A Probabilistic Measure of State Fragility*

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Abstract

This paper develops a novel measure of state fragility: the probability of state failure. We define state failure as the inability to perform core functions and operationalize it through observable breakdowns—conflict, territorial control, institutional deficiency, and public service deterioration. Using a machine-learning approach, we estimate failure probabilities for 160 countries and assess their predictive performance and key predictors. The proposed measure is forward-looking, continuous, comparable across countries and over time, and exhibits strong predictive power. Political and institutional factors are the main predictors of failure, whereas aggregate macroeconomic conditions contribute little. State failure is highly persistent, different breakdowns tend to accumulate, and conflict emerges as the predominant mode of failure. This framework provides a clear and theoretically grounded approach to analyze fragility that is useful for both academic research and policy analysis.

Keywords: State fragility, State failure, Measurement, Forecasting

JEL Classification: C53, D74, O19

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1 Introduction

State fragility has become a catch-all term to describe the extent to which a state struggles to sustain its functions. Because fragile situations undermine economic performance and social welfare, fragility represents a central challenge for development.[1] Researchers use fragility measures to study its determinants and consequences,[2] while governments and international organizations[3] use them to guide interventions, including aid allocation, technical assistance, and stabilization programs. Prominent measures are the composite indices developed by the World Bank, the Fund for Peace, and the CIFP.[4] How fragility is conceptualized and measured therefore shapes how it is understood and addressed.

However, fragility indices are facing increasing criticism.[5] These stem from two related issues. The first is conceptual. The complexity of the state and the lack of consensus on how to conceptualize fragility have led to a proliferation of disconnected interpretations that are broad, imprecise, and often implicit.[6] Many approaches also conflate fragility with its consequences. Classifying states as fragile because they experience conflict is akin to labeling a glass as fragile once it has already broken. This departs from how fragility is understood in other fields: as the propensity toward failure, not the failure itself.

This conceptual ambiguity feeds into a second problem: measurement. Fragility indices aggregate multiple indicators, often with limited theoretical guidance and arbitrary weighting schemes and thresholds. They frequently risk double-counting, build on other fragility indices, rely heavily on subjective expert assessments, or adopt ranking-based approaches.[7] The resulting indices are then often discretized into binary classifications—"fragile" versus

1. Fragile states experience low growth and concentrate a substantial share of global poverty (World Bank 2011; Corral et al. 2020).

2. See studies on the determinants (Bertocchi and Guerzoni 2012; Feeny, Posso, and Regan-Beasley 2015; Tusalem 2016), macroeconomic consequences (Chuku and Onye 2019), aid effectiveness (Feeny and McGillivray 2009; Samy and Carment 2019), growth convergence (Johnson and Papageorgiou 2020), fragility convergence (Koseoglu and Yucel 2025), and internal conflict (Rizvi and Véganzonès-Varoudakis 2023).

3. This includes the World Bank, the OECD, the IMF, the African Development Bank, the Asian Development Bank, the *g7+*, and government agencies in the US, EU, and the UK, among others.

4. These correspond to the Fragile and Conflict-Affected Situations classification, the Fragile States Index, and the CIFP Fragility Index. Other indices include the OECD's States of Fragility framework, the IDOS's Constellations of State Fragility index, and the INSCR's State Fragility Index and Matrix.

5. For critical reviews, see Sanín (2011), Bertoli and Ticci (2012), Nay (2013), Ferreira (2016), and Asylbek kyzy et al. (2023). Related concerns arise in Besley and Persson (2011) and Milante and Woolcock (2017).

6. Fragility is often defined as the measurement itself or as a condition of fragile states. Labels such as "fragile," "failed," "failing," "weak," or "ineffective" are often used interchangeably and loosely defined. See Table A1 in the Appendix for a summary of definitions.

7. See Asylbek kyzy et al. (2023) for an assessment of the limitations of existing fragility measures.

"non-fragile"—using thresholds with no clear foundation.[8] As a result, such indices are opaque, difficult to compare across countries and over time, and reflect largely methodological choices.

This paper proposes a probabilistic measure of state fragility that mitigates these issues. Building on the fragility framework from Margalef et al. (2025), we conceptualize fragility as proneness to failure and measure it using the probability of state failure. State failure is defined as the inability to perform core coercive and administrative functions and we operationalize it through observable breakdowns—conflict, territorial control loss, institutional deficiency, and public service deterioration. Using panel data on political, institutional, economic, and demographic indicators, we conduct a prediction exercise using machine learning to estimate the probability of state failure in the following year—our measure of fragility—for each country and year. We also estimate failure probabilities separately for each type of breakdown to preserve interpretability and examine their interaction. We report annual estimates for 160 countries from 2005 to 2021 and evaluate their predictive performance and main predictors.

The result is a forward-looking, continuous, high-coverage measure with a clear interpretation that separates fragility from its consequences and is comparable across countries and over time. Predictive power is high, making the measure well-suited to forecasting and early-warning applications. We show that state failure is substantially easier to predict following prior failure than at first onset. Political and institutional factors account for most of the predictive power, while aggregate macroeconomic indicators contribute little. Our operationalization of state failure further shows that failure is highly persistent, that different breakdowns tend to accumulate, and that conflict is the predominant form of state failure.

We view our measure as a second-best solution, given the inherent constraints in evaluating the state. While our conceptualization of state fragility is clear, the operationalization of state failure still rests on variables and threshold choices that are contestable. In other words, the remaining conceptual challenges are reduced to the state failure concept. A second limitation is that our machine-learning estimates provide predictive insights rather than causal effects. The measure is intended to support crisis preparedness, but it does not directly identify the mechanisms to reduce fragility and thus prevent state failure. Overall,

8. Milante and Woolcock (2017) argues that the World Bank's fragility index uses an arbitrary threshold (3.2) to classify countries as fragile.

our approach alleviates the "wickedness" of state fragility.[9]

Related literature - This paper bridges three strands of the literature. The first concerns political science conceptualizations of the state's functions. Much of this literature builds on an institutional, Weberian view of the state, according to which the state is defined by its monopoly over the legitimate use of force.[10] While there is broad consensus that security is a core state function, there is substantial variation in the inclusion of other functions, such as the satisfaction of citizens' basic needs, economic management, administrative capacity, and rule enforcement (Chhibber et al. 1997; Rotberg 2004; Ghani, Lockhart, and Carnahan 2006).[11] Parts of the literature also treat legitimacy as a necessary condition for a well-functioning state, capturing whether state authority is accepted as rightful (Goldstone 2008; Call 2011). We adopt an effectiveness-based approach that focuses on the state's realized performance in its coercive and administrative functions, which we operationalize using direct indicators closely linked to citizens' well-being: battle-related deaths, territorial control, and access to basic services such as water, electricity, and vaccination.[12]

The second strand, largely policy-oriented, focuses on constructing measures of state fragility. Here, we restrict attention to measures explicitly labeled as state fragility. Beyond composite indices, which suffer from the limitations discussed above (OECD 2016; Marshall and Elzinga-Marshall 2019; Ziaja, Grävingholt, and Kreibaum 2019; CIFP 2023; World Bank 2024; The Fund for Peace 2025), recent work has proposed alternative approaches, including probabilistic measures. Chami et al. (2021) study, in a theoretical model, how incorporating the probability of state failure alters optimal macro-fiscal policy. Mueller (2018) is the most closely related empirical work, using a prediction exercise on failure events encompassing declines in GDP per capita, changes in political institutions, and civil war. In contrast, Cebotari et al. (2024b) conceptualize fragility in terms of economic performance, defining it as the inability to generate or sustain growth or as a disproportionately adverse response to

9. State fragility is considered a "wicked problem" (Rittel and Webber 1973; Brinkerhoff 2014), as it has no clear definition or single solution, involves complex causes, and requires context-specific responses with uncertain effects.

10. Weber (1978) defines the state as a compulsory political organization whose administrative apparatus successfully claims the monopoly over the legitimate use of physical force within a given territory.

11. See also Patrick (2007) and Rice and Patrick (2008). Acemoglu (2005) and Tabellini (2005) provide a more economically grounded perspective on state functions. See the Table A2 in the Appendix for definitions of state functions.

