yield curve control*, deployed in recent years by Australia and Japan, has delivered mixed results. Although it can support monetary policy transmission under certain conditions, both countries experienced impaired market functioning and exit difficulties, raising credibility concerns (RBA 2022; IMF 2023e). These experiences suggest that central banks should consider (or keep considering) QE ahead of YCC in the future.[60]

Important open questions remain about the use of UMP tools at the ELB. Further work is needed on the timing and calibration of QE, including the appropriate tolerance for temporary undershooting of the inflation target and the design of escape clauses.[61] For FFL schemes, key issues include structuring programs to support lending while minimizing credit misallocation and financial stability risks and determining exit strategies that avoid abrupt tightening in bank funding conditions. Further research is also needed to assess FFL's effectiveness relative to other UMP tools. For EMDEs, the decision to use specific UMP tools will have to account for attendant risks to central bank credibility linked to perceptions of fiscal dominance. Figure 11 presents a summary of challenges and possible adjustments.

Figure 11. Monetary Policy IT Frameworks: Challenges and Possible Adjustments

Challenges	Possible Adjustments
More frequent supply shocks	React more decisively to large supply shocks and establish conditions when "looking through" remains appropriate Analyze how megatrends affect the inflation-output trade-off
Higher uncertainty about the nature and transmission of shocks	Make greater use of risk scenarios to formulate and communicate uncertainty and the central bank reaction function
Fiscal dominance risk	Preserve/strengthen central bank independence Pay greater attention to effective fiscal and monetary policy interactions
Effective lower bound risk	Consider more use of negative interest rates, forward guidance with escape clauses, cautious use of QE, tolerate small inflation undershooting

Source: IMF staff.
Note: QE = quantitative easing.

[60] This is especially so in emerging markets and development economies, where bond markets are thinner (Hofman and Kamber 2020).

[61] Adrian, Erceg, and others (2024) discuss how central bank policies could be made more risk based and forward looking to help manage potential central bank losses because of asset purchase programs.

5. External Sector Policy Frameworks

The structural transformations are also likely to create a more challenging external environment, as they are occurring amid large and widening global imbalances (IMF 2025a), which can in turn exacerbate geoeconomic fragmentation. The IMF's IPF[62] provides a systematic framework for the use of additional policy instruments—FXI, CFMs, and MPMs—which, alongside standard fiscal and monetary policy tools, can help maintain macroeconomic and financial stability (IMF 2020, 2023d). In an environment characterized by reduced policy space, higher trade and capital flow volatility, and elevated uncertainty, policymakers are likely to consider these additional tools more frequently. The section outlines the IPF-based approach to policy design and highlights areas where further work is needed, including on FX reserve adequacy frameworks.

The IPF emphasizes both ex ante measures to reduce vulnerabilities and ex post policy responses tailored to the nature of shocks and frictions present in the economy. A central principle is that FXI, CFMs, and MPMs should be deployed only when specific frictions justify their use and when their benefits outweigh their costs. In countries with floating exchange rates and limited financial frictions, exchange rate flexibility provides the greatest benefits. However, in the presence of frictions, the use of additional tools may be warranted under certain circumstances:

- Under *use case A*, in the context of arbitrage frictions in shallow FX markets, volatile capital flows can result in destabilizing financing premia.
- Under *use case B*, large depreciations can increase financial stability risks when there are sizable FX mismatches on the balance sheets of local household, nonfinancial corporate, and financial sectors.[63]
- Under *use case C*, large exchange rate movements have the potential to de-anchor inflation expectations of local households and firms and thus pose risks to price stability.

The distinction between fundamental and nonfundamental shocks is important for IPF-based advice. *Fundamental shocks* are those that require macroeconomic adjustments to restore stability, irrespective of whether financial frictions exist.[64] *Nonfundamental shocks* result from specific market imperfections, like "noise trader shocks" (De Long and others 1990), which are generally temporary shifts in the sentiment of some investors. In *use case A,* in the presence of shallow FX markets, addressing nonfundamental shocks through FXI and/or CFMs can give monetary and fiscal policy greater flexibility to pursue their primary objectives, provided their use is consistent with IPF principles for FXI[65] (IMF 2023a) and the Institutional View (IMF 2022, 2023h). In *use case B*, when FXI is used to counter financial amplification, its use should be limited to smoothing severe depreciations. In *use case C*, FXI can support monetary policy when a large exchange rate depreciation threatens to de-anchor inflation expectations, but only when reserves are sufficient, the marginal cost of relying solely on monetary policy is high, and the costs of deploying FXI are low. In the context of low inflation and low rates, FXI may also have a role in leaning against sustained appreciation pressures.

[62] The IMF's Integrated Policy Framework (IPF) was developed in recognition that, while international capital flows can provide significant benefits, they also pose challenges. Moreover, many countries use multiple tools to manage shocks and stabilize their economies and would benefit from a more systematic analytical approach. The IPF was developed to provide such a unified framework, which explains how the entire policy mix should be selected to achieve macroeconomic and financial stability. A key insight from the IPF is that the optimal policy mix depends on the nature of shocks, the financial frictions experienced by a country, and initial conditions (IMF 2020). Specifically, the IPF clarifies when the use of MPMs, FXI, and CFMs in response to shocks *may* or *may not* be appropriate, in conjunction with monetary and fiscal policy.

[63] The Review of the Institutional View on the Liberalization and Management of Capital Flows, which concluded in March 2022, incorporated the IPF's insights on CFMs and CFM/MPMs—including the finding that preemptive CFM/MPMs can be useful to mitigate financial stability risks from stock vulnerabilities, in particular unhedged currency mismatches—and explained how to operationalize such measures.

[64] Fundamental shocks include unexpected movements in remittances, tourism flows, supply of agricultural output, commodity prices, or FDI flows (particularly if driven by changes in anticipated capital productivity), as well as shocks to fiscal sustainability.

[65] The IPF principles for the use of FXI are tailored to open economies that operate under a floating exchange rate, typically alongside inflation targeting. They assume that the country's exchange rate is substantially market determined, thereby potentially creating a role for the use of FXI in the presence of frictions, irrespective of whether the economy is an AE, EM, or a LIC.

A. Challenges

The structural transformations will further increase the complexity of external environment, leading to several challenges:

(1) **More volatile trade and capital flows.** As geoeconomic fragmentation unfolds, more changes in tariffs and nontariff barriers could lead to more volatile trade flows and more frequent terms-of-trade shocks, while trade restrictions on high-tech goods combined with the AI race could lead to further realignment in global supply chains. In addition, geoeconomic fragmentation could entail a reconfiguration of capital flows that could make it more difficult for vulnerable EMs and LICs to meet their external financing needs at a time when spending pressures related to adaptation to other structural transformations are increasing as well.

(2) **Changing shock characteristics and higher uncertainty about shocks.** The structural transformations and their interactions are likely to increase the frequency and severity of both fundamental and nonfundamental shocks. Higher uncertainty may also increase the likelihood of risk-off episodes triggered by fundamental shocks. For example, AI-powered algorithmic trading could amplify volatility in financial markets (Gopinath 2024). A breakdown in historical relationships between the US$ and other macrofinancial variables could also lead to abrupt shifts in investor behavior.[66]

(3) **Deepening financial frictions that heighten vulnerability to financing shocks.** Although larger EMs have made progress in reducing financial frictions, fragmentation-induced changes in the international monetary system could reverse some of these gains.

- *FX market depth* may decline due to restrictions on cross-border financial flows and reduced foreign investor participation.
- *Balance sheet mismatches.* Despite improvements in prudential frameworks, FX mismatches could rise if investors take on less duration risk or if borrowers shift toward non-US$ foreign currency liabilities.
- *Uncertainty.* Higher aggregate uncertainty can strain FX markets by raising funding costs, reducing liquidity, and amplifying excess exchange rate volatility. The FX market stress can spill over to other asset classes, posing risks to macrofinancial stability—particularly where currency mismatches and fiscal vulnerabilities are significant (IMF 2025d).

(4) **Availability and effectiveness of policy instruments and reserve buffers.**

- *CFMs.* Higher exchange rate volatility may lead to greater incentives to use CFMs. At the same time, the expansion of crypto assets, including stablecoins, could facilitate CFM evasion by weakening the enforceability of residency-based CFMs. Evidence from Cardozo and others (2024) shows these flows are already altering cross-border dynamics and escaping detection.
- *FXI and FX reserves.* FXI may become more frequent, potentially requiring higher FX reserves. Although many EMs appear to hold adequate reserves and have begun diversifying their reserve holdings (Arslanalp, Eichengreen, and Simpson-Bell 2022), reserve adequacy remains uneven (IMF 2025c) and some countries may require higher reserve buffers in a more fragmented global financial system with fewer risk-sharing opportunities and a higher incidence or severity of shocks. As an illustration, Figure 12 presents estimates of required FX reserves when the frequency of sudden stops rises above the current level for a sample of 40 EMs.[67] About half the sample of 40 EMs had adequate reserves in 2025 according to the IMF's Assessing Reserve Adequacy metric.[68] When the probability of sudden stops rises to historical levels

[66] If a positive correlation between oil prices and the US$ persists, it will lead to larger terms-of-trade shocks from oil prices for net oil importers with floating exchange rates and greater financial stability risks for importers with short (net) exposure to the US$ (IMF 2023a).

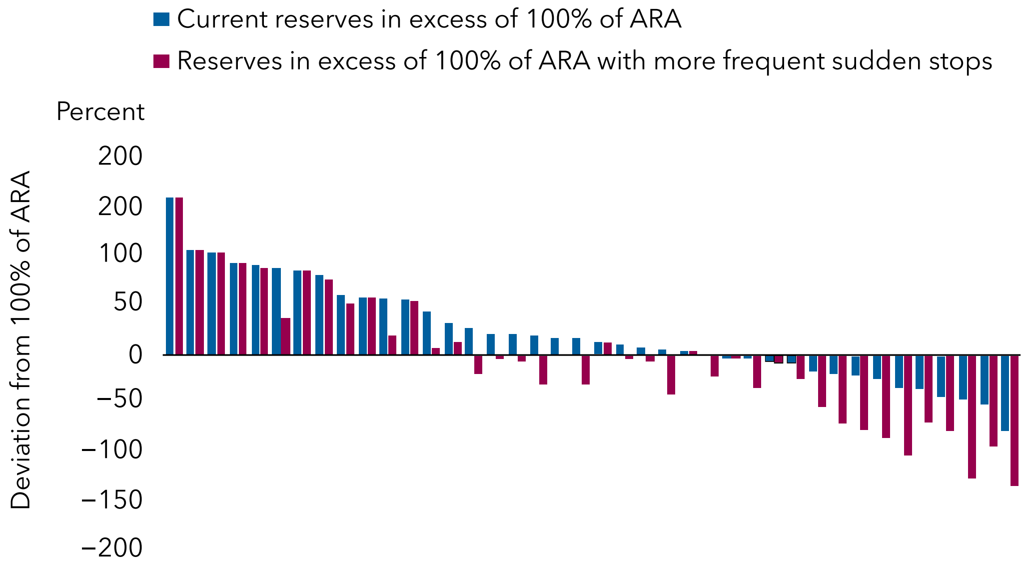
[67] Simulations are based on Jeanne and Rancière (2011), which models the effect of the probability and size of sudden stops on the optimal level of foreign exchange reserves. In the model, the optimal level of reserves is determined primarily by the probability and size of a sudden stop, the potential loss in output and consumption, the opportunity cost of holding reserves, and the degree of risk aversion.

[68] See IMF 2016 Guidance Note to Staff on Assessing Reserve Adequacy and Related Issues, as well as IMF 2011, 2013, and 2015 which developed the framework. Reserves in the range of 100–150 percent of the metric are considered to be adequate.

associated with high global risk aversion, the share of EMs with reserve shortfalls increases from under one-half to two-thirds of the sample.

Figure 12. FX Reserve Simulations

(FX reserve surpluses [positive] and shortfalls [negative] relative to ARA metric)



Sources: IMF ARA data set; *World Economic Outlook*; and IMF staff estimates. Sample of 40 EMs.

Note: The *y*-axis value of zero represents reserves at 100 percent of ARA metric. Blue bar shows current reserves/ARA in excess of 100 percent of ARA (positive indicates excess reserves, negative indicates shortfall). Optimal reserves estimated as level needed to insure against sudden stops following Jeanne and Rancière (2011). For each EM, model parameters are calibrated to match current reserves/GDP. Right-hand bar shows the needed increase in reserves/ARA if the probability of a sudden stop increases from 10 percent to 20 percent. ARA = Assessing Reserve Adequacy; EM = emerging market.

B. Possible Adjustments

To address challenges discussed in the previous section, policymakers should focus on the following priorities:

Reduce Vulnerabilities to Increase Resilience to External Shocks

In a more shock-prone world, reducing vulnerabilities, including through ex ante use of policy tools such as MPMs, as well as broader efforts to lessen financial frictions should be a priority. Diversification of economic and financial exposures, including in trade patterns and financing flows such as FDI that were previously viewed as more stable, will also be important. Use of MPMs can mitigate the impact of shocks, allow for more decisive monetary policy actions, and reduce the need for the use of CFMs or FXI. For example, borrower-based MPMs that contain the financial stability impact of higher interest rates allow central banks to hike rates with less concern about an increase in defaults and nonperforming loans among local currency borrowers. Similarly, MPMs that limit FX mismatches on borrowers' balance sheets can reduce the need for FXI under use case B.[69]

Preserve Exchange Rate Flexibility

For countries with floating exchange rate regimes, exchange rate flexibility will continue to play an important role in facilitating adjustment to fundamental shocks.[70] For countries facing significant financial frictions, FXI will remain a useful part of the toolkit (IMF 2023a). However, with a higher incidence of shocks, policymakers will face sharper intertemporal trade-off between deploying reserves to counteract their effects versus accumulating FX reserves to respond to future shocks. Countries will also continue to grapple with the

[69] The IMF IPF paper on MPMs (forthcoming-c) elaborates, building on existing IMF guidance on MPMs (IMF 2014) and setting out when policy tools should be activated, tightened, or relaxed.

[70] Aside from countries with fixed exchange rate regimes where, in the absence of an exchange rate movement, the burden of macroeconomic adjustment falls to fiscal policy.

real-time uncertainty about the nature of shocks,[71] raising the threshold for using limited FX reserves. Given geoeconomic fragmentation-related risks, more attention will likely be devoted to the currency composition of reserves. In settings where financial frictions are becoming more severe and nonfundamental shocks more frequent, the use of additional instruments may become more prevalent.

Maintain Adequate Buffers and Strengthen the GFSN

Greater volatility in trade and capital flows, along with changes in the nature of shocks, has important implications for the level and composition of adequate FX reserves. This underscores the growing importance of scenario analysis in assessing reserve adequacy. Strengthening the GFSN is also essential and requires addressing uneven access, enhancing crisis preparedness, and fostering better coordination across the various layers of the GFSN (IMF 2025c). Given increased demand for safe assets, holding reserves may also become more costly, necessitating revisiting the role and design of reserve pooling arrangements and exploring ways to reduce the cost of building reserve buffers globally (Gourinchas 2026).

These challenges point to several priority areas for further analysis. First, further analysis is needed to support real-time identification of shocks, including developing an empirical toolkit to identify drivers of exchange rate movements to help identify episodes that may warrant policy intervention (e.g. IMF, forthcoming-b). Second, further work is needed to improve monitoring of CFMs, supported by enhanced data collection and analytical capabilities to track digital money flows and assess macroeconomic effects. Further work is also required on the feasibility of moving from today's predominantly residency-based CFM design toward more transaction-based or risk-based approaches. Third, additional guidance on how to deploy FX reserves most effectively—including the design of targeted FXI modalities—would help policymakers make the best use of limited reserves. Finally, upgrading the reserve adequacy framework to account for higher volatility in trade and capital flows, as well as mismatches between the currency composition of external liabilities and that of FX reserves, is needed to help countries calibrate appropriate precautionary reserves and determine the pace at which buffers should be rebuilt following shocks.[72] Figure 13 presents a summary of challenges and possible adjustments.

Figure 13. External Sector Policy Frameworks: Challenges and Possible Adjustments

Challenges	Possible Adjustments
Higher volatility of trade and capital flows	More systematic application of the Integrated Policy Framework
Higher uncertainty about the nature and transmission of shocks	Improve real-time shock identification Develop effective modalities of FXI, MPM, and CFMs (magnitude and instruments)
Deepening financial frictions under structural transformations	Prioritize developing domestic financial markets, incl. adaptation to ongoing structural transformations
Possibly lower effectiveness of CFMs. More fragmented GFSN	Establish conditions for using FXI under more frequent shocks and higher uncertainty, upgrade reserve adequacy metrics

Source: IMF staff.

Note: CFM = capital flow management measure; FXI = foreign exchange intervention; GFSN = global financial safety net; MPM = macroprudential policy measure.

[71] Using the April 2025 tariff shocks as an example, a country resisting exchange rate depreciation under the assumption that the tariff increases are temporary would lead to ineffective FXI if the tariffs remain, thus requiring the full exchange rate adjustment.

[72] For EMs with floating exchange rates, the IMF's Assessing Reserve Adequacy metric is calculated as *ARA Metric* = 0.05 × *Exports* + 0.05 × *Broad Money* + 0.3 × *Short-Term Debt* + 0.15 × *Other Liabilities*. Adjustments to the Assessing Reserve Adequacy metric are made for countries with CFMs or fixed exchange rates. Reserves in the range of 100–150 percent of the metric are considered to be adequate.

6. Considerations for Non-IT Frameworks

Countries with non-IT frameworks will also face challenges arising from the ongoing structural transformations.[73] Although most AEs and many EMs employ IT frameworks alongside floating exchange rates, about 40 percent of EMs and LICs rely on the exchange rate as the nominal anchor, and a small share have monetary aggregate targeting frameworks (see Table 2). Correspondingly, about one-third of EMs and LICs have intermediate exchange rate regimes.[74]

Non-IT frameworks are also likely to be tested in a world with more frequent or larger external shocks.

For countries with conventional pegs, the exchange rate may come under pressure as larger or more frequent shocks place a disproportionate burden on other policies, especially fiscal policy, given the absence of a monetary policy lever. Such countries should prioritize building fiscal buffers and FX reserves and could consider increasing exchange rate flexibility over time to enable the development of an independent monetary policy, provided that other country-specific factors are also supportive of such a transition (Casiraghi, Habermeier, and Harjes 2022).

Table 2. Prevailing Monetary Policy Frameworks and Exchange Rate Arrangements

Sector	Subcategory	AE	EM	LIC
Monetary framework				
	Inflation target	33 (85)	25 (26)	3 (5)
	Monetary aggregate target	0	10 (10)	8 (14)
	Exchange rate anchor	6 (15)	37 (39)	22 (39)
	Other	0	6 (6)	6 (11)
De facto exchange rate arrangement				
	Floating	33 (85)	21 (22)	3 (5)
	Intermediate	1 (3)	27 (28)	17 (30)
	Hard peg	5 (13)	30 (31)	19 (33)

Sources: IMF AREAER 2023 Database.

Note: The IMF member countries and territories that have had an Article IV consultation in the past five years include 39 AEs, 96 EMs, and 57 LICs. Values in parentheses indicate the share of economies within each income group that apply the relevant framework. The table shows the AREAER classification of monetary policy frameworks, except for euro area members, Switzerland, and the United States, which have been included in the "inflation target" category in the table. AEs = advanced economies; AREAER = Annual Report on Exchange Arrangements and Exchange Restrictions; EMs = emerging markets; LICs = low-income countries.

[73] As noted earlier, considerations regarding the *choice* of monetary policy framework and exchange rate regime are outside the scope of this paper. Article IV of the IMF's Articles of Agreement enshrines countries' right to choose their exchange rate regime in such a manner that assures orderly exchange arrangements and promotes a stable system of exchange rates.

[74] Exchange rate regimes are grouped into three broad categories based on the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions: (1) floats, which include both "floating" and "free-floating" regimes; (2) intermediate regimes, corresponding to the "soft pegs" and "other managed arrangements" categories; and (3) hard pegs, including "currency boards" and "no separate legal tender." Soft pegs include conventional pegged arrangements, exchange rates pegged within horizontal bands, crawling pegs, and crawl-like arrangements. In intermediate regimes, the exchange rate can be a nominal anchor, but the parity is occasionally changed. In hard pegs, the exchange rate parity is credibly fixed.

For intermediate arrangements, the focus should be on clarifying the framework and prioritization of policy objectives as well as on effective operational design.

In soft peg regimes with an exchange rate band surrounding a reference rate, authorities may be tempted to widen the band to allow the exchange rate to absorb larger or more frequent shocks associated with the structural transformations. Although bandwidth should reflect country-specific conditions, it remains essential that the band is not so wide as to undermine the anchor's credibility or weaken its nominal stabilization role.

In countries that have adopted a crawling peg to help deliver low inflation amid a secular rise in the relative price of nontradables or to target a different average inflation rate than the anchor country, adjustments to the rate of crawl should reflect the ongoing structural transformations and associated shocks to both home and foreign economies. However, such reviews should occur infrequently to preserve the credibility of the crawling peg and its role as nominal anchor. To handle exceptional circumstances, for example, unexpected large capital flows, it may be desirable to have contingency arrangements that allow for off-cycle reviews of the crawl rate (How-to Note, Hiraki and Rhouzlane, forthcoming).

For non-IT EM and LIC central banks that have scope for independent monetary policy, some of the considerations discussed previously for inflation targeters also apply. In particular, these countries could benefit from a greater use of scenario analysis in policy formulation and from strengthened central bank independence to counter fiscal dominance risk. Where capacity is low, strengthening core operational capacity may need to precede the adoption of more sophisticated risk-based approaches.

When policymakers use additional policy instruments—such as FXI, CFMs, and MPMs—they should be used in a manner that strengthens rather than undermines their perceived commitment to the nominal anchor and to macroeconomic and financial stability. Many EMs and LICs face shallow FX markets, FX mismatches, and weakly anchored inflation expectations and therefore may need to employ additional policy tools to maintain or strengthen coherence of their monetary policy and exchange rate regimes. Calibration of the policy response to shocks must also account for other common challenges, especially in LICs, including low reserves, weak monetary transmission, and limited operational capacity and governance constraints. The paper on applying the IPF to LICs (IMF 2026) provides guidance for the use of a range of policy instruments under such conditions.[75] Importantly, FXI, CFMs, and MPMs should be used in ways that support rather than substitute for necessary monetary policy and fiscal adjustments. Inappropriate deployment, including efforts to offset needed macroeconomic tightening, can blur policy objectives, diminish tool effectiveness, and erode credibility. Policies should take a medium-term perspective, going beyond short-term stabilization to focus on building stronger frameworks, including by enhancing fiscal sustainability to reduce fiscal dominance risks (see also IMF 2015), and gradually reducing financial frictions over time.

