

# Strengthening Fiscal Frameworks in the Presence of Rising Risk of Natural Disasters

Olusegun Ayodele Akanbi, Jessie Nabulambo Kilembe, and Do Yeon Park

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**Strengthening Fiscal Frameworks in the Presence of Rising Risk of Natural Disasters**  
**Prepared by Olusegun Ayodele Akanbi, Jessie Nabulambo Kilembe, and Do Yeon Park\***

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**ABSTRACT**

This study investigates the impact of rising risk of natural disasters on rule-based fiscal frameworks. It explores the extent to which countries adhere to their fiscal rules in the presence of rising risk of natural disasters. To ensure a consistent analysis, we construct an index measuring the strength of fiscal rules, utilizing principal component analysis for a panel of 104 countries. The study employs a panel two-stage least squares estimation method to assess the impact of natural disaster risks on fiscal rules. The results, which are robust across various country groupings, suggest that natural disaster risks play a significant role in the determination of rule-based fiscal framework. After controlling for other determinants, the results show that countries with established fiscal rules are strengthening these rules in response to rising natural disaster risks. Nonetheless, the results are mixed across different country groups, with varying magnitude of impact. This suggests that countries currently operating fiscal rules will need to enhance their efforts to more comprehensively integrate natural disaster risks into their fiscal frameworks.

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## WORKING PAPERS

# Strengthening Fiscal Frameworks in the Presence of Rising Risk of Natural Disasters

Prepared by Olusegun Ayodele Akanbi, Jessie Nabulambo Kilembe, and  
Do Yeon Park<sup>1</sup>

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# I. INTRODUCTION

**Natural disasters remain key threats to fiscal stability.** It undermines economic and social development while imposing substantial fiscal costs. As key sources of vulnerability for public finances, natural disasters can weaken a country's fiscal position by increases expenditures or reducing tax revenues. These fiscal strains often lead to rising public debt levels and downgraded sovereign credit ratings, with long-lasting impacts on fiscal sustainability.

**The frequency of natural disasters has increased significantly in recent decades, fueled by climate change and intensifying weather conditions.** Over the past 50 years, the global incidence of such events has quintupled, with total economic losses from natural hazards estimated at approximately USD 6 trillion. Notably, the first three years of the 2020s alone accounted for USD 228 billion in losses (United Nations, 2021; World Bank, 2024).

**In response, some countries have begun integrating natural disaster risks into their rule-based fiscal frameworks.** However, the literature remains inconclusive on the extent to which these risks influence the design and enforcement of fiscal rules. Akanbi et al. (2023) provides a practical foundation for integrating natural disaster risks into fiscal rule calibration, but an empirical investigation into how these risks shape fiscal frameworks is warranted.

**This paper examines the relationship between natural disaster risks and the strength of fiscal rules,** focusing on whether increased risks lead to stronger fiscal frameworks aimed at enhancing fiscal sustainability. Unlike long-term trend analysis (which suggest that countries proactively adjust their fiscal rules in response to long-term trends in risk), this paper investigates whether fiscal rules are reinforced in the same year that natural disaster risks increased. Cross-sectional evidence presented in Section III supports this hypothesis, demonstrating that increased natural disaster risks can drive improvements in fiscal frameworks. However, the strength of this relationship is influenced by macroeconomic and institutional factors.

**While rising natural disaster risks challenge fiscal stability, they also provide an impetus for countries to strengthen fiscal frameworks through improved risk awareness and management.** This dynamic underscore the need to reevaluate rule-based fiscal frameworks to support adaptation investments and establish fiscal buffers that can be mobilized during emergencies. Although natural disasters can disrupt fiscal planning, the associated risks may also prompt governments to reinforce fiscal rules to better withstand future shocks.<sup>1</sup>

**To effectively mitigate the fiscal impacts of natural disasters, countries must adopt structural, financial, and post-disaster resilience strategies** (Cevik and Huang, 2018; IMF, 2022). These strategies include incorporating disaster risk considerations into fiscal rule frameworks, ensuring robust legal foundations, formal enforcement mechanisms, flexibility, and supportive procedures.

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<sup>1</sup> According to Akanbi et al. (2023), a practical approach to strengthening fiscal frameworks in anticipation of natural disasters involves maintaining substantial fiscal buffers and prioritizing adaptation investments. This can be accomplished by setting lower debt limits and implementing expenditure or budget balance rules, which provide greater fiscal flexibility.

**To properly measure the strength of the rule-based fiscal framework**, the paper derived an overall fiscal rules index using the IMF fiscal rules database on 104 countries currently operating fiscal rules from 2000 to 2021. The index reflects the evolution of fiscal frameworks based on key characteristics such as coverage, enforcement, legal basis, flexibility, and supporting procedures. To assess the impact of natural disaster risks on fiscal rules, the paper employs a panel two-stage least squares (2SLS) estimation method.

**The findings reveal that natural disaster risks significantly influence the design of fiscal frameworks, with countries strengthening their fiscal rules as disaster risks rise.** Over the past two decades, fiscal rules have become more robust in response to these risks. However, disaggregated panel estimations suggest that additional efforts are needed to ensure natural disaster risks are comprehensively accounted for in fiscal rule design.

**The results highlight the importance of designing and calibrating fiscal rules to account for natural disaster risks.** Strengthened fiscal rules can create fiscal space to mitigate the impacts of future disasters, making them a critical component of fiscal sustainability. Consequently, rethinking rule-based fiscal frameworks is essential to address rising disaster risks effectively.

**This paper makes two key contributions.** First, it extends the existing literature (e.g., Badinger & Reuter, 2017a) by including natural disaster risks as determinants of fiscal rules. Building on the framework of Badinger & Reuter, which outlines five arguments for constraining fiscal policy through fiscal rules, this study posits that fiscal rules may also evolve in response to economic conditions triggered by natural disasters. Second, the study develops a new index for measuring the strength of fiscal rules, building on methodologies from IMF (2009) and Schaechter et al. (2012).

**The rest of the paper is organized as follows.** Section II presents background literature on fiscal rules and the macro-criticality of climate change. Section III presents the data analysis and stylized facts. Section IV describes the empirical approach (methodology and estimation techniques). Section V discusses empirical results. Section VI concludes with policy implications.

## II. BACKGROUND ON FISCAL RULES

**Fiscal rules have demonstrated positive effects on macroeconomic outcomes, particularly by strengthening budgetary discipline.** They have been shown to curtail excessive deficits across a wide range of countries over extended periods (Badinger & Reuter, 2017b; Neyapti, 2013; Eyraud et al., 2018). Among the various types of fiscal rules, budget balance rules are the most effective, as they significantly improve primary balances and establish a clear trajectory toward fiscal sustainability (Bergman et al., 2016; Enzinger, 2014).

**Historically, fiscal rules have been instrumental in supporting macroeconomic stability in the aftermath of economic crises.** Their prompt implementation has yielded improved outcomes in the Euro area during the 1990s, in emerging economies in the early 2000s, following the 2008 Global Financial Crisis, and more recently, in response to the COVID-19 pandemic (Schaechter et al., 2012; Davoodi et al., 2022). Despite these successes, the effectiveness of fiscal rules can be enhanced by ensuring transparency (simplicity), adaptability (flexibility), and commitment to enforcement (enforceability) (Davoodi et al., 2022).

**The growing emphasis on strengthening fiscal frameworks has spurred interest in understanding the factors that determine the robustness of fiscal rules.** Poterba (1994) argued for the need to endogenize fiscal rules in empirical models, while Badinger and Reuter (2017a) identified key determinants from economic, political, and institutional perspectives. Their findings highlight that fiscal rules tend to be more stringent in countries with: (i) greater government fragmentation, (ii) more lobbies from interest groups, (iii) weaker systems of checks and balances, (iv) stable government under a parliamentary political regime, (v) an existence of monetary union membership or central bank following an inflation targeting regime, (vi) lower inflation, and (vii) slower GDP growth.

**In the European Union, fiscal rules have been strengthened in response to economic crises.** Enzinger (2014) observed that key components of fiscal frameworks include numerical fiscal rules, independent fiscal institutions, and robust budgetary procedures, with crises prompting stronger rule adoption across the region.

**Climate change, with its long-term implications for global economies, has become a critical consideration in fiscal policymaking.** Global average temperatures are approaching 1.5°C above pre-industrial levels, necessitating significant adaptation and mitigation measures. For small developing countries, climate-related investments are estimated to cost 2–3% of GDP annually through 2030 (Aligishiev et al., 2022). These challenges are compounded by tighter budgetary constraints following the pandemic, prompting policymakers to balance climate goals, fiscal sustainability, and political feasibility. Emerging and developing economies face the greatest difficulty in this regard due to larger climate investment needs and higher borrowing costs (IMF, 2023).

**Calibrating fiscal frameworks to account for natural disaster risks has become increasingly urgent as global warming intensifies the frequency and severity of these events.** Caselli et al. (2022) emphasize the integration of climate priorities into budgetary processes through green public financial management (PFM). This approach involves adapting financial practices to accommodate environmental and climate considerations, enabling policymakers to balance long-term fiscal priorities such as climate action, demographic shifts, and gender equality (Aydin et al., 2023).

**Akanbi et al. (2023) advances the IMF's fiscal rules calibration toolkit (Eyraud et al., 2018) by incorporating diverse debt-reduction timeframes, natural disaster shocks, and government climate investment profiles.** Their refinements enable tailored operational deficit ceilings for various fiscal rules, including expenditure and budget balance rules. Similarly, Caselli et al. (2024) advocate for green medium-term fiscal frameworks (MTFFs), which integrate climate change impacts and policies, such as carbon pricing, into fiscal and debt objectives.

**The fiscal implications of natural disasters vary widely depending on the type of disaster and country-specific circumstances.** Variability in fiscal capacity and resource constraints influence the ability of governments to respond effectively (Fuje et al., 2023). The literature suggests that as disaster risks rise, fiscal frameworks will need to evolve to incorporate more comprehensive provisions, such as escape clauses or emergency mechanisms, to address these challenges effectively.

### III. DATA AND STYLIZED FACTS

Throughout the paper, the analysis uses panel data for 104 countries which are currently operating fiscal rules and covering the period from 2000 to 2021.<sup>2</sup> All countries are listed in the Appendix 1, and the sample includes 34 advanced economies (AE), 47 emerging market economies (EM), and 23 low-income countries (LIC) as of 2021. The panel is also divided into countries with 36 high exposure risk index (high ERI), 26 medium exposure risk index (medium ERI), and 42 low exposure risk indices (low ERI).<sup>3</sup> This disaggregation also helps explicitly in detecting whether countries with varying exposure to natural disaster risks are taking appropriate actions to strengthen their fiscal rules.<sup>4</sup>

The paper uses the IMF fiscal rules database to derive indices of the strength of fiscal rules.<sup>5</sup> We built on the methodology used in IMF (2009) and Schaechter et al. (2012) to derive and update the fiscal rules index. This index is created from a set of sub-indices for each type of rule (debt, budget balance, expenditure, and revenue rules) and each key characteristic (number of fiscal rules, coverage, legal basis, formal enforcement, supporting procedures, and flexibility), which are then combined into an overall fiscal rules index (Figure 1 & 2). The index also includes both national and supra-national rules.<sup>6</sup>

To ensure proper aggregation of the fiscal rules strength index, the principal component analysis (PCA) is employed. In line with IMF (2009), the strength of fiscal rules index was constructed using PCA of the following variables: (i) enforcement score; (ii) coverage score; (ii) legal basis score; (iii) supranational rules score; (iv) index of supporting procedures for monitoring of compliance and enforcement; (v) flexibility score; (vi) average number of fiscal rules; and (vii) the ratio of national to total fiscal rules in each country. These scores have been weighted using the PCA to create an index that retains more than 80 percent of the original data variance and represents the strength of various rules' dimensions, including coverage, legal basis, enforcement, flexibility, and supporting procedures. The index is standardized to have a zero mean and a standard deviation of one.<sup>7</sup>

<sup>2</sup> The choice of the period (2000 to 2021) is based on the availability of data from the World Risk Report which begins from 2000 and the fiscal rule index database which has its last update until 2021. All 104 countries have observations starting from 2000 and ending with 2021 according to both measures.

<sup>3</sup> The criteria for ERI is based World Risk Report which publishes fixed thresholds for the country classifications.

<sup>4</sup> See Appendix 1 for comprehensive list of country coverage by ERI classification, and Appendix 2 for ERI distribution by region.

<sup>5</sup> Details of the two databases can be found here: <https://www.imf.org/external/datamapper/fiscalrules/map/map.htm> (IMF fiscal rules); <https://weltrisikobericht.de/en/> (World risk index)

<sup>6</sup> In countries with the same supra-national fiscal rules (i.e., EU), differences in fiscal indices may result not only from national fiscal rules but also from variations in supporting procedures, the number of fiscal rules, and the ratio of national to total fiscal rules.

<sup>7</sup> The fiscal rules strength index measures *de jure* strength and does not measure *de facto* adherence to fiscal rules.