12. We abstract from the concept of state capacity, which we understand as the underlying potential of the state to perform its functions, rather than their realized performance. Conflating state effectiveness with state capacity is another conceptual problem in the literature (Fukuyama 2004; Call 2011).

negative shocks.[13] Relative to this literature, the paper provides a theoretically grounded framework that distinguishes fragility from state failure and motivates a forward-looking measure suited for anticipation.

Finally, our approach relates to the literature on forecasting state failure. While a large body of work studies the drivers and correlates of state failure, especially conflict, we restrict attention to studies that explicitly conduct forecasting exercises. This body of work has largely focused on threats to political order and security. Early efforts to predict state failure operationalized it through conflict and regime breakdown, including revolutionary and ethnic wars, autocratization, and genocide or politicide (Esty et al. 1998; King and Zeng 2001). A later literature instead focuses on predicting specific breakdowns associated with political instability: armed conflict (Hegre et al. 2013; Brandt, Freeman, and Schrodt 2011; Chadefaux 2014; Chiba and Gleditsch 2017; Mueller and Rauh 2018, 2022), coups d'État (Cebotari et al. 2024a), and autocratization (Goldstone et al. 2010; Mueller 2018). However, to the best of our knowledge, there is no prior work that conducts predictive exercises for other forms of state breakdown, such as losses of territorial control or failures in public service provision. We fill this gap by forecasting a broader concept of state failure that encompasses multiple breakdowns, while estimating each component separately to retain interpretability and examine their interaction.

Outline - The paper is structured as follows. Section 2 presents the conceptual framework of state fragility and motivates the use of a probabilistic measure. Section 3 develops the empirical measure. The concluding section summarizes the main findings and outlines directions for future research.

2 Conceptual framework

Our framework applies the general fragility framework developed in Margalef et al. (2025) to the context of the state. In that framework, fragility is defined as the ease with which an object fails, and a fragility measure quantifies this "ease" conditional on a definition of failure. Knowledge of the failure process and the purpose of the analysis then determine which type of fragility measure is most appropriate. Applied to states, fragility therefore

13. Their notion draws on Taleb and Douady (2013) concept of fragility, whereby small uncertainty in macro-level parameters can generate disproportionately large adverse outcomes.

refers to the proneness to state failure; accordingly, defining what constitutes state failure is a prerequisite for discussing its measurement.

2.1 Defining state failure

We define state failure as the inability of the state to perform its core coercive or administrative functions. These functions and their associated breakdowns are defined as follows:

- **Coercive functions:** prevent violence and maintain a monopoly on the use of force.
  - *Conflict* occurs when political violence escalates sharply or remains persistently high.
  - *Territorial control loss* arises when the state no longer governs a substantial share of its territory.
- **Administrative functions:** enforce rules and deliver essential public services.
  - *Institutional deficiency* is present when legal systems fail to enforce rules and corruption is pervasive.
  - *Public service deterioration* occurs when the state fails to provide basic services such as education, healthcare, or infrastructure.

State failure occurs when the state fails in one or both core functions. Failure in coercive functions is defined by the occurrence of either conflict or loss of territorial control. These outcomes represent alternative manifestations of a breakdown in the state's monopoly over the use of force. A state may retain formal sovereignty while experiencing sustained internal violence, or it may lose effective control over parts of its territory without widespread fighting. By contrast, failure in administrative functions is defined as the joint occurrence of institutional deficiency and public service deterioration. This requirement ensures that failures in service provision reflect deficiencies in governance rather than deliberate policy choices or temporary disruptions driven by exogenous shocks, such as natural disasters.

We operationalize these breakdowns using simple and widely available indicators to ensure broad cross-country and temporal coverage. We draw on standard cross-country datasets commonly used in the literature on conflict, governance, and development outcomes. The indicators are defined as follows:

- **Conflict**. A country is classified as experiencing conflict if either of the following conditions holds:
  - Conflict-related deaths exceed 250 and 2 per 100,000 population using data from the (ACLED), or exceed 150 and 1 per 100,000 using data from the (UCDP).
  - Conflict-related deaths are between 1–2 per 100,000 (ACLED) or 0.5–1 per 100,000 (UCDP), and total fatalities more than double relative to the previous year.[14]
- **Territorial control loss**. The state is classified as having lost territorial control if it governs less than 75 percent of its territory, based on indicators from the (V-Dem).
- **Institutional deficiency**. Institutions are deficient when the rule of law index falls below the 30 percent and executive corruption exceeds the 70 percent (V-Dem).[15]
- **Public service deterioration**. Public service provision is classified as deteriorating when the annual change in an index averaging six indicators falls by at least 2 percent. The indicators include access to electricity, access to clean water, DPT and measles vaccination rates (from the WB), and enrollment in primary and lower secondary education (from UNESCO).

The conflict definition follows the WB's operational approach, which characterizes conflict based on intensity thresholds in conflict-related fatalities and their evolution over time. The threshold for territorial control loss is set at 75 percent to capture substantial losses, since even highly capable states rarely exhibit full territorial control.[16] Institutional deficiency is defined using percentile thresholds for rule of law and executive corruption to capture severe and persistent weaknesses, while maintaining comparability across countries and time. Finally, public service deterioration is measured using a set of indicators that capture the

14. To avoid classifying isolated episodes of intense violence, such as a single battle or terrorist attack, we exclude country–years in which at least 75 percent of annual fatalities occur within a three-day window and the remaining deaths fall below the absolute thresholds defined above. In addition, we exclude non-state conflicts from the UCDP data and fatalities associated with protests, riots, and strategic development events from the ACLED data.

15. The rule of law indicator captures the extent to which legal rules are enforced in a transparent, impartial, and consistent manner across actors and over time. Executive corruption measures the prevalence of corrupt practices among members of the executive, including bribery, embezzlement, and the misuse of public resources for private benefit.

16. For example, Germany's territorial control score in V-Dem was around 90 in the early 2000s.

provision of essential services. Aggregation prevents identifying state failure when small shocks in individual components would otherwise drive failure classifications.

Given our operationalization of state failure, it is useful to examine the empirical properties of the data. State failure exhibits strong persistence over time: countries that experience failure tend to remain in that state in subsequent years. Figure 1 illustrates the evolution of the probability of remaining in a state of failure, conditional on being in failure in the previous period. Approximately 75 percent of states that fail remain in failure in the following year. Although this probability declines over time, it remains above 50 percent even after ten years.

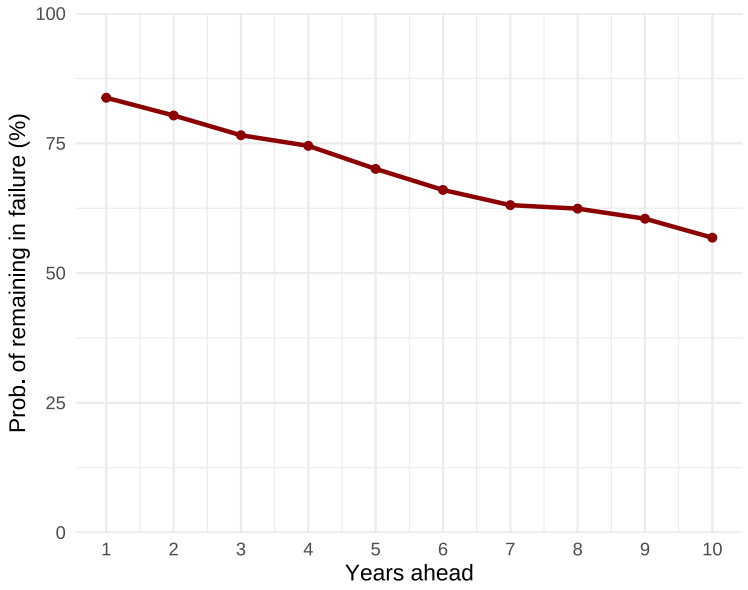


Figure 1: Persistency of state failure

Notes: The figure shows the probability that a country remains in state failure at horizons from one to ten years after an initial failure.
Sources: Authors' elaboration based on the data discussed in Section 2.