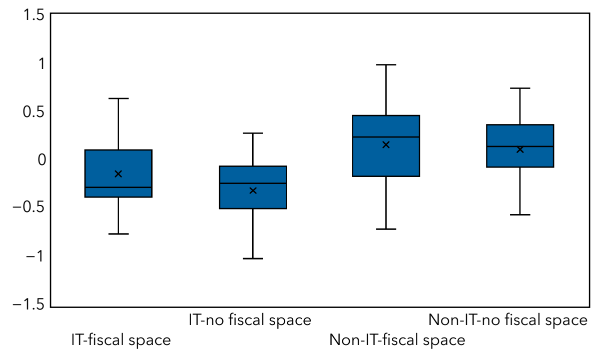
[75] The considerations in the note for policy advice in LICs apply in both IT and non-IT framework and across exchange rate regimes.

7. Policy Interactions and Trade-Offs

In a more shock-prone environment, with higher public spending pressures, the optimal policy response depends not only on the design of individual policy instruments but also on policy interactions and trade-offs. Figure 14 shows the estimated GDP effects of the four megatrends grouped by economies with and without IT frameworks, as well as by available fiscal space. Notably, inflation targeters with limited fiscal space is the group that is most affected by the ongoing structural transformations, in large part because of the aging trends in these economies.

Figure 14. Estimated GDP Impacts from Structural Transformations by Inflation-Targeting Framework and Fiscal Space

(Average yearly impact on GDP per capita growth)



Source: The underlying data are drawn from Figure 3.

Note: All effects are relative to hypothetical baseline without the trend. Sample covers 34 AEs, 68 EMs, and 41 LICs. Fiscal space defined as a debt level below the maximum sustainable debt level presented in the fiscal policy frameworks section, after inclusion of the structural transformations. AEs = advanced economies; EMs = emerging markets; IT = inflation targeting; LICs = low-income countries.

We begin by examining *monetary–fiscal constraints and interactions*. Although monetary policy is generally seen as better suited to addressing inflationary shocks—reflecting the credibility of inflation mandates and the speed and flexibility of interest rate adjustments—the case for a complementary and supportive role for fiscal policy has become increasingly nuanced.

To fix ideas, consider a temporary global supply shock—such as a reduction in oil supply that raises oil prices. The shock is inflationary, with higher input costs depressing output and raising unemployment as firms scale back production, whereas the associated decline in real incomes reduces consumption. Lower activity, in turn, may weaken government revenues. In an unconstrained environment—that is, one with more favorable initial conditions and absent the structural transformations discussed in this paper—the optimal policy response is relatively well understood. When the shock is temporary, inflation expectations should remain well anchored and, since the disturbance is external and not driven by excess domestic demand, monetary policy would typically "look through" the shock, keeping policy rates broadly unchanged and avoiding unnecessary output losses from tighter rates. On the fiscal side, automatic stabilizers operate through lower tax revenues and higher cyclical spending (for example, unemployment benefits), potentially complemented by targeted transfers to vulnerable households. Although such fiscal support may carry some inflation risks, this is limited by its targeted design and generally viewed as a reasonable trade-off to mitigate output losses and protect the most-exposed groups.

How Might the Structural Transformations Alter the Optimal Monetary and Fiscal Policy Response?

Two developments of the evolving global economy highlighted in the previous sections are particularly relevant. First, shocks are likely to be larger, more persistent, and more frequent. Second, rising spending pressures related to demographics, climate change, and geoeconomic fragmentation may significantly constrain fiscal space. More intense or persistent shocks raise the risk of larger inflation responses and stronger second-round effects, as workers demand higher wages to preserve real incomes, and firms raise prices to offset cost increase. Limited fiscal space constrains the ability of fiscal policy to respond, whereas concerns about debt sustainability may restrict the scope for monetary tightening given the associated increase in borrowing costs.

To investigate these issues, this paper applies a variant of the *quantitative micro-founded IPF model* (see Adrian and others 2021), modified to allow for persistent de-anchoring of inflation expectations following large adverse supply (or positive demand) shocks as in Erceg, Lindé, and Trabandt (2024). The two-country open-economy New Keynesian Dynamic Stochastic General Equilibrium model incorporates nonlinear price and wage Phillips curves and an endogenous level of indexation of prices and wages to past inflation rates. When inflation exceeds the central bank's inflation target persistently, wages and prices become increasingly determined by lagged inflation, generating state-dependent inflation responses: Larger shocks produce disproportionately larger and more persistent inflation responses. This mechanism helps explain inflation dynamics during the 1970s and the inflation surge during the post-COVID-19 pandemic period. Annex 6 provides details and additional impulse response functions.

First, consider the role of monetary and fiscal policies in responding to a large global cost-push shock.[76] For standard-sized shocks, monetary tightening alone is generally sufficient to stabilize inflation. For large shocks, however, nonlinearities in the Phillips curve and the endogenous indexation increase the size and persistence of the inflation response. Stabilizing inflation by monetary policy alone would require much larger interest rate hikes, with correspondingly larger declines in output, private consumption, and increases in government debt. Although an unconstrained fiscal response—through stabilizers and targeted transfers—remains possible, it may inadvertently require even stronger monetary tightening. In contrast, if fiscal policy cuts spending quickly to offset the increase in government debt, it allows the central bank to tighten less aggressively while still achieving the same inflation reduction.[77] This result holds for both advanced and emerging market economies:

- *Scenario A (a typical AE, with deep FX markets and without foreign debt)* shows that a tighter fiscal stance can deliver similar output and inflation outcomes as greater monetary tightening, but with lower private consumption losses and lower debt because of reduced expenditures and lower interest rates (Figure 15). As evidence accumulates on nonlinear inflation responses to larger shocks, the case for fiscal policy playing a larger stabilization role strengthens. In this particular simulation, driven by adverse supply shocks, fiscal policy that aims to stabilize debt typically implies a procyclical stance. However, if strong demand contributes to the inflation surge, the fiscal stance could remain countercyclical.
- *Scenario B (vulnerable economy with high foreign debt, significant negative NFA and shallow FX markets)*[78] shows similar patterns. Here, fiscal consolidation leaves the real exchange rate unchanged because of offsetting interest rate differentials and the improvement in the NFA position and is even more effective at curbing inflationary pressures than in the nonvulnerable case. Both scenarios A and B illustrate that even when fiscal restraint is challenging, an expansionary fiscal stance would still be counterproductive: It would force central banks to lean against the stimulus and ultimately leave the economy even more indebted.

Second, consider the role of monetary and fiscal policies in the context of more frequent shocks. Scenario C (Box 4) shows that repeated moderate shocks can generate dynamics similar to those from a single large shock. When a second shock arrives before inflation has been fully stabilized, elevated inflation triggers nonlinearities even when single shocks—if hitting the economy when inflation is closer to target—would have triggered only modest nonlinearities. Stabilizing inflation then requires a much larger secondary monetary

[76] We consider an inflation surge driven entirely by a large adverse cost-push shock for illustrative purposes. In reality, sustained above-target inflation is often driven by a mix of demand and supply shocks.

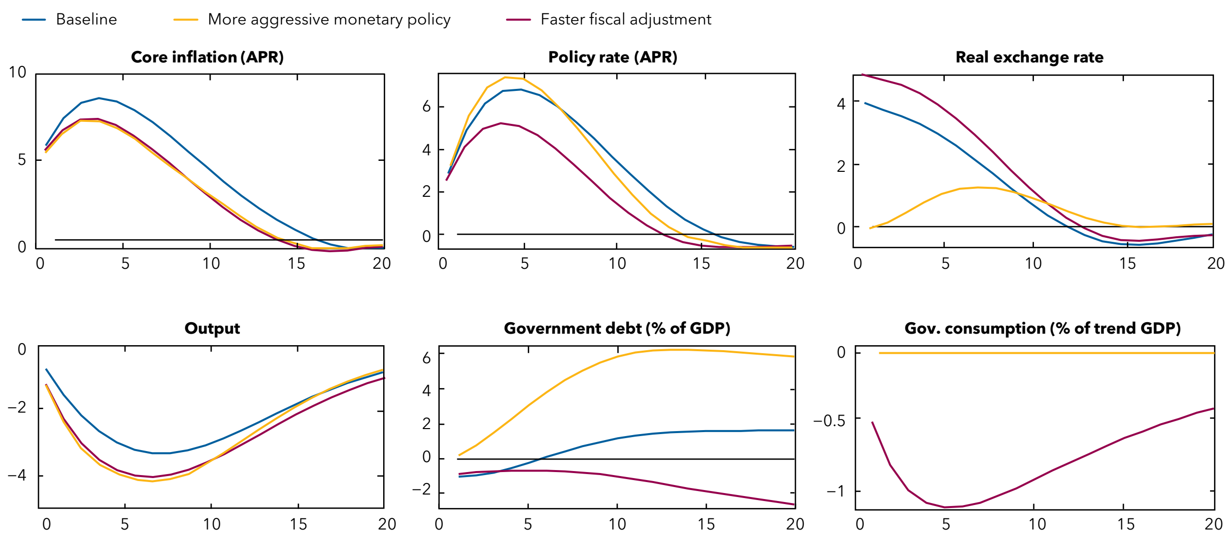
[77] Our analysis carries the implication that fiscal restraint is also effective in curbing inflationary pressures at low output cost when many countries need to consolidate at the same time to prevent government debt to rise further in response to unfavorable shocks. In a linear framework, Chen and others (2023) argues that coordinated fiscal restraint is effective to curb inflationary pressures in response to global adverse supply shocks. Our nonlinear model approach further strengthens their argument. Moreover, our model implies that consumption inequality rises a bit more under fiscal tightening. However, as in Chen and others (2023), such adverse effects can be addressed by combining the cuts in government spending with modest targeted transfers to vulnerable households.

[78] Shallow markets are modeled by a larger foreign exchange market frictions parameter.

policy response, with correspondingly larger output and private consumption losses. Faster adjustment when inflation has risen significantly above target can therefore play a more important role not only when shocks are large but also when shocks occur more frequently.

Figure 15. Key Impulse Response Functions: Scenario A—The Role of Fiscal Policy in Responding to a Large Cost-Push Shock

(Percent of GDP)



Source: IMF staff calculations.

Note: Response to large 3 standard deviation shock at time t =1. All variables are reported as deviations from baseline paths. APR = Annualized Percentage Rate.

Third, consider the role of monetary and fiscal policies in responding to a large global cost-push shock when monetary and fiscal frameworks are weak (*scenario D*).[79] In a country with strong frameworks, a combination of moderately tight monetary policy (reflecting well-anchored expectations) and fiscal consolidation stabilizes inflation and debt after a large shock. In the economy with weak frameworks, much more aggressive monetary tightening is required, yet inflation remains elevated and debt rises sharply. When fiscal space is already limited—given the spending pressures outlined earlier—even economies with weaker frameworks may have little choice but to prevent further debt deterioration. Scenario E extends scenario D by requiring government debt to return to its pre-shock level within five years. Model simulations show that different combinations of monetary and fiscal policy tightening produce different growth and inflation outcomes and highlight that fiscal authorities need to consider the joint impact of monetary and fiscal policy adjustments, considering the central bank's reaction function. Although the optimal monetary–fiscal policy mix depends on country-specific preferences and constraints, the broader lesson is clear: Improving policy frameworks *before* shocks hit is crucial to avoid more painful trade-offs as structural transformations intensify.

The analysis thus far has focused on monetary–fiscal interactions, but structural transformations may also amplify other cross-policy trade-offs. Some of these trade-offs include:

[79] By strong monetary and fiscal frameworks, we mean policies that can keep the inflation forecast and inflation expectations close to the central bank's target at the end of the forecast horizon (three years) and bring back government debt to its preshock value within five years even for large adverse shocks. Countries with weaker frameworks will eventually also bring inflation back to target and bring real government debt to its preshock value, but will do so much more gradually, using a mix of debt deflation and taxes. Hence, we do not consider a fiscal theory of the price level equilibrium (see, for example, Leeper 2023), in which inflation alone restores the real value of debt. Hence, the central bank is assumed not to monetize fiscal debt (for example, through QE) and the maturity structure of government debt is not critical for the analysis.

- *More limited fiscal policy space could constrain monetary and external sector policy*: Elevated fiscal risks—stemming from increased spending pressures or intensified shocks—can raise financing premia, induce capital flight, and complicate macroeconomic management. Wu and Xie (2025), for example, show that unsustainable fiscal paths weaken monetary transmission through expectations, risk premia, and exchange rate. If higher term premia on government debt translate into higher private borrowing costs, monetary policy may need to offset this effect, thereby reducing the policy space available to respond to adverse shocks. A tight sovereign-financial-sector nexus would further complicate this trade-off.
- *Monetary policy constraints could limit fiscal policy responses*: Adrian, Erceg, and others (2025) show that when monetary policy is at the ELB and public debt is near its sustainability limits, fiscal stimulus may not be feasible even after a negative demand shock, as future funding costs are expected to rise sharply once the economy exits the ELB. Under fiscal dominance, high policy rates and rising interest expenses may also limit the flexibility to provide fiscal stimulus if needed (IMF 2025, April 2025 *Fiscal Monitor*).
- *External sector policy constraints could limit fiscal and monetary policy responses:* In a more shock-prone environment, countries may need to hold higher FX reserve buffers, which could raise the bar for using FXI in responding to external shocks. The quantitative IPF model (Adrian and others 2021) shows that FXI can improve policy trade-offs in economies with nominal frictions, such as backward-looking expectations formation and price and wage indexation, where exchange rate depreciations are contractionary. When FX reserves are insufficient, monetary or fiscal tightening may become necessary after financing shocks or depreciations associated with FX mismatches—even when initial policy settings were appropriate.
- *Monetary policy may also be constrained by financial stability concerns*. Fragmentation-related increases in cross-border financial barriers may reduce international risk sharing and increase risk premia. Concerns over rapid increases in AI equity valuations or risks of climate-related stranded assets may heighten financial stability concerns, limiting the scope for higher policy rates. A robust prudential framework can help mitigate these risks, granting monetary policymakers greater flexibility.

8. Conclusions and Future Work

The paper argues that the world is potentially entering a period of great turbulence and high uncertainty – one in which multiple structural transformations interact, shocks strike more frequently and with greater persistence, and traditional sources of policy space may be more limited. Fiscal, monetary, and external sector policy frameworks could be increasingly strained by nonlinear inflation dynamics, tightening debt constraints, heightened external volatility, and persistently high uncertainty. These shifts underscore the urgency of reexamining how macroeconomic frameworks are designed and implemented.

Although the paper strives to provide a consistent set of estimates of economic impact of the four ongoing structural transformations across a large set of economies, further granular, country-level analysis is needed to better understand exposures and policy constraints. There is significant heterogeneity in demographic pressures, climate vulnerabilities, exposure to geoeconomic fragmentation and AI readiness, fiscal space, and the depth of financial markets—differences that will shape both the impact of shocks and the feasibility of policy responses.

Although AI-related productivity gains could help offset the negative macroeconomic effects of other megatrends, there is significant uncertainty about the future growth impact of AI. Much depends on the pace of technological diffusion, firms' ability to reorganize production processes, the extent of complementary investment, and the speed of labor market adjustment—all of which are subject to considerable unknowns. Given this uncertainty, future research should shift away from point estimates of AI-driven growth and focus instead on mapping upside and downside risks, identifying sectoral reallocation dynamics, and assessing the effects on fiscal and monetary policies and financial stability (Dabla-Norris and Korinek 2026).

Furthermore, interactions across megatrends could generate additional significant effects on macro variables. Fragmentation may amplify demographic pressures and impede AI diffusion, whereas climate shocks and heightened uncertainty can raise risk premia, slow investment, and weaken debt dynamics. Developing tractable ways to model these cross-megatrend feedback loops—including their implications for $r-g$ differentials, natural rates, and term premia—should be an important direction for future research.

Fiscal Policy Frameworks

The paper highlights that rising spending needs and lower MSD levels will significantly narrow fiscal space in many economies. In a more shock-prone world, static rules calibrated to past volatility may be inadequate. Then, the question is how best to design risk-based fiscal anchors that balance credibility with flexibility when shocks are more frequent and persistent.

Another issue is the financing mix for transformation-related spending. The analysis shows that debt-financed responses quickly run up against debt sustainability constraints, especially in AEs, whereas revenue mobilization can alleviate such constraints in most EMs and LICs. Further work is needed to assess the political economy viability, distributional consequences, and growth effects of different fiscal instruments, including how digitalization and AI may reshape tax bases and compliance.

Monetary Policy Frameworks

For monetary policy, the paper emphasizes that IT frameworks have proven resilient but face new challenges. A key issue is how central banks should operationalize the concept of "looking through" supply shocks when shocks are larger, more persistent, and more likely to interact with wage setting and the formation of expectations. Simulations of repeated-shock scenarios highlight important nonlinearities that require further empirical and model-based analysis.

Another priority area is the systematic use of scenarios in policy formulation and communication. Although reliance on a single baseline forecast may be insufficient, translating analysis of multiple scenarios into clear policy design is not straightforward. Further work is needed on how to design, weigh, and communicate scenarios to ensure that uncertainty is conveyed in a way that helps shape inflation expectations.

Mitigating fiscal dominance risks ultimately requires addressing fiscal vulnerabilities, but preserving central bank independence remains critical. This includes maintaining operational control over policy instruments, prohibiting monetary financing, and ensuring strong institutional, financial, and transparency frameworks.

Finally, the appropriate design and calibration of UMP tools in a low-neutral-rate environment warrant further study, including exit strategies, fiscal–monetary interactions, and distributional implications.

External Sector Frameworks and the IPF

Greater volatility in trade and capital flows may compel policymakers to consider use of FXI, CFMs, and MPMs more often, in both IT and non-IT frameworks. This raises the importance of employing the IPF to select the policy mix, as well as measures to reduce financial frictions.

Future work should focus on empirical toolkits to help distinguish the nature of shocks in real time, improving data on cross-border flows (including digital and AI-enabled channels), effective deployment of limited FX reserves, including modalities for targeted FXI, and upgrading reserve adequacy frameworks.

To Sum Up

To remain fit for purpose in this emerging "new normal," macro policy frameworks must balance credibility and flexibility, be more risk based, and better integrated. *First*, reduced policy space and more frequent supply shocks raise the premium on *ex ante robustness of policy frameworks*. Stronger buffers, robust prudential safeguards, and credible institutions are essential for preserving room to maneuver when shocks hit. *Second*, more limited scope for countercyclical policies and acute policy trade-offs require greater focus on effective policy interactions, while mandates remain distinct, and on *coherent policy mixes*, rather than on any single policy instrument. *Third*, persistently high uncertainty strengthens the case for *risk-based frameworks and state-contingent policy design*, where scenarios, stress tests, and sensitivity analysis play a prominent role alongside baseline point forecasts.

The paper also highlights the limits of macro policies alone. Structural transformations require structural policy responses—policies that enhance productivity, facilitate reallocation, strengthen labor market adjustment, and support the transition to new economic models. Without structural adjustments, macroeconomic policies will face an ever-narrowing set of options to secure stability and sustainability.

Annex 1. Growth Impact of Structural Transformations: Methodology, Key Assumptions, and Main Results

This annex provides further details on the methodology used for the growth impact estimates of the structural transformations, along with providing context on the uncertainty surrounding these estimates.

For all transformations, the growth impact is measured as the difference between the annual *real GDP per capita growth* including the trend and a "hypothetical baseline" without the trend going *forward* (for example, for climate, this means future temperatures remain the same as the current level). We present a "moderate" scenario consistent with moderate-sized effects across the range of possible scenarios, rather than a "central" or the most likely scenario given significant uncertainty over the likelihood of different paths.

We focus on a 10-year horizon (2026–35), where the growth impact estimates presented are the *average* annual effect. The sample covers 143 economies, with 34 advanced economies (AEs), 68 emerging markets (EMs), and 41 low-income countries (LICs).

Geoeconomic Fragmentation

Methodology

The GDP impacts are generated using a quantitative multicountry, multisector general equilibrium trade model following Caliendo and Parro (2015). The model is calibrated to the 2023 EORA input–output matrix, such that the baseline implicitly embeds 2023 trade barriers. Trade elasticities are taken from Fontagné, Guimbard, and Orefice (2022), following the implementation in Bolhuis, Chen, and Kett (2023). The model covers 185 economies, with the 26 EORA sectors aggregated to 10 for computational tractability. Counterfactual GDP effects of geoeconomic fragmentation are obtained by introducing changes in iceberg trade costs.[80]

Moderate scenario: The moderate fragmentation scenario assumes prohibitively high trade costs between the US-EU and Russia, as well as in high-tech sectors between the US-EU and China.[81] The United States imposes a 10 percent increase in trade barriers on the rest of the world, including Chinese sectors other than high tech. Trade barriers increase by 5 percent for all remaining trade. This scenario aims to capture a stylized increase in trade costs following recent trends; however, the swift changes in trade policies during 2025 mean the analysis avoids making a specific prediction about where trade costs will land. The increase across the board of trade costs in part reflects the increase in uncertainty hampering trading connections as well as the preponderance of efforts to reshore elements of production.

Uncertainty in Estimates

The effects of geoeconomic fragmentation on output faces significant uncertainty due to several factors.

First, there is a large variance in the possible paths for trade barriers to evolve going forward. For example, 2025 saw effective US tariffs on imports from China increase from under 20 percent in January to over 100

[80] Iceberg trade costs represent a broader set of trade costs than tariffs alone to encompass nontariff barriers and a degree of increased uncertainty.

[81] High-tech sectors are defined here as in Bolhuis, Chen, and Kett (2023) and Cerdeiro and others (2021), using the classification in OECD (2011), which is based on sectoral research and development intensities. This methodology highlights two high-tech sectors: electronics and machinery and transport equipment.

percent in April, before dropping back to around 40–50 percent for the rest of the year. News on global trade barriers has evolved quickly during 2025, with repeated cycles of swift-moving threats, tariff hikes, retaliation, negotiation, and tariff reduction making forward-looking estimates very challenging to pin down.

Second, there are varying assumptions that can be taken in the modeling framework. Instead of increasing iceberg trade costs, the Caliendo and Parro (2015) model allows for an increase in tariffs, which can reduce costs through rebating the tariff revenue as a lump sum to households. This paper employs iceberg trade costs to capture trade costs and uncertainty, which go beyond the simple tariff effects. The Caliendo-Parro model is also inherently a long-run model, where sectors are allowed to fully adapt in response to the trade cost counterfactual. There is increasing evidence that trade elasticities are smaller in the short -run (see Boehm, Levchenko, and Pandalai-Nayar 2023) leading to larger losses during the transition period. Furthermore, the Caliendo-Parro model, as a static framework, abstracts from dynamic capital accumulation, which could exacerbate effects. Finally, the level of long-run trade elasticities remains widely debated in the literature and, whereas we take conservative estimates as discussed in Bolhuis, Chen, and Kett (2023), different assumptions inherently lead to different overall effects.