Figure 1. Fiscal Rules Sub-indices by Types of Rule

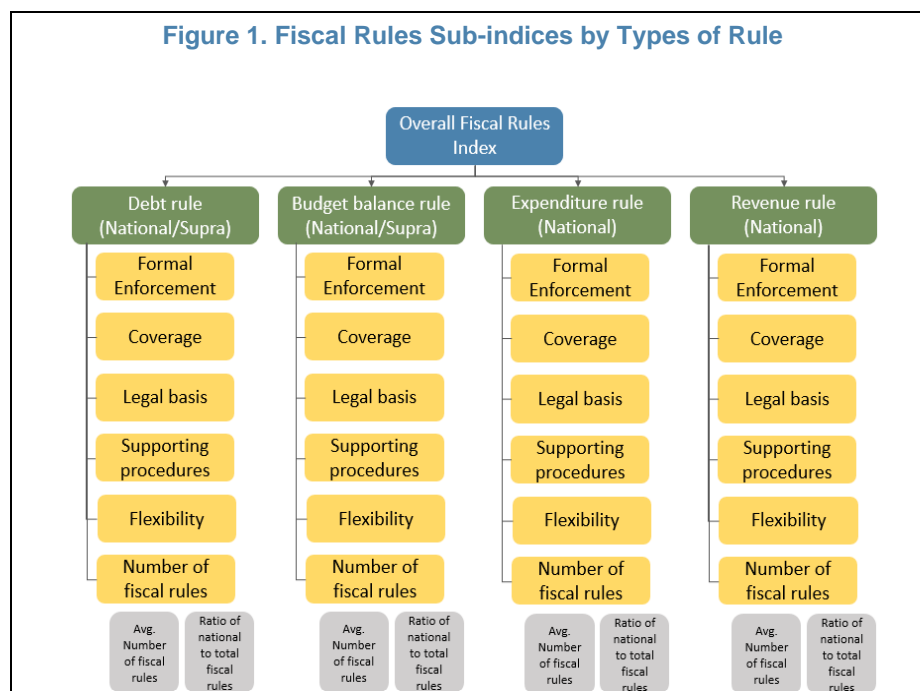
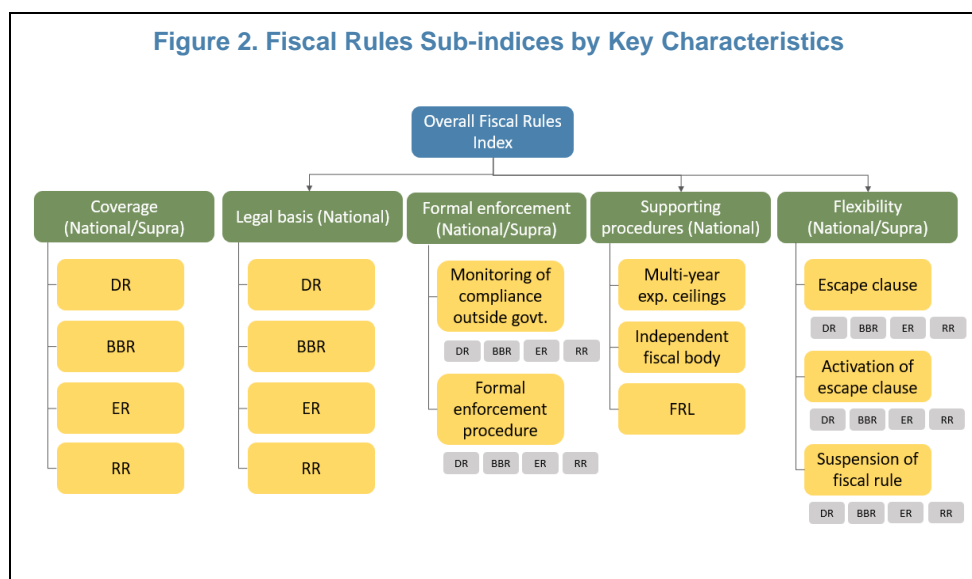


Figure 2. Fiscal Rules Sub-indices by Key Characteristics



**To capture natural disaster risks, we adopt the World Risk Index (WRI).** The WRI database from 2023 World Risk Report published by Bündnis Entwicklung Hilft is used to assess the disaster risks of countries. The WRI contains two components: (i) exposure to natural disaster risks (such as earthquakes, tsunamis, cyclones, coastal floods, riverine floods, drought, and sea-level rise); and (ii) vulnerability which includes susceptibility (social disparities/deprivation), lack of coping capacities (social shocks, political stability, health care, infrastructure, and security), and lack of adaptive capabilities (developments in education and research, reduction of disparities, investments, and disaster preparedness). In this paper, natural disaster risks are captured by employing the first component from the WRI, the exposure risk index (ERI), which includes climate-related and non-climate-related disasters. Based on the World Risk Report, countries are further

classified into three risk categories by ERI level: low (0 – 0.56), medium (0.57 – 1.76), and high (1.77 – 100).<sup>8</sup> The remaining data used in the paper are based on the updated explanatory variables adopted in Badinger and Reuter (2017a), which are mostly extracted from the International Monetary Fund and the World Bank databases as shown in Appendix 3.

**Evaluating the evolution of fiscal rules and exposure to natural disaster risks of all panel groups, we identify the following stylized facts** (Figure 3 to 5).<sup>9</sup>

- (1) *Budget balance and debt rules are most frequently used across all countries (Figure 3).* Expenditure and revenue rules are implemented relatively less in LIC. Setting expenditure and revenue rules could be challenging for LIC as they have wider fluctuations within the business cycle.
- (2) *Relative to the base year in 2000, there is an increase in the exposure risk index preponderantly in LIC (Figure 4a).*<sup>10</sup> Although the average ERI is generally high in AE, it has been decreasing relative to the base year over the past two decades whereas the average ERI has been increasing in EM and LIC. In addition, high-ERI and low-ERI countries maintained their base year risk level over the past two decades on average, while medium-ERI countries risk has been increasing at 0.71 percent on average.
- (3) *Strength of aggregate fiscal rules strength index increased rapidly after the global financial crisis with advanced economies as the frontrunner (Figure 4b).* Following the recovery from global financial crisis in 2008, about half of OECD countries announced medium-term fiscal plans for about three years (2010 – 2013), including implementation of fiscal rules to reduce public debt (OECD, 2011). This change is addressed as the “second generation” of fiscal rules, which evolved from existing rules rather than the shifting paradigm (Eyraud et al., 2018). The gap in the strength of fiscal rules widened among AE, EM, and LIC since 2011, due to the elevated debt level in AE and consequent further strengthening of fiscal rules.
- (4) *According to ERI levels, the strength of aggregate fiscal rules strength index has gradually converged in recent years, suggesting a trend toward similar fiscal rules design features across countries (Figure 4b).* In the 2000s, countries with high exposure risk to natural disasters (high-ERI) adopted stricter fiscal rules, as evidenced by higher fiscal rules strength index from 2000 to 2013. However, since 2010, medium- and low-ERI countries have strengthened their fiscal rules at a faster pace than high-ERI countries. Consequently, by 2015, the hierarchical ordering of fiscal rules strength among high-, medium-, and low-ERI countries had shifted. By 2021, the indexes for all three ERI categories had converged to approximately 0.47.
- (5) *European countries exhibit a high aggregate fiscal rule strength index, despite having a relatively low exposure risk index.*<sup>11</sup> This strong fiscal rule strength index in Europe can be attributed to the supranational regulations implemented by the European Union. In response to the 2009 European

<sup>8</sup> The World Risk Report classifies the level of ERI to five categories (very low, low, medium, high, and very high). This paper groups ‘very low’ and ‘low’ ERI groups as ‘low-ERI,’ and ‘high’ and ‘very high’ ERI groups as ‘high-ERI.’

<sup>9</sup> Further detail analysis of the data on alternative exposure risk index and expected variations in exposure risk and fiscal rules strength indexes can be found in Appendix 4 and 5, respectively.

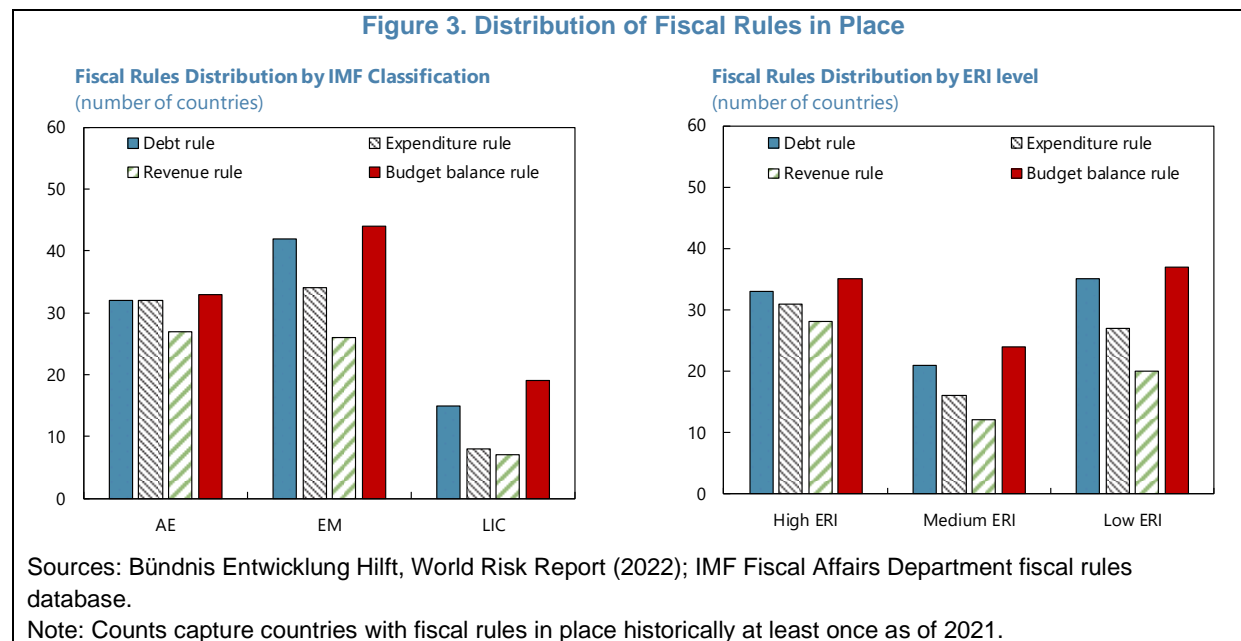
<sup>10</sup> See Appendix 6 for development of ERI between 2000 and 2021.

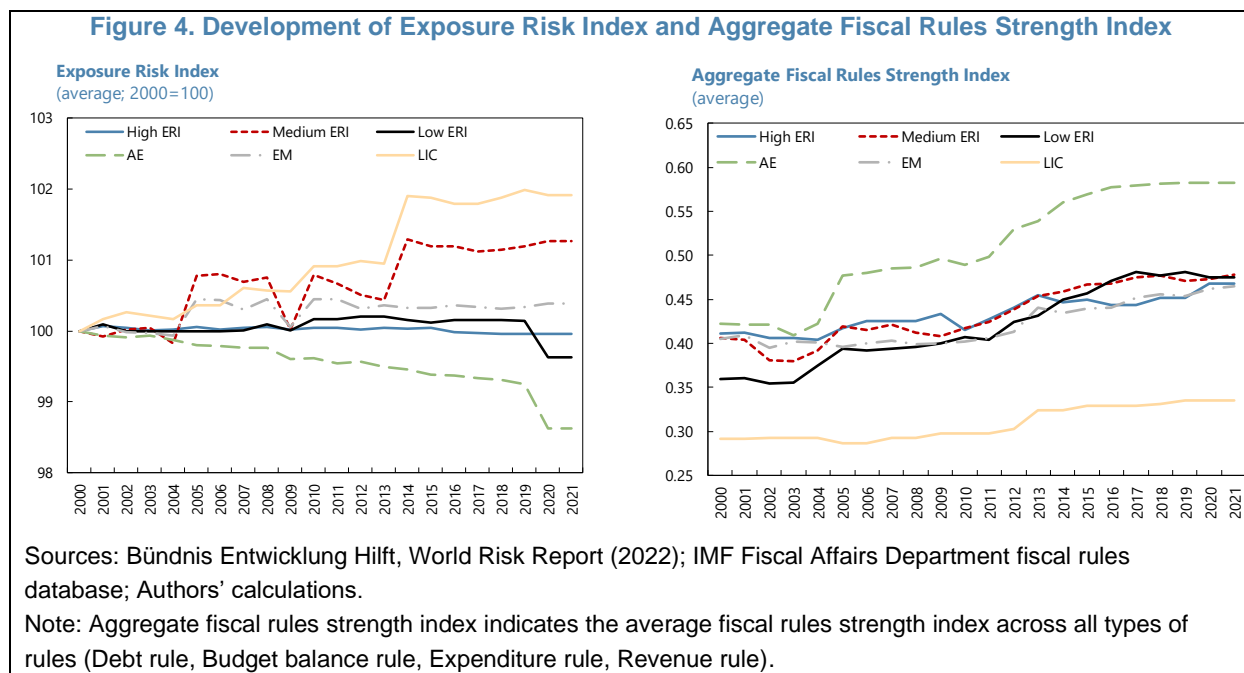
<sup>11</sup> Appendix 7 and 8 shows development of average fiscal rules across 2000 and 2021 and scatterplots of different types of fiscal rule index and ERI, respectively.

debt crisis, the EU introduced two key chapters, the "Fiscal Compact" and the "Six Pack," as part of its fiscal governance reforms during 2011–12. However, the activation of escape clauses during the 2020 pandemic led to a modest reduction in the growth of the aggregate fiscal rule strength index for the Eurozone.

- (6) *Asia and the Americas have high average exposure risk indices, ahead of other continents.* Asia (APD) has the highest average exposure risk index of 16.14 and the Americas (WHD) ranks second with 11.59. Middle East (MCD), Europe (EUR), and Africa (AFR) follows with an average of 3.21, 2.46, and 0.79, respectively. There is much variation in the risk distribution within each continent. Within the Americas, for instance, the ERI in the Caribbean is below the global median whereas North, Central, and South America have countries with high ERI. There are noticeable outliers in APD and WHD countries with very high exposure risk indices that increases the average ERI of the region. Three most outstanding countries include Japan (43.88), Indonesia (38.54), India (35.91) in APD, and Mexico (50.02), United States (39.81), Colombia (31.49) in WHD.