A second feature of the data is that breakdowns often overlap, whereas public service deterioration tends to stand apart. Figure 2 reports the pairwise correlations between the four breakdowns. Breakdowns are positively associated. Conflict and territorial control loss display the strongest correlation (0.48), reflecting the fact that high-intensity violence is often accompanied by loss of territorial authority. Institutional deficiency is also moderately correlated with conflict (0.29) and territorial loss (0.27). In contrast, public service deterioration shows substantially weaker correlations with the other breakdowns. This weaker association

is consistent with the fact that service provision may be affected by factors partly orthogonal to the state's coercive role, such as natural disasters. Overall, these patterns indicate that breakdowns tend to co-occur, but with important asymmetries across them.

Figure 2: Correlation across breakdown dimensions

Notes: Pairwise correlations between conflict (C), territorial control loss (T), institutional deficiency (I), and public service deterioration (P).
Sources: Authors' elaboration based on the data discussed in Section 2.

Figure 3 displays the configurations of breakdowns observed among state failures, distinguishing between failure onsets (countries not in failure in the previous year) and continuations (countries already in failure). Conflict alone (C) is the most common configuration and accounts for the largest share of onsets. It is followed by configurations that combine conflict with territorial control loss and institutional deficiency (CTI), as well as conflict with institutional deficiency (CI). In this sense, failures in coercive functionality—conflict in particular—emerge as the primary breakdown observed in the data. While institutional deficiencies are also prevalent, strong institutions play a critical role in preventing conflict from cascading into broader systemic disruptions with adverse consequences for human well-being (World Bank 2011; Acemoglu and Robinson 2012). Note also that the full combination of conflict, territorial loss, institutional deficiency, and public service deterioration (CTIP) is more common than many of its individual subsets. These patterns also suggest that breakdowns frequently coexist and reinforce one another.

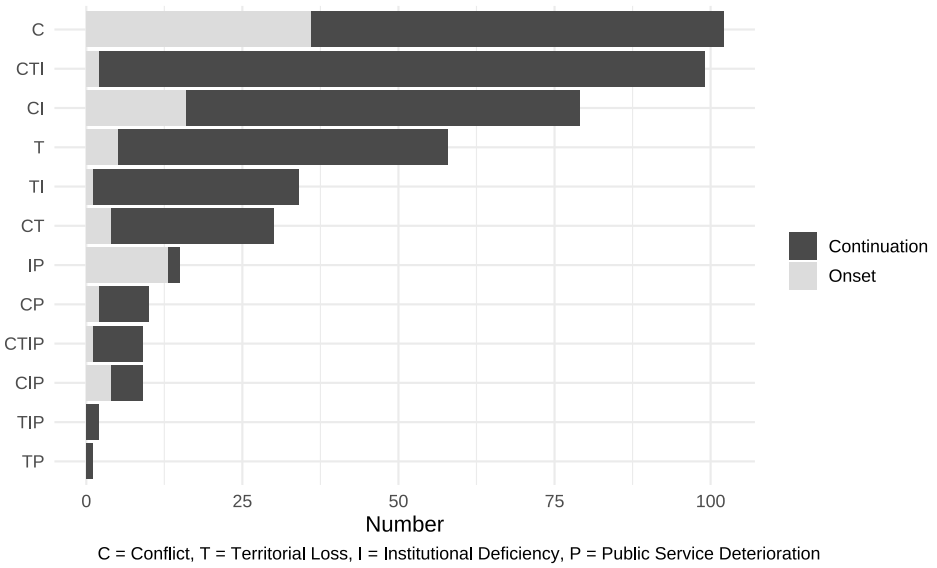


Figure 3: Frequency of state failure configurations

Notes: Breakdown configurations among ineffective states, distinguishing onsets and continuations.
Sources: Authors' elaboration based on the data discussed in Section 2.

2.2 The failure process

We identify stress factors that are widely used in the literature and plausibly contribute to state failure.[17] We distinguish among a broad set of economic, political, demographic, and contextual factors. In addition, the current state of the country—whether it is already in failure or not—affects future failure through persistence. We therefore also include breakdown variables. Figure 4 illustrates our conceptualization of the state failure process.

The variables in these categories are as follows:[18]

- **Economic variables**. Official development assistance per capita (ODA), foreign direct investment inflows (FDI), natural resource rents, GDP per capita growth, and inflation.
- **Political variables**. Institutional and participatory features, including civil liberties, electoral democracy, power sharing among social groups, political participation, civil

17. Margalef et al. (2025) distinguishes between stress variables, object characteristics, and external factors, depending on whether they act as primary stressors, controls, or properties inherent to the object. In the context of state failure, however, these distinctions are often complex and blurred, and we therefore do not impose them.
18. A description of each variable and its data source is provided in Table A3 in the Appendix.

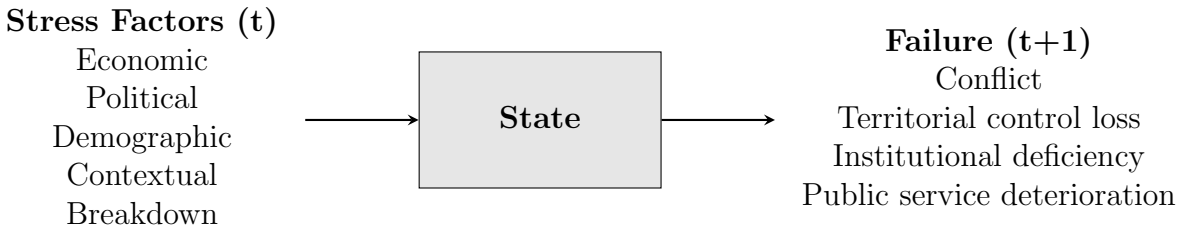


Figure 4: Process for State Failure

Notes: This figure illustrates the stress–damage process applied to states. Broad categories of stress inputs interact with the state to generate breakdowns in coercive and administrative core functions, which determine failure.
Sources: Authors' elaboration.

society participation, central bank independence, women's representation in parliament, and the exclusion of social groups from power.

- **Demographic variables**. Population shares aged 0–14 and 15–64, male youth unemployment, employment in agriculture, and urban population growth.
- **Contextual factors**. Presence of conflict in neighboring countries.
- **Breakdown variables**. Access to basic sanitation and electricity, DPT and measles immunization coverage, primary and lower secondary school enrollment, battle-related deaths per capita, territorial authority, executive corruption, and the rule of law.

2.3 Arguments for a probabilistic measure

Margalef et al. (2025) distinguishes five types of fragility measures: critical stress measures, damage condition measures, conditional probability measures, unconditional probability measures, and indices. The first three require conditioning on a single, well-defined stress variable (such as GDP growth). A critical stress measure identifies the level of stress at which failure occurs (the growth rate at which a state fails). A damage condition measure assesses whether a given level of stress produces failure (whether a specific growth rate leads to state failure). A conditional probability measure captures the probability of failure conditional on a particular stress level (the probability that a state fails given a certain growth rate). These approaches are not well-suited to the context of state failure, where no single factor drives failure, and multiple factors instead interact in complex ways.

This leaves composite indices and unconditional probability measures as the main alternatives. Indices are particularly common in settings where failure is difficult to define, relevant data are limited, or failure events are too rare to support statistical modeling. In this paper, we argue that sufficient information exists to adopt an unconditional probability measure of state failure.

3 Measurement

We perform a forecasting exercise using machine learning based on the variables described in the previous section. Machine learning methods are well-suited to this setting because they can capture complex and nonlinear relationships across a large set of predictors, which is essential for modeling a multifaceted phenomenon such as state failure. We use a random forest model.[19]

Predictions are generated using an expanding-window forecasting approach. For each country–year, we forecast future state failure using only information available prior to the outcome. As new data become available, the model is updated and re-estimated, allowing predictions to incorporate newly observed information. To ensure sufficient data for initial training, we begin the exercise with a five-year estimation window. This design mimics an early-warning system and ensures that no contemporaneous or future information is used in prediction, which is standard practice in forecasting applications.

The model estimates the probability of state failure for each country and year, which is our measure of state fragility. The resulting dataset covers 160 countries over the period 2005–2021. Figure 5 provides a snapshot of the fragility measure in 2010 for countries with a predicted failure probability above one percent. It distinguishes between countries that were already in failure and those that were not. The model assigns higher probabilities to countries already experiencing failure, as it learns and exploits the persistence of failure in the data. However, some countries not currently in failure exhibit elevated fragility scores, while others in failure display relatively lower probabilities. These patterns highlight the model's ability to identify both countries on the verge of entering state failure and those with a higher likelihood of recovery.