Third, although this paper chooses to focus on the trade effects of geoeconomic fragmentation as a first-order concern, there are several other relevant dimensions. For example, using a set of structural general equilibrium frameworks, Cerdeiro and others (2021) quantify the welfare implications of fragmentation along three dimensions—international trade, sectoral allocation, and cross-border knowledge spillovers—under alternative fragmentation configurations. They find that welfare effects are heterogeneous, with some economies benefiting from trade diversion, while aggregate losses can reach up to 8.5 percent once all channels are jointly considered. Bekkers and Góes (2022) instead concentrate on disruptions to international knowledge diffusion, partitioning the global economy into Eastern and Western blocs using UN General Assembly voting patterns. Their simulations imply GDP losses ranging from about 0.4 percent in relatively limited fragmentation scenarios to as much as 12 percent for the most-exposed economies under complete technological separation. Model simulations in IMF (2023b) imply that sustained foreign direct investment fragmentation could reduce global GDP by around 2 percent in the long run, with larger losses for emerging markets and developing economies (EMDEs) that rely on foreign direct investment from AEs. In addition, trade policy uncertainty has been linked to weaker export growth and lower investment, while the macroeconomic effects of fragmentation in international payment systems are examined in a small but growing literature.

Demographics

Methodology

The methodology is based on a Cobb-Douglas production function with country-specific labor shares. The effects of demographics on GDP and GDP per capita is calculated by taking into account the changes in the size and composition of labor force and population between the starting time t and the target horizon time t + 10 years. The K/L ratio is assumed to remain constant throughout the time horizon in order to isolate the pure effect of demographic change, that is, to conduct a *ceteris paribus* exercise.

The total change in population is the sum of (1) the net balance of newly born and deceased people in each country and (2) net migrations. Net migrations are projected based on historic trends and using official data provided by the UN population division (UN Population Division: World Population Prospects Dataset 2024).

In addition to the size of labor force, which affects output directly, GDP is also affected through the composition of labor force, which has bearing on the level of total factor productivity (TFP). Specifically, TFP is reduced in countries with larger shares of older workers (see Aiyar and Ebeke 2016) and the relevant coefficient is denoted by A.

Putting everything together, it follows for the change of GDP between years *t* and *t* + *i*:

$$\frac{y(t+i)}{y(t)} - 1 \sim \frac{L(t+i)}{L(t)} + A\frac{share\ old(t+i)}{share\ old(t)}. \tag{1}$$

Equation (1) is a linear approximation for the change in level of GDP. The effect on growth rate in the linear approximation is simply [$y(t + i) / y(t) - 1] \div i$, which is the relative change in the level of GDP, divided by the length of the horizon, *i*.

Change in the GDP per capita is determined from the change in output per capita between *t* and *t* + *i*:

$$\left[\frac{y(t+i)}{y(t)}\right] \div \left[\frac{population(t+i)}{population(t)}\right] - 1. \tag{2}$$

Moderate scenario: The moderate scenario of GDP per capita growth is determined by the central scenario of population changes as projected by the UN and applying the equations (1) and (2) for each country in the sample. The scenario is based on projections from the UN's cohort-component model for projecting population. The model keeps track of the three main forces driving population: fertility, mortality, and migration flows. The change of the population in a given year is given by the difference between the number of newly born and deceased, to which the model adds the net migration. In this framework, the individual components need to be forecast, and the framework relies on a number of models to predict fertility, mortality, and migration.[82] Specifically, fertility is projected based on the demographic phase specific to each country, which for most countries presently assumes a Bayesian AR model. Life expectancy is based on expected future improvements in health care and socioeconomic developments, and migration flows are modeled using hierarchical Bayesian models.

Uncertainty in Estimates

The sources of uncertainty of demographic estimates over the 10-year period are those that primarily affect the working-age population, that is, the uncertainty of fertility and to a much larger extent the uncertainty in migration. In a closed country with no migration, the working-age population 10 years down the road is largely determined by the difference between those who will enter the workforce and those who will retire. The uncertainty in this number is due to the stochastic mortality and to the second order due to the changes in mortality rates. But given that both processes are driven by Poisson-type mechanisms with low population level uncertainty, the overall uncertainty in the working-age population (and also total population) in a country without migration is small. The uncertainty in GDP projections over the 10-year horizon comes from the uncertainty over migration flows which are much more volatile and driven by hard to predict geopolitical factors. We use the central scenarios produced by the UN population projections as the relevant country-level point estimates of population developments.

The moderate scenario uses the median UN population projections by five-year age-groups to track the total and working-age population in each country. The effect of population changes on per capita GDP growth is negative in AEs and EMs and positive in LICs. The uncertainty of population projections over the forecasting horizon primarily affects the total population, while the working-age population is largely predetermined for time horizons shorter than 15 years. For this reason, the uncertainty of GDP per capita growth because of demographics comes from changes in the number of dependents with the deviations from the moderate scenario of about +0.2 and −0.2 percent per year for low- and high-fertility scenarios, respectively, while the total GDP remains unchanged over the time period as shown in this table which shows the average effect of demographic movements on GDP per capita over the next 10 years by country group.

[82] The methodology is described in *World Population Prospects 2024, UN DESA/POP/2024/DC/NO.10*.

	Moderate	High Fertility	Low Fertility
AE	−0.49	−0.69	−0.29
EM	−0.10	−0.33	0.14
LIC	0.40	0.15	0.66

Note: AE = advanced economy; EM = emerging market economy; LIC = low-income country.

Artificial Intelligence (AI)

Rapid advances in training and deploying large-language models (LLMs) promise the next wave of automation with potentially profound effects on labor productivity and growth. The launch of ChatGPT in 2022 renewed excitement around the possibilities surrounding generative artificial intelligence (GenAI). Use cases are not restricted to text—GenAI's capabilities extend to image, audio, video, and speech recognition and generation. OpenAI's ChatGPT quickly faced competition, including from more cost-effective open-weight LLMs such as DeepSeek; LLMs launched by other Big Techs; and specialized models for image, audio, and video generation. GenAI's capabilities continue to multiply as performance improves, models are adapted to new applications and integrated into workflows.

This leap in technology occurs in the context of slowing labor productivity growth across AEs since the mid-2000s. Linked to fading of the information and communications technology boom, declining investment because of weak demand and policy uncertainty, and diminishing returns to technological progress, this slowdown led to stagnating GDP and average income (Fernald, Inklaar, and Ruzic 2023). The impressive gains in performance of machine learning in the decade prior to the rise in GenAI had not raised measured productivity growth. Measurement issues aside, this may largely be because of a "J-curve" effect—costly investment and adjustment in production processes lead to initial underestimation of productivity growth before the full effect shows up in the data (Brynjolfsson, Rock, and Syverson 2021). Against this background, the speed, ease of use, and scale of adoption of GenAI—a major leap in machine learning—have fueled enthusiasm about the potential to reinvigorate sluggish productivity growth.

AI can potentially have profound effects on labor markets. Identifying tasks that could be performed by AI (labor displacing) or are exposed to AI (labor augmenting) across occupations is the most widely used approach. Examples of the first channel include AI taking on writing tasks or replacing call centers with an AI-powered chatbot. On the other hand, AI may be labor augmenting if it improves information processing or speeds up subtasks. Felten, Raj, and Seamans (2023) develop an AI Occupational Exposure (AIOE) index using O*NET and crowdsourced data, finding that highly paid, white-collar jobs requiring advanced levels of education are most exposed. Pizzinelli and others (2023) extend the AIOE index to account for complementary, that is, whether tasks cannot be delegated to AI without human supervision. They also highlight cross-country differences in exposure between AEs and EMs because of employment compositions. Both indices measure *relative* exposure of occupations based on whether AI capabilities overlap with occupational abilities, not the absolute share of tasks, jobs, or output that could be delegated to AI. Similarly, Eloundou and others (2023) collect human annotations and GPT-4 classifications to measure the exposure of occupations specifically to LLMs, a subset of AI, and define exposure based on whether LLMs can reduce the time to complete a task by more than 50 percent. They find that around 80 percent of the US workforce could have at least 10 percent of their work tasks affected by the introduction of LLMs, whereas approximately 19 percent of workers may see at least 50 percent of their tasks affected.

To quantify the upside from AI to GDP growth across countries, we extend the approach proposed in Acemoglu (2024) to capture key cross-country differences. Through the lens of the task-based framework of production, Acemoglu (2024) shows how the initial micro-evidence on the productivity gains from deploying

AI in the United States can be translated into aggregate gains in productivity and growth. To capture the heterogeneous effect across countries, the estimates in this paper also consider three main country characteristics—(1) the extent of exposure to AI because of differences in sectoral composition, (2) differences in labor cost that affect the profitability of switching from human labor to AI, and (3) heterogeneity in AI preparedness affecting the projected speed of adoption.

Emerging and low-income economies may see fewer benefits of AI, especially initially. Many EMs have a sectoral composition skewed toward less-exposed sectors, which lowers potential productivity gains (IMF 2024). Lower preparedness, because of lack in digital infrastructure, access to AI, and gaps in legal and regulatory frameworks, is likely to slow adoption (Cazzaniga and others ,2024)). In addition, cheaper labor in many countries may make automation with AI less profitable, whereas aging economies with scarce labor may benefit more. The median AE may see a real GDP per capital growth boost of 0.3 percentage points per year, whereas the median LIC will only see a marginal effect of around 0.1 percentage points per year. With a median effect of 0.2 percentage points per year, EMs lie between AEs and LICs. Overall, AI is expected to accelerate global growth but only modestly.

There are both upside and downside risks to the moderate scenario estimates. Gains could be substantially larger if GenAI increases research productivity and thus technological progress more broadly. For example, in health care, AI may speed up the discovery of new drugs. Similarly, new products and services may improve welfare in ways not captured in this framework. Downside risks include not only lower-than-expected productivity gains or sluggish adoption but also adverse effects on labor markets and demand because of rapid displacement of workers and skill mismatch as well as cybercrimes or higher energy costs.

Methodology

The estimates of the growth impact required to make assumptions on three variables: (1) the economy's overall exposure to AI, (2) efficiency gains from AI (productivity gains and profitability), and (3) speed of adoption captured by the time horizon over which the gains are likely to materialize.

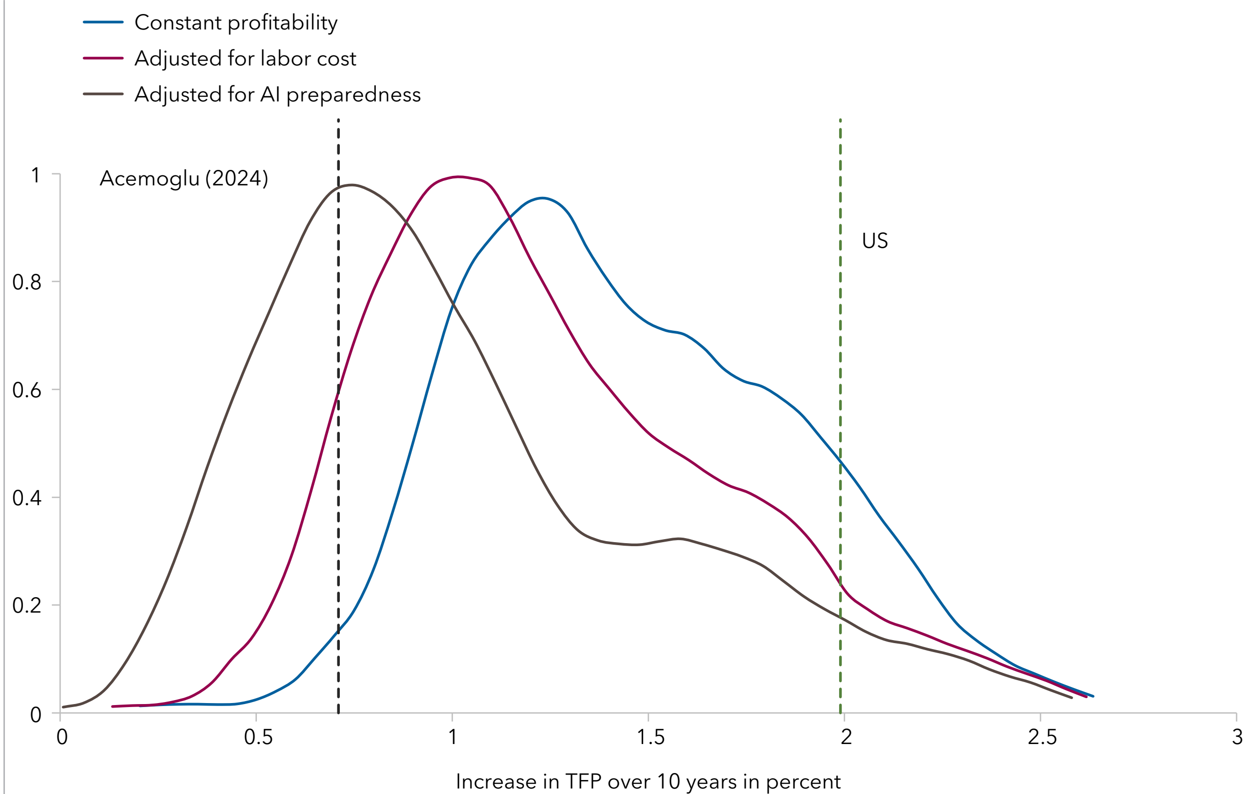
- *Exposure to AI based on workforce composition*. To measure the share of GDP exposed to AI, this paper creates an exposure measure based on the aggregate wage bill potentially affected by cost savings. We use the C-AIOE index proposed in Cazzaniga and others (2024) to quantify exposure to AI at the occupation level. However, the index only shows the relative exposures of different occupations, which cannot be directly translated to aggregate exposure. To convert the index into a measure of absolute exposure, the index is rescaled to match the mean and variances of AI exposure found by Eloundou and others (2023) for the United States as the share of tasks is more closely linked to cost savings. To compute the aggregate exposure, we weight each occupation by its share in the total wage bill using International Labour Organization data. Exposure tends to be lower in most EMDEs because low-exposure occupations (such as agricultural) account for a higher share in the total wage bill than in AEs. This approach has some drawbacks. First, since country-specific information on tasks by occupation is not available, extrapolating AI exposure from US occupational data may potentially understate cross-country differences. Second, the sectoral composition is assumed to remain broadly the same over the next decade. Over the medium term, this may underestimate the benefit from AI in EMDEs that are in transition to knowledge-intensive sectors and with a decreasing agricultural workforce. However, projecting changes in sectoral composition is beyond the scope of this exercise.
- *Gains from AI: profitability and the role of labor cost.* Out of all AI-exposed tasks, firms will only automate those for which it is economically profitable to do so. Even if AI is highly capable, meaning that many tasks are "exposed" to AI automation as defined in the C-AIOE index, AI will only boost productivity to the extent that it is also cheap enough for firms to adopt. Here we depart from Acemoglu (2024) who uses Svanberg and others (2024) and assume that 40 percent of tasks could be profitably automated in the next 10 years, motivated by the rapid expansion of AI offers including lower cost models such as DeepSeek and the concerns laid out in Aghion and Bunel (2024). With the cost of AI largely depending

on the technological frontier and abstracting from potential differences in energy cost and regulations, the cost of AI will likely be similar across countries. However, labor costs vary markedly across countries: Although PPP-adjusted wages in some advanced European economies are comparable or slightly higher than in the United States, average wages in LICs are only about 17 percent of the US level. This implies substantial cross-country differences in the share of tasks that can be profitably outsourced to AI. Similar to Misch and others (2025), we find that wage levels are highly correlated with AI adoption in European firms. Using occupation-level PPP-adjusted wage cost relative to the United States from the ILO, we exploit this correlation to create country-specific estimates of profitability.

- *Productivity gains.* Although the rollout of GenAI has been relatively fast, the size of the productivity gains is highly uncertain. Evidence from experiments introducing AI in the workplace find performance improvements in the range of 14 percent (Brynjolfsson, Li, and Raymond 2023) to 55 percent (Peng and others 2023). For the automation using robots, cost savings were estimated to have been around 30 percent of labor costs (see Acemoglu and Restrepo 2022). We use one-third as the baseline productivity gain over 10 years, somewhat higher than the 27 percent used in Acemoglu (2024), following Aghion and Bunel (2024). The same productivity gain is used for all economies.
- *Adoption time*. Speed of adoption of GenAI will likely vary across countries. Because of the "digital divide," LICs with low access to internet and lack of Inflation-targeting infrastructure may benefit significantly later from productivity increases compared with AEs. Scaling again relative to the United States, we use the IMF AI Preparedness Index (https://www.imf.org/external/datamapper/datasets/AIPI) to capture variation in the time it takes for the gains estimated in steps 1–3 to materialize in different economies. We scale the adoption time for GenAI such that the average lag is 3 years and the maximum lag is 10 years. This assumes somewhat faster diffusion than what Comin and Mestieri (2018) estimate for the internet (six years on average) and in line with their finding that adoption lags have narrowed over time. Given the exponential growth in users, AI diffusion seems likely to happen relatively quickly. However, if lack of AI preparedness slows adoption more than expected, the divergence between AEs and EMDEs could be stronger.
- *Capital accumulation*. To translate the improvements in TFP to GDP, it matters how investment responds to the higher productivity. This paper assumes a constant capital-to-labor ratio in the medium term. If AI were to cause even more capital deepening, the effect on GDP growth could be even larger.

Considering these sources of cross-country heterogeneity suggests that most economies are likely to see a relatively modest effect from AI over the next 10 years. Annex Figure 1.1 compares the distribution of productivity gains with and without the adjustments for labor cost and adoption lags. Considering the lower labor cost and lack of AI preparedness increases the differences in how much economies benefit from GenAI.

Annex Figure 1.1. Cross-Country Distribution of Productivity Gains from AI over 10 Years—Effect of Adjusting for Heterogeneity in Labor Cost and AI Preparedness



Source: IMF staff calculations.
Note. Showing results for the United States from Acemoglu (2024) for comparison. AI = artificial intelligence; TFP = total factor productivity.

Uncertainty in Estimates

See Box 1 in the main text for further discussion of the literature.

Climate Change

Methodology

The main chronic GDP effects are sourced from the IMF How-To Note (Centorrino, Massetti, and others 2025) based on the methodology of Kahn and others (2021). This approach employs a panel econometric model that exploits deviations from historic temperature trends to identify effects on GDP. Projections are then based on forward-looking slow-moving changes in temperature, consistent with specific Shared Socioeconomic Pathways. The main estimates from this paper represent GDP deviations relative to forward temperature projections which correspond to historic trends. To align these estimates with the other transformations, we therefore apply a modification that incorporates the average GDP effect difference between the historic trend and no further temperature changes up to 2100.

Chronic damages capture persistent, long-term GDP losses from gradual changes in average temperature that affect productivity levels, whereas acute damages reflect short-lived but potentially severe output losses from discrete extreme weather events. The acute physical risk layer is sourced from the Phase IV output from the Network for the Greening of the Financial System (NGFS).[83]

[83] https://www.ngfs.net/ngfs-scenarios-portal/explore/. This paper does not employ results from the Phase V output because of ongoing revisions in the econometric underpinnings of the damage function.

Given that the NGFS data are only produced for 49 economies (see the next section for country coverage), 32 AEs and 17 EMs, Figure 3 in the main text presents the results separately for chronic and acute damages. When presenting total average effects including both chronic and acute, the text adds together the average chronic effects for the full sample and the average effects for the subsample of acute damages. This approach implicitly assumes that missing acute observations are set to the average for the income group. Given no data are available for acute effects for LICs, only chronic estimates are presented.

Moderate scenario: The moderate chronic climate scenario applies the Shared Socioeconomic Pathway 2–4.5, which equates to "current policies," and 2.7 degrees of warming by 2100 relative to preindustrial period. The moderate acute estimates employ the closest similar scenario for NGFS' "Current Policies (Hot House World)," with a temperature increase of 3°C by 2060.

Uncertainty in Estimates

Estimates of macroeconomic losses from climate change span a wide range, but most studies find that increases in temperature are associated with lower aggregate output on average. Disagreement instead centers on functional form (level versus growth effects), persistence, the speed of adaptation, and the treatment of nonlinearities and extreme events (more details in Box 2 of the main text).

A key distinction is whether temperature affects the level of GDP or its growth rate. Models with level effects imply bounded losses once temperatures stabilize, whereas growth-based specifications generate persistent and compounding losses over time. Empirical evidence (for example, Burke, Hsiang, and Miguel 2015) finds large, nonlinear productivity effects, particularly in hotter countries, whereas Kahn and others (2021) emphasize that persistent increases in temperature relative to historical norms can reduce growth for extended periods, leading to cumulative output losses even when long-term growth eventually stabilizes.

However, these estimates are subject to considerable uncertainty. In the IMF-based projections, statistical uncertainty around the Kahn and others estimates—captured by 95 percent confidence intervals—widens over time and compounds, with effects often indistinguishable from zero in the near term but becoming economically large by end of the century. More importantly, uncertainty across climate scenarios and adaptation assumptions dominates parameter uncertainty. For example, projected GDP outcomes range from modest gains under strong mitigation (reflecting slower warming trends) to losses of several percentage points—reaching around 8 percent in high-warming, slow-adaptation scenarios—by 2100.

Quantitatively, estimates differ widely across approaches. Models that abstract from persistence or assume rapid adaptation tend to yield moderate losses, whereas those incorporating persistent productivity effects imply much larger effects. For example, Bilal and Känzig (2024) estimate that a permanent 1°C increase in global temperature reduces world GDP by roughly 20–30 percent in the long term. Survey evidence (Tol 2024; Morris and others 2025) confirms that estimates differ by an order of magnitude, largely reflecting differences in assumptions about persistence, adaptation, and the treatment of tail risks.

Overall, although the sign of the effect is broadly agreed, quantitative outcomes depend critically on modeling choices and scenario assumptions, underscoring the importance of interpreting point estimates with caution.

Interactions between Structural Transformations

Aside from the direct effect of transformations, there is the possibility for these transformations to interact with each other, either mitigating or exacerbating the effects. Annex Table 1.1 highlights some of these potential interactions; it is notable that many of the interactions appear more likely to lead to an exacerbation of costs (cells highlighted in red), although some have ambiguous effects (cells highlighted in blue).

Given the complexity of the interactions, detailed modeling is left for future research. This paper, however, does provide some indicative estimates for three specific interactions: the effect of global economic fragmentation (GEF) on demographics, the effect of GEF of AI, and the effect of AI and demographics on GEF.

The impact of GEF on demographics. Greater geopolitical fragmentation between economies may lead to increased barriers to migration. To explore the effect of this interaction, the demographic model is adjusted to shut down all migration between economies. This leads to worse economic outcomes as countries with decreasing populations do not receive additional workers to offset the rise in the dependency ratio, and countries with increasing populations retain excess workers who are assumed not to contribute to production.

The impact of GEF on AI. Increasing geopolitical frictions inhibits the sharing of knowledge and technology between countries, risking a slowdown in the speed of AI-related productivity growth globally. This is modeled as an adaptation of the AI framework, with productivity growth halved relative to the moderate scenario, hence worsening growth outcomes.