**Figure 3. Distribution of Fiscal Rules in Place**





## IV. EMPIRICAL APPROACH

To investigate the impact of rising risks to natural disasters on the strength of fiscal rules the paper augments the Badinger and Reuter (2017a) model of the determinants of fiscal rules. Their framework is bounded within five main arguments for constraining fiscal policy via fiscal rules which are related to incentive structures that could create a government deficit bias. These include: (i) *Common pool theory*: where more political leaders involved in the budgetary process results in a high likelihood of large spending and deficits – captured by government fragmentation and age dependency variables; (ii) *Information asymmetry*: where voters with lower average education have less interest in constraining the actions of officials and parties, and therefore, a tight system of political checks and balances and government accountability may be viewed as an implicit contract between governments and voters, reducing the need for (further) fiscal rules; (iii) *Impatience and short-sightedness of governments and political competition*: where governments tend to discount future events at a higher rate and tend to be less disciplined fiscally when anticipating the possibility of being replaced in the future –captured by government stability and political regime variables; (iv) *Spillovers and outside pressure*: (i.e. subnational government level or in fiscal or monetary unions), where governments may fail to internalize all spillover costs which could make fiscal policy to interfere with and lead to sub-optimal outcomes of monetary policy –captured by monetary union and inflation targeting variables; and (v) *Macro economic and fiscal conditions*: where fiscal rules may be introduced (or strengthened) in response to general economic and fiscal conditions (captured by inflation rate, debt levels, and GDP per capita) –which includes rising risks of natural disaster shocks. Given the pronounced trends in both the fiscal rule index and the exposure risk index, we incorporate a trend variable into the model to control for temporal effects.

**The link between natural disasters and fiscal rules underscores their macro-critical importance.** The rising risk of natural disasters significantly raises the likelihood of macroeconomic shocks and associated fiscal

risks. To better manage these risks, fiscal rules could be reinforced in its key features by: (i) explicitly covering expenditures related to natural disasters, including emergency and recovery costs, for more comprehensive financial protection (Heller, 2005); (ii) strengthening the legal framework of the fiscal rules, ensuring they are embedded in the national law, enhancing stability, and reducing the likelihood of circumvention during crises (Debrun et al., 2009); (iii) adding robust enforcement mechanisms, such as independent fiscal councils, that oversee compliance, monitor deviations, and recommend corrective actions to uphold fiscal discipline during emergencies (Blanchard and Leigh, 2013); (iv) incorporating flexibility into fiscal rules allows for necessary adjustments during natural disasters while maintaining long-term fiscal sustainability—adding predefined escape clauses or adjustment mechanisms (Porteba and von Hagen, 1999); and (v) establishing detailed procedures for emergency budgeting, fund reallocation, and inter-agency coordination for effective management during disasters (Alesina et al., 2008). Enhancing these aspects can help countries better manage the economic and fiscal pressures arising from natural disasters.

**Against the above theoretical background, a panel econometric model is considered in the form:**

$$fr_{i,t} = \beta_1 X_{i,t} + v_i + t_i + e_{i,t} \quad (1)$$

Where  $fr$  is the fiscal rules index in country  $i$  and year  $t$ . The vector  $X$  includes the determinants of fiscal rules. These include, government fragmentation, age dependency, checks and balances, political regime, government stability, inflation targeting, monetary union, inflation, GDP per capita, debt level and to which we add the exposure risk index (to capture natural disaster risks). The country fixed effect is captured by  $v$ , time trend by  $t$  and an idiosyncratic error term is represented as  $e$ .

**The model addresses possible endogeneity problem among the regressors.** Using the ordinary least squares (OLS) is inappropriate as independent variables in the model could be determined by each other and therefore could be correlated with the error term. For instance, weak system of checks and balances could create instability in government and at the same time an unstable political environment could generate weak system of checks and balances. To derive robust estimates of the parameters, we adopted a two-stage least squares (2SLS) estimation method with an autoregressive (AR) term. Possible omitted variable bias in variables was mitigated with suitable instruments.

As suggested in Wooldridge (2010). We use a set of instruments that are highly correlated with the observed explanatory variables and uncorrelated with the error term. The core instruments used are the past exposure risk index of close neighbors –to proxy exposure risk index, working-age population –to proxy age dependency, political stability –to proxy government stability, GDP –to proxy GDP per capita, GDP growth –to proxy inflation, rule of law –to proxy political regime, government expenditure as a percent of GDP –to proxy public debt, lag of inflation targeting –to proxy inflation targeting, lag of monetary union –to proxy monetary union, and government effectiveness –to proxy government fragmentation. The strength and validity of these instruments are tested and therefore could be regarded to have met the conditions of relevance and exogeneity<sup>12</sup>. These instruments are applied in the below reduced form equation:

$$X_{i,t} = \alpha_1 X_{i,t-1} + w_i + \mu_{i,t} \quad (2)$$

<sup>12</sup> The results of the first stage regression with the F-statistics for weak instruments are shown in Appendix 10.

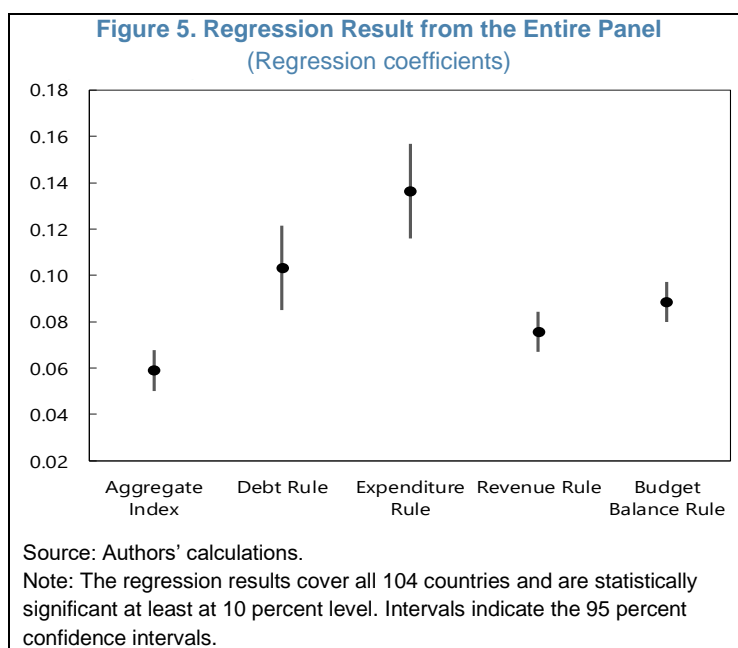
Where  $X_1$  is the vector which includes the above-mentioned instruments and  $\mu_{i,t}$  is the error term. The structural equation is identified when  $\alpha_1 = 0$  and all other parameters in the reduced-form equation are not equal to zero because of instrument relevance in the equation. Furthermore, country-specific characteristics were considered under the assumption that these countries have different economic structures and fiscal rules patterns.

## V. EMPIRICAL RESULTS

**The panel 2SLS model is estimated in two approaches.** The estimation strategy considers the general approach of including the complete set of explanatory variables associated with the five-rationales related to the incentive structures which create the government deficit bias. First, the entire panel dataset is considered for each individual fiscal rule index. Second, six disaggregated panel data groupings (AE, EM, LIC; High-ERI, Medium-ERI, Low-ERI) are employed to each fiscal rule index. Furthermore, we check robustness of the model by comparing the predictive power of the derived explanatory variables relative to those in Badinger and Reuters (2017a) and by using an alternative measure of natural disaster exposure risk.

**Results from the entire panel suggest that natural disaster risks matter in determining fiscal frameworks for all countries.** The regression coefficients are all positive across each fiscal rule index, although with small magnitude, indicating that many of the countries' fiscal rules have strengthened as risks to natural disasters rises (Figure 5). On aggregate, a 1 percent rise in the natural disaster risk index will lead to a 0.06 percent increase in the overall strength of fiscal rules. When natural disaster risks increase by 1 percent, for each individual fiscal rule index, the strength of fiscal rules will increase, ranging from about 0.08 percent (revenue rule) to 0.14 percent (expenditure rule). The higher magnitude for countries operating an expenditure rule reflects the ease of reallocating spending towards climate adaptation while maintaining a strong fiscal rule as natural disaster risks rises.<sup>13</sup>

<sup>13</sup> See detailed regression results are presented in Appendix 10. The coefficients of the natural disaster variable are all statistically significant at least at 10 percent level across all country groupings.



**Results from disaggregated panel estimations are mixed.** A mixed result implies that some countries currently operating fiscal rules will require more efforts to incorporate natural disaster risks into their fiscal framework (Figure 6).

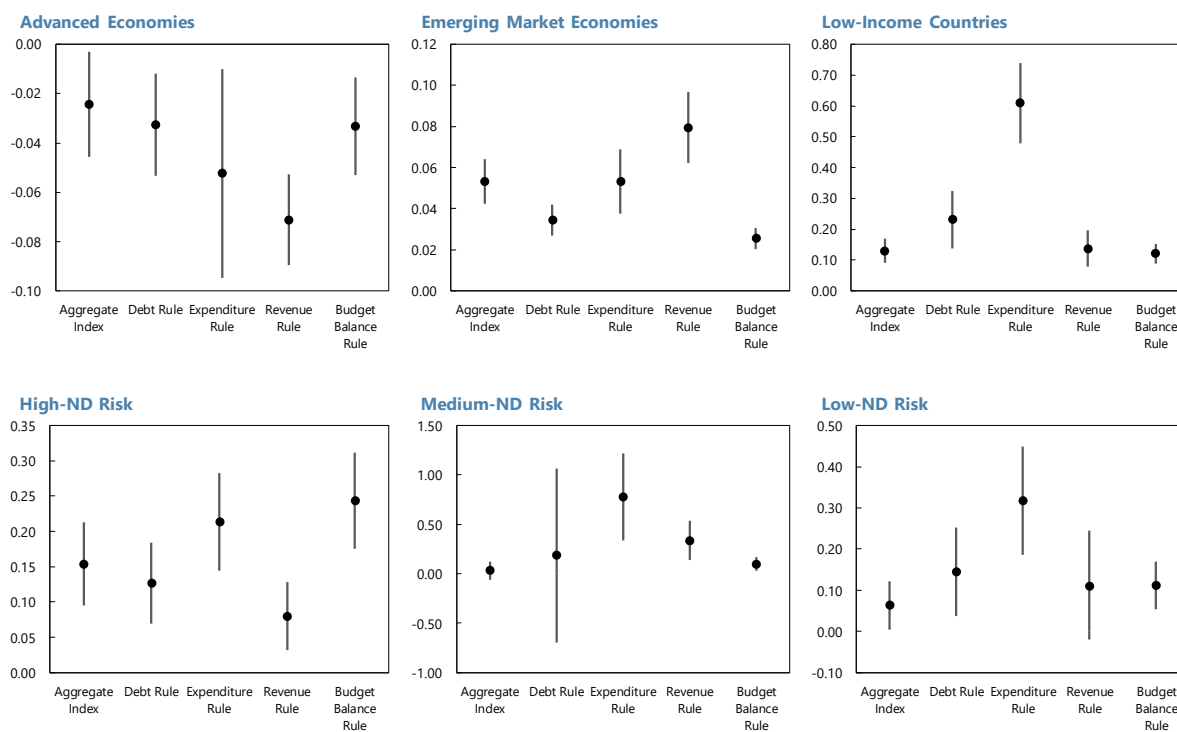
- *Classification by country groupings (AE, EM, LIC) suggests that EM and LIC tend to strengthen their fiscal rules as natural disaster risk rises.* An increase of 1 percent in the natural disaster risk index will strengthen fiscal rule by about 0.05 percent on average for EMs—ranging from about 0.03 percent (debt rule) to 0.08 percent (revenue rule), and about 0.12 percent to 0.6 percent for LICs.
- *As indicated in the stylized facts, the negative coefficients from the AE panel groupings suggest that fiscal rules are being strengthened regardless the risks to natural disasters.* Also, while natural disaster risks matter in the determination of fiscal rules in the advanced economies, a rising risk to natural disasters may not suggest that these countries fiscal rules will weaken. The provision for escape clauses in the rule-based fiscal framework could partly explain this result.<sup>14</sup> The results from the AE panel indicate that the strength of fiscal rules could rise as much as 0.07 percent when the risk of natural disasters declines by 1 percent across most fiscal rule indices.
- *The results based on the level of natural disaster risks groupings (High-ERI, Medium-ERI, Low-ERI) also suggest that all countries tend to strengthen their fiscal rules as natural disaster risk (ND) rises.*<sup>15</sup> For countries with high exposure to ND risks (High-ERI), when risk to natural disaster rises by 1 percent, fiscal rules will strengthen by about 0.15 percent – ranging from about 0.08 percent (revenue rule) to 0.24 percent (balance budget rule). In countries with medium exposure to ND risks (Medium-ERI), when risk to natural disaster rises by 1 percent, fiscal rules will strengthen by about 0.03 percent –ranging from about 0.1 percent (balance budget rule) to 0.8 percent (expenditure rule). Similar

<sup>14</sup> Majority of the Advanced Economies (AE) have escape clauses in place and have been activating these clauses over the years.

<sup>15</sup> Appendix 9 examines if countries with higher ERI has built stronger fiscal frameworks, regardless of the push for fiscal frameworks adoption by regulators of international monetary and financial system, such as the IMF fund arrangements.

response is found in countries with low exposure to ND risks (Low-ERI), ranging from about 0.11 percent (revenue rule) to 0.32 percent (expenditure rule).