19. This is a relatively simple and transparent method that combines many decision trees estimated on random subsamples of the data and subsets of predictors. Each tree produces a prediction, and the final forecast is obtained by aggregating predictions across trees.

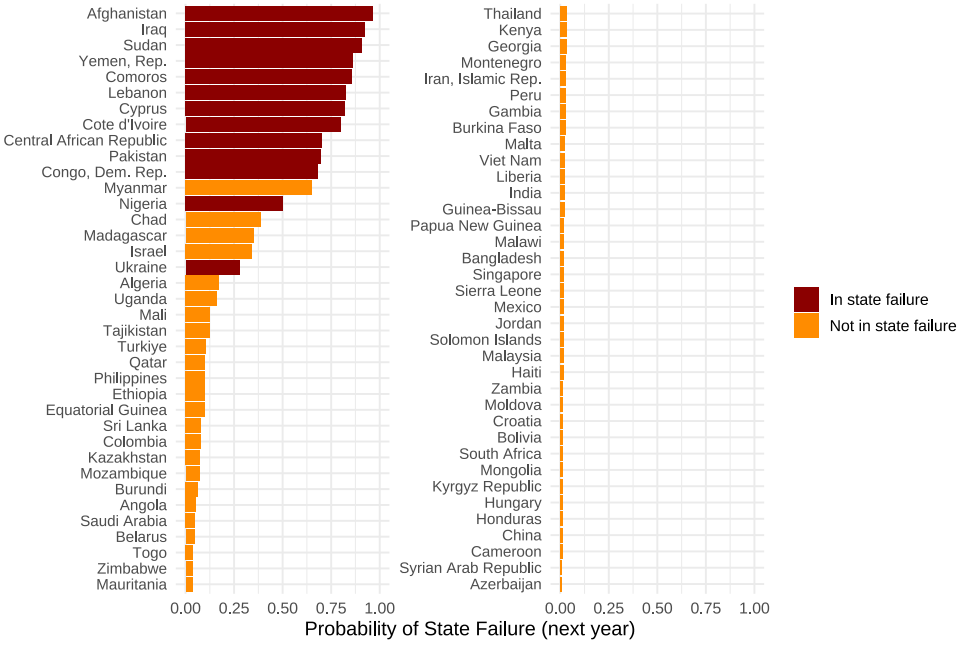


Figure 5: Fragility measure for 2010

Notes: Country-level fragility scores for 2010, distinguishing states in failure from those not in failure.
Sources: Authors' elaboration based on the data discussed in Section 2.

Figure 7 illustrates the evolution of the fragility measure for a selected set of countries exhibiting different trajectories. Afghanistan displays persistently high fragility throughout the period. Chad exhibits a U-shaped pattern, with fragility declining between 2007 and 2013 before rising again. Nigeria shows a gradual increase in the probability of state failure over time. Ukraine, by contrast, experiences a sharp increase followed by a rapid return toward baseline levels. These trajectories highlight critical moments at which fragility intensifies or recedes, indicating which countries warrant closer attention and identifying points at which trajectories may be influenced or altered.

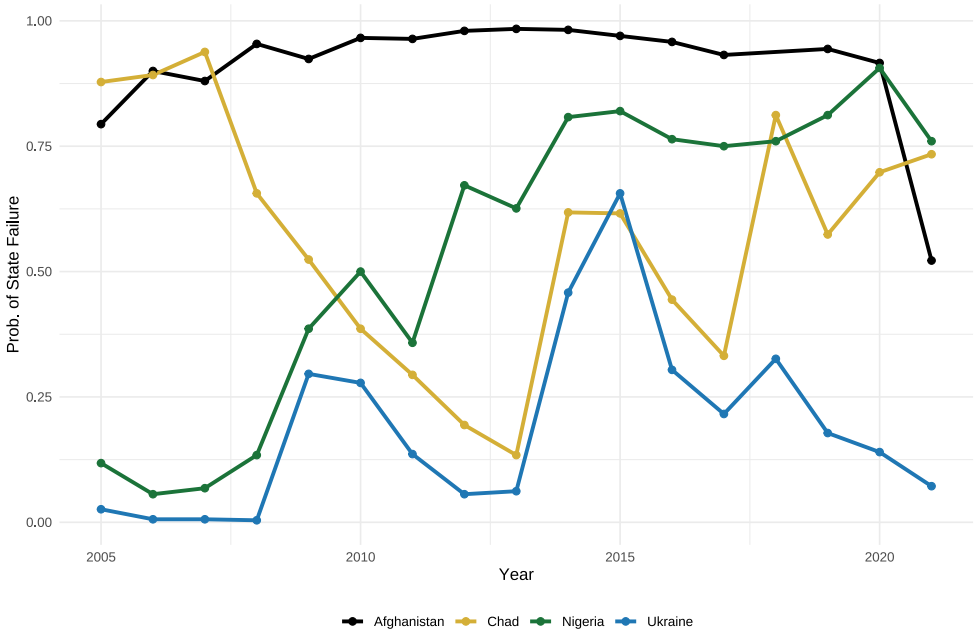


Figure 6: Evolution of fragility over time

Notes: Time paths of the fragility measure for selected countries illustrating different persistence and recovery patterns.
Sources: Authors' elaboration based on the data discussed in Section 2.

However, to understand which specific dimensions of state failure drive these changes, a more granular decomposition of the underlying breakdowns is required. We therefore repeat the forecasting exercise separately for each breakdown, which allows us to construct country-specific fragility profiles. Figure 7 illustrates this decomposition for Nigeria. The risk of institutional deficiency remains persistently high throughout the period. By contrast, conflict risk increases gradually in the early years and reaches high levels by around 2015. The risk of territorial control loss is largely absent until the late 2010s, while public service deterioration displays moderate risk around 2011–2012 before stabilizing.

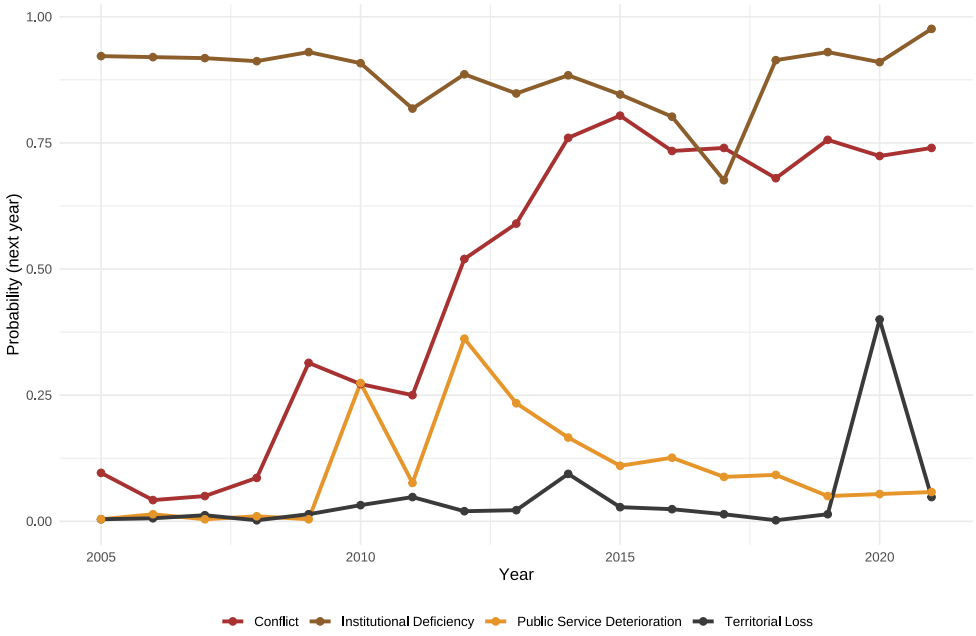


Figure 7: Evolution of Nigeria's fragility profile

Notes: The figure shows the decomposition of Nigeria's predicted fragility into its underlying breakdown dimensions over time.
Sources: Authors' elaboration based on the data discussed in Section 2.