The impact of AI and demographics on GEF. Competitive pressure between countries in the race for AI dominance has already begun increasing barriers to trade, for example, through the US CHIPS Act. The chips required to train and run large AI models require very specific inputs that in turn require a wide range of raw materials, including rare earth minerals. AI competition may therefore lead to increased trade barriers between countries in efforts to slow each other down. Furthermore, relating to demographics, trade barriers have been used by host countries to pressure source countries into intensified efforts to bring down illegal immigration. Together, these interactions could lead to an increase in trade barriers relative to the moderate scenario. This is modeled by adjusting the GEF results to double US import barriers (from 10 percent to 20 percent) as well as barriers between third economies (from 5 percent to 10 percent).

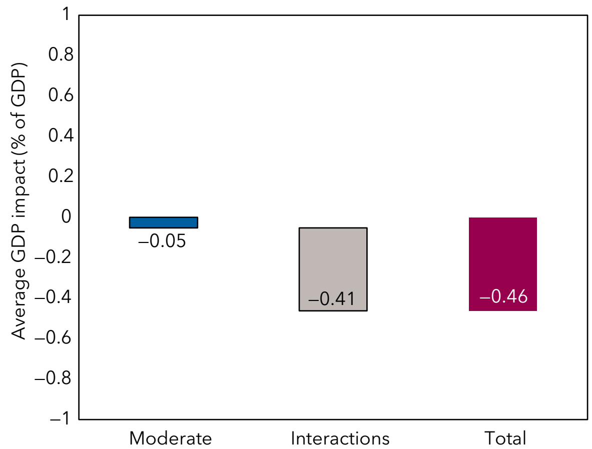
Together, these channels magnify macroeconomic headwinds beyond the effect of each transformation in isolation. On average across economies, stylized estimates of the interactions suggest they add an additional negative effect of −0.41 percent on average annual per capita growth across economies to the moderate scenario effect (see Annex Figure 1.2).

Annex Table 1.1. Key Possible Interactions between Structural Transformations

	Climate	Demographics	AI
GEF	*Low cooperation → higher emissions* *Reduced technology sharing* *Lower financing for climate adaptation in EMDEs*	*Immigration barriers reduce migration to aging economies* *Conflicts increase forced migration*	*Cross-border barriers slow AI development/adoption* *Reduced regulatory coordination* *Increased cyberattacks*
Climate		*Climate damages induce migration* *Population growth increases energy demand (and emissions)*	*Data center energy consumption (negative effect)* *Increased energy efficiency (positive effect)*
Demographics			*Older workers exposed to displacement (negative effect)* *AI may substitute for scarce younger workers (positive effect)*

Note: AI = artificial intelligence; GEF = global economic fragmentation; EMDEs = emerging markets and developing economies.

Annex Figure 1.2. Moderate Scenario plus Interactions, 2026–35
(Average yearly impact on GDP per capita growth)



Sources: Demographics, staff calculations based on UN population projections with Cobb-Douglas production function; climate change, chronic effects sourced from Centorrino, Massetti, and others (2025), acute effects from NGFS (n.d.); GEF, based on staff calculations using Caliendo and Parro (2015) long-run GE trade model; AI, based on staff calculations following Acemoglu (2024), incorporating labor market exposure from Cazzaniga and others (2024); and IMF staff calculations.

Note: Sample covers 34 AEs, 68 EMs, and 41 LICs. Detailed description of methodologies is described in Annex I. AEs = advanced economies; EMs = emerging markets; LICs = low-income countries.

Economy Coverage

The following 143 economies are included in the GDP effect estimates (starred economies also present in NGFS acute climate effects data set):

Australia (AE)*	Austria (AE)*	Belgium (AE)*	Canada (AE)*
Croatia (AE)	Cyprus (AE)	Czech Republic (AE)*	Denmark (AE)*
Estonia (AE)*	Finland (AE)*	France (AE)*	Germany (AE)*
Greece (AE)*	Hong Kong SAR (AE)*	Iceland (AE)	Ireland (AE)*
Israel (AE)	Italy (AE)*	Japan (AE)*	Korea (AE)*
Latvia (AE)*	Lithuania (AE)*	Luxembourg (AE)	Netherlands (AE)*
Norway (AE)*	Portugal (AE)*	Singapore (AE)*	Slovak Republic (AE)*
Slovenia (AE)*	Spain (AE)*	Sweden (AE)*	Switzerland (AE)*
United Kingdom (AE)*	United States (AE)*	Algeria (EM)	Angola (EM)
Argentina (EM)*	Armenia (EM)	Azerbaijan (EM)	Belarus (EM)
Belize (EM)	Bolivia (EM)	Bosnia and Herzegovina (EM)	Botswana (EM)
Brazil (EM)*	Brunei Darussalam (EM)	Bulgaria (EM)*	Cabo Verde (EM)
Chile (EM)*	China (EM)*	Colombia (EM)	Costa Rica (EM)
Dominican Republic (EM)	Ecuador (EM)	Egypt (EM)*	El Salvador (EM)
Eswatini (EM)	Fiji (EM)	Georgia (EM)	Guatemala (EM)
Guyana (EM)	Hungary (EM)*	India (EM)*	Indonesia (EM)*

Iran (EM)	Iraq (EM)	Jamaica (EM)	Jordan (EM)
Kazakhstan (EM)	Lebanon (EM)	Malaysia (EM)*	Mauritius (EM)
Mexico (EM)*	Mongolia (EM)	Montenegro (EM)	Morocco (EM)
Namibia (EM)	North Macedonia (EM)	Oman (EM)	Pakistan (EM)
Panama (EM)	Paraguay (EM)	Peru (EM)	Philippines (EM)
Poland (EM)*	Qatar (EM)	Romania (EM)*	Russia (EM)*
Saudi Arabia (EM)	Serbia (EM)	South Africa (EM)*	Sri Lanka (EM)
Suriname (EM)	Thailand (EM)	Trinidad and Tobago (EM)	Tunisia (EM)
Turkey (EM)	Ukraine (EM)	United Arab Emirates (EM)	Uruguay (EM)
Vanuatu (EM)	Vietnam (EM)*	Afghanistan (LIC)	Bangladesh (LIC)
Benin (LIC)	Bhutan (LIC)	Burkina Faso (LIC)	Burundi (LIC)
Cambodia (LIC)	Cameroon (LIC)	Chad (LIC)	Côte d'Ivoire (LIC)
Djibouti (LIC)	Ethiopia (LIC)	Gambia (LIC)	Ghana (LIC)
Guinea (LIC)	Honduras (LIC)	Kenya (LIC)	Kyrgyz Republic (LIC)
Lao PDR (LIC)	Lesotho (LIC)	Liberia (LIC)	Madagascar (LIC)
Mali (LIC)	Moldova (LIC)	Mozambique (LIC)	Myanmar (LIC)
Nepal (LIC)	Niger (LIC)	Nigeria (LIC)	Papua New Guinea (LIC)
Rwanda (LIC)	São Tomé and Príncipe (LIC)	Senegal (LIC)	Sierra Leone (LIC)
Somalia (LIC)	Tanzania (LIC)	Togo (LIC)	Uganda (LIC)
Uzbekistan (LIC)	Zambia (LIC)	Zimbabwe (LIC)	
Note: AE = advanced economy; EM = emerging market; LIC = low-income country.			

Annex 2. Fiscal Frameworks: Assessing Medium-Term Spending Pressures

Megatrend-related spending may arise because of preexisting commitments or to new policies. Expenditure pressures arise even in the absence of new policies, driven by existing commitments or structural trends, including demographic-related spending on pensions and health as well as climate adaptation and resilience investment. Expenditure needs are policy-driven responses to megatrends, such as higher defense spending in response to fragmentation and increased human capital and infrastructure investment to achieve the sustainable development goals (SDGs). These categories may overlap, for example, when rapid demographic growth requires proactive investment in education and health to harness a demographic dividend.

The main data sources are the IMF's October 2024 *World Economic Outlook*, IMF Government Finance Statistics (GFS) functional expenditure (COFOG) data, the Finance for Development 2025 staff paper, and expert estimates based on authorities' data.[84,85]

- *Pensions and health* projections reflect aging and long-term cost drivers. Pension spending relies on national authorities' no-policy-change estimates where available; otherwise, spending per beneficiary is held constant, and projections evolve with the old-age dependency ratio.[86] Health spending projections are based on long-term cost trends (as a share of GDP) and UN demographic forecasts. Changes are measured as deviations (percent of GDP) from the 2024 baseline and averaged over 10-year horizons for the maximum sustainable debt calculations. These estimates exclude SDG-related health spending and, where data allow, private health spending. Estimates are the IMF staff estimates based on WHO, Organisation for Economic Co-operation and Development, UN population projections, and authorities' estimates.
- *Climate investment* focuses on adaptation only and includes upgrading public investment, retrofitting existing infrastructure, and coastal protection. Upgrading and retrofitting costs are from Aligishiev, Massetti, and Bellon (2022) with upgrading assumed constant as a share of GDP and retrofitting concentrated in the first 10 years. Coastal protection estimates follow Nicholls and others (2019) and are allocated evenly over 15 years. All estimates are expressed as annual additional spending (percent of GDP) relative to a 2024 baseline that assumes no prior adaptation.
- *Defense spending* is assumed to rise in response to geopolitical tensions. For North Atlantic Treaty Organization members, pressures are measured as the gap between current defense spending and 3.5 percent of GDP (the 2025 NATO target); for other economies, the benchmark is 2 percent of GDP.[87] If current spending exceeds the benchmark, additional spending is set to zero. The country coverage is limited, and so latest available values are assumed to be constant beyond 2024, whereas missing data are treated as zero for maximum sustainable debt calculations.[88]

---

84 Detailed Expense Breakdown—IMF Data (https://data.imf.org/en/Data-Explorer?datasetUrn=IMF.STA:GFS_COFOG(11.0.0)).

85 Note that 10-year horizon estimates are subject to uncertainty and caveats. These spending pressures are the spending changes we would expect if historical growth continued into the future. In practice, it is likely that countries would look to contain sharp increases in spending. Therefore, country-level estimates should not be used to form policy advice.

86 Pension system reforms in emerging markets and development economies are not included in the projections. The latter are only included for EU countries to the extent that these effects are captured in the country statistics. Even for EU countries, pension pressures are measured relative to the 2024 baseline, which assumes netting out the existing contribution financing embedded in current systems. The contribution rates are assumed to be unchanged, and the increase in pension spending translates into additional fiscal pressure. Although contribution increases are possible, no additional tax increases are assumed in the model.

87 For NATO members, we assume they increase spending immediately to 2 percent and then gradually to 3.5 percent of GDP.

88 The outbreak of the war in Ukraine environment led to significant increases in defense spending, particularly in AEs (Atlantic Council 2023). There is also a growing debate over raising NATO's defense spending target beyond 2 percent (PIIE 2024). Therefore, actual spending pressures could be higher than estimated, particularly in AEs.

- *Human (education and health) and infrastructure investment* pressures (roads, electricity, and water) are provided by Carapella and others (2023) and the *Finance for Development* (henceforth FfD) staff paper. FfD adapts these estimates to account for absorption costs for a large but limited sample of emerging markets (EMs) and low-income countries (LICs).[89] In Carapella and others (2023), health and education expenditures are treated as recurrent from 2030 onward to achieve meaningful SDG outcomes, whereas infrastructure spending reflects the annualized spending required to close infrastructure gaps over 2020–30 (Gaspar and others 2019; Carapella and others 2023). For the 20-year horizon used here, these spending levels are assumed to be constant annually, with infrastructure investment scaled down by half. Estimates from Carapella and others (2023) are further scaled by 0.75 to capture public spending only. All spending is treated as additional annual spending (percent of GDP) over a 20-year horizon relative to the 2024 baseline.

Methodology

The spending estimates are studied in the context of assessing the MSD level across economies. Accordingly, we adopt conservative and moderate spending profiles relative to the large-scale needs typically reported in Carapella and others (2023) and FfD (2025) staff paper. For SDG-related spending, we do not assume full achievement of targets within a fixed horizon. Instead, spending is set at levels assessed to be plausible and consistent with gradual progress, accounting for absorptive capacity and efficiency constraints, as well as macroeconomic and debt sustainability risks.

Annex Table 2.1. Change in Total Public Expenditure in Percent of GDP, 80th Percentile within Subsample for EMs and LICs' Quartiles

	Quartile	One Year	Five Year
LICs	1	1.6	3.4
	2	2.8	4.5
	3	4.0	5.2
	4	9.8	11.9
EMs	1	1.5	2.6
	2	2.4	3.1
	3	3.6	5.8
	4	5.9	5.9

Source: Finance for Development paper, Annex I. Box 2. Figure 1. The 4th Financing for Development Conference—Contribution of the IMF to the International Financing for Development Agenda—Annexes in: Policy Papers Volume 2025 Issue 022 (2025).
Note: EMs = emerging markets; LICs = low-income countries.

(1) Country coverage in the FfD paper is extended using estimates from Carapella and others (2023). For consistency, public expenditure paths for these additional countries are constrained following the FfD methodology, as summarized next. Public spending growth is constrained following the FfD approach, based on historical spending increases over 1999–2019. Rather than country-specific limits, common caps are derived for EMs and LICs using the 80th percentile of positive one-year spending changes (2009–19), aggregated through quartiles to obtain group-level one-year and five-year caps. We replicate this procedure while extending the sample to 53 countries.

- The one-year cap applies in the first year, whereas spending in years 2–4 can increase cumulatively up to the five-year cap. From year 6, a new one-year increase is allowed, and a new five-year cap, incremental to the previous, is applied from year 7. This pattern repeats every five years until 2044. Final caps by group

[89] Estimates for physical infrastructure are calculated such that countries meet the relevant SDGs in 10 years. For a 20-year horizon, estimates are assumed to be halved per year.

are reported in Annex Table 2.1. The spending caps are applied to the values of the ratio of spending to GDP given by Carapella and others (2023), which are calibrated to be constant as a percent of GDP annually.[90]

- Using the FfD annual total nominal estimates, we assume that this results in a multiplier effect on GDP levels. We then apply the assumed fiscal multipliers to total output with a contemporaneous effect as well as a lagged effect up to six years.[91] The cumulative effect is computed by applying the relevant lagged spending amounts to each year's multiplier and summing across the six-year window. This cumulative effect is then added to the exogenous GDP to generate an endogenous GDP path that reflects growth-enhancing effects of SDG-related spending.[92,93]
- To have a smooth spending profile across the time horizon and to avoid spending paths that are too heavily front-loaded or back-loaded, we distribute the SDG total spending (in US$) for the countries with FfD data, over the time horizon of interest 2025–44, to create a smooth and realistic spending ramp-up, reflecting implementation constraints and institutional capacity.[94,95]

(2) We assume that nominal spending on defense, health, pensions, and climate scales proportionally with endogenous GDP, leaving spending-to-GDP ratios unchanged. Given our smoothing profile, and extended implementation horizon, our average spending ratios are intentionally lower, and not directly comparable to those in Carapella and others (2023) and the FfD for both LICs and EMs. Thus, these estimates should be treated as indicative and should not be used for country-level policy analysis. For the MSD estimates, the average per country is taken across the 10- and 20-year time horizons. All estimates are expressed as an annual percent of GDP relative to 2024. We present the estimates for all the categories and across two periods in Annex Figure 2.1,

[90] For 2025, the additional spending ratio is capped at the minimum of the unconstrained target and a one-year ceiling. From 2026 onward, each year's constrained ratio is the minimum of (1) the unconstrained target for that year, (2) a one-year increment cap equal to last year's constrained level plus one-year ceiling, and (3) a cumulative cap tied to five-year blocks multiples since 2025.

[91] Fiscal multipliers are 0.4 for first year, 0.5 for second, 0.4 for third, 0.3 for fourth, 0.3 for fifth, and 0.1 for sixth year. Estimates are applied to GDP output and for each year in the horizon. The source of these multipliers is the *Finance for Development* paper 2025. We apply these multipliers to total spending on total GDP, whereas the paper applies these multipliers to spending-to-GDP ratios for GDP growth. Our endogenous GDP path is higher than in the *Finance for Development* paper because of a longer time horizon.

[92] As an alternative approach, one could implement the multiplier recursively by updating GDP year by year as a function of prior-year GDP and that year's spending effect, allowing for feedback effects and dynamic compounding over time. However, we opt for a cumulative implementation as not to overestimate the effect and for simplicity.

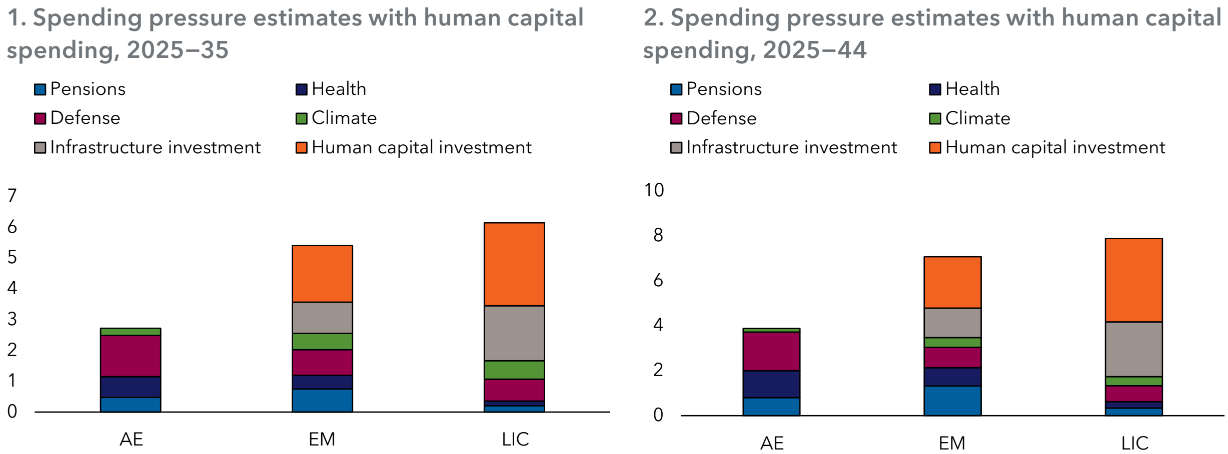
[93] The analysis incorporates the first-order effect of fiscal multipliers by allowing GDP to grow above baseline in response to higher public spending, while keeping nominal spending constant. This reduces the spending-to-GDP ratios over time and reflects the potential easing of relative pressures because of higher growth. However, the framework does not endogenize second-round feedback such as higher nominal spending from income-linked expenditures, increased financing needs, or interest rate responses. Rising debt and debt service costs—particularly in a high-interest rate environment—could themselves become new sources of fiscal pressure. These dynamics are not fully captured here. As such, the results should be interpreted as indicative and partial equilibrium in nature.

[94] To smooth the distribution of SDG spending over 2025–44, we apply a smooth S-shaped growth function (Gompertz function: $w(t) = a \cdot exp[-b \cdot e^{(-ct)}]$) for both EMs and LICs, with different parameter calibrations. Parameters for LICs and EMs are calibrated through iterative testing to generate a realistic and internally consistent spending ramp-up in the absence of observed year-by-year execution patterns. A Gompertz curve is used to allow for gradual institutional buildup, accelerating spending, and eventual convergence to a plateau, avoiding sharp front- or back-loading. This functional form represents a stylized, income-group average assumption rather than an empirically estimated path and is intended to illustrate plausible investment dynamics rather than prescribe an exact spending schedule (see, for example, Kuzmenko, Vasylyeva, and Bozhenko 2020). For countries, for which *Finance for Development* (IMF 2025b) data are unavailable and for which the Carapella and others (2023) estimates do not have a smoothing profile, we use constrained annual constant estimates.

[95] Gaspar and others (2019) indicate that even for the case of human capital spending, spending may have to rise before 2030, so the assumption of a ramp-up is consistent with that.

Annex Figure 2.1. Additional Fiscal Spending Driven by the Four Transformations

(Average additional spending, percent of GDP, simple average)



Source: IMF staff calculations.

Note: For panel 1: The graph shows estimated additional spending linked to the four transformations for AEs, EMs, and LICs. Estimates show the mean across years and economies of the average annual percentage point increases in spending/GDP during 2025–35 relative to 2024. Country coverage is 190 but varies by category of spending, so means shown take each sample separately. Health and pensions reflect spending pressures under no policy change based on demographic shifts and Fiscal Affairs Department's estimates. Climate reflects adaptation-related investment needs, and infrastructure reflects spending toward closing gaps to sustainable development goals and is adjusted to reflect absorption capacity constraints for some economies. Defense spending relies on most recent data (COFOG 2022) and reflects the gap needed to reach the NATO target of 2 percent, yearly, and economies with higher spending that are assumed to have zero increase in spending. Estimated human capital spending is incorporated.

For panel 2: The graph shows estimated additional spending linked to the four transformations for AEs, EMs, and LICs. Estimates show the mean across years and economies of the average annual percentage point increases in spending/GDP during 2025–44 relative to 2024. Country coverage is 190 but varies by category of spending, so means shown take each sample separately. Health and pensions reflect spending pressures under no policy change based on demographic shifts and Fiscal Affairs Department's estimates. Climate reflects adaptation-related investment needs, and infrastructure reflects spending toward closing gaps to sustainable development goals and is adjusted to reflect absorption capacity constraints for some economies. Defense spending relies on most recent data (COFOG 2022) and reflects the gap needed to reach the NATO target of 3.5 percent, yearly, and economies with higher spending than that are assumed to have zero increase in spending. Estimated human capital spending is incorporated. AE = advanced economy; EM = emerging market; LIC = low-income country; NATO = North Atlantic Treaty Organization.

Annex 3. Fiscal Frameworks: Estimates of Maximum Sustainable Debt (MSD) Levels

Sovereign Default Model

The quantitative estimates of the MSD are based on Jiang and others (2024) and Cao and others (2025). The paper builds a stochastic continuous-time model that extends Barro (1979) by incorporating limited commitment (default risk) and a convenience yield on risk-free government debt. The government issues risk-free debt and a GDP-linked "Shiller security" to hedge standard business cycle risks (not against disaster shocks), whereas GDP follows a stochastic process. At the debt limit, a zero-drift condition ensures indifference between default and repayment. The MSD level is determined at the point where the marginal cost of servicing debt, the economic burden of raising taxes to repay debt, equals the benefit of preserving the debt and avoiding default costs. We refer readers to the papers for full model details and summarize the two closed-form solutions at the default threshold.