**Figure 6. Regression Results from Disaggregated Panel**  
(Regression coefficients)



Source: Authors' calculations.

Note: The regression result covers all 104 countries across six panel groupings and are statistically significant at least at 10 percent level. Intervals in the panel charts indicate 95 percent confidence intervals.

**Results from other determinants of fiscal rules are also mixed.**<sup>16</sup> This reflects the structural variations within panel groupings or specific type of fiscal rules. It indicates that the five arguments for constraining fiscal policy by fiscal rules can be interpreted as below:<sup>17</sup>

- *Common pool theory:* The results suggest that countries will have stronger fiscal rules if their government is more fragmented (positive coefficient), and the population is less dependent on the government (negative coefficient). Whilst there could also be weaker fiscal rules the more decision makers (less fragmented government) involved in the budgetary process (negative coefficient), and the population is more dependent (positive coefficient) on the government (Roubini and Sachs 1989; Calderón and Schmidt-Hebbel, 2008).

<sup>16</sup> See Appendix 10 for details. Regression coefficients for other determinants are broadly statistically significant at least at 10 percent level.

<sup>17</sup> Figure 7 provides corresponding signs (positive or negative) of the coefficients of the other determinants of fiscal rules in the existing literature (Badinger and Reuters, 2017a)

- *Information asymmetry*: The results in most cases indicate that fiscal rules will be stronger in countries with weaker systems of political checks and balances (negative coefficient). However, in a few instances such as in advanced economies, the coefficients are positive, suggesting that citizens with higher average education, could hold their government more accountable thereby leading to more interest in constraining fiscal actions (Stratmann and Aparicio-Castillo, 2006).
- *Impatience and short-sightedness of governments, and political competition*: The results find that government term length (political regime) and/or political stability has a positive effect on the strength of fiscal rules. This indicates that the longer politicians can stay in office, the less incentive there will be to create room for fiscal maneuver to increase spending to achieve their short-term goals. However, for countries with strong checks and balances in place such as in advanced economies, a shorter political regime or less stable government may not weaken their fiscal rules (Woo, 2005; Persson and Svensson, 1989).<sup>18</sup>
- *Spillovers and outside pressure*: The results indicate that countries that are part of a monetary union and/or have a central bank that follows an inflation targeting regime have more stronger fiscal rules in place to reduce negative spillovers to other union members or monetary policy spillovers (Von Hagen and Eichengreen, 1996; Combes et al. 2014).
- *Economic and fiscal conditions*: While our results partially confirm the findings in IMF (2009) that fiscal rules are generally strengthened in periods of declining inflation, many countries on the contrary may strengthen their fiscal rules in the event of a macroeconomic shock (high inflation and low growth). Finally, we find that a rising level of government debt triggers the introduction or strengthening of fiscal rules, possibly to facilitate the implementation of consolidation policies.

**The robustness of the empirical results is tested in two ways (Figure 7).** First, we compare the results with explanatory variables from the established empirical literature. The results for selected panels (Debt rule, Budget balance rule, and Aggregate fiscal rule index) confirm that most of the determinants of fiscal rules used in the study significantly align with the result from Badinger and Reuter (2017). Second, the IMF climate driven INFORM risk index (ECFRMH) is applied as an alternative measure of natural disaster risk in the model estimations. Despite the weaknesses of the climate driven INFORM risk index (ECFRMH) described in Section III and Appendix 4, which could impact the magnitude of the regression coefficients, the results are found to be in line with those using the exposure risk index (ERI). The regression coefficients from using the climate driven INFORM risk index (ECFRMH) as an alternate measure for the natural disaster risk index are all positive and statistically significant across each fiscal rule index. This indicates that, as natural disaster risks rise, fiscal rules tend to be more strengthened in countries operating fiscal rules.

<sup>18</sup> In cases where fiscal rules are stronger as (rather than weaker) system of checks and balances are strengthened, it could suggest that a longer government term length (political regime) has a negative (rather than positive) effect on the strength of fiscal rules. Meaning that, a robust system of checks and balances could translate into a shorter political regime for more stronger fiscal rules.

Figure 7. Robustness Check

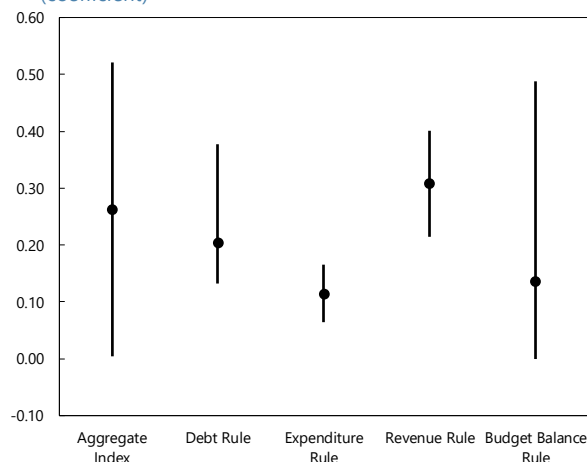
## Comparison Chart on Selected Panels

(signs of coefficients)

Explanatory Variables	Debt Rule		Budget Balance Rule		Aggregate Index	
	Badinger &	Authors'	Badinger &	Authors'	Badinger &	Authors'
	Reuter (2017)	Calculations	Reuter (2017)	Calculations	Reuter (2017)	Calculations
Government Fragmentation	+	+	+	+	+	+
Age Dependency	-	-	-	-	-	-
Checks and Balances	-	-	-	-	-	-
Political Regime	+	+	+	+	+	+
Government Stability	+	+	+	+	+	+
Inflation Targeting	+	+	+	+	+	+
Monetary Union	+	+	+	+	+	+
Inflation	-	-	-	-	-	-

## Regression Result from using ECFRMH

(coefficient)



Sources: Bündnis Entwicklung Hilft, World Risk Report (2022); IMF-INFORM database; Authors' calculations.

Note: The regression result covers all 104 countries across six panel groupings. Intervals indicate the 95 percent confidence intervals.

## VI. CONCLUSION AND POLICY IMPLICATIONS

**This paper empirically investigates the role of natural disaster risks in the determination of countries' rule-based fiscal frameworks.** It explores the extent to which rising risk of natural disasters would make countries adhere to their fiscal rules. To properly measure the strength of the fiscal rule, we derived an overall fiscal rules index using the IMF fiscal rules database on 104 countries currently operating fiscal rules from 2000 to 2021 and employed a panel 2SLS estimation strategy to assess the impact natural disaster risks on the strength of fiscal rules.

**The stylized fact analysis supports the case to carry out this investigation.** It indicates that approximately 60 percent of countries operating fiscal rules have medium to high exposure to natural disaster risk and the

strength of aggregate fiscal rules strength index has increased over the last two decades –suggesting a strong positive correlation between fiscal rules and natural disasters.

**Results from the entire panel suggest that natural disaster risks matter in determining fiscal frameworks for all countries.** More specifically, it broadly indicates that an increasing natural disaster risk should lead to strengthening of fiscal rules. This suggest that countries should consider strengthening their fiscal rules amidst rising risk of natural disasters. The mixed result found in the disaggregated panels implies that some countries currently operating fiscal rules will require more efforts to incorporate natural disaster risks into their fiscal frameworks.<sup>19</sup>

**The findings in this paper have important policy implications,** particularly as natural disasters entail sizeable impacts on the macroeconomy. They underscore the importance of dynamic fiscal frameworks that can adapt to the evolving risks posed by natural disasters, emphasizing the need for a more resilient and flexible approach to fiscal management. The recurrent occurrence of natural disasters constitutes a key source of vulnerability for public finances across many countries. Therefore, integrating natural disaster risks considerations into the design and calibration of countries' fiscal framework is imperative for policymakers aiming to mitigate the effects of these frequent shocks. Furthermore, there is a critical need for a more strategic integration of climate policies within countries fiscal frameworks, including the enhancement of structural, financial, and post-disaster resilience to ensure the long-term sustainability of fiscal policy (IMF, 2023).

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<sup>19</sup> Possible future area of research could explore the impact that rising frequency of natural disasters are having on actual fiscal expenditures.

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## Appendix 1. Country coverage

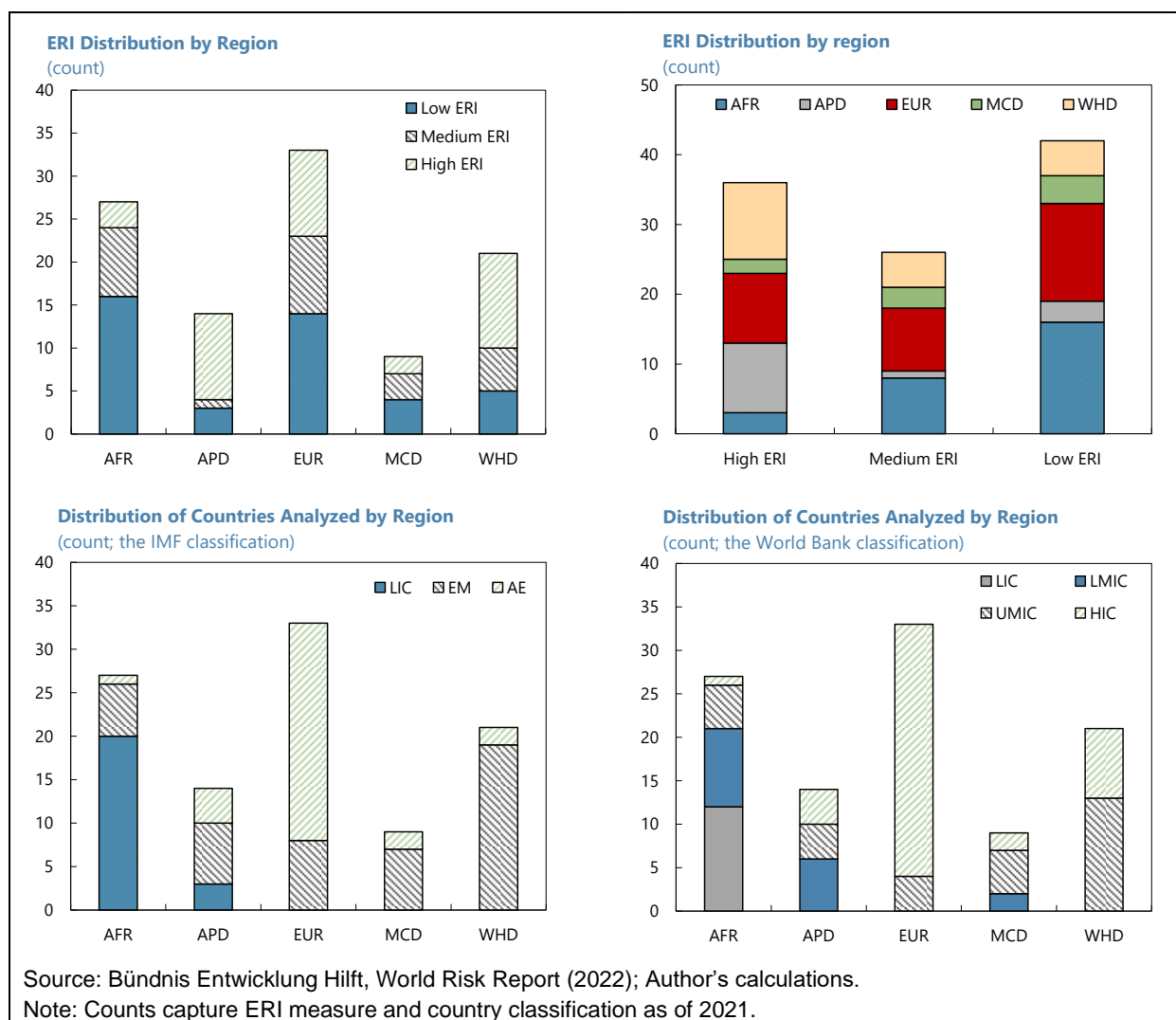
List of countries currently operating fiscal rules (2000-2021) classified by the **IMF** classifications.

Advanced Economies	Emerging Market and Middle-income Economies	Low-income and Developing Countries
Andorra	Antigua and Barbuda	Benin
Australia	Argentina	Burkina Faso
Austria	Armenia	Burundi
Belgium	Azerbaijan	Cambodia
Canada	Bahamas, The	Cameroon
Cyprus	Botswana	Central African Republic
Czech Republic	Brazil	Chad
Denmark	Bulgaria	Congo, Republic of
Estonia	Cabo Verde	Côte d'Ivoire
Finland	Chile	Guinea Bissau
France	Colombia	Kenya
Germany	Costa Rica	Liberia
Greece	Croatia	Mali
Iceland	Dominica	Niger
Ireland	Ecuador	Nigeria
Israel	Equatorial Guinea	Rwanda
Italy	Gabon	Senegal
Japan	Georgia	South Sudan
Latvia	Grenada	Tanzania
Lithuania	Hungary	Timor-Leste
Luxembourg	India	Togo
Malta	Indonesia	Uganda
Netherlands	Iran	Vietnam
New Zealand	Jamaica	
Norway	Kazakhstan	
Portugal	Malaysia	
Singapore	Maldives	
Slovak Republic	Mauritius	
Slovenia	Mexico	
Spain	Mongolia	
Sweden	Montenegro, Rep. of	
Switzerland	Namibia	
United Kingdom	Pakistan	
United States	Panama	
	Paraguay	
	Peru	
	Poland	
	Romania	
	Russia	
	Serbia	
	Sri Lanka	
	St. Kitts and Nevis	
	St. Lucia	
	St. Vincent and the Grenadines	
	Thailand	
	Turkmenistan	
	Uruguay	

List of countries currently operating fiscal rules (2000-2021) classified by **Exposure Risk Index (ERI)**.