4 Evaluation

We evaluate predictive performance using two standard metrics: the area under the receiver operating characteristic curve (AUC–ROC) and the area under the precision–recall curve (AUC–PR). The ROC curve plots the true positive rate against the false positive rate across classification thresholds.[20] The ROC–AUC summarizes this relationship into a single statistic, where a value of one indicates perfect discrimination and a value of 0.5 corresponds to random classification. Higher ROC–AUC values indicate a stronger ability to distinguish between failure and non-failure states.

The PR curve instead evaluates the trade-off between precision and recall, focusing on performance for the positive class.[21] This metric is particularly informative in settings with

20. The true positive rate (TPR), also known as sensitivity, is defined as $\text{TPR} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$. The false positive rate (FPR) is defined as $\text{FPR} = \frac{\text{False Positives}}{\text{False Positives} + \text{True Negatives}} = 1 - \text{Specificity}$.

21. Precision is defined as $\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$. Recall is equivalent to the true

class imbalance, where positive events are relatively rare.

Figure 8 reports the ROC and PR curves of the model, together with their corresponding AUC values, for two evaluation scenarios. The first considers all country–year observations, regardless of whether a country was already in state failure. The second restricts attention to onsets, defined as cases in which a country transitions into failure. The model performs strongly when evaluated over all observations, with a ROC–AUC of 0.96 and a PR–AUC of 0.84. Predictive performance declines substantially when focusing only on onsets: the ROC–AUC falls to 0.84 and the PR–AUC to 0.17. This gap highlights the greater difficulty of forecasting new episodes of state failure relative to identifying continuing cases.

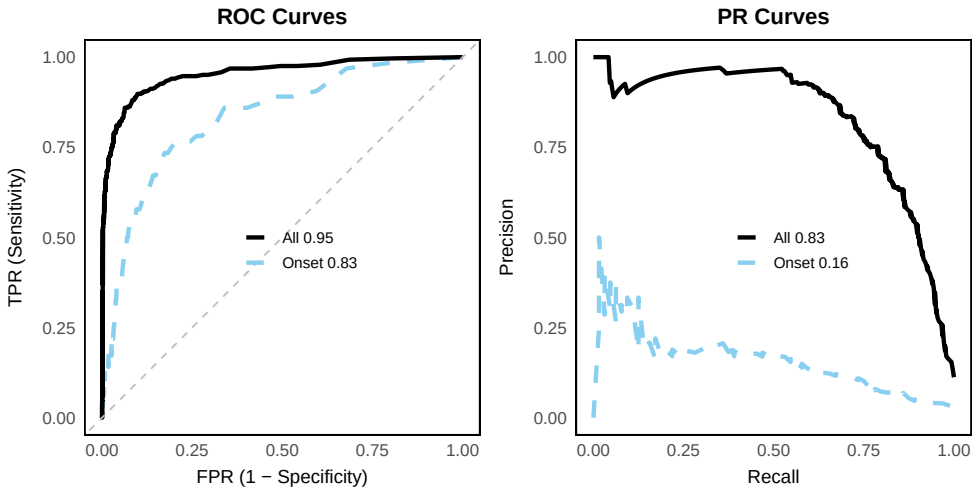


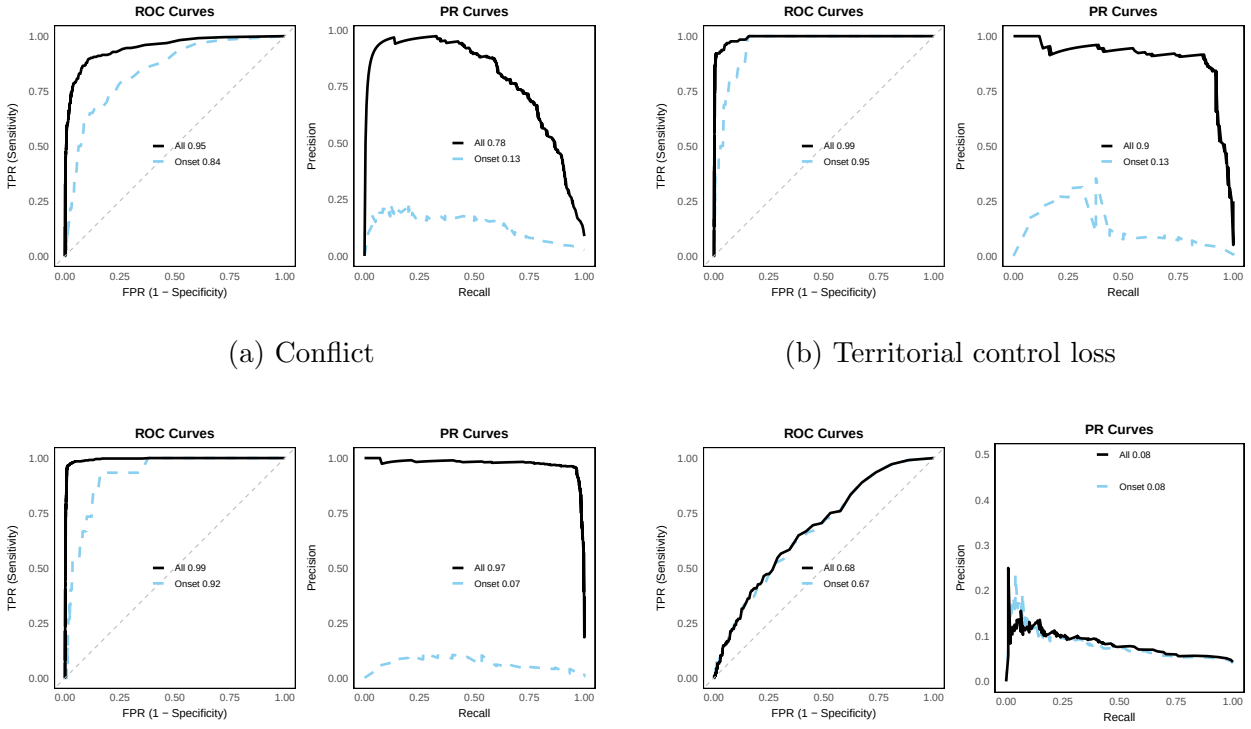
Figure 8: ROC and PR curves

Notes: The figure reports ROC and PR curves for the full sample of country-year observations and for failure onsets only. Areas under the curves summarize predictive performance.
Sources: Authors' elaboration based on the data discussed in Section 2.

Figure 9 reports the corresponding predictive performance for each breakdown. Conflict follows a pattern similar to overall state failure, with strong predictive performance for continuations and weaker performance for onsets. Institutional deficiency and territorial control loss exhibit near-perfect performance, with ROC–AUC values approaching one, indicating almost perfect discrimination. By contrast, public service deterioration is considerably harder to predict, with an ROC–AUC value of 0.68. As in the aggregate analysis, predicting onsets is generally more challenging than predicting all cases. An exception arises for public service

positive rate.

deterioration, which is largely driven by this breakdown occurring predominantly as onsets rather than continuations, as shown in Figure 3.



(a) Conflict

(b) Territorial control loss

(c) Institutional deficiency

(d) Public service deterioration

Figure 9: ROC and PR curves by breakdown

Notes: Each panel reports ROC and PR curves for the corresponding breakdown dimension, evaluated on the full sample and on failure onsets only. Areas under the curves summarize predictive performance.
Sources: Authors' elaboration based on the data discussed in Section 2.

We examine how different variables contribute to the fragility measure. Given that persistence is a well-established and dominant predictor of state failure, we retrain the random forest after excluding the variables used to define the breakdowns to focus on other contributing factors. Importantly, these results should not be interpreted as causal relationships.

Figure 10 reports variable importance based on the mean decrease in accuracy, which measures the reduction in predictive performance when a given variable is omitted. Higher values indicate greater importance. Political variables emerge as the most influential predictors, with civil liberties, electoral democracy, power sharing among social groups, and the exclusion of social groups ranking highest. Demographic factors, including population age structure, contribute meaningfully. Within the economic domain, sectoral characteris-

tics—such as employment in agriculture and natural resource rents—are more informative than aggregate macroeconomic indicators such as inflation or GDP per capita growth.