1. Optimal taxes (τ_N)

$$\tau_N = min\left\{\bar{\tau}, \frac{1}{\phi}\left(\sqrt{1+2\phi\left(1-\alpha+\gamma+\frac{\phi\kappa\gamma^2}{2\alpha}\right)}-1\right)\right\} \tag{3}$$

Higher spending (γ) requires higher taxation, but this is constrained by a finite tax capacity $\bar{\tau}$, reflecting government's maximum tax capacity because of institutional or political constraints. As spending rises, the required tax effort increases nonlinearly, with sharply higher tax rates beyond a threshold because of growing distortionary costs (ϕ). Default risk (α) affects the need for sustainable taxation.

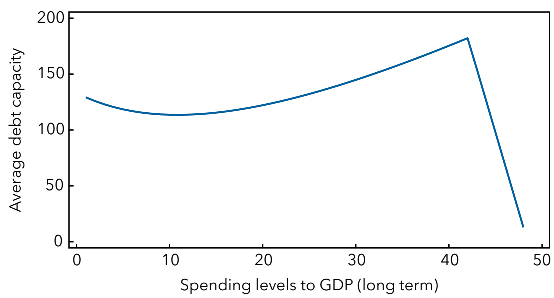
2. Maximum sustainable debt ($\bar{b}$)

$$\bar{b} = \frac{\tau_N - \gamma}{r+\varepsilon+\lambda-\delta-g}$$

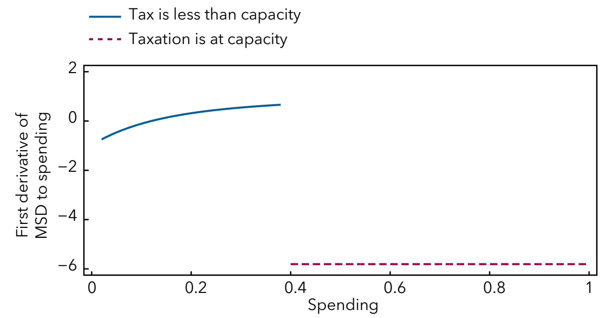
Higher spending raises optimal taxes (to a certain extent) and reduces MSD. Higher interest rates (r), greater debt surge risk (ϵ), and higher growth volatility (λ) further erode MSD by raising effective borrowing costs. In contrast, stronger convenience yields (δ) and higher GDP growth (g) expand MSD by lowering those costs. Annex Figure 3.1 shows how MSD changes in response to growth in spending and "r-g".

Annex Figure 3.1. Simulations of the MSD under Different Parameter Assumptions

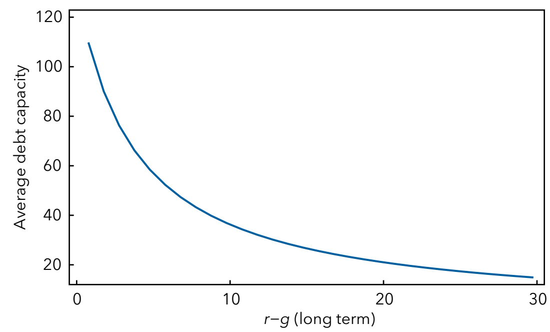
1. Increase in Spending



2. First Derivative of Debt to Spending



3. Increase in $(r-g)$



Source: IMF staff calculations.

Note: Charts plot for a hypothetical country scenario and specific set of parameters the variation in debt capacity if spending or (r-g) changes.

Decomposing Contributions of Transformations

To assess the contribution of each transformation: demographics, fragmentation, climate, and artificial intelligence, to changes in MSD, we adopt a Shapley value decomposition approach, which considers each transformation's marginal contribution across all possible sequences in which it could be introduced. This method ensures that individual contributions add up to the total effect.

Conceptually, $N = \{1,2,3,4\}$ be the set of all transformations. Let $n!$ be the number of ways to form a combination of n transformations, S be a coalition (subset) of transformations, $|S|$ be the number of transformations in S. $|S|!$ is the number of ways coalition S can form. The number of ways transformations can still be added after transformation i is represented by $(n - |S| - 1)!$

Let $\bar{b}(S)$ denote the MSD when a subset S of transformations is incorporated.

For each trend $i \in n$, the Shapley value ϕ_i is computed as the average marginal contribution of i across all possible permutations of the elements in n:

$$\phi_i = \sum_{S\subseteq\{1,\ldots,p\}\setminus\{i\}} \frac{|S|!(n-|S|-1)!}{n!}\left[\bar{b}(S\cup\{i\})-\bar{b}(S)\right],$$

where $\frac{|S|!(n-|S-1|)!}{n!}$ is the *weight*, and $\bar{b}(S \cup \{i\}) - \bar{b}(S)$ is the *marginal effect* of adding trend i to subset S. Then the sum adds over all possible coalitions that transformation i is added to. The equation weights all the marginal contributions of the transformation i by the probability that it makes these contributions then sums over all possible coalitions that transformation i can contribute to.

As for implementation in our framework, we first compute the baseline MSD prior to incorporating any megatrends. We then recompute MSD under all 24 permutations of sequentially introducing the four mega-trends. For each permutation, trends are added cumulatively, and MSD is recalculated after each additional trend. Marginal contributions are defined as the difference in MSD between two consecutive layers in the sequence (for example, when a trend is introduced as the second, third, or fourth shock). The first marginal contribution in each permutation is defined as the difference between the MSD after introducing the first trend and the baseline MSD. Note that each calculated MSD is bound at zero, reflecting the economically meaningful constraint that MSD cannot be negative, but the contributions are not capped.[96,97]

Contributions are then averaged across permutations to obtain the Shapley value for each trend across the 24 permutations:[98,99]

$$\phi_i = \frac{1}{24}\sum\nolimits_{k=1}^{24} Marginal_{i,k}.$$

The Shapley decomposition considers the transformations individual contribution and its interaction with others. It satisfies four axioms: efficiency, symmetry, null player, and additivity.

Model Assumptions and Additional Results

Advanced economies face a larger gap between model-implied MSD and current debt levels (Annex Figure 3.2), indicating greater fiscal space than in emerging markets and developing economies. At the same time, emerging markets and low-income countries (LICs) remain well below their tax capacity, whereas advanced economies are close to—or at—their tax limits (Annex Figure 3.2). This "tax gap"—the difference between projected optimal taxes and tax capacity—is a key determinant of future MSD in the presence of megatrends. It captures the scope for revenue mobilization to offset adverse macro developments and rising spending pressures. In the simulations, and recognizing political and social constraints, countries are assumed to move toward—but not reach—full tax capacity over the next decade. The implied tax increases are reported in Annex Table 3.1. The required adjustment is larger for LICs when human capital spending is included. Calibration ensures that average increases remain within the tax gaps documented by Gaspar, Mansour, and Vellutini (2023). Accordingly, EMs are assumed to raise optimal tax revenues by about 2.2 percent of GDP, and LICs by about 2.0 percent of GDP, on average per year.

96 Arguably the stand-alone effect can have the largest impact given that it is not attenuated by other factors, and at the same time, it is cushioned by a larger available increase in optimal taxation.

97 The zero lower bound assumption makes sense economically because the MSD is not meaningful when negative. This may undermine positive contributions of a permutation that follows a zero-bounded one or could underestimate a negative contribution. Note that the zero lower bound in our analysis only affects Zimbabwe, and results are robust to relaxing this assumption, or to dropping Zimbabwe from the sample.

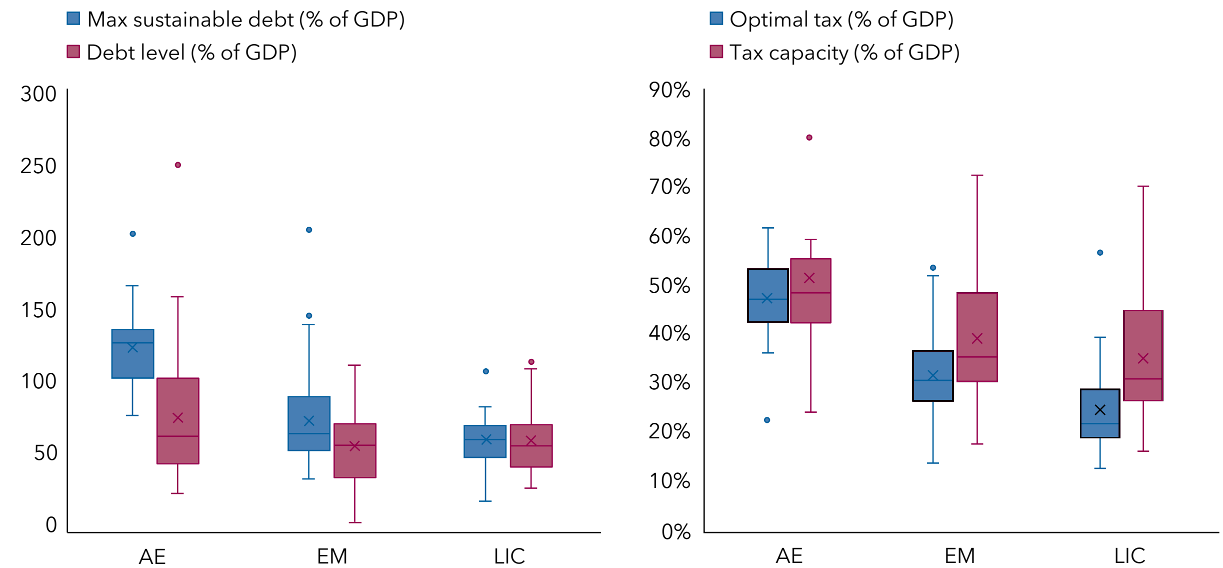
98 This empirical average is mathematically equivalent to the formal Shapley value equation earlier, because of the equal probability assigned to each permutation (that is, uniform weights).

99 We include the marginal contribution from all possible permutations (24) in the average. We perform a robustness check that the sum of the averaged contributions is equal to the difference between the resulting MSD after all transformations are added and the baseline MSD. We perform robustness checks where we exclude permutations where the trend appears first if its stand-alone effect has already been included, in order to avoid double counting the same marginal effect under a different permutation label, and the results are qualitatively similar. Similarly, results hold when we only include the unique results from each permutation.

Annex Figure 3.2. MSD, Actual Debt Levels, Optimal Tax and Tax Capacity

1. MSD and Actual Debt Levels across Economies, by Income Group

2. Optimal Tax Rates and Tax Capacity across Economies, by Income Group



Source: IMF staff calculations.

Note: Panel 1: The graphs show the actual debt level and MSD levels estimated using the framework in Jiang and others (2024) and Cao and others (2025). The charts plot the MSD based on 2024 estimated parameters. Debt as a percent of GDP represents gross debt for all economies.

Panel 2: The graph shows the box plot distribution in optimal taxes at baseline and with the scenario of an increase in spending. AE = advanced economy; EM = emerging market; LIC = low-income country; MSD = maximum sustainable debt.

The model's parameters reflect long-term values of spending-to-GDP ratios, borrowing costs, and growth rates. The four structural transformations considered in the paper are assumed to shift these values (Annex Table 3.2). Growth effects are in percentage points and are added to the long-term total growth in the model.[100] For demographics, effect on total growth could be different than the per capita growth estimates reported in the paper. Demographic trends can lower per capita growth through aging-related declines in productivity, reduced labor-force participation, shifts toward lower-productivity sectors, or rising dependency ratios yet still raise total GDP growth when the overall population or labor force expands, whether through natural increase, higher participation, sectoral shifts, or immigration. As for borrowing costs in the model, we map the assumed change in natural rate onto an adjustment to the risk-adjusted interest rate in the model, which reflects in addition to the risk-free rate, the convenience yield, debt surge probability, and growth volatility.[101] The comparison with gross debt to GDP is based on October 2024 *World Economic Outlook*.

[100] Growth effects of fragmentation, AI, and climate are assumed to reflect total GDP growth directly, as they are treated as marginal effects. In contrast, demographic growth effects are estimated in per capita terms and then converted into total GDP growth.

[101] Rising debt issuance can erode "convenience premium" on sovereign bonds.

Annex Table 3.1. Descriptive Statistics in the MSD Simulations

	Tax Capacity		Optimal Tax		Tax Gap		Percent of Tax Gap Allowed to Vary in MSD Simulations without Human Capital Investment		Percent of Tax Gap Allowed to Vary in MSD Simulations with Human Capital Investment	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
AE	51.5%	48.3%	47.3%	47.1%	4.2%	−0.7%	4.2%	−0.7%	4.2%	−0.7%
EM	39.2%	35.4%	31.5%	30.5%	7.7%	5.2%	3.9%	2.6%	5.0%	3.4%
LIC	35.5%	31.6%	24.7%	21.6%	10.9%	8.1%	2.6%	2.0%	5.3%	4.0%

Source: IMF staff calculations.

Note: The table shows the mean and median for maximum tax capacity and optimal tax as a percent of GDP in the model, per income group. The first and second columns show the mean and median value of taxation capacity as a percent of GDP by income group. The third and fourth columns show the mean and median of optimal taxation, which is backed out from the model (see equation (1) in Annex III) by income group. The last four columns show the mean and median of the additional tax as a percent of GDP that is allowed to be raised on top of the baseline optimal taxation per income group. A negative gap means the tax capacity is binding. The last three columns show the median of the variables. AE = advanced economy; EM = emerging market; LIC = low-income country; MSD = maximum sustainable debt.

Annex Table 3.2. Effects of Structural Transformations on Growth and Natural Rate in the MSD Simulations[1]

Growth Effects (Average Annual Percentage Point Change)					
	Demographics	**GEF**	**Climate**	**AI**	**All**
AE	−0.33	−0.20	−0.02	0.31	−0.24
EM	0.46	−0.18	−0.02	0.2	0.46
LIC	2.12	−0.20	−0.02	0.13	2.02
Natural Rate Effects (Percentage Point Change)					
	Demographics	**Climate**	**GEF**	**AI**	**All**
AE	−0.02	−0.08	0.17	0.15	0.22
EM	−0.5	−0.08	0.02	0.1	−0.46
LIC	−0.5	−0.08	0.03	0.1	−0.45

Source: IMF staff calculations.

Note: These data are for the sample of 131 economies used in the MSD simulations. These estimates are added to the baseline parameters of the model. Defense assumes for NATO countries a gradual target of 3.5 percent, and 2 percent for all other economies. Climate estimates include only chronic effects. AE = advanced economy; EM = emerging market; GEF = global economic fragmentation; LIC = low-income country; MSD = maximum sustainable debt; NATO = North Atlantic Treaty Organization.

[1] This table summarizes estimates used in the MSD analysis for 128 countries so the spending estimates may differ from the ones reported in text for the full sample of 190 countries.

Spending pressures from transformations risk reducing fiscal space unless accompanied by the necessary tax adjustments. For the climate megatrend, the adaptation spending assumed in the fiscal scenario is assumed to offset acute damages. In addition to the results presented in the main text, we present additional set of results as follows in Annex Figure 3.3 and 3.4. Median MSD estimates and accounting for additional human capital investments for moderate scenario assumes higher tax increases if the demographic dividend is to be specified. We also present sensitivity analysis on more ambitious measurements of infrastructure and human capital investments, which under the current assumptions of tax increases will likely reduce fiscal space, and may necessitate further revenue mobilization to cushion against this effect. Indeed, increasing primary balance is key to cushioning the MSD as sensitivity tests, when assuming no tax increases are allowed, show a deterioration for the MSD for all income groups.

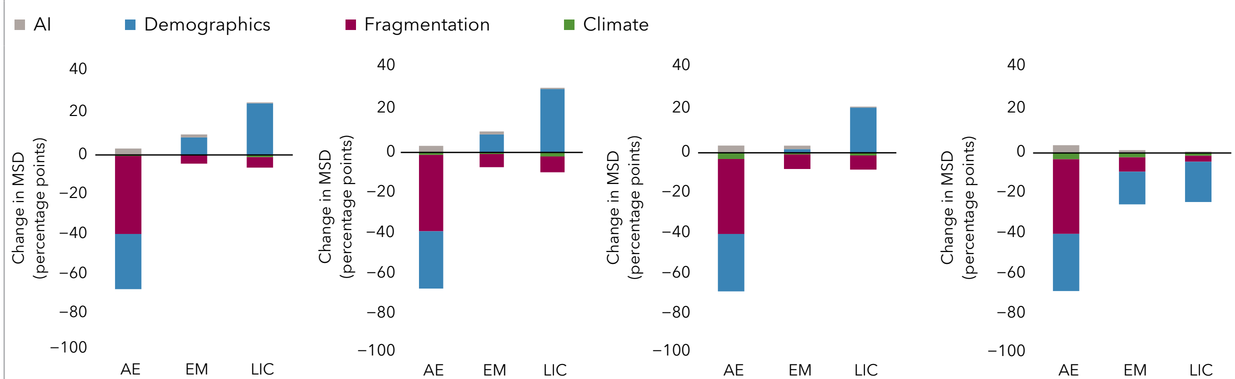
Annex Figure 3.3. Effect of Structural Transformations on MSD Levels across Economies, by Income Group

1. Moderate Scenario
(Change in MSD, median)

2. Moderate Scenario
(Change in MSD, trimming outliers)

3. Moderate Scenario with Human Capital
(Change in MSD, simple average)

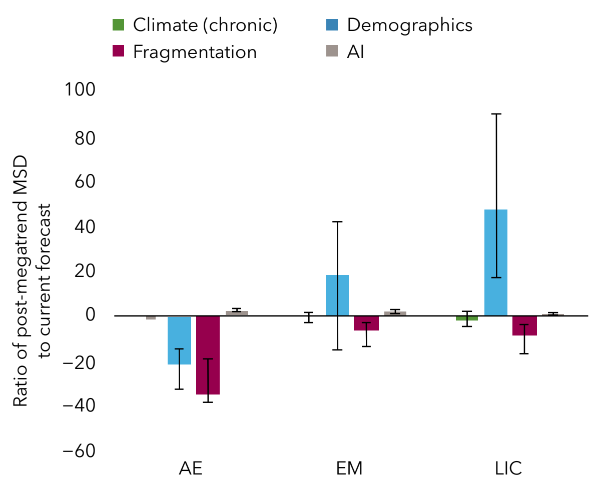
4. Sensitivity Analysis: Moderate Scenario with Higher Infrastructure and Human Capital
(Change in MSD, simple average)



Source: IMF staff estimates.

Note: MSD is defined as the maximum sustainable level of debt without default (Jiang and others 2024; Cao and others 2025). The graphs show the average contributions of each of the scenarios to the change in the MSD and are estimated through a Shapley value decomposition. Panel 4 shows sensitivity to the results when higher estimates on infrastructure and human capital are assumed without further tax increases. Climate estimates include only chronic effects. We allow a higher increase in taxation for human capital when added (see Annex Table 3.1). The sample includes 129 economies. AE = advanced economy; AI = artificial intelligence; EM = emerging market; LIC = low-income country; MSD = maximum sustainable debt.

Annex Figure 3.4. Contributions of Structural Transformations to Shifts in MSD Levels



Source: IMF staff estimates.

Note: MSD is defined as the maximum sustainable level of debt without default (Jiang and others 2024; Cao and others, 2025). The left-hand side chart shows the median (bar) and the range of 25th and 75th percentiles, with each contribution winsorized at 5th and 95th percentiles and estimated based on a Shapley value decomposition. Climate estimates include only chronic effects. AE = advanced economy; AI = artificial intelligence; EM = emerging market; LIC = low-income country; MSD = maximum sustainable debt.

Annex 4. Fiscal Frameworks: Additional Spending and Debt Dynamics

We use a model developed by Nguyen, Lam, and Sher (2025) to illustrate how to finance additional spending for three income groups.[102] The model integrates several elements in the literature:

(1) The model framework builds on the literature on public investment and output multipliers, as in Traum and Yang (2015) and Drautzburg and Uhlig (2011).

(2) Our model allows endogenous relationship between government debt and its borrowing costs, which is in line with Mian, Straub, and Sufi (2025). The endogeneity can be interpreted from both demand and supply perspectives of government bonds (asset). From the asset demand side, household savers require higher yields to hold increasing government debt. From the supply perspective of government bond, the bond provides certain convenience benefits (for example, Krishnamurthy and Vissing-Jorgensen 2012), because of its safety, and regulatory advantages. As government incurs higher debt, these benefits diminish and lead to higher borrowing costs.

(3) The model allows for nonlinear and time-varying elasticity of interest rates to debt levels, which depends on the probability of debt distress. This reflects the case that high-debt countries, the rise in debt could lead to a disproportionate surge in sovereign risk premia, with higher probability of debt distress in the spirit of Bi and Traum (2012).

(4) The model incorporates the pass-through of sovereign borrowing costs to private sector funding costs, following Corsetti and others (2013) and Bevilaqua, Hale, and Tallman (2020).

Key equations of the dynamic general equilibrium model:

The Euler equation of the representative household is described that:

$$\lambda_t - CY_t = \beta E_t \frac{\lambda_{t+1} R_t}{z_{t+1}}, \tag{4}$$

where β is the discount factor, λ_t is the marginal utility, CY_t the convenience yield, R_t the gross interest rate on one-period government bond, and z_{t} = Z_t / Z_{t-1}, where Z_t captures the trend along the balanced growth path.

The convenience yield is linked to debt as in Mian, Straub, and Sufi (2025):

$$CY_t = \overline{\lambda} \left(\overline{CY} - \varphi_t \left(\frac{B_t - \overline{B}}{\overline{B}} \right) \right), \tag{5}$$

where B_t is the level of debt, φ_t is the elasticity of debt on convenience yield, and variables denoted with a bar correspond to the steady state of the variable. A deviation from Mian, Straub, and Sufi (2025) is that the elasticity is φ_t allowed to be time varying, reflecting different probability of debt distress ρ_t:

$$\rho_t = \frac{\exp\,(a_1 + a_2 b_{t-1})}{1 + \exp\,(a_1 + a_2 b_{t-1})}, \tag{6}$$

where b_t is the debt-to-GDP ratio. This specification is similar to that proposed in Bi and Traum (2012), indicating that the probability of debt distress rises with the debt-to-GDP ratio in the previous year. The logistic function guarantees that ρ_t lies between 0 and 1. The parameters α_1 and α_2 are the intercept and slope

[102] The model is also featured in the Online Technical Annex in Acalin and others (2025).

parameter decide the shape of the curve. In case of debt distress $\rho_t = 1$, it is assumed that the premium goes up by 1 percentage point for each 10 percentage points increase in debt, that is, $\Delta = 0.1$, which aligns with the increase of spread in Greece during the sovereign debt crisis. As a result, φ_t can be expressed as:

$$\varphi_t = \rho_t \Delta + (1 - \rho_t)0 = \rho_t \Delta. \tag{7}$$

To capture the spillover and the pass-through from stress in sovereign yields to the borrowing cost of the private sector, the model adopts the approach in Burriel and others (2020) in the financial sector. The return on investment is described as:

$$1 + \psi_t = \beta \mathrm{E}_t \lambda_{t+1} \frac{(1-\delta)q_{t+1} + r^k_{t+1}}{z_{t+1} q_t \lambda_t}, \tag{8}$$

where q_t is the de-trended Tobin's q and is the wedge associated with the sovereign risks:

$$\psi_t = \frac{\varphi_t}{2}\left(\frac{B_t - \overline{B}}{\overline{B}}\right). \tag{9}$$

It is based on the empirical evidence in Bevilaqua, Hale, and Tallman (2020) that shows the sensitivity of corporate yields to sovereign yields is about 0.5 in a cross-country panel regression.