High ERI	Medium ERI	Low ERI
Argentina	Antigua and Barbuda	Andorra
Australia	Bahamas, The	Armenia
Belgium	Congo, Republic of	Austria
Brazil	Croatia	Azerbaijan
Cambodia	Cyprus	Benin
Cameroon	Dominica	Botswana
Canada	Equatorial Guinea	Bulgaria
Chile	Gabon	Burkina Faso
Colombia	Georgia	Burundi
Costa Rica	Guinea Bissau	Cabo Verde
Ecuador	Ireland	Central African Republic
France	Israel	Chad
Germany	Jamaica	Czech Republic
Greece	Latvia	Côte d'Ivoire
India	Lithuania	Denmark
Indonesia	Mauritius	Estonia
Iran	Montenegro, Rep. of	Finland
Italy	Namibia	Grenada
Japan	Nigeria	Hungary
Kenya	Norway	Iceland
Malaysia	Poland	Kazakhstan
Mexico	Romania	Liberia
Netherlands	Senegal	Luxembourg
New Zealand	Sri Lanka	Maldives
Pakistan	Sweden	Mali
Panama	Uruguay	Malta
Peru		Mongolia
Portugal		Niger
Russia		Paraguay
Spain		Rwanda
Tanzania		Serbia
Thailand		Singapore
Timor-Leste		Slovak Republic
United Kingdom		Slovenia
United States		South Sudan
Vietnam		St. Kitts and Nevis
		St. Lucia
		St. Vincent and the Grenadines
		Switzerland
		Togo
		Turkmenistan
		Uganda

## Appendix 2. ERI and Countries Distribution by Different Groupings



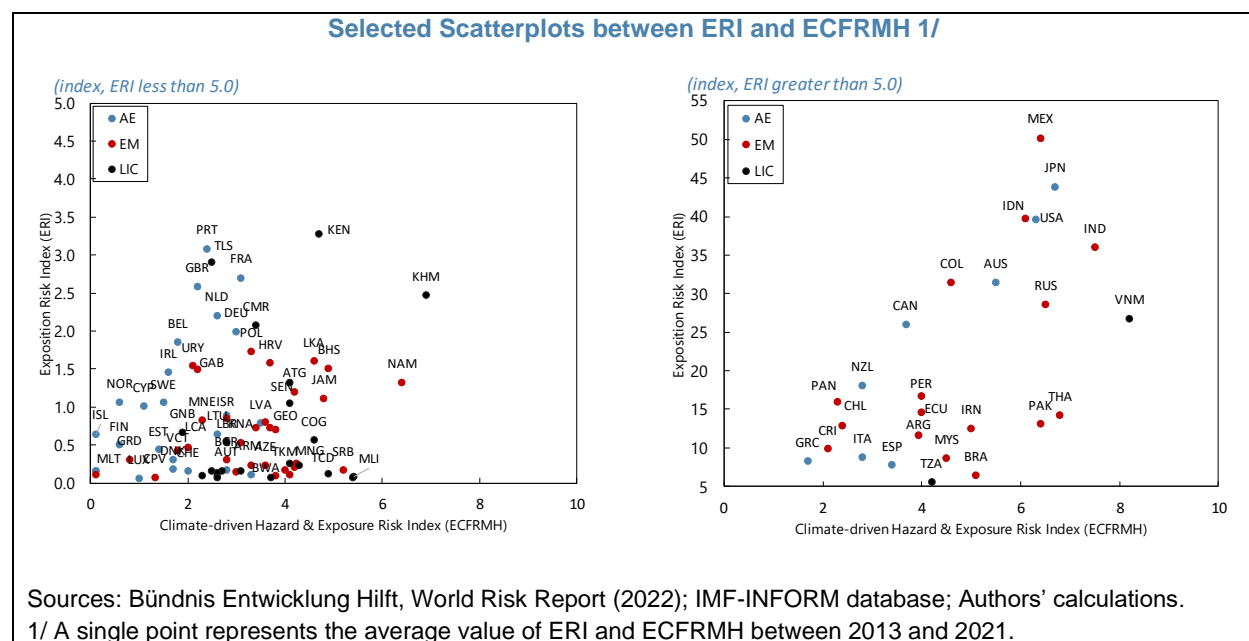
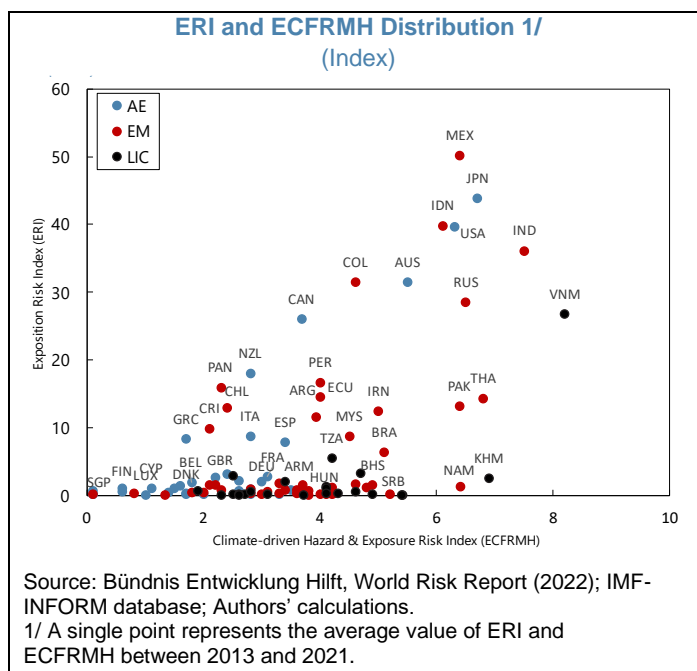
### Appendix 3. Explanatory Variables

Concept	Variable	Description	Year	Source
Natural disaster risk	Exposure risk index	Extent to which populations in hazard-prone areas are exposed to and burdened by the impacts of extreme natural events of the negative consequences of climate change	2000-2022	World Risk Index Report
Macroeconomic conditions	Debt-to-GDP ratio	General government gross debt (% of GDP)	1980-2022	IMF-WEO
	Inflation	Inflation rate, average consumer prices, percentage change	1980-2022	IMF-WEO
	GDP per capita	Real GDP per capita	1980-2022	IMF-WEO
Impatience and short-sightedness of governments and political competition	Political regime	Parliamentary (2), Assembly-elected President (1), Presidential (0)	1975-2020	WB-DPI
	Government stability	Term length of governments (years)	1975-2020	WB-DPI
Common pool theory	Age dependency	Population aged below 15 or above 64 (% of total)	1980-2022	WB-WDI
	Government fragmentation	Fractionalization index	1975-2020	WB-DPI
Information asymmetry	Checks and balances	Measure of the institutional constraints faced by authorities	1975-2020	WB-DPI
Spillovers and outside pressure	Inflation targeting	1 if central bank operates with inflation targeting, 0 otherwise	1980-2022	Hammond (2012)
	Monetary union	1 if in currency union, 0 otherwise	2000-2022	Authors' input

## Appendix 4. Comparing ERI and ECFRMH

**The alternative exposure risk index produced by the IMF aligns with the ERI.**

The IMF climate driven INFORM risk index can be complimented with ERI.<sup>1</sup> The index has three dimensions, climate-driven hazard and exposure (ECFRMH), vulnerability (ECFRMV), and lack of coping capacity (ECFRMC). We take the IMF's climate-driven hazard and exposure index (ECFRMH) to compare with the World Risk Index's exposure risk index (ERI) as a robustness check. Compared to ERI, the ECFRMH index is characterized by a shorter period coverage ranging between 2013 and 2021 and has a small degree of index variation over time.<sup>2</sup> Yet, the scatterplot between average values of ERI and ECFRMH index between 2013 and 2021 shows a positive correlation, implying that the ERI used in our model aligns with the alternative exposure risk measurement from different source.



<sup>1</sup> The INFORM Risk Index is a global, open-source risk assessment for crises and disasters. The Climate-driven INFORM Risk is an adaptation of the INFORM Risk Index, adjusted by IMF staff to distill, and centralize on climate-driven risks. See <https://climatedata.imf.org/pages/fi-indicators> for further information on the INFORM risk index.

<sup>2</sup> In particular, there is no significant changes prior to 2021 for ECFRMH index to draw meaningful analysis results.

## Appendix 5. Descriptive Statistics of Fiscal Rules Strength and Exposure Risk Indexes

Here are some key observations from the descriptive statistics of exposure risk and fiscal rules strength indexes:

- The exposure risk index (ERI) tends to be right-skewed and features notable outlier countries, whereas the fiscal rules strength index does not exhibit the same degree of skewness.
- Within the ERI, middle-income countries (both Emerging Markets and Upper-Middle-Income) show a higher third quartile compared to other income groups.
- Regarding the fiscal rules strength index, higher-income countries generally have both a higher mean and median compared to lower-income groups.

By looking at the variations, the computed time and cross-section standard deviation is significantly different from each other, suggesting that much of the variations in both fiscal rules and exposure risk index are not periodical. Cross-country variations in ERI are also significantly larger than fiscal rules index. There is a clear variation across country groups, with LICs having the lowest cross-section and time variations in both fiscal rules and exposure risk indexes. Exposure risk indexes shows several variations across cross-country and with not much time variations within country groups.

### Descriptive Statistics of Fiscal Rules Strength Index and ERI

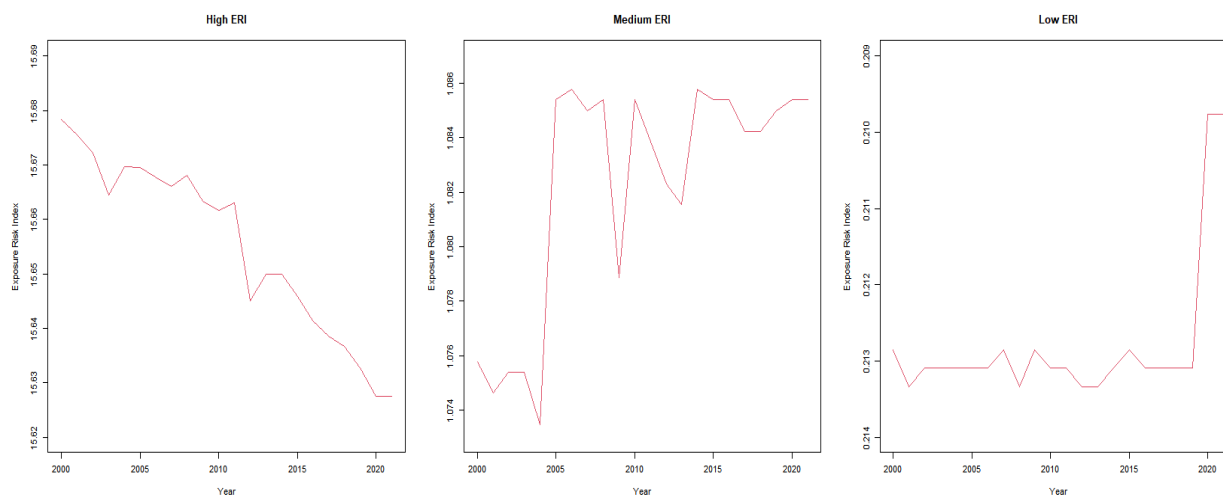
Country Groups	Fiscal Rules Strength Index						Exposure Risk Index (ERI)					
	Mean	Min	Q1	Median	Q3	Max	Mean	Min	Q1	Median	Q3	Max
All countries	0.434	0.000	0.294	0.378	0.557	1.000	5.776	0.020	0.203	0.870	3.815	50.200
AE	0.513	0.000	0.378	0.523	0.652	0.881	6.143	0.020	0.180	1.035	3.120	44.120
EM	0.427	0.059	0.374	0.378	0.496	1.000	7.301	0.070	0.300	1.200	12.240	50.200
LIDC	0.313	0.210	0.266	0.266	0.378	0.580	2.116	0.070	0.120	0.250	2.030	27.070
HIC	0.503	0.000	0.378	0.503	0.643	0.881	5.607	0.020	0.400	1.135	2.808	44.120
UMIC	0.416	0.059	0.351	0.378	0.471	1.000	7.812	0.090	0.250	0.830	11.568	50.200
LIC+LMIC	0.333	0.210	0.266	0.294	0.378	0.767	3.855	0.070	0.130	0.490	2.490	36.050
LMIC	0.350	0.210	0.266	0.378	0.378	0.767	6.426	0.070	0.490	2.055	5.490	36.050
LIC	0.308	0.580	0.266	0.266	0.294	0.001	0.214	0.070	0.078	0.160	0.233	0.670
High ERI	0.435	0.000	0.349	0.405	0.571	0.916	15.655	1.840	3.148	11.930	26.540	50.200
Medium ERI	0.440	0.210	0.294	0.412	0.580	0.804	1.082	0.480	0.788	1.050	1.460	1.760
Low ERI	0.429	0.154	0.294	0.378	0.524	1.000	0.213	0.020	0.100	0.160	0.250	0.670