Figure 11 shows variable importance for each breakdown. The prominence of political variables persists across breakdowns. An exception arises for territorial control loss, for which demographic variables emerge as the most influential predictors. By contrast, aggregate macroeconomic variables and measures of conflict in neighboring countries rank low across breakdowns.

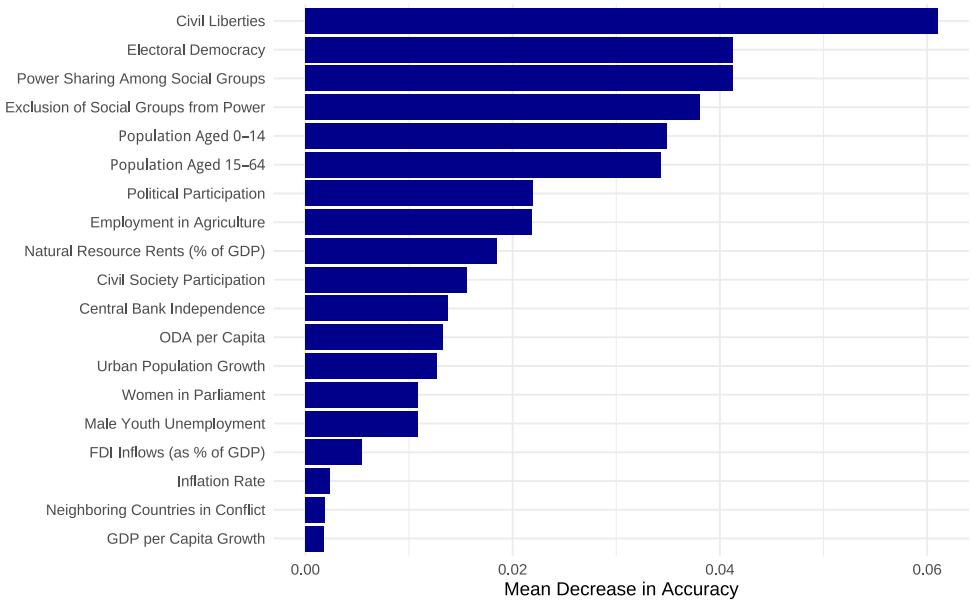
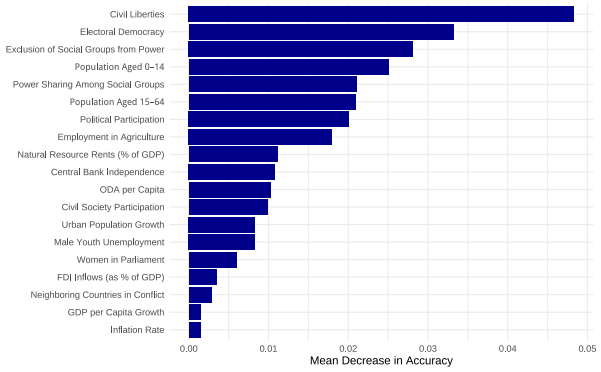
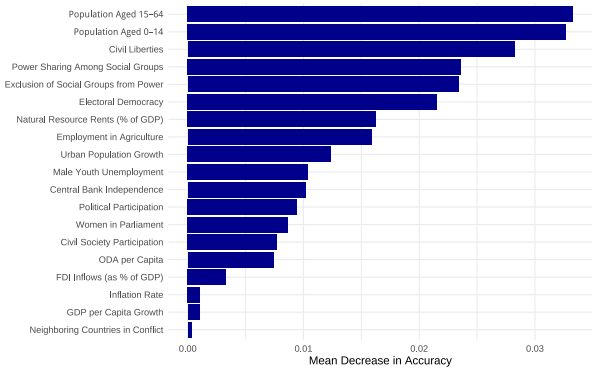


Figure 10: Variable importance for overall state failure

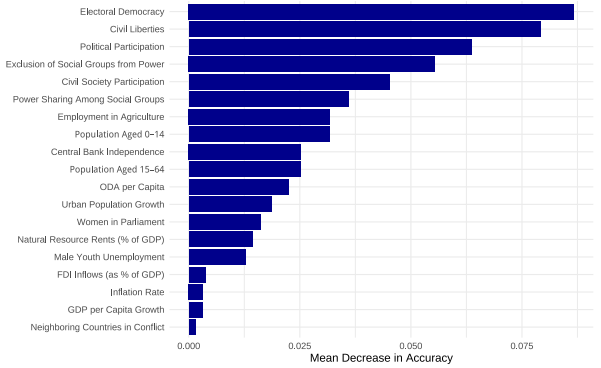
Notes: Variable importance is measured using the mean decrease in accuracy from the random forest model. Breakdown-defining variables are excluded to abstract from persistence effects.
Sources: Authors' elaboration.



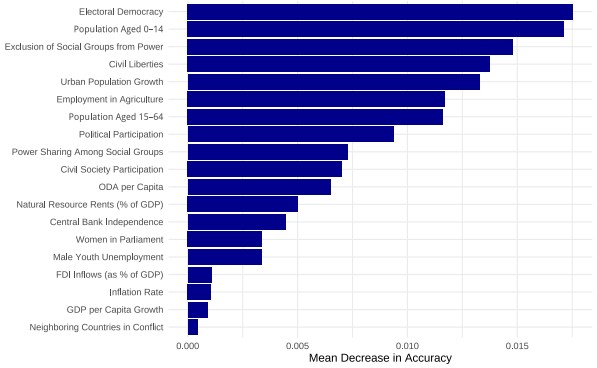
(a) Conflict



(b) Territorial control loss



(c) Institutional deficiency



(d) Public service deterioration

Figure 11: Variable importance by breakdown

Notes: Variable importance is computed separately for each breakdown dimension using the mean decrease in accuracy. Breakdown-defining variables are excluded in all specifications.
Sources: Authors' elaboration based on the data discussed in Section 2.

A complementary approach to analyzing predictors uses SHAP (Shapley Additive Explanations) values, which quantify the contribution of each variable to the predicted probability of state failure at the observation level. SHAP values account for interactions among predictors and provide local explanations of model predictions, including the direction of each variable's influence. Positive SHAP values indicate that a variable increases the likelihood of state failure, while negative values indicate that it decreases it.

Figure 12 illustrates how observed predictor values map into SHAP values for the main predictors of state failure. Civil liberties exhibit a negative relationship with failure risk: higher levels of civil liberties reduce the predicted probability of state failure, while lower levels increase it. By contrast, exclusion of social groups from power has a positive effect on failure risk, particularly once it exceeds the 0.75 threshold. Electoral democracy and

power sharing do not display a clear monotonic relationship with state failure. Demographic factors show that younger populations are associated with higher probabilities of state failure, a pattern consistently reflected across both indicators: countries with a larger share of the population aged 0–14 and a smaller share aged 15–64 face higher predicted probabilities of state failure.