Calibration:

The key parameters that distinguish three country groups are presented in the following table. For other parameters, see the Online Technical Annex in Acalin and others (2025).

Parameters	AE	EM	LIC
Prob. of debt distress: intercept parameter	−5.2	−4.3	−4.4
Prob. of debt distress: slope parameter	3.5	3.7	5.5
Consumption tax rate (SS)	20%	15%	1.5%
Labor income tax rate (SS)	25%	20%	0.7%
Government consumption as percent of GDP (SS)	20%	15%	10%
Government investment as percent of GDP (SS)	4%	6.5%	15%
Steady-state growth	2.1%	3.7%	4.8%

Note: AE = advanced economy; EM = emerging market; LIC = low-income country. SS = steady state

Simulation:

- Additional expenditure is decomposed into two components: government consumption (including health, pension, and half of defense spending) and government investment (including infrastructure, climate adaptation, and half of defense spending)
- In line with the discussion on potential growth, it assumes (1) for advance economy, a gradual decrease in potential growth, resulting in a drop of 0.32 percent by year 10; (2) for emerging market, a small increase in potential growth by 0.46 percent by year 10; and (3) for low-income country, an increase in potential growth of 2.05 percent by year 10.

Annex 5. Monetary Policy Frameworks: Possible Adjustments

Annex Table 5.1. Possible Adjustments to Inflation-Targeting Frameworks to Respond to New Challenges Posed by Megatrends

Possible Adjustments	Related Challenges	How Would This Adjustment Work?	Pros	Cons	Net Benefit
Institutional foundations/mandate					
Safeguard/ strengthen central bank independence	Fiscal dominance	Less pressure on central bank to give in to government and special interest pressures	Greater ability to deliver price stability	Potential concerns about political accountability	+
Framework settings					
Expand de jure horizon to reach target	Supply-side shocks, ELB	Expand monetary policymakers' discretion to respond to larger shocks	Could reduce output volatility. Preserve space to respond to future shocks (in case of low inflation)	Could reduce credibility and accountability. More volatile inflation	+/–
Wider tolerance band	Supply-side shocks, ELB	Expand monetary policymakers' discretion to respond to larger shocks	If intended as a source of flexibility, could reduce output volatility and preserve space to respond to future shocks (in case of low inflation) If used as a communication device, could help avoid unrealistic public expectations about policymakers' ability to "fine-tune" inflation outcomes	Could reduce credibility and accountability, while making inflation more volatile, especially if misinterpreted as a zone of indifference Tolerance band not really needed as an additional flexibility device when the policy horizon is medium term	+/–
Higher inflation targets	Supply-side shocks, ELB	Increase space for monetary policy easing	Reduced likelihood of hitting the ELB and may mitigate downward nominal wage rigidity	Could reduce credibility; disruptive asset market/contracts adjustment, affecting allocative efficiency; more volatile inflation	– (if current target or midpoint of target range is 2 percent or higher)

Annex Table 5.1. Possible Adjustments to Inflation-Targeting Frameworks to Respond to New Challenges Posed by Megatrends (continued)

Possible Adjustments	Related Challenges	How Would This Adjustment Work?	Pros	Cons	Net Benefit
Average inflation targeting	Supply-side shocks, ELB	Allow prolonged deviations from target. Potentially make up for them over time to provide greater certainty about price level in long term	Can provide greater certainty about future price level. Can help anchor medium-term inflation expectations	Difficult to maintain credibility that policy will over/undershoot to hit average. More inflation volatility	–
Implementation strategies					
Increase tolerance to small deviations from target when inflation is low	ELB	Stay away from ELB and preserve space to respond to bigger negative demand-side shocks	Reduce prolonged periods of low rates that could incentivize buildup of vulnerabilities and may lower *r**	Could reduce credibility; communication may be difficult; hard to precommit convincingly to respond in the future	+/–
Expand de facto horizon to reach target	Supply-side shocks, ELB	Expand monetary policy space for responding to larger shocks	Could reduce output volatility. Preserve space to respond to future shocks (in case of low inflation)	Could reduce credibility and accountability. More volatile inflation	+/–
More decisive response to risk of higher inflation or expectations de-anchoring	Supply-side shocks	Respond more decisively to the bigger supply shocks and prevent de-anchoring to the upside	Maintain anchored expectations by responding aggressively when risk of de-anchoring emerges	Bigger short-term output losses; short-term financial stability risks; reduced public support because of rate volatility	+
Instruments					
Negative policy rate	ELB	Decrease policy rate below zero and potentially down to the ELB, to further stimulate the economy	Policy instrument is the same as for conventional monetary policy. Easy to exit	Works only until the ELB is hit; uncertainty about ELB; potential disintermediation concerns	+ (until the ELB)
(Unconventional) Forward guidance	ELB	Communication about future economic conditions and policy actions can reduce uncertainty and increase policy effectiveness	Could stimulate demand when conventional policy space has been exhausted. Relatively low cost and straightforward	Could lock in suboptimal policies if no or poorly designed escape clauses	+ (with appropriate escape clauses) – (if unconditional)

(*continued*)

Annex Table 5.1. Possible Adjustments to Inflation-Targeting Frameworks to Respond to New Challenges Posed by Megatrends (continued)

Possible Adjustments	Related Challenges	How Would This Adjustment Work?	Pros	Cons	Net Benefit
QE	ELB	Reduce term premium by making purchases of government securities (and other risk premiums if purchasing other types of securities in addition)	Stimulates demand when conventional policy space has been exhausted .	QE transmission channels not all well understood; difficult to unwind; potential trade-offs between price and financial stability over the medium term	+ (deep liquidity trap, escape clauses) – (shallow liquidity trap, no escape clauses)
YCC	ELB	Cap specific interest rates along the yield curve by committing to buy government bonds to maintain those rates	Stimulates demand when conventional policy space has been exhausted May require lower volume of asset purchases than QE	YCC transmission channels not all well understood; difficult to exit; potential trade-offs between price stability and financial stability over the medium term; risk of loss of control over the central bank balance sheet	+/– (if deep liquidity trap and escape clauses) – (if shallow liquidity trap or no escape clauses)
Forecasting and risk assessment					
Risk-management approach to Monetary Policy	Uncertainty	Greater use of scenarios (alongside baseline) to account for uncertainty	Richer, more risk-sensitive approach to policy formulation; allows better communication of uncertainty and central bank's policy reaction function	Greater complexity of interactions between decision makers and staff in the formulation stage. Potentially greater risk of miscommunication	+
Improve forecasting	Uncertainty	Better inflation forecasts allow more adequate monetary policy response, including with real-time shock analysis	Better policy calibration	May require more resources and potentially disruptive reorganization of forecasting process	+

Source: IMF staff.
Note: QE = quantitative easing; ELB = effective lower bound; YCC = yield curve control.

Annex 6. Policy Interactions: Model and Scenarios

Model Description

The IMF's Quantitative Integrated Policy Framework model is an open-economy, New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model designed to capture the interaction between real activity, inflation, financial conditions, and external balance in response to a range of shocks. The New Keynesian framework has forward-looking agents, nominal rigidities, and imperfect international capital mobility, augmented by financial frictions and balance sheet effects.

The model formulation applied in this paper augments the nonlinear price and wage Phillips curves in the baseline model of Adrian and others (2021) with endogenous intrinsic wage and price indexation following Erceg, Lindé, and Trabandt (2024).

Nonlinear price and wage Phillips curves make inflation respond in a measured (in line with vector autoregressions and local projection evidence on monetary transmission) way when inflation is near target but makes inflation much more sensitive to shocks when inflation is already high. Hence, large shocks can have disproportionately large effects that linear models miss. Endogenous intrinsic wage and price indexation allows inflation persistence to emerge endogenously: When inflation runs persistently above target, firms and workers increasingly index to past inflation, amplifying and prolonging inflation even after the original shock fades.

Together, these features explain how large supply shocks can generate sustained inflation with initially resilient activity if the central bank underestimates inflationary pressures, why linearized models underpredict inflation persistence, and why policy responses that are appropriate for small shocks can become risky in high-inflation states.

The two-country model features one small "home economy," and a large "foreign economy." One-third of households are Ricardian, whereas two-thirds live hand to mouth. Home monetary policy follows a forecast-based Taylor-type policy rule, and fiscal policy relies primarily on transfers to return debt to the steady state in the long-run.

Scenario A: Role of Fiscal Policy in Stabilizing Inflation in Response to Large Supply Shocks—Nonvulnerable Economy

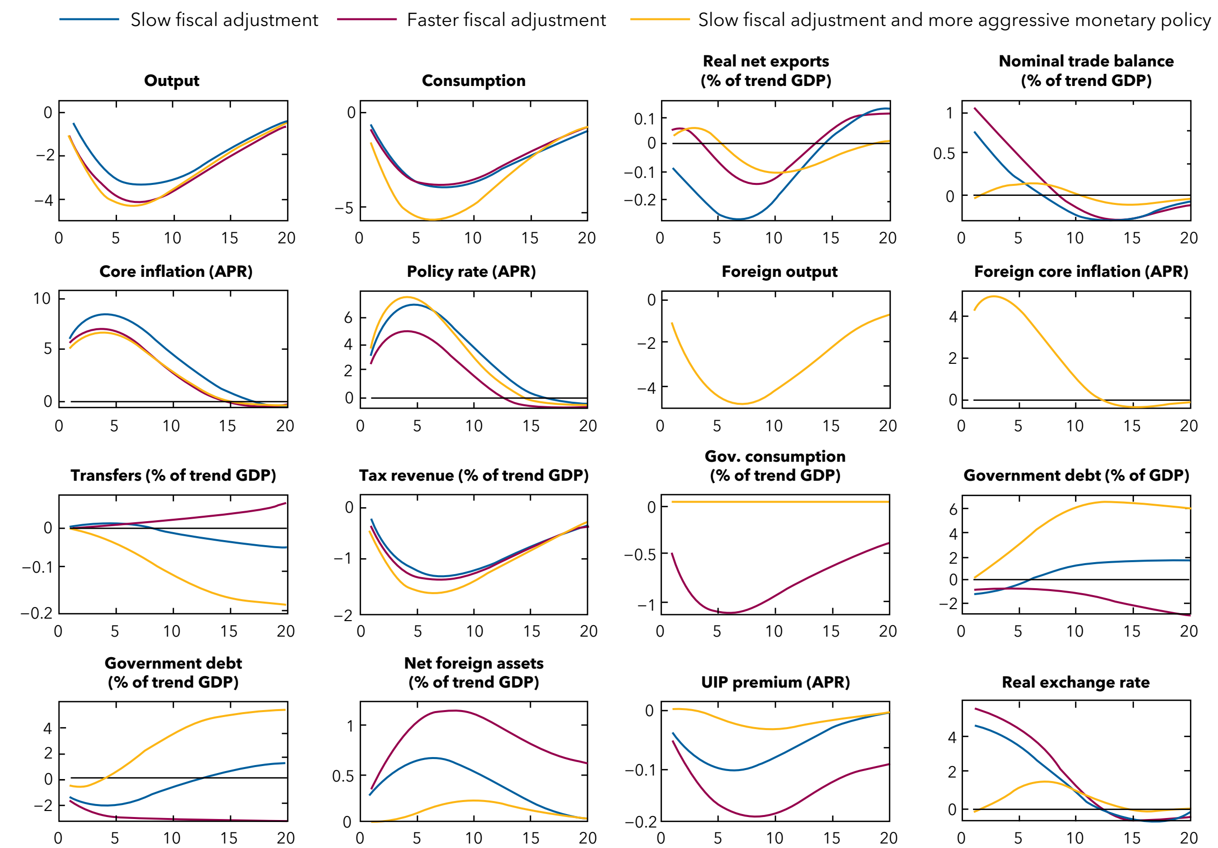
In this framework, the inflation response to a "normal"-sized (1 standard deviation) global cost-push shock can be stabilized by monetary policy without severe output or debt implications. However, for a large adverse cost-push shock that drives inflation well above target, there is a greater importance of the nonlinear Phillips curve and endogenous indexation, and hence larger policy rate increases are needed to stabilize inflation, with adverse consequences for output and debt. We first focus on the case where the "home economy" is calibrated as "nonvulnerable" (equivalent to an "advanced economy") with deep foreign exchange (FX) markets and no foreign debt. The "foreign economy" is assumed to pursue a tighter monetary policy stance than "home" and hence not need to tighten its policy stance further.

The scenario with tighter monetary policy is represented by the yellow line in Annex Figure 6.1, where the policy mix features slow fiscal adjustment with more aggressive monetary policy taking the lead. The policy rate must be elevated to control inflation, whereas government consumption remains at trend, such that the government debt path increases throughout the time period. Private consumption also reduces because of higher interest rates.

In contrast, the red line represents faster fiscal adjustment through an additional discretionary cut to government consumption aiming to keep government debt in check while also supporting monetary policy in stabilizing inflation. As a result, the policy rate does not increase as significantly, core inflation and output remain broadly similar, while the private consumption path improves and debt does not increase relative to the initial steady state. Fiscal restraint allows monetary policy to be less tight and carries the dual benefit of supporting private consumption and lower government debt. The tighter fiscal policy does, however, depreciate the exchange rate by lowering real rates, which slightly offsets the direct inflation benefits of reduced aggregate demand.

A more shock-prone world may feature larger shocks more frequently, with the spending from structural transformations leaving less fiscal space. It is therefore important that monetary and fiscal frameworks can adapt to swiftly restabilize the economy without systematically increasing debt. The results, presented in this section, speak to the interactions between these policy frameworks, highlighting the potential role for fiscal policy in supporting monetary policy when responding to large supply shocks.

Annex Figure 6.1. Impulse Response Functions for Scenario A–Nonvulnerable Economy

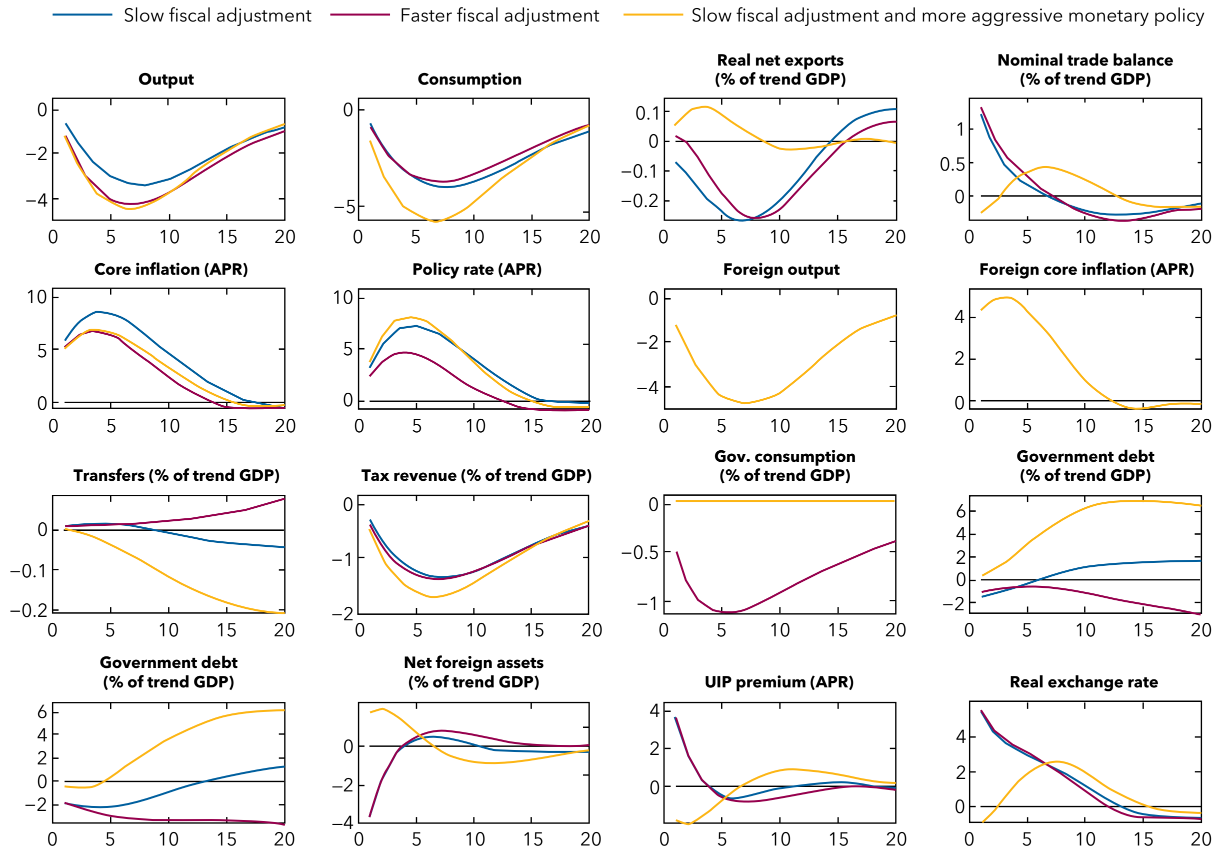


Source: IMF staff calculations.
Note: Response to large 3 standard deviation shock at time t = 1. All variables are reported as deviations from baseline paths. APR=annual percentage rate; UIP=uncovered interest parity; NFA=net foreign assets.

Scenario B: Vulnerable Economy Case

This scenario (presented in Annex Figure 6.2) is similar to scenario A, except that the nonvulnerable "home economy" is replaced by a vulnerable economy with shallow FX markets (a larger FX market frictions parameter) and significant foreign debt (negative NFA of 95 percent of GDP). This implies that the real exchange rate moves less under fiscal consolidation because of offsetting effects of interest rate differentials and the improvement in the NFA position. Hence, fiscal restraint is even more effective in curbing inflationary pressures than in the small open advanced economy case.

Annex Figure 6.2. Impulse Response Functions for Scenario B—Vulnerable Economy



Source: IMF staff calculations.

Note: Response to large 3 standard deviation shock at time $t = 1$. All variables are reported as deviations from baseline paths. APR=annual percentage rate; UIP=uncovered interest parity; NFA=net foreign assets.

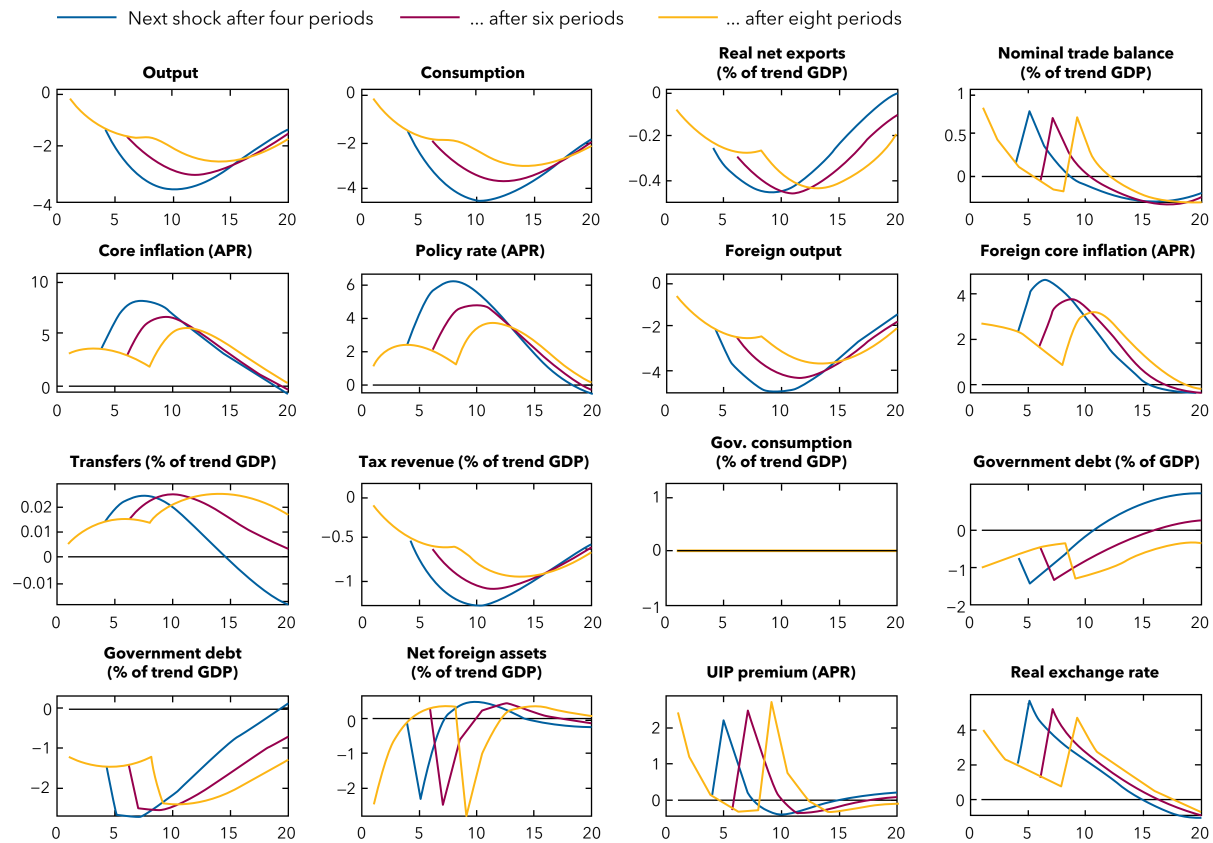
Scenario C: Repeated Supply Shocks

While scenario A speaks to the effect of a single large shock, this section explores the dynamics of repeated moderate-sized shocks. Annex Figure 6.3 presents the IRFs for a scenario with a global cost-push shock at $t = 1$, followed by a second identical cost-push shock at various subsequent times.

The blue line features a second shock four quarters after the first, when the initial inflation response is just past its peak. The secondary inflation response, although broadly similar to the first, requires a much larger policy rate response to ensure stabilization (roughly 4 percentage points versus just over 2), with adverse consequences for output and private consumption.

The initial shock, while manageable itself with a moderate monetary policy response, elevates inflation, hence bringing the economy closer to the nonlinear section of the Phillips curve and elevated wage indexation. As a result, the second shock risks creating a much larger and more persistent inflationary pressure if left unchecked. These results support the case for monetary policy being more wary about looking through temporary supply shocks when risks of repeated shocks increase.

Annex Figure 6.3. Impulse Response Functions for Scenario C



Source: IMF staff calculations.

Note: Response to moderate 2 standard deviation shock at time *t* = 1, followed by an identical subsequent shock in varying periods. All variables are reported as deviations from baseline paths. APR=annual percentage rate; UIP=uncovered interest parity; NFA=net foreign assets.