### Time and Cross-Section Variations of Fiscal Rules Strength Index and ERI

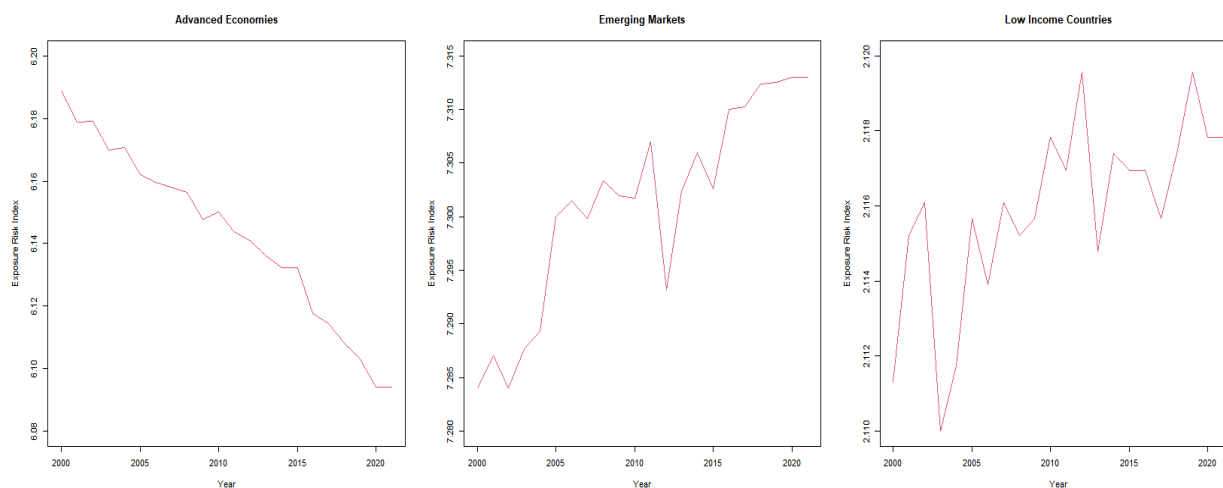
Country Groups	Fiscal Rules Strength Index		ERI (from the World Risk Report)		ECFRMH (from the IMF-INFORM database)	
	Cross-section variations	Time variations	Cross-section variations	Time variations	Cross-section variations	Time variations
All countries	0.1534	0.0548	10.8244	0.0312	1.7200	0.0045
AE	0.1728	0.0830	11.6664	0.0313	1.5817	0.0020
EM	0.1208	0.0550	11.8609	0.0394	1.6154	0.0071
LIDC	0.0689	0.0128	5.5729	0.0144	1.5357	0.0029
HIC	0.1646	0.0771	10.5942	0.0286	1.5060	0.0016
UMIC	0.1210	0.0603	12.9550	0.0421	1.6538	0.0075
LIC+LMIC	0.0901	0.0151	8.3883	0.0235	1.6678	0.0057
LMIC	0.1048	0.0184	10.3027	0.0391	1.8802	0.0059
LIC	0.0469	0.0105	0.1924	0.0015	1.1970	0.0056
High ERI	0.1658	0.0646	13.8128	0.0790		
Medium ERI	0.1424	0.0485	3.4084	0.0129		
Low ERI	0.1506	0.0503	0.1534	0.0016		

## Appendix 6. Evolution of Average Exposure Index

### (a) by ERI level

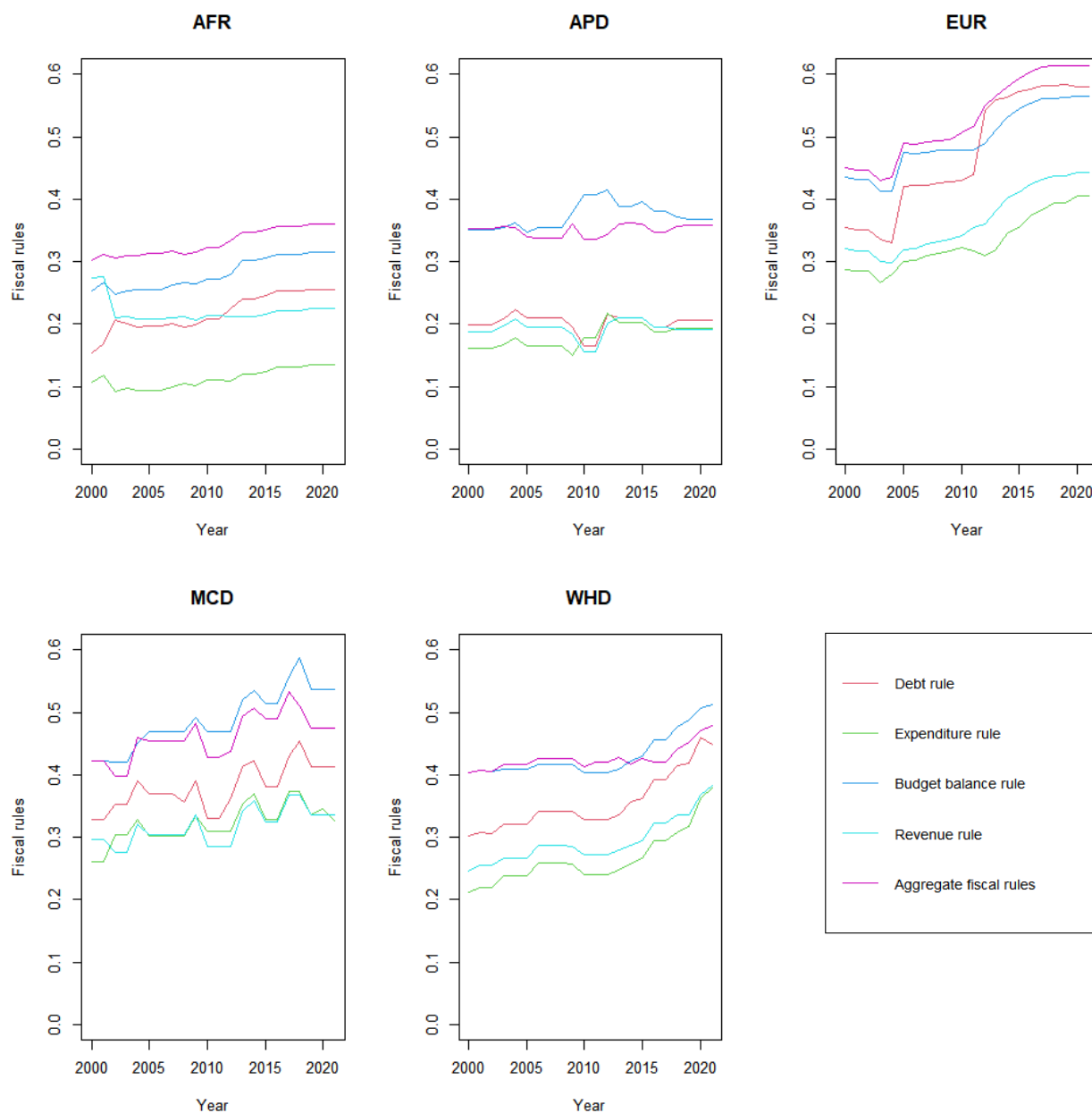


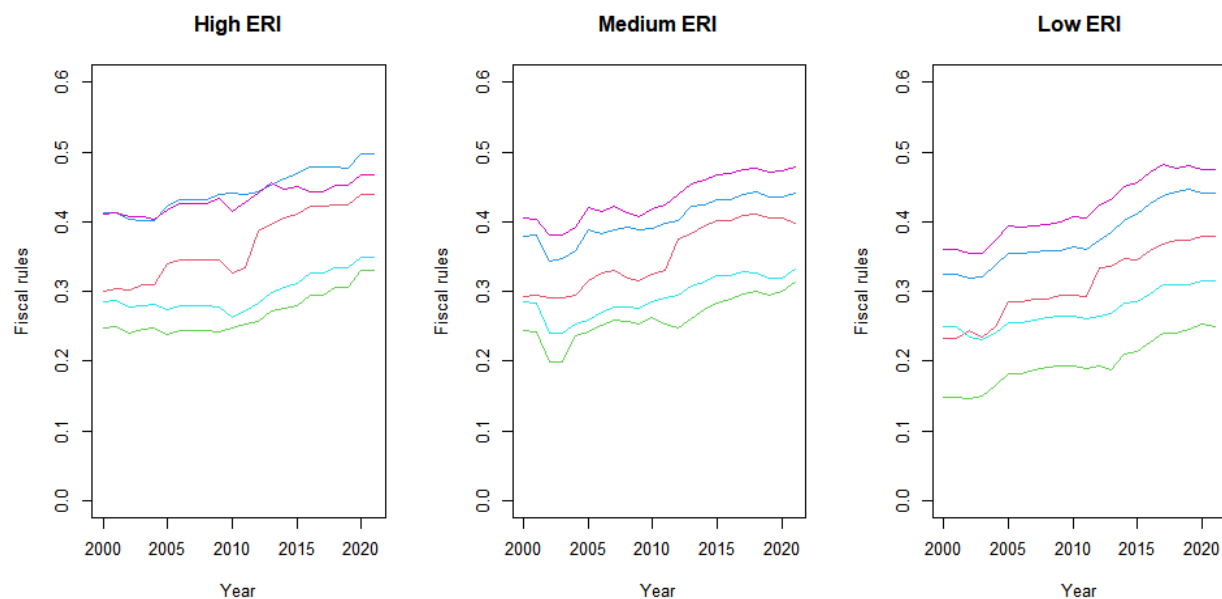
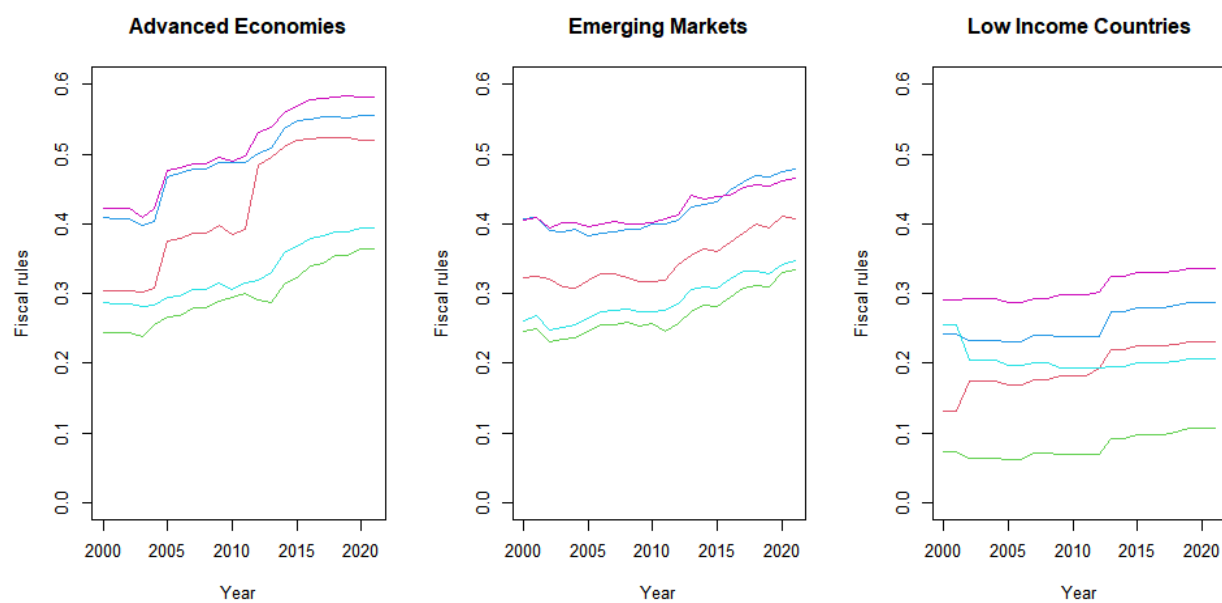
### (b) by the IMF classification