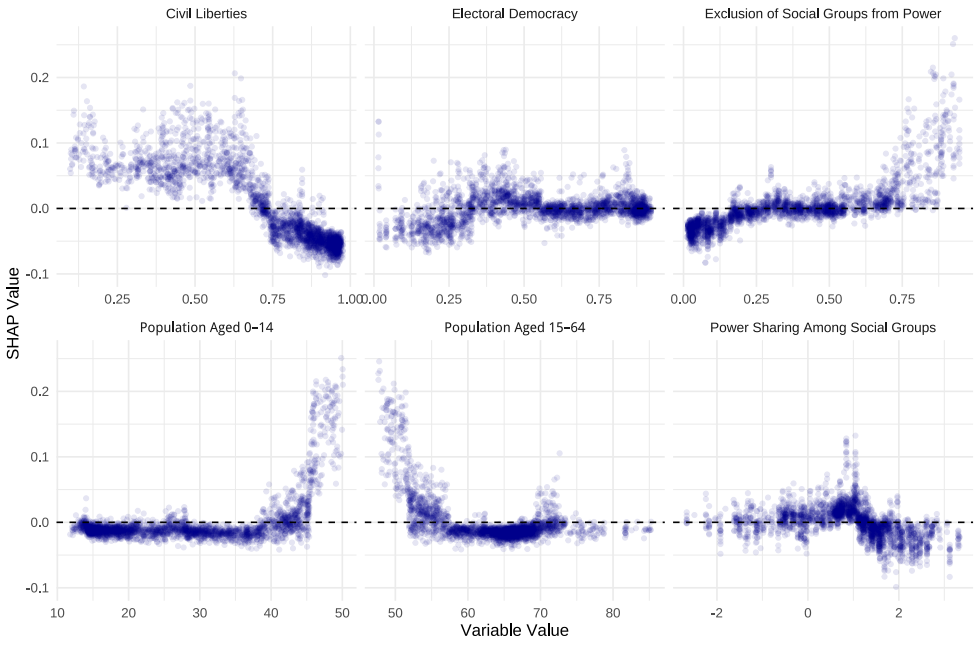
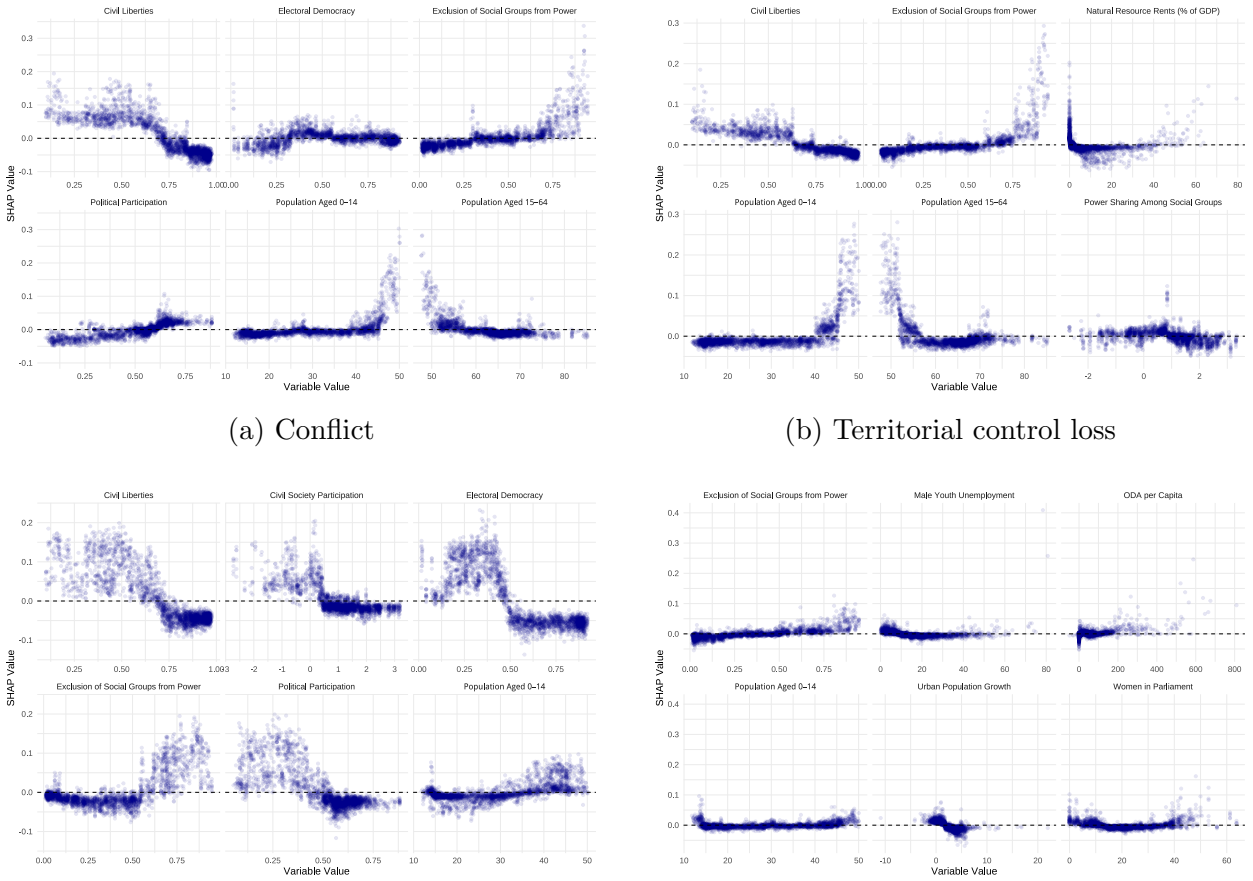


Figure 12: SHAP values and predictor levels

Notes: Relationship between predictor values and corresponding SHAP values.
Sources: Authors' elaboration based on the data discussed in Section 2.

Figure 13 reports SHAP values separately for each breakdown. For conflict, the pattern closely mirrors that of overall state failure. Political variables play a particularly prominent role in institutional deficiency, reflecting the strong interdependence among predictors related to the rule of law and other institutional features that capture closely related dimensions. In addition to civil liberties and the exclusion of social groups, lower levels of political participation and electoral democracy also contribute positively to the probability of institutional deficiency. Finally, public service deterioration exhibits very weak relationships across predictors, consistent with the model's limited ability to predict this breakdown.



(a) Conflict

(b) Territorial control loss

(c) Institutional deficiency

(d) Public service deterioration

Figure 13: SHAP values and predictor levels by breakdown

Notes: Predictor values plotted against SHAP values for each breakdown dimension.
Sources: Authors' elaboration based on the data discussed in Section 2.

5 Conclusion

This paper proposes measuring state fragility using the probability of state failure. By conceptualizing fragility as proneness to failure rather than failure itself, the approach resolves a central ambiguity in the literature and departs from index-based measures. The measure is forward-looking, continuous, and comparable across countries and time, making it well suited for forecasting and early-warning applications.

Empirically, we operationalize state failure through observed breakdowns in conflict, territorial control, institutional performance, and public service provision. Using a forecasting exercise based on machine learning methods and panel data for 160 countries over 2005–2023,

we document strong predictive performance, particularly for continuing episodes of failure. State failure is highly persistent, different breakdowns tend to accumulate, and conflict emerges as the most prevalent and predictive form of failure. Political and institutional variables account for most of the model's predictive power, while aggregate macroeconomic conditions contribute relatively little.

The analysis also shows the value of disaggregating state failure into its constituent dimensions. Estimating failure probabilities separately for each breakdown preserves interpretability and allows users to distinguish between risks arising from coercive versus administrative failures. This decomposition provides a more nuanced assessment of fragility profiles and avoids masking heterogeneous dynamics behind a single aggregate score.

Several limitations remain. The operationalization of state failure necessarily relies on threshold choices that are contestable, and the probabilistic estimates are predictive rather than causal. As such, the measure is not designed to identify policy levers that would directly reduce fragility. Instead, it is intended to support crisis preparedness.

Overall, the framework and measure developed in this paper provide a tractable and conceptually grounded alternative to existing fragility indices. By aligning the definition of fragility with its purpose—anticipating failure—the approach contributes to both the academic literature and policy guidance.

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Appendices

A Appendix tables

Table A1: List of fragility definitions

Author	Definition
African Development Bank Group. (2022)	Fragility is a condition where the exposure to internal or external pressures exceeds existing capacities to prevent, respond to, and recover from them, creating risks of instability.
Chami et al. (2021)	Fragility is the probability of becoming a failed state, which is a situation in which a country's governmental apparatus is of limited effectiveness in delivering a broad range of public services.
CIFP Fragility Index (CIFP 2023)	*Fragility is the extent to which weaknesses in a state's authority, legitimacy, or capacity undermine its ability to govern.
Constellations of State Fragility (Ziaja, Grävingholt, and Kreibaum 2019)	Fragility is defined as deficiencies in one or more of the three core functions of the state, namely state authority, state capacity, and state legitimacy.
Council of the European Union (2007)	Fragility refers to weak or failing structures and to situations where the social contract is broken due to the State's incapacity or unwillingness to deal with its basic functions, meet its obligations and responsibilities regarding the rule of law, protection of human rights and fundamental freedoms, security and safety of its population, poverty reduction, service delivery, the transparent and equitable management of resources and access to power.
Crisis States Research Centre (2006)	*Fragility refers to a condition in which a state is highly susceptible to crisis in one or more of its core subsystems. This susceptibility arises when institutional arrangements are unable to withstand internal or external shocks, manage conflict, or provide stable economic, social, and political order. In fragile states, institutions tend to reinforce rather than resolve underlying vulnerabilities, making them prone to breakdown under stress and vulnerable to challenges from alternative sources of authority.
Fragile States Index (The Fund for Peace 2025)	*Fragility is the condition in which social, economic, and political pressures within a state exceed the state's capacity to manage those pressures, thereby increasing the risk of instability, conflict, or state failure.