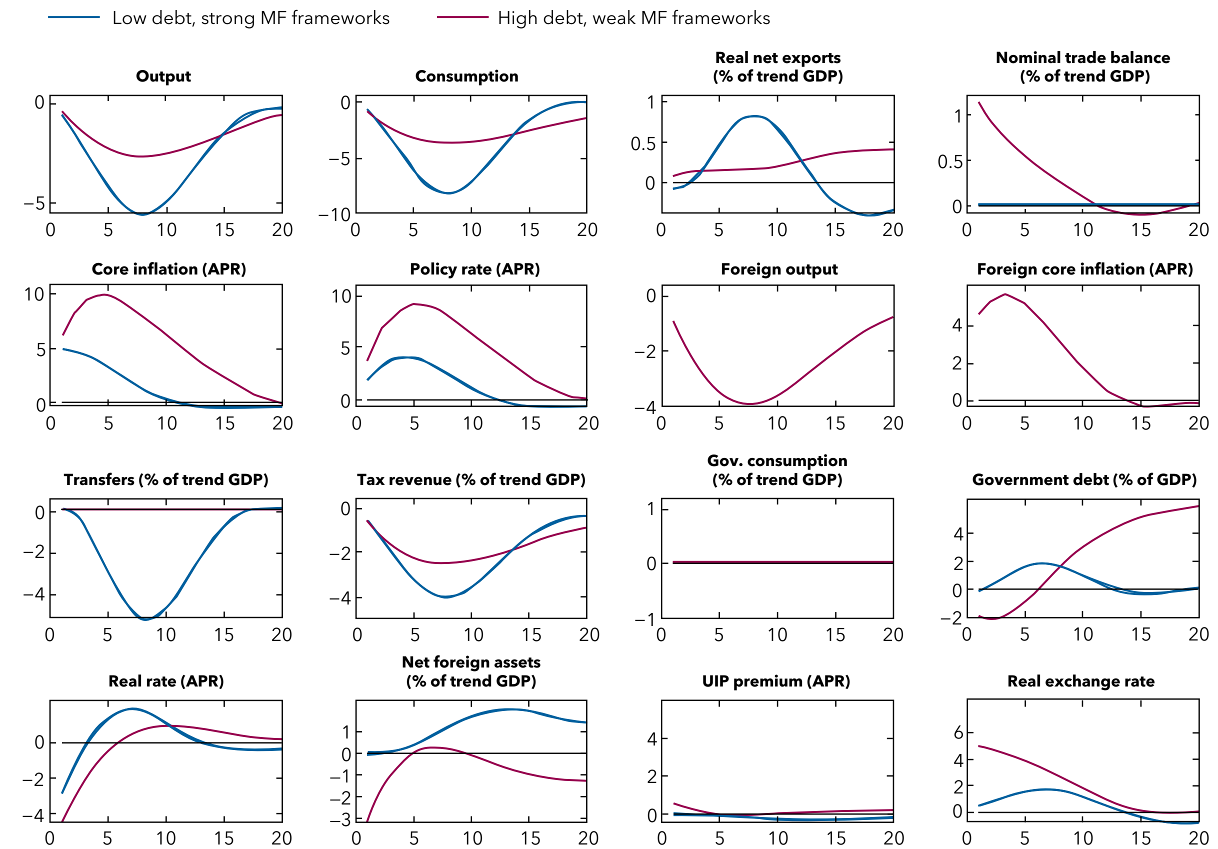
Scenario D: Weak Versus Strong Monetary–Fiscal Frameworks

In this scenario, we analyze the transmission of an adverse cost-push shock under two alternative "home-economy regimes" that differ in debt levels and monetary–fiscal credibility, while assuming deep FX markets throughout. In the low-debt regime, public debt and net foreign liabilities are low, monetary and fiscal frameworks are strong and credible, and inflation expectations are well anchored. In the high-debt regime, public and external debts are elevated, policy frameworks are weaker, and inflation expectations are less firmly anchored, allowing for greater intrinsic inflation persistence.

FX markets are assumed to be deep in both regimes, calibrated in line with the advanced economy case considered by Adrian and others (2021). This implies that deviations from uncovered interest parity remain limited, with only small movements in uncovered interest parity (UIP) premia, consistent with evidence for advanced open economies. No endogenous term premia are introduced, and all other structural and policy assumptions are held fixed across regimes.

Within this setting, the comparison of the two economies in Annex Figure 6.4 highlights how differences in debt burdens and policy credibility shape the macroeconomic adjustment to a supply shock when exchange rate frictions are low. Even with deep FX markets, weaker monetary–fiscal frameworks in the high-debt economy amplify inflation persistence and worsen policy trade-offs relative to the low-debt, strong-framework case.

Annex Figure 6.4. Impulse Response Functions for Scenario D



Source: IMF staff calculations.

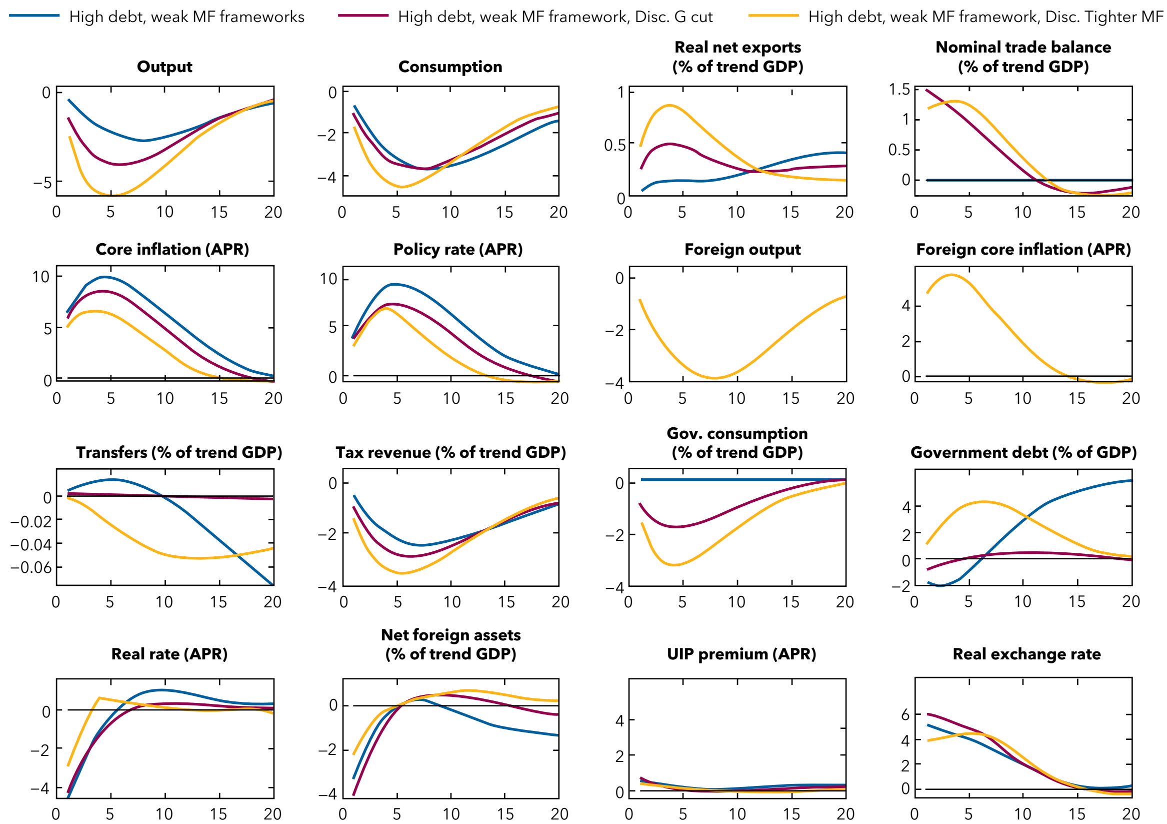
Note: Response to large 3 standard deviation shock at time t = 1. All variables are reported as deviations from baseline paths. APR=annual percentage rate; UIP=uncovered interest parity; NFA=net foreign assets.

Scenario E: Using a Discretionary Spending Cut to Control Debt

This simulation builds on the weak monetary-fiscal frameworks scenario from the previous subsection by constraining debt to return to its preshock level within five years. In a world with increasingly limited fiscal space, countries with weaker monetary-fiscal frameworks may need to apply discretionary policies to keep a lid on debt.

The red line in Annex Figure 6.5 relies on a moderate discretionary cut to government consumption, which worsens output but somewhat improves inflation outcomes. The yellow instead applies a mix of tighter monetary policy stance (higher real rates)—aimed at reducing inflation more quickly to the target—and even tighter fiscal stance to keep debt unchanged. This latter policy mix succeeds in lowering inflation, but at a more significant output cost. Here the trade-offs are palpable, and the appropriate policy response will depend on just how little fiscal space exists, as well as how close the economy is to inflation expectations de-anchoring,

Annex Figure 6.5. Impulse Response Functions for Scenario E



Source: IMF staff calculations.

Note: Response to large 3 standard deviation shock at time t = 1. All variables are reported as deviations from baseline paths. APR=annual percentage rate; UIP=uncovered interest parity; NFA=net foreign assets. Disc. G cut refers to a discretionary cut to government consumption.

References

Acalin, J., V. Alonso-Albarran, C. Arroyo, W. R. Lam, L. Martinez, A. D. M. Nguyen, F. Roch, G. Sher, and A. Solovyeva. 2025. "Fiscal Guardrails Against Rising Debt and Looming Spending Pressures." IMF Staff Discussion Note 2025/004, International Monetary Fund, Washington, DC.

Acemoglu, D. 2024. "The Simple Macroeconomics of AI". NBER Working Paper 32487, National Bureau of Economic Research, Cambridge, MA.

Acemoglu, D., and P. Restrepo. 2022. "Robots and Jobs: Evidence from US Labor Markets." *Journal of Political Economy* 128 (6): 2188–244.

Adrian, T., R. K. Crump, and E. Moench. 2013. "Pricing the Term Structure with Linear Regressions." *Journal of Financial Economics* 110 (1): 110–38.

Adrian, T., C. J. Erceg, M. Kolasa, J. Lindé, R. McLeod, R. M. Veyrune, and P. Zabczyk. 2024. "New Perspectives on Quantitative Easing and Central Bank Capital Policies." IMF Working Paper 2024/103, International Monetary Fund, Washington, DC.

Adrian, T., C. J. Erceg, M. Kolasa, J. Lindé, and P. Zabczyk. 2021. "A Quantitative Microfounded Model for the Integrated Policy Framework." IMF Working Paper 2021/292, International Monetary Fund, Washington, DC.

Adrian, T., C. J. Erceg, M. Kolasa, J. Lindé, and P. Zabczyk. 2025. "Macroeconomic and Fiscal Consequences of Quantitative Easing." IMF Working Paper 2025/158, International Monetary Fund, Washington, DC.

Adrian, T., D. Giannone, M. Luciani, and M. West. 2025. "Scenario Synthesis and Macroeconomic Risk". IMF Working Paper 2025/105, International Monetary Fund, Washington, DC.

Adrian, T., A. Khan, and L. Menand. 2024. "A New Measure of Central Bank Independence." IMF Working Paper 2024/35, International Monetary Fund, Washington, DC.

Aerts, S., L. Stracca, and A. Trzcińska. 2024. "Economic Losses from Climate Change Are Probably Larger Than You Think: New NGFS Scenarios." VoxEU (CEPR), March 27.

Aghion, P., and S. Bunel. 2024. "AI and Growth: Where Do We Stand?" Federal Reserve Bank of San Francisco.

Aiyar, S., J. Chen, C. H. Ebeke, R. Garcia-Saltos, T. Gudmundsson, A. Ilyina, A. Kangur, and others. 2023. "Geoeconomic Fragmentation and the Future of Multilateralism." IMF Staff Discussion Note 2023/001, International Monetary Fund, Washington, DC.

Aiyar, S., and H. C. Ebeke. 2016. "The Impact of Workforce Aging on European Productivity." IMF Working Paper 2016/238, International Monetary Fund, Washington, DC.

Aksoy, Y., H. S. Basso, T. Grasl, and R. P. Smith. 2015. "Demographic Structure and Macroeconomic Trends." Working Paper, Birkbeck College, University of London.

Aligishiev, Z., E. Massetti, and M. Bellon. 2022. "Macro-Fiscal Implications of Adaptation to Climate Change." IMF Staff Climate Notes 2022/002, International Monetary Fund, Washington, DC.

Altavilla, C., M. Boucinha, M. Pagano, and A. Polo. 2024. "Climate Risk, Bank Lending and Monetary Policy." ECB Working Paper 2969, European Central Bank, Frankfurt.

Arce, Ó., M. Ciccarelli, A. Kornprobst, and C. Montes-Galdón. 2023. "What Caused the Euro Area Post-Pandemic Inflation?" ECB Occasional Paper Series 343, European Central Bank, Frankfurt.

Arslanalp, S., B. J. Eichengreen, and C. Simpson-Bell. 2022. "The Stealth Erosion of Dollar Dominance: Active Diversifiers and the Rise of Nontraditional Reserve Currencies." IMF Working Paper 2022/058, International Monetary Fund, Washington, DC.

Aubakirova, M., A. Atallah, C. Clark, J. Summerville, and A. Midha. 2025. "State of AI: An Empirical 100 Trillion Token Study with OpenRouter." arXiv preprint arXiv:2601.10088, January. https://arxiv.org/abs/2601.10088

Baer, K., P. Barra, and J. Benitez. 2025. "Closing the Gap: How Tax Administration Performance Shapes Compliance." IMF Working Paper 2025/209, International Monetary Fund, Washington, DC.

Baer, K., M. Bellon, M. Davies, R. de Mooij, V. Gaspar, A. Lemgruber, M. Mansour, F. Sawadogo, M. Takebe, and C. Vellutini. 2025. "Building Tax Capacity for Growth and Development: Evidence-Based Analysis for Mobilizing Domestic Revenue." IMF Departmental Paper 2025/007, International Monetary Fund, Washington, DC.

Baily, N. M., E. Brynjolfsson, and A. Korinek. 2023. *Machines of Mind: The Case for an AI-Powered Productivity Boom*. Washington, DC: Brookings Institution.

Bank for International Settlements (BIS). 2023. "Funding for Lending Programmes: Insights from a Markets Committee Workshop." Markets Committee Report, Abdul Rasheed Ghaffour (Chair), BIS, Basel.

Bank for International Settlements (BIS). 2025. "Artificial Intelligence and Central Banks: Monetary and Financial Stability Implications." Remarks Prepared for Delivery by Mr. Tao Zhang, BIS Chief Representative for Asia and the Pacific at the Global Fintech Fest 2025, Mumbai, October 8.

Bank of Canada. 2025. *Review of the Bank of Canada's Exceptional Policy Actions During the Pandemic: Executive Summary*. Ottawa: Bank of Canada.

Bank of England. 2024. *Forecasting for Monetary Policy Making and Communication at the Bank of England: A Review*. London: Bank of England.

Barro, R. J. 1979. "On the Determination of the Public Debt." *Journal of Political Economy* 87 (5): 940–71.

Beaudry, P., T. J. Carter, and A. Lahiri. 2023. "The Central Bank's Dilemma: Look Through Supply Shocks or Control Inflation Expectations?" NBER Working Paper 31741, National Bureau of Economic Research, Cambridge, MA.

Bekkers, E., and C. Góes. 2022. "The Impact of Geopolitical Conflicts on Trade, Growth, and Innovation: An Illustrative Simulation Study." VoxEU (CEPR), March 29.

Benitez, J. C., M. Mansour, M. Pecho, and C. Vellutini. 2023. "Building Tax Capacity in Developing Countries." IMF Staff Discussion Note 2023/006, International Monetary Fund, Washington, DC.

Bevilaqua, J., G. Hale, and E. Tallman. 2020. "Corporate Yields and Sovereign Yields." *Journal of International Economics* 124 (6): 103304.

Beyer, R. C. M., and L. Brandão-Marques. 2025. "Real Equilibrium Interest Rates in the Euro Area." IMF Working Paper 2025/123, International Monetary Fund, Washington, DC.

Bi, H., and N. Traum. 2012. "Estimating Sovereign Default Risk." *American Economic Review* 102 (3): 161–66.

Bianchi, F., H. Kung, and M. Tirskikh. 2023. "The Origins and Effects of Macroeconomic Uncertainty." *Quantitative Economics* 14:855–96.

Bilal, A., and D. R. Känzig. 2024. "The Macroeconomic Impact of Climate Change: Global vs. Local Temperature." *Quarterly Journal of Economics* 139 (3): 1887–929.

Blanchard, O. 2005. "Fiscal Dominance and Inflation Targeting: Lessons from Brazil." In *Inflation Targeting, Debt, and the Brazilian Experience*, edited by F. Giavazzi, I. Goldfajn, and S. Herrera. Cambridge, MA: MIT Press.

Blanchard, O. J., and B. S. Bernanke. 2023. "What Caused the US Pandemic-Era Inflation." NBER Working Paper 31417, National Bureau of Economic Research, Cambridge, MA.

Boehm, C. E., A. A. Levchenko, and N. Pandalai-Nayar. 2023. "The Long and Short (Run) of Trade Elasticities." *American Economic Review* 113 (4): 861–905.

Bogmans, C., P. Gomez-Gonzalez, G. Ganpurev, G. Medina, A. Pescatori, and S. D. Thube. 2025. "Power Hungry: How AI Will Drive Energy Demand." IMF Working Paper 2025/081, International Monetary Fund, Washington, DC.

Bolhuis, M., J. Chen, and B. Kett. 2023. "Fragmentation in Global Trade: Accounting for Commodities." IMF Working Paper 2023/073, International Monetary Fund, Washington, DC.

Bolhuis, M. A., C. M. Rui, and H. Thorell. Forthcoming. "Consequences of Undermining Central Bank Independence: Evidence from Governor Transitions." IMF Working Paper, International Monetary Fund, Washington, DC.

Brand, C., N. Lisack, and F. Mazelis. 2024. "Estimates of the Natural Interest Rate for the Euro Area: An Update." ECB Economic Bulletin Issue 1/2024, European Central Bank, Frankfurt.

Brandão-Marques, L., M. Casiraghi, G. Gelos, O. Harrison, and G. Kamber. 2023. "Is High Debt Constraining Monetary Policy? Evidence from Inflation Expectations." IMF Working Paper 2023/33, International Monetary Fund, Washington, DC.

Brandão-Marques, L., M. Casiraghi, G. Gelos, G. Kamber, and R. Meeks. 2024. "Negative Interest Rate Policies: A Survey." *Annual Review of Economics* 16:305–28.

Brandão-Marques, M. L., M. R. Meeks, and V. Nguyen. 2024. "Monetary Policy with Uncertain Inflation Persistence." IMF Working Paper 2024/047, International Monetary Fund, Washington, DC.

Briggs, J., and D. Kodnani. 2023. "The Potentially Large Effects of Artificial Intelligence on Economic Growth." *Goldman Sachs Global Investment Research, March 26.*

Brollo, F., E. Dabla-Norris, R. de Mooij, D. Garcia-Macia, T. Hanappi, L. Liu, and A. D. M. Nguyen. 2024. "Broadening the Gains from Generative AI: The Role of Fiscal Policies." IMF Staff Discussion Note 2024/002, International Monetary Fund, Washington, DC.

Brynjolfsson, E., D. Li, and L. Raymond. 2023. "Generative AI at Work." NBER Working Paper 31161, National Bureau of Economic Research, Cambridge, MA.

Brynjolfsson, E., D. Rock, and C. Syverson. 2021. "The Productivity J-Curve: How Intangibles Complement General Purpose Technologies." *American Economic Journal: Macroeconomics* 13 (1): 333–72.

Budina, N., C. H. Ebeke, F. Jaumotte, A. Medici, A. J. Panton, M. M. Tavares, and B. Yao. 2023. "Structural Reforms to Accelerate Growth, Ease Policy Trade-offs, and Support the Green Transition in Emerging Market and Developing Economies." IMF Staff Discussion Note 2023/007, International Monetary Fund, Washington, DC.

Burke, M., S. Hsiang, and E. Miguel. 2015. "Global Non-linear Effect of Temperature on Economic Production." *Nature* 527 (7577): 235–39.

Burriel, P., C. Checherita-Westphal, P. Jacquinot, M. Schön, and N. Stähler. 2020. "Economic Consequences of High Public Debt: Evidence from Three Large Scale DSGE Models." ECB Working Paper 2450, European Central Bank, Frankfurt.

Cacciatore, M., B. Feunou, and G. K. Ozhan. 2024. "The Neutral Interest Rate: Past, Present and Future." Bank of Canada Staff Discussion Paper 2024-3, Bank of Canada, Ottawa.

Cairó, I., C. Gust, J. Hebden, E. Herbst, S. Konzem, and G. Nicolò. 2025. "Risk-Adjusted Optimal Policy for Scenario Analysis." IMF Working Paper 2025/71, International Monetary Fund, Washington, DC.

Caliendo, L., and F. Parro. 2015. "Estimates of the Trade and Welfare Effects of NAFTA." *Review of Economic Studies* 82 (1): 1–44.

Canova, F., and G. De Nicoló. 2002. "Monetary Disturbances Matter for Business Fluctuations in the G-7." *Journal of Monetary Economics* 49 (6): 1131–59.

Cao, Y., R. Lam, W. Jiang, and N. Wang. 2025. "Debt Carrying Capacity Across Countries: An Assessment Using p-Theory." IMF Working Paper, International Monetary Fund, Washington, DC.

Carapella, P., T. Mogues, J. Pico-Mejia, and M. Soto. 2023. "How to Assess Spending Needs of the Sustainable Development Goals: The Third Edition of the IMF SDG Costing Tool." IMF How-To Note 2023, International Monetary Fund, Washington, DC.

Cardozo, P., A. Fernández, J. Jiang, and F. D Rojas. 2024. "On Cross-Border Crypto Flows: Measurement Drivers and Policy Implications." IMF Working Paper 2024/261, International Monetary Fund, Washington, DC.

Carter, T. J., G. Kamber, and J. Otten. 2026. "How to Design and Review Inflation Targets in Emerging Market and Developing Economies." IMF How-To Note 2026/004, International Monetary Fund, Washington, DC.

Casiraghi, M., K. Habermeier, and T. Harjes. 2022. *Choice of Exchange Rate Arrangement: Monetary and Capital Markets Department Technical Assistance Handbook*. Washington, DC: International Monetary Fund.

Cazzaniga, M., F. Jaumotte, L. Li, G. Melina, A. J. Panton, C. Pizzinelli, E. Rockall, and M. M. Tavares. 2024. "Gen-AI: Artificial Intelligence and the Future of Work." IMF Staff Discussion Note 2024/001, International Monetary Fund, Washington, DC.

Centorrino, S., A. Diakantoni, A. Keck, M. Ruta, M. Sztajerowska, and Y. Wei. 2025. "Measuring Global Trade Policy Activity." IMF Working Paper 2025/220, International Monetary Fund, Washington, DC.