## Appendix 7. Average Fiscal Rules Strength Index Across Years

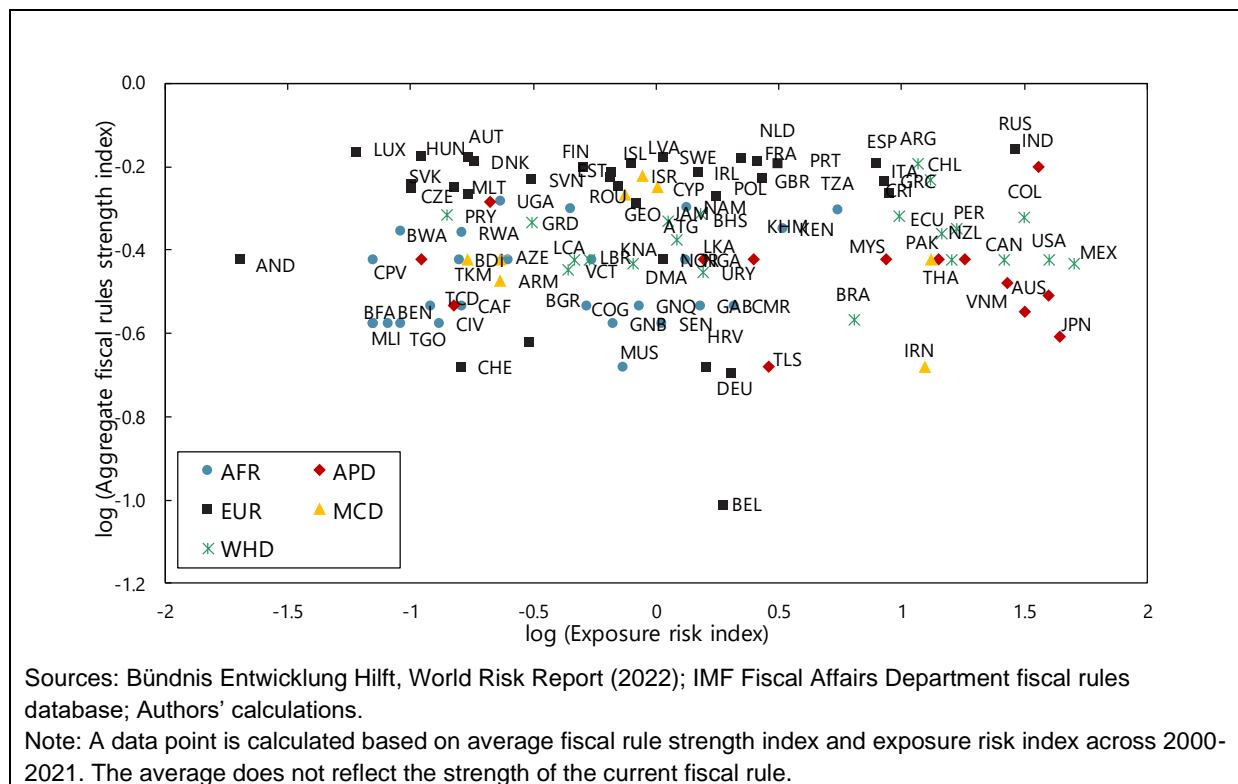
### (a) by region



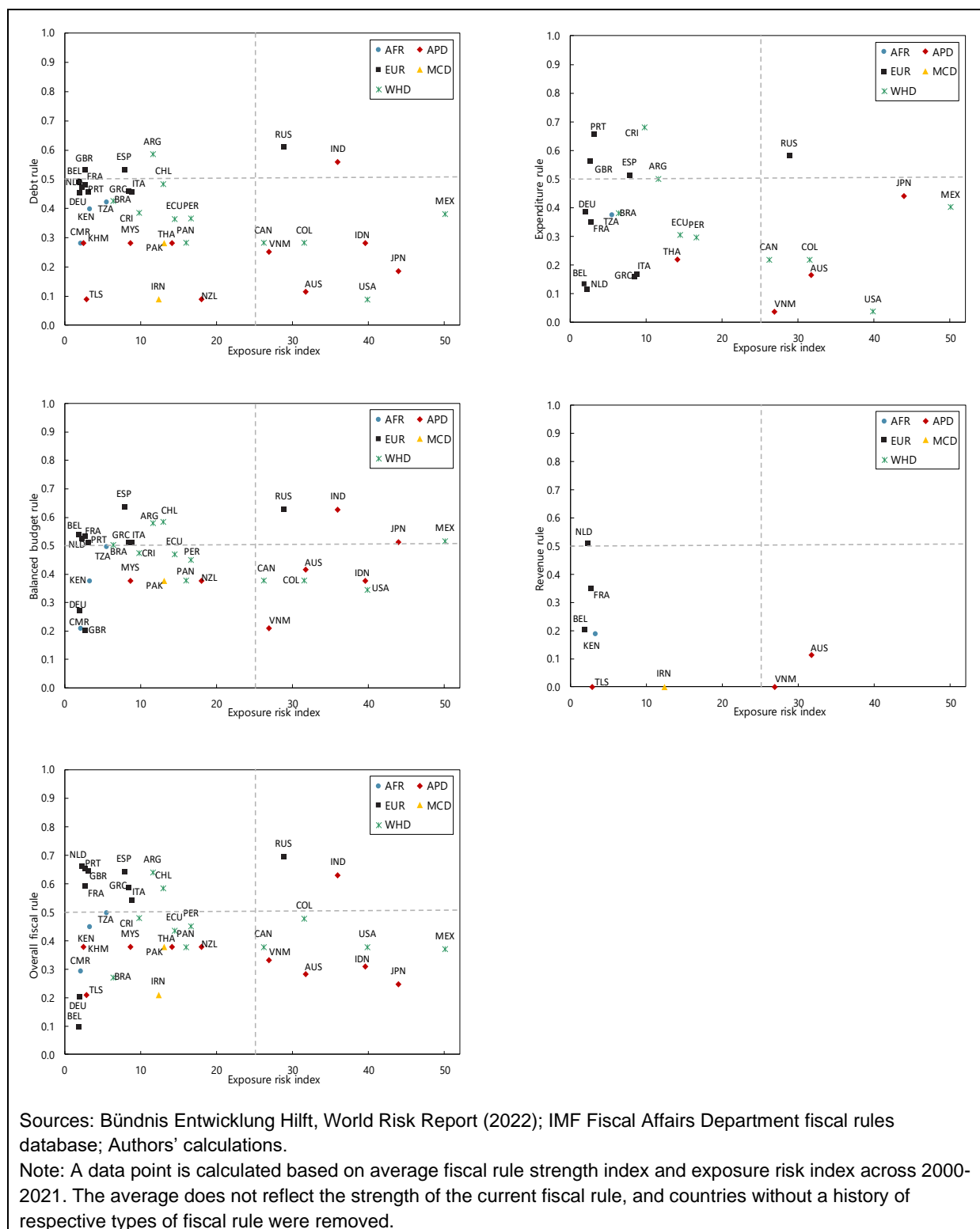
**(b) by ERI level****(c) by the IMF country classification**

## Appendix 8. Scatterplots of Different Types of Fiscal Rules Strength Index and ERI

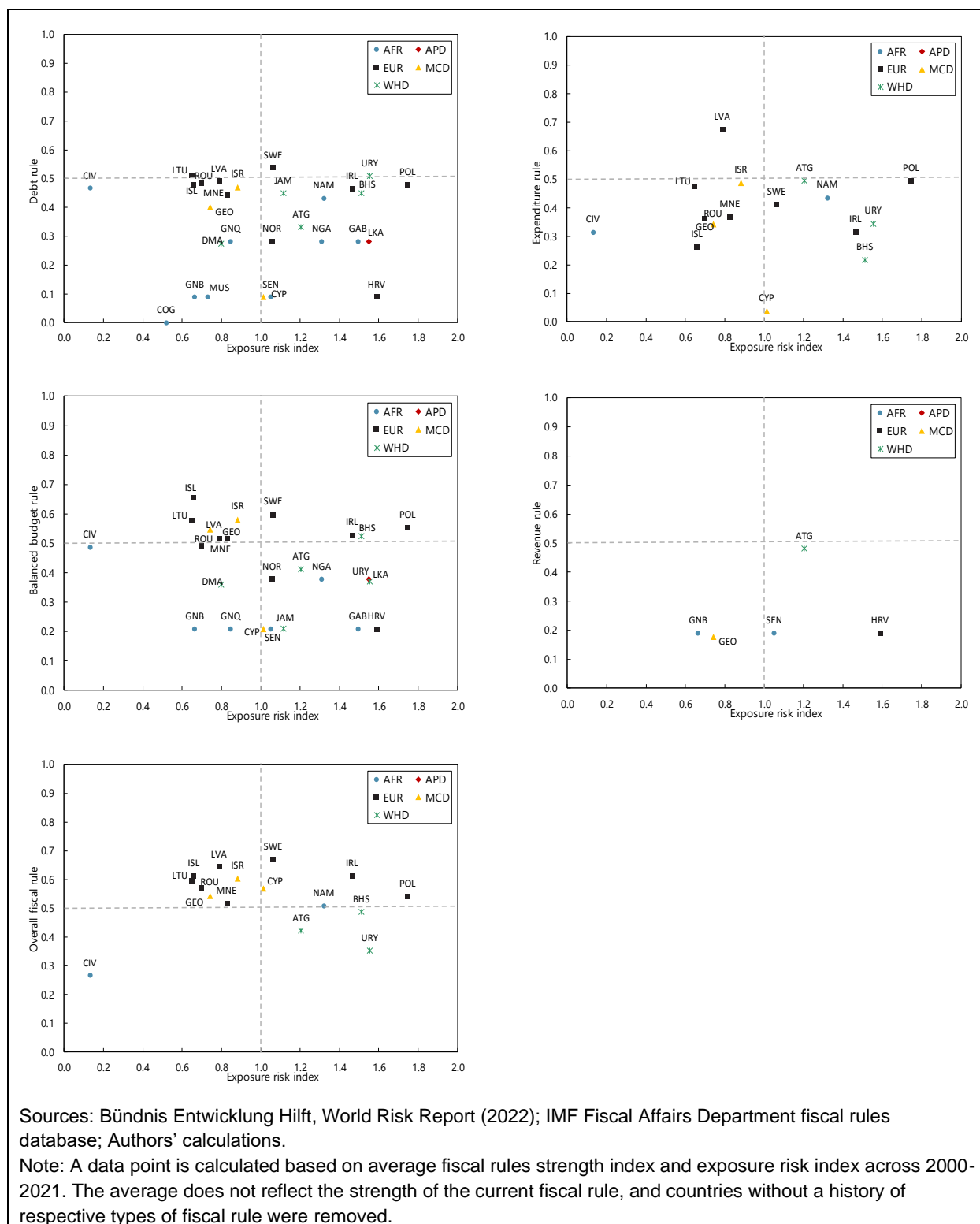
### (a) Aggregate Fiscal Rules Strength Index

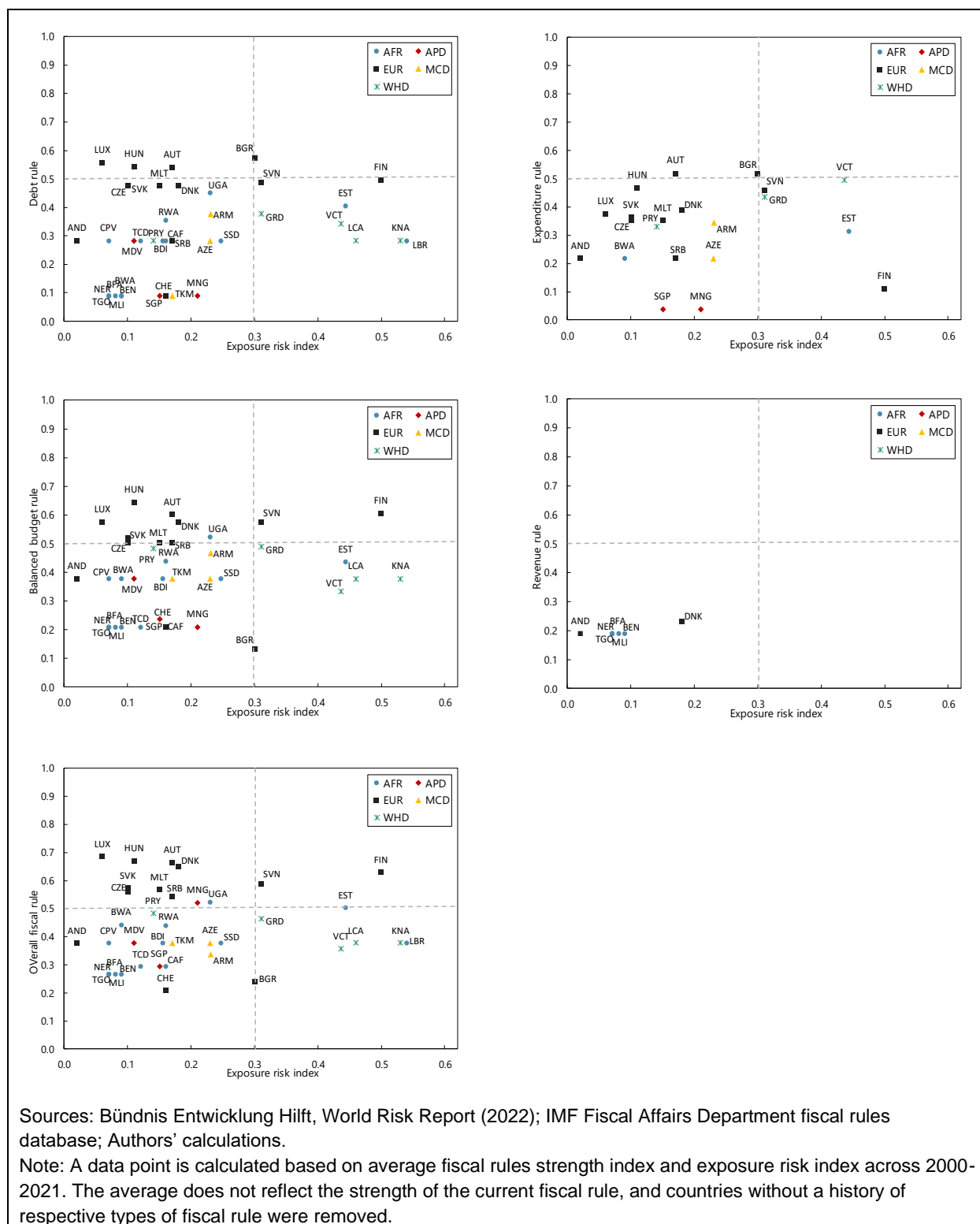


## (b) High ERI



## (c) Medium ERI

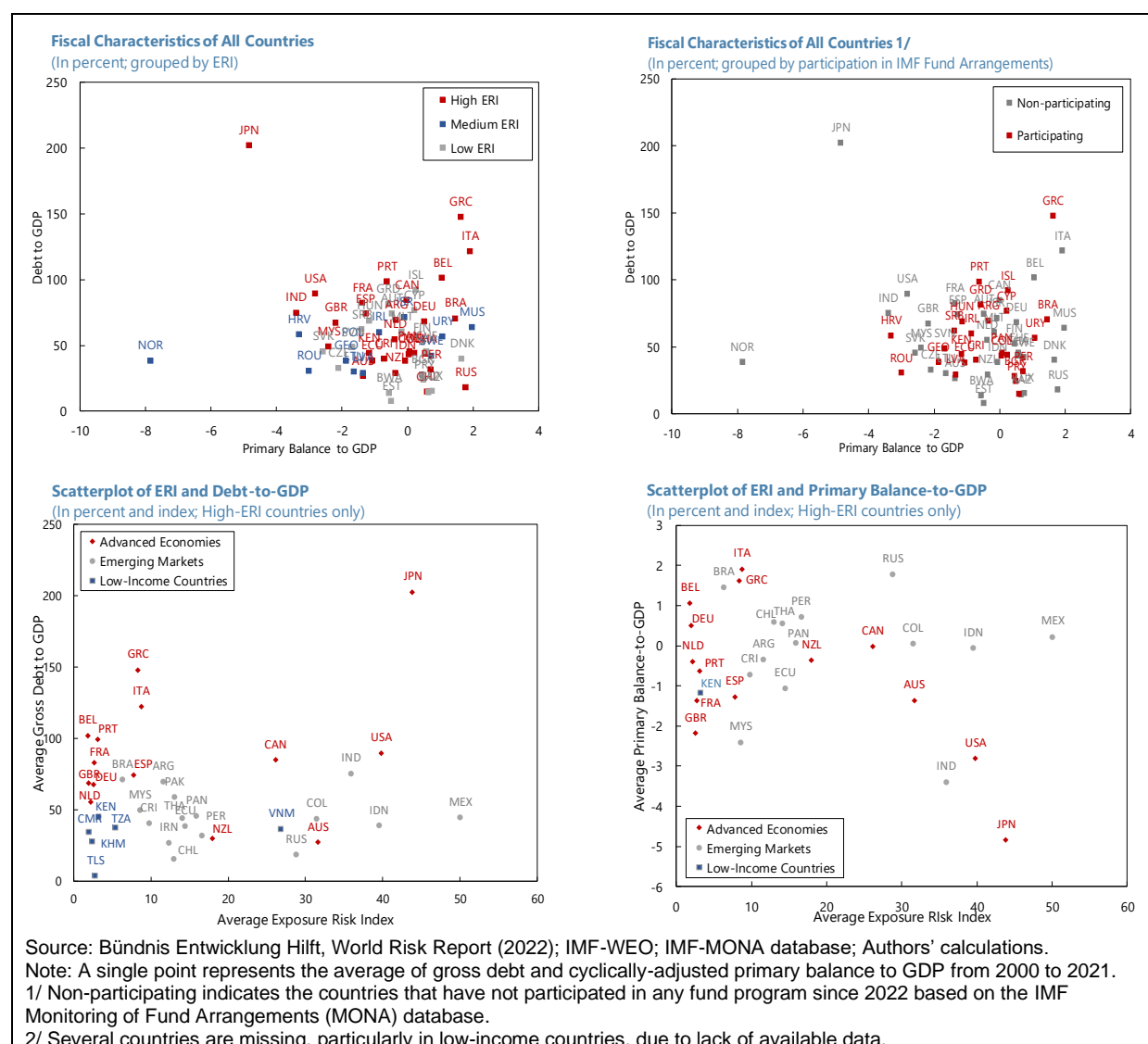


**(d) Low ERI**

## Appendix 9. ERI and Regulatory Enforcement on Fiscal Frameworks

The fiscal stances of countries are first assessed with the average of debt-to-GDP and primary balance-to-GDP ratios between 2000 and 2021. The countries with high-ERI are marked by higher debt-to-GDP ratio, while there is no outstanding characteristics in primary balance-to-GDP distribution.

By marking the fiscal characteristics chart by ERI and participation in the fund arrangements, we observe that countries with high-ERI do not necessarily participate in the fund arrangements because high-ERI countries are composed of high- and low-income level countries. This implies that the push for fiscal frameworks adoption is not highly relevant with strengthening of fiscal frameworks. The scatterplot of ERI and fiscal indicators show that there is no observable relationship among the explanatory variables, addressing potential multicollinearity problem.



## Appendix 10. Regression Results

### (a) First-Stage Regression (F-statistics), All Countries

Independent Variables: Instruments	All Countries										
	1	2	3	4	5	6	7	8	9	10	11
Log Exposure risk index	1.83 (0.17)										
Log Debt-to-GDP ratio		0.35 (0.55)									
Inflation			0.02 (0.90)								
Log GDP per capita				0.03 (0.86)							
Log Government fragmentation					0.01 (0.93)						
Political regime						0.16 (0.68)					
Log Government stability							0.94 (0.33)				
Log Age dependency								0.19 (0.66)			
Log Checks and balances									1.26 (0.26)		
Inflation targeting										0.08 (0.77)	
Monetary union											0.42 (0.51)

Null Hypothesis:  $\alpha_1 = 0$ ; p-values are in parentheses ( $p < 0.1$  rejects null hypothesis)

Note: Instruments represent the following: Lag of exposure risk index (instrument 1), Government expenditure as percent of GDP (instrument 2), GDP growth (instrument 3), GDP (instrument 4), Government effectiveness (instrument 5), Rule of law (instrument 6), Political stability (instrument 7), Working age population (instrument 8), Government accountability (instrument 9), Lag of inflation targeting (instrument 10), and Lag of monetary union (instrument 11).

### (b) 2SLS Regression, All Countries

Dependent variable	All Countries				
	FR	ER	DR	RR	BBR
Log Exposure risk index	0.06*	0.14*	0.10*	0.08*	0.09*
Log Debt-to-GDP ratio	0.12*	0.07*	0.11*	0.11*	0.07*
Inflation	-0.03*	-0.07*	-0.05*	-0.02*	-0.02*
Log GDP per capita	-0.02*	-0.10*	-0.04*	-0.01*	-0.02*
Log Government fragmentation	0.10*	0.54*	0.01*	0.39*	0.19*
Political regime	0.03*	0.03*	0.05*	0.03*	0.00*
Log Government stability	0.46*	1.22*	0.55*	0.79*	0.66*
Log Age dependency	-0.28*	-0.55*	-0.06*	0.68*	-0.13*
Log Checks and balances	-0.05*	-0.13*	-0.10*	-0.05*	-0.01*
Inflation targeting	0.12*	0.25*	0.16*	0.19*	0.13*
Monetary union	0.03*	0.33*	0.01*	0.10*	0.06*
Trend	0.01*	0.03*	0.03*	0.02*	0.02*
Constant	-2.90*	0.27*	2.04*	-5.15*	-2.21*
No. of Observations	1,079	1,070	1,083	1,078	1,086
R-Square	0.64	0.65	0.61	0.64	0.63

\* = Significant at least at 10 percent level ( $p < 0.1$ )

Note: Dependent variable = FR, ER, DR, RR, and BBR represent overall fiscal rules, expenditure rule, debt rule, revenue rule, and balanced budget rule respectively. No. of Observations is the total pool observations. Some countries have multiple rules in place simultaneously, which could be contributing to the similar number of observations across some rule types.

**(c) 2SLS Regression, by the IMF country classification**

Dependent variable	Advanced Economies (AE)					Emerging Markets (EM)					Low-income Developing Countries (LIDC)				
	FR	ER	DR	RR	BBR	FR	ER	DR	RR	BBR	FR	ER	DR	RR	BBR
Log Exposure risk index	-0.02*	-0.05*	-0.03*	-0.07*	-0.03*	0.05*	0.05*	0.03*	0.08*	0.02*	0.13*	0.60*	0.23*	0.14*	0.12*
Log Debt-to-GDP ratio	-0.04*	-0.13*	-0.04*	-0.10*	-0.05*	0.05*	0.22*	0.05*	0.17*	0.03*	-0.04*	-0.25*	-0.19*	0.07*	-0.04*
Inflation	-0.02*	0.09*	0.00	-0.01	-0.01*	0.02*	0.06*	0.01*	0.02*	0.01*	-0.01	-0.01	0.02	0.02	0.02*
Log GDP per capita	0.11*	0.12*	0.15*	0.22*	0.17*	0.01*	-0.07*	-0.01*	-0.05*	-0.03*	0.01*	0.25*	-0.06*	0.28*	0.01*
Log Government fragmentation	-0.18*	-0.61*	-0.13*	-0.01	-0.05	0.02*	-0.03*	0.03*	0.15*	0.09*	0.18*	1.02*	0.21*	0.34*	0.15*
Political regime	-0.02*	-0.16*	-0.02*	-0.01*	-0.01	-0.01	-0.11*	-0.04*	-0.03*	-0.03*	0.19*				0.23*
Log Government stability	-0.32*	-0.25*	-0.51*	-0.32*	-0.46*	0.49*	0.21*	0.11*	0.21*	0.03*	0.18*	0.60*	-0.08*	0.59*	0.12*
Log Age dependency	0.19*	0.58*	0.52*	0.27*	0.35*	0.18*	-0.12*	-0.03*	0.23*	-0.04*	1.16*	0.72*	1.02*	0.89*	1.11*
Log Checks and balances	0.14*	0.18*	0.11*	0.04*	0.01	-0.02	-0.23*	-0.17*	-0.14*	-0.10*	0.08*	0.43*	0.05*	0.19*	-0.06*
Inflation targeting	0.48*	0.18*	0.79*	0.61*	0.73*	0.06*	0.33*	0.26*	0.05*	0.21*					
Monetary union	0.10*	0.52*	0.06*	0.46*	0.08*	0.21*	0.61*	0.01	0.74*	0.17*	0.24*	1.04*	0.24*	0.46*	0.26*
Trend	0.02*	0.03*	0.03*	0.01*	0.01*	0.01*	0.02*	0.01*	0.01*	0.01*	0.01*	0.02*	0.01*	0.00	0.01*
Constant	2.38*	-5.05*	-4.01*	-3.40*	-3.06*	-2.45*	-1.45*	-1.30*	-2.33*	0.57*	-6.32*	-30.48*	-5.07*	-18.02*	-5.99*
No. of Observations	317	316	324	324	324	538	423	535	530	522	244	217	134	254	258
R-Square	0.60	0.61	0.75	0.75	0.61	0.60	0.59	0.60	0.70	0.60	0.69	0.72	0.94	0.62	0.67

\* = Significant at least at 10 percent level (p &lt; 0.1)

Note: Dependent variable = FR, ER, DR, RR, and BBR represent overall fiscal rules, expenditure rule, debt rule, revenue rule, and balanced budget rule respectively. No. of Observations is the total pool observations. Some countries have multiple rules in place simultaneously, which could be contributing to the similar number of observations across some rule types.

**(d) 2SLS Regression, by ERI level**

Dependent variable	High Exposure Risk Index					Medium Exposure Risk Index					Low Exposure Risk Index				
	FR	ER	DR	RR	BBR	FR	ER	DR	RR	BBR	FR	ER	DR	RR	BBR
Log Exposure risk index	0.15*	0.21*	0.13*	0.08*	0.24*	0.03	0.71*	0.18*	0.33*	0.10*	0.10*	0.32*	0.14*	0.11*	0.11*
Log Debt-to-GDP ratio	0.11*	-0.05*	-0.04*	0.11*	-0.08*						0.13*	0.34*	0.13*	0.24*	0.15*
Inflation	-0.02*	0.01*	-0.03*	-0.01*	0.02*	-0.04*	0.00	0.11*	-0.02*	-0.02*	-0.01	0.04*	0.02	-0.15*	-0.02*
Log GDP per capita	0.01*	-0.12*	-0.01*	-0.05*	-0.05*	-0.08*	-0.26*	-0.17*	-0.16*	-0.13*	0.01*	0.03*	-0.07*	-0.03*	0.05*
Log Government fragmentation	0.26*	0.51*	0.54*	0.39*	0.26*	0.06*	-0.38	0.01	0.35*	0.07*	0.09*	0.31*	0.03*	0.83*	-0.33*
Political regime	0.10*	-0.04	0.25*	0.08*	0.18*	0.06*	0.13*	0.88*	0.10*	0.06*	-0.01*	0.02	0.02	0.05	-0.12*
Log Government stability	0.13*	0.08*	0.56*	0.04	0.45*	-0.23*	0.08*	0.90*	-0.16*	-0.34*	0.28*	0.58*	-0.22*	0.80*	0.52*
Log Age dependency	0.66*	-1.10*	0.84*	-0.41*	-0.11*	-0.43*	0.39*	0.05	0.05	-0.59*	0.34*	-0.21*	-0.73*	1.53*	0.18*
Log Checks and balances	-0.06*	-0.24*	-0.12*	-0.15*	-0.24*	-0.15*	-0.07*	-1.98*	-0.30*	-0.25*	-0.03	-0.29*	0.13*	-0.26*	-0.10*
Inflation targeting	0.22*	0.23*	0.04	0.04	0.16*	0.08*	0.31*	0.20*	0.29*	0.22*	0.27*	0.20*	0.65*	0.45*	0.30*
Monetary union	0.15*	0.54*	0.15*	0.41*	0.29*	0.04*	0.57*	0.04*	0.12*	0.01	0.10*	0.58*	0.19*	0.71*	0.08*
Trend	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.02*	0.06*	0.02*	0.02*	0.01*	0.01*	0.01*	0.02*	0.02*
Constant	-4.12*	4.47*	4.55*	0.75*	-1.19*	2.37*	-0.52	-6.68*	0.99*	3.56*	-3.15*	-1.54*	2.34*	-6.72*	-3.21*
No. of Observations	245	274	236	245	293	278	70	239	302	278	298	298	298	258	298
R-Square	0.67	0.71	0.67	0.80	0.65	0.78	0.97	0.62	0.74	0.88	0.70	0.84	0.88	0.58	0.68

\* = Significant at least at 10 percent level (p &lt; 0.1)

Note: Dependent variable = FR, ER, DR, RR, and BBR represent overall fiscal rules, expenditure rule, debt rule, revenue rule, and balanced budget rule respectively. No. of Observations is the total pool observations. Some countries have multiple rules in place simultaneously, which could be contributing to the similar number of observations across some rule types.



## PUBLICATIONS

**Strengthening Fiscal Frameworks in the Presence of Rising Risk of Natural Disasters**  
Working Paper No. WP/2025/038