Centorrino, S., E. Massetti, M. Raissi, and F. Tagklis. 2025. "How to Include the Effects of Rising Temperatures in Long-Term GDP Projections." IMF How-To Note 2025/009, International Monetary Fund, Washington, DC.

Cerdeiro, D. A., R. Mano, J. Eugster, M. D. V. Muir, and M. S. J. Peiris. 2021. *Sizing Up the Effects of Technological Decoupling*. Washington, DC: International Monetary Fund.

Cerutti, E. M., A. I. Garcia Pascual, Y. Kido, L. Li, G. Melina, M. Mendes Tavares, and P. Wingender. 2025. "Mind the Gap." IMF Working Paper 2025/076, International Monetary Fund, Washington, DC.

Chen, J., E. Dabla-Norris, C. Goncalves, Z. Jakab, and J. Lindé. 2023. "Can Fiscal Consolidation Help Central Banks' Fight Inflation?" IMF Working Paper 2023/260, International Monetary Fund, Washington, DC.

Christensen, J. H. E., and G. D. Rudebusch. 2012. "The Response of Interest Rates to U.S. and U.K. Quantitative Easing." Working Paper 2012-06, Federal Reserve Bank of San Francisco.

Coibion, O., Y. Gorodnichenko, and M. Weber. 2021. "Fiscal Policy and Households' Inflation Expectations: Evidence from a Randomized Control Trial." NBER Working Paper 28485, National Bureau of Economic Research, Cambridge, MA.

Comin, D., and M. Martí. 2018. "If Technology Has Arrived Everywhere, Why Has Income Diverged?" *American Economic Journal: Macroeconomics* 10 (3): 137–78.

Corsetti, G., K. Kuester, A. Meier, and G. J. Müller. 2013. "Sovereign Risk, Fiscal Policy, and Macroeconomic Stability." *Economic Journal* 123 (566): F99–F132.

De Long, J. B., A. Shleifer, L. H. Summers, and R. J. Waldmann. 1990. "Noise Trader Risk in Financial Markets." *Journal of Political Economy* 98 (4): 703–38.

Dietz, S, and N. Stern. 2015. "Endogenous growth, convexity of damage and climate risk: How Nordhaus' framework supports deep cuts in carbon emissions." *The Economic Journal* 125(583): 574–620.

Eble, S., A. Pitt, I. Bunda, O. E. Adilbish, N. Budina, G. H. Hong, M. Malak, S. Mohona, A. Myrvoda, and K. Primus. 2025. "Long-Term Spending Pressures in Europe." IMF Departmental Paper 2025/002, International Monetary Fund, Washington, DC.

Eloundou, T., S. Manning, P. Mishkin, and D. Rock. 2023. "GPTs Are GPTs: An Early Look at the Labor Market Impact Potential of Large Language Models." Technical Report, arXiv 2023.

Emeksiz, E. O., G. Kamber, J. Otten, and G. K. Pasricha. 2026. "Still Packing a Punch: Monetary Policy Transmission in a New Cross-Country High-Frequency Dataset." IMF Working Paper 2026-018, International Monetary Fund, Washington, DC.

Erceg, C. J., J. Lindé, and M. Trabandt. 2024. "Monetary Policy and Inflation Scares." IMF Working Paper 2024/260, International Monetary Fund, Washington, DC.

European Central Bank (ECB). 2024. "Artificial Intelligence: A Central Bank's View." Keynote Speech by Piero Cipollone, Member of the Executive Board of the European Central Bank, at the National Conference of Statistics on Official Statistics at the Time of Artificial Intelligence, Rome, July 4.

Eyraud, L., A. Baum, A. Hodge, M. Jarmuzek, H. E. Ture, S. Mbaye, and Y.-B. Kim. 2018. "How to Calibrate Fiscal Rules: A Primer." IMF How-To Note 2018/002, International Monetary Fund, Washington, DC.

Felten, E. W., M. Raj, and R. Seamans. 2023. *Occupational Heterogeneity in Exposure to Generative AI*. SSRN.

Fernald, J., R. Inklaar, and D. Ruzic. 2023. "The Productivity Slowdown in Advanced Economies: Common Shocks or Common Trends?" Working Paper 2023-07, Federal Reserve Bank of San Francisco.

Feyrer, J. 2007. "Demographics and Productivity." *Review of Economics and Statistics* 89 (1): 100–109.

Filippucci, F., P. Gal, and M. Schief. 2024. "Miracle or Myth? Assessing the Macroeconomic Productivity Gains from Artificial Intelligence." OECD Artificial Intelligence Paper 29, OECD Publishing, Paris.

Flores, E., P. Gupta, Y. Lu, P. A. Medas, D. Prihardini, H. Selim, W. Xin, and M. Yabara. 2024. "Upgrading Fiscal Frameworks in Asia-Pacific." IMF Departmental Paper 2024-008, International Monetary Fund, Washington, DC.

Fontagné, L., H. Guimbard, and G. Orefice. 2022. "Tariff-Based Product-Level Trade Elasticities." *Journal of International Economics* 137:103593.

Freedman, C., and M. D. Laxton. 2009. *Inflation Targeting Pillars-Transparency and Accountability*. Washington, DC: International Monetary Fund.

Furceri, D., D. Giannone, F. Kisat, W. Raphael Lam, and H. Li. 2025. "Debt-at-Risk." IMF Working Paper 2025-086, International Monetary Fund, Washington, DC.

Gaspar, V., M. Garcia-Escribano, D. Prady, and M. Soto. 2019. "Fiscal Policy and Development: Human, Social, and Physical Investments for the SDGs." Staff Discussion Notes 2019, International Monetary Fund, Washington, DC.

Gaspar, V., M. Mansour, and C. Vellutini. 2023. "Countries Can Tap Tax Potential to Finance Development Goals." *IMF Blog*, September 19.

Gnan, E., and R. Holzmann. 2023. "Should Central Banks Raise Inflation Targets?" SUERF Policy Note Issue 304, March.

Gopinath, G. 2022. "How the Pandemic and War Shape Future Monetary Policy." Jackson Hole Symposium: Federal Reserve Bank of Kansas City.

Gopinath, G. 2024. "Crisis Amplifier? How to Prevent AI from Worsening the Next Economic Downturn." Speech at AI for Good Global Summit, Geneva, May 30.

Gornicka, L., S. R. Mirza, V. Nguyen, and J. Vandenbussche. Forthcoming. "When Policy Bites: State-Dependent Monetary Policy Transmission in Emerging Markets." IMF Working Paper, International Monetary Fund, Washington, DC.

Gourinchas, P. O. 2026. "Adequate Reserves Shield Economies from Shocks and Strengthen Resilience." *IMF Blog*, March 5.

Guerrieri, V., G. Lorenzoni, and I. Werning. 2025. "Global Price Shocks and International Monetary Coordination." NBER Working Paper 33840, National Bureau of Economic Research, Cambridge, MA.

Harding, M., J. Lindé, and M. Trabandt. 2023. "Understanding Post-COVID Inflation Dynamics." *Journal of Monetary Economics* 140:S101–S118.

Hartmann, P., and V. Maver. 2025. "Implications of Artificial Intelligence for Monetary Policy: A First Conceptual Assessment." SUERF Policy Brief 1080.

Hiraki, K., and M. Rhouzlane. Forthcoming. "How to Operationalize an Exchange Rate Peg." IMF How-To Note, International Monetary Fund, Washington, DC.

Hofman, D., and G. Kamber. 2020. "Unconventional Monetary Policy in Emerging Market and Developing Economies." IMF MCM Special Series on COVID-19, International Monetary Fund, Washington, DC.

Howard, P. H., and T. Sterner. 2017. "Few and Not So Far Between: A Meta-Analysis of Climate Damage Estimates." *Environmental and Resource Economics* 68 (1): 197–225.

Howard, P. H., and D. Sylvan. 2020. "Wisdom of the Experts: Using Survey Responses to Address Positive and Normative Uncertainties in Climate-Economic Models." *Climatic Change* 162 (2): 213–32.

Imam, P. 2013. "Shock from Graying: Is the Demographic Shift Weakening Monetary Policy Effectiveness." IMF Working Paper 2013/191, International Monetary Fund, Washington, DC.

International Monetary Fund (IMF). 2011. "Assessing Reserve Adequacy." IMF Policy Paper, Washington, DC, February. https://www.imf.org/external/np/pp/eng/2013/111313e.pdf

International Monetary Fund (IMF). 2013. "Assessing Reserve Adequacy—Further Considerations: Supplementary Information." IMF Policy Paper, Washington, DC, November 15. https://www.imf.org/external/np/pp/eng/2014/121914.pdf

International Monetary Fund (IMF). 2014. "Assessing Reserve Adequacy—Specific Proposals." IMF Policy Paper, Washington, DC, December 19. https://www.imf.org/external/np/pp/eng/2016/060316.pdf

International Monetary Fund (IMF). 2015. "Evolving Monetary Policy Frameworks in Low-Income and Other Developing Countries." IMF Policy Papers, Washington, DC.

International Monetary Fund (IMF). 2016. "Guidance Note on the Assessment of Reserve Adequacy and Related Considerations." IMF Policy Paper, Washington, DC, June.

International Monetary Fund (IMF). 2020. "Toward an Integrated Policy Framework." IMF Policy Paper 2020/046, Washington, DC.

International Monetary Fund (IMF). 2022. *Review of the Institutional View on the Liberalization and Management of Capital Flows*. Washington, DC, March.

International Monetary Fund (IMF). 2023a. *External Sector Report: External Rebalancing in Turbulent Times*. Washington, DC, July.

International Monetary Fund (IMF). 2023b. *Global Financial Stability Report: Geopolitics and Financial Fragmentation: Implications for Macro-Financial Stability*. Washington, DC, April.

International Monetary Fund (IMF). 2023c. "Guidance Note on the Liberalization and Management of Capital Flows." IMF Policy Paper 2023/055, Washington, DC.

International Monetary Fund (IMF). 2023d. "Integrated Policy Framework—Principles for the Use of Foreign Exchange Intervention." IMF Policy Paper 2023/061, Washington, DC.

International Monetary Fund (IMF). 2023e. "Japan: 2023 Article IV Consultation—Press Release; Staff Report; and Statement by the Executive Director for Japan." IMF Country Report 23/127, Washington, DC.

International Monetary Fund (IMF). 2023f. *World Economic Outlook: Fragmentation and Commodity Markets: Vulnerabilities and Risks*. Washington, DC, October.

International Monetary Fund (IMF). 2023g. *World Economic Outlook: Geoeconomic Fragmentation and FDI*. Washington, DC, April.

International Monetary Fund (IMF). 2023h. *World Economic Outlook: The Natural Rate of Interest: Drivers and Implications for Policy*. Washington, DC, April.

International Monetary Fund (IMF). 2024a. *Fiscal Monitor: Putting a Lid on Public Debt*. Washington, DC, October.

International Monetary Fund (IMF). 2024b. *Global Financial Stability Report: Cyber Risk: A Growing Concern for Macrofinancial Stability*. Washington, DC, April.

International Monetary Fund (IMF). 2024c. *World Economic Outlook: Global Prospects and Policies*. Washington, DC, April.

International Monetary Fund (IMF). 2024d. *World Economic Outlook: Global Prospects and Policies*. Washington, DC, October.

International Monetary Fund (IMF). 2025a. "External Positions and Policies." In *External Sector Report: Global Imbalances in a Shifting World*. Washington, DC, July.

International Monetary Fund (IMF). 2025b. "The 4th Financing for Development Conference—Contribution of the IMF to the International Financing for Development Agenda." IMF Policy Paper 2025/022, Washington, DC.

International Monetary Fund (IMF). 2025c. *The Global Financial Safety Net—A Stocktaking*. Washington, DC, October 9.

International Monetary Fund (IMF). 2025d. *Global Financial Stability Report: Risk and Resilience in the Global Foreign Exchange Market*. Washington, DC, October.

International Monetary Fund (IMF). 2025g. "The Rise of the Silver Economy: Global Implications of Population Aging." In *World Economic Outlook: A Critical Juncture Amid Policy Shifts*. Washington, DC.

International Monetary Fund (IMF). 2025h. *World Economic Outlook, October 2025: Global Economy in Flux, Prospects Remain Dim*. Washington, DC.

International Monetary Fund (IMF). 2026. "Applying the Integrated Policy Framework to Low Income Countries: Shocks, Frictions, and Policy Considerations." IMF Policy Paper 2026/014, Washington, DC, April.

International Monetary Fund (IMF). Forthcoming-a. *Comprehensive Surveillance Review*. Washington, DC.

International Monetary Fund (IMF). Forthcoming-b. "Exchange Rate Premia: Drivers and Policy Implications." IMF Staff Discussion Note, Washington, DC.

International Monetary Fund (IMF). Forthcoming-c. "Integrated Policy Framework: Use of Macroprudential Policies." IMF Policy Paper, Washington, DC.

Jacks, D. S., C. M. Meissner, and D. Novy. 2008. "Trade Costs, 1870–2000." *American Economic Review* 98 (2): 529–34.

Jeanne, O., and R. Rancière. 2011. "The Optimal Level of International Reserves for Emerging Market Countries: A New Formula and Some Applications." *Economic Journal* 121 (555): 905–30.

Jiang, W., T. J. Sargent, N. Wang, and J. Yang. 2024. "A p Theory of Taxes and Debt Management." *Journal of Finance*, forthcoming.

Kahn, M. E., K. Mohaddes, R. N. C. Ng, M. H. Pesaran, M. Raissi, and J. C. Yang. 2021. "Long-Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis." *Energy Economics* 104:105624.

Kalkuhl, M., and L. Wenz. 2020. "The Impact of Climate Conditions on Economic Production: Evidence from a Global Panel of Regions." *Journal of Environmental Economics and Management* 103:102360.

Kolasa, M., S. Lassen, and J. Lindé. 2025. "Unconventional Monetary Policies in Small Open Economies." IMF Working Paper 25/66, International Monetary Fund, Washington, DC.

Kompas, T., V. H. Pham, and T. N. Che. 2018. "The Effects of Climate Change on GDP by Country and the Global Economic Gains from Complying with the Paris Climate Accord." *Earth's Future* 6 (8): 1153–73.

Krishnamurthy, A., and A. Vissing-Jorgensen. 2012. "The Aggregate Demand for Treasury Debt." *Journal of Political Economy* 120 (2): 233–67.

Kuzmenko, O., T. Vasylyeva, and V. Bozhenko. 2020. "Modeling of Capital Investments Public Financing Volume Using Logistic Curves." Proceedings of the International Scientific Conference "Sustainable and Innovative Development in the Digital Age," Atlantis Press, Paris.

Laubach, T., and J. C. Williams. 2003. "Measuring the Natural Rate of Interest." *Review of Economics and Statistics* 85 (4): 1063–70.

Laxton, D., H. Igityan, and S. Mkhatrishvili. 2025. "Monetary Policy Credibility, Avoiding Dark Corners, and Risk Management: A Response to Ben Bernanke's Review of Monetary Policy-Making at the Bank of England." *Oxford Review of Economic Policy* 41 (2): 452–83.

Leeper, E. M. 2013. "Fiscal Limits and Monetary Policy." NBER Working Paper 18877, National Bureau of Economic Research, Cambridge, MA.

Leeper, E. M. 2023. "Fiscal Dominance: How Worried Should We Be?" Mercatus Policy Brief, April 3.

Levin, A. T., A. Onatski, J. C. Williams, and N. Williams. 2005. "Monetary Policy Under Uncertainty in Micro-Founded Macroeconometric Models." *NBER Macroeconomics Annual* 20:229–87.

Macklem, T. 2025. "Flexible Inflation Targeting in a Shock-Prone World." Speech at the Bank of Mexico's 100th Anniversary Seminar.

McKibbin, W., and W. L. Liu. 2025. "Long-Term Projections of the World Economy." CEPR Discussion Paper DP20293, Centre for Economic Policy Research, London.

McKinsey. 2023. "The Economic Potential of Generative AI." McKinsey Report, January.

Melina, G., and S. Villa. 2025. "From Servers to Rates AI, ICT Capital, and the Natural Rate." IMF Working Paper 2025/224, International Monetary Fund, Washington, DC.

Mian, A., L. Straub, and A. Sufi. 2025. "A Goldilocks Theory of Fiscal Deficits." *American Economic Review* 115 (12): 4253–91.

Misch, F., B. Park, C. Pizzinelli, and G. Sher. 2025. "AI and Productivity in Europe." IMF Working Paper 2025/067, International Monetary Fund, Washington, DC.

Morris, J., S. K. Rose, J. Reilly, A. Gurgel, S. Paltsev, and C. A. Schlosser. 2025. "Reconciling Widely Varying Estimates of the Global Economic Impacts from Climate Change." *Nature Climate Change* 15 (2): 124–27.

Nachega, J.-C. 2005. "Fiscal Dominance and Inflation in the Democratic Republic of the Congo." IMF Working Paper 2005/221, International Monetary Fund, Washington, DC.

Nakano, S., Y. Sugioka, and H. Yamamoto. 2024. "Recent Developments in Measuring the Natural Rate of Interest." Bank of Japan Working Paper Series 24-E-12.

Network for Greening the Financial System (NGFS). 2020. "Climate Change and Monetary Policy: Initial Takeaways." https://www.ngfs.net/en/publications-and-statistics/publications/climate-change-and-monetary-policy-initial-takeaways

Network for Greening the Financial System (NGFS). n.d. "Climate Scenarios Enable Us To." https://www.ngfs.net/ngfs-scenarios-portal/explore/

Nguyen, A. D. M., W. R. Lam, and G. Sher. 2025. "Fiscal Rules and Growth-Enhancing Investment: Technical Annex 3." In *Fiscal Guardrails Against Rising Debt and Looming Spending Pressures*, edited by Acalin and others. Washington, DC: IMF.

Nicholls, R. J., J. Hinkel, D. Lincke, and T. van der Pol. 2019. "Global Investment Costs for Coastal Defense Through the 21st Century." Open Knowledge Repository. https://openknowledge.worldbank.org/entities/publication/0dbcb045-3207-5a61-a4ee-e0542c5c0f60

Nordhaus, W. D., and J. Boyer. 2000. "Warming the world: Economic models of global warming." The MIT Press.

Nordhaus, W. 2014. "Estimates of the social cost of carbon: Concepts and results from DICE-2013R model and alternative approaches." *Journal of the Association of Environmental and Resource Economists* 1(1/2): 273–312.

Okuda, T., and T. Tsuruga. 2024. "Geoeconomic Fragmentation and International Diversification Benefits." IMF Working Paper 2024/048, International Monetary Fund, Washington, DC.

Organization for Economic Cooperation and Development (OECD). 2011. "ISIC Rev. 3 Technology Intensity Definition." OECD Directorate for Science, Technology and Industry, Economic Analysis and Statistics Division. https://www.oecd.org/sti/ind/48350231.pdf

Orphanides, A., and J. C. Williams. 2002. "Robust Monetary Policy Rules with Unknown Natural Rates." *Brookings Papers on Economic Activity* 2002 (2): 63–145.

Ötker-Robe, M. I., and D. Vavra. 2007. "Moving to Greater Exchange Rate Flexibility: Operational Aspects Based on Lessons from Detailed Country Experiences." IMF Occasional Paper 256, International Monetary Fund, Washington, DC.

Peng, S., E. Kalliamvakou, P. Cihon, and M. Demirer. 2023. "The Impact of AI on Developer Productivity: Evidence from Github Copilot." Technical Report, arXiv. https://doi.org/10.48550/arXiv.2302.06590

Pizzinelli, C., A. J. Panton, M. Mendes Tavares, M. Cazzaniga, and L. Li. 2023. "Labor Market Exposure to AI: Cross-country Differences and Distributional Implications." IMF Working Papers 2023, International Monetary Fund, Washington, DC.

Platzer, J., and M. Peruffo. 2022. "Natural Rate of Interest in the United States: A Quantitative Evaluation." IMF Working Paper 2022/030, International Monetary Fund, Washington, DC.

Poplawski-Ribeiro, M. 2020. "Labour Force Ageing and Productivity Growth." *Applied Economics Letters* 27 (6): 498–502. https://doi.org/10.1080/13504851.2019.1637509

Rachel, Ł., and L. H. Summers. 2019. "On Falling Neutral Real Rates, Fiscal Policy, and the Risk of Secular Stagnation." NBER Working Paper 2619, National Bureau of Economic Research, Cambridge, MA.

Reis, R. 2026. "Financial Repression in the XXIst Century." CEPR Discussion Paper 21072, CEPR Press, Paris.

Reserve Bank of Australia (RBA). 2022. "Review of the Yield Target." Sydney.

Sargent, T. J. 1982. "The Ends of Four Big Inflations." In *Inflation: Causes and Effects*, edited by R. E. Hall. Chicago: University of Chicago Press.

Schnabel, I. 2025. "No Longer Convenient? Safe Asset Abundance and r*." Keynote Speech, Bank of England 2025 BEAR Conference, London.

Schroeder, Wayne. "The pathway to NATO's '2/20' goal is through real growth of defense spending." *New Atlanticist*, Atlantic Council, September 15, 2023. https://www.atlanticcouncil.org/blogs/new-atlanticist/the-pathway-to-natos-2-20-goal-is-through-real-growth-of-defense-spending/

Shapiro, A. H. 2022. "Decomposing Supply and Demand Driven Inflation." Working Paper 2022-10, Federal Reserve Bank of San Francisco.

Svanberg, M., L. Wensu, M. Fleming, B. Goehring, and N. Thompson. 2024. "Beyond AI Exposure: Which Tasks Are Cost-Effective to Automate with Computer Vision?" January 19. http://dx.doi.org/10.2139/ssrn.4700751

Tol, R. S. J. 2024. "A Meta-Analysis of the Total Economic Impact of Climate Change." *Energy Policy* 185:113922.

Traum, N., and S. C. Yang. 2015. "When Does Government Debt Crowd Out Investment?" *Journal of Applied Econometrics* 30 (1): 24–45.

Waidelich, P., F. Batibeniz, J. Rising, J. S. Kikstra, and S. I. Seneviratne. 2024. "Climate Damage Projections Beyond Annual Temperature." *Nature Climate Change* 14:592–99.

Weitzman, M. L. 2012, "GHG targets as insurance against catastrophic climate damages", *Journal of Public Economic Theory* 14(2): 221–44.

Wong, A. 2019. "Refinancing and the Transmission of Monetary Policy to Consumption." Unpublished Manuscript. https://jfhoude.wiscweb.wisc.edu/wp-content/uploads/sites/769/2019/09/Arlene-Wong-refinancing.pdf

Wu, J. C., and Y. Xie. 2025. "Unconventional Monetary and Fiscal Policy." *Review of Economic Dynamics* 56:101259.

PUBLICATIONS

Resilience amid Structural Transformations: Are Macro Policy Frameworks Fit for Purpose?

ISBN 9798229042925