Ikpe (2007)	*Fragility refers to the condition in which a state lacks sufficient capacity and resilience to perform its core functions. Capacity denotes the state's ability to protect itself, deliver basic public services, and manage economic risks, while resilience refers to its ability to manage social relations and political risks and to cope with shocks without descending into failure.
Mueller (2018)	Fragility is defined as the likelihood of state failure, which is the inability of a state to prevent an economic or political crisis that threatens the welfare of its population.
OECD (2016)	Fragility is the combination of exposure to risk and insufficient capacity of the state, system, or community to manage, absorb, or mitigate those risks.
State Fragility Index and Matrix (Marshall and Elzinga-Marshall 2019)	*Fragility is the degree to which a state lacks the effectiveness and legitimacy needed to manage conflict, formulate and implement public policy, deliver essential services, and sustain social cohesion, resilience, and development.
Stewart and Brown (2009)	*Fragility is the condition in which a state is failing, or at risk of failing, in terms of authority, comprehensive service provision, or legitimacy.
Tikuisis and Carment (2017)	*Fragility is the extent to which a state exhibits weaknesses in authority, legitimacy, and capacity, reflecting its limited ability to exercise authority, sustain accepted political order, and mobilize resources.
USAID (2005)	*Fragility is the condition of a state that is either vulnerable, meaning unable or unwilling to adequately provide security and basic services and whose governmental legitimacy is in question, or in crisis, meaning unable or unwilling to exercise effective territorial control, provide vital services, or prevent violent conflict.
World Bank (2024)	Fragility is defined as a systemic condition characterized by extremely low levels of institutional and governance capacity, which significantly impede the state's ability to function effectively, maintain peace, and foster economic and social development.

Note: This table presents a non-exhaustive set of definitions that conceptualize state fragility. We exclude alternative terminology such as weak, ineffective, or failed states. *Interpretation based on terms like "fragile state" or the measure of fragility.
Source: Authors' elaboration.

Table A2: State's Core Functions

Author	State Functions
Acemoglu (2005)	[W]Rise taxes, regulate economic activity, and maintain authority in the face of political and social challenges from non-state actors.
Call (2011)	[F]Deliver minimal public goods and services to the population (capacity). Provide basic levels of security against organized armed groups (security). Sustain legitimate rules governing the exercise of power and the accumulation and distribution of wealth that are broadly accepted by political elites and society (legitimacy).
Chhibber et al. (1997)	Provide pure public goods: defense, law and order, property rights, macroeconomic management, public health, antipoverty programs, and disaster relief (minimal functions). Address externalities: basic education and environmental protection. Regulate monopolies: utility regulation and antitrust policy. Overcome imperfect information: insurance–health, life, and pensions, financial regulation, and consumer protection. Provide social insurance: redistributive pensions, family allowances, and unemployment insurance (intermediate functions). Coordinate private activity: fostering markets and cluster initiatives. Redistribute assets (activist functions).
Esty et al. (1998)	[F]Avoid revolutionary or ethnic war, catastrophic regime collapse, and genocide or politicide.
Ghani, Lockhart, and Carnahan (2006)	Legitimate monopoly on the means of violence. Administrative control. Management of public finances. Investment in human capital. Delineation of citizenship rights and duties. Provision of infrastructure services. Formation of the market. Management of the state's assets (including the environment, natural resources, and cultural assets). International relations (including entering into international contracts and public borrowing). Rule of law.
Goldstone (2008)	Effectiveness: how well the state carries out state functions such as providing security, promoting economic growth, making law and policy, and delivering social services. Legitimacy: whether state actions are perceived by elites and the population as "just" or "reasonable" in terms of prevailing social norms.
Patrick (2007)	Maintain security and sovereignty over its territory (security basket). Government rules legitimately and capably (political basket). Provide stable economic environment conducive to growth (economic basket). Meet the basic human needs of its citizens including nutrition, health, education, access to drinking water, and improved sanitation (social welfare basket).

Rice and Patrick (2008)	[W]Fostering an environment conducive to sustainable and equitable economic growth. Establishing and maintaining legitimate, transparent, and accountable political institutions. Securing the population from violent conflict and exercising control over the territory. Meeting the basic human needs of the population.
Rotberg (2004)	Provide security: protecting territorial integrity from external threats, preventing internal violence and crime, and ensuring that political and social conflicts are resolved without recourse to physical coercion. Supply predictable and institutionalized mechanisms for adjudicating disputes and regulating social relations through an enforceable legal order, including property rights, contracts, and an effective judicial system. Enable political participation by safeguarding basic civil and political rights, supporting representative institutions, and tolerating dissent. Provide a range of collective goods, including health care, education, physical infrastructure, monetary and financial systems, a stable environment for economic activity, space for civil society, and mechanisms for managing shared environmental resources.
Tabellini (2005)	Protection of property rights. Contract enforcement. Rule of law. Legal and institutional infrastructure. Constraints on government abuse. Market-enabling institutions. Public goods provision. Market failure correction. Redistribution. Macroeconomic stabilization.

Note: This table presents a non-exhaustive set of conceptualizations of the core functions of the state. [F]Interpretation based on the notion of a "failed state." [W]Interpretation based on the notion of a "weak state."

Source: Authors' elaboration.

Table A3: Variables used in the analysis

Variable	**Description**	**Source**
Access to basic sanitation	People using at least basic sanitation services (% of population)	WB/WDI
Access to electricity	Access to electricity (% of population)	WB/WDI
Battle-related deaths (ACLED)	Number of reported fatalities aggregated by country-year	ACLED
Battle-related deaths (UCDP)	Best estimate of total conflict-related fatalities aggregated by country-year	UCDP
Central bank independence	Unweighted index measuring the degree of central bank independence	QoG
Civil liberties	Expert-assessed index measuring respect for civil liberties	V-Dem
Civil society participation	Expert-assessed index measuring popular involvement in civil society organizations	V-Dem
Conflict in neighboring countries	Indicator for sharing a border with at least one neighboring country experiencing conflict	ACLED, UCDP
DPT immunization coverage	Immunization, DPT (% of children ages 12–23 months)	WB/WDI
Electoral democracy	Expert-assessed index measuring the extent to which electoral democracy is achieved	V-Dem
Employment in agriculture	Employment in agriculture (% of total employment), modeled ILO estimate	WB/WDI
Exclusion of social groups from power	Expert-assessed index measuring political exclusion based on identity or group membership	V-Dem
Executive corruption	Expert-assessed index measuring frequency of executive corruption practices	V-Dem
Foreign direct investment inflows	Foreign direct investment, net inflows (% of GDP)	WB/WDI
GDP per capita growth	Annual growth rate of GDP per capita (constant 2015 US$)	WB/WDI
Inflation	Inflation, consumer prices (annual %)	WB/WDI
Lower secondary school enrollment	Complement of the out-of-school rate for lower secondary school age, both sexes (%)	UNESCO
Male youth unemployment	Unemployment, youth male (% of male labor force ages 15–24), modeled ILO estimate	WB/WDI
Measles immunization coverage	Immunization, measles (% of children ages 12–23 months)	WB/WDI
Natural resource rents	Total natural resource rents (% of GDP)	WB/WDI
ODA per capita	Net official development assistance per capita (constant 2021 US$)	WB/WDI

Political participation	Expert-assessed index measuring popular participation in political processes	V-Dem
Population	Total population	WB/WDI
Population aged 0–14	Population ages 0–14 (% of total population)	WB/WDI
Population aged 15–64	Population ages 15–64 (% of total population)	WB/WDI
Power sharing among social groups	Expert-assessed index measuring distribution of political power across social groups	V-Dem
Primary school enrollment	Complement of the out-of-school rate for primary school age, both sexes (%)	UNESCO
Rule of law	Expert-assessed index measuring impartial enforcement of laws	V-Dem
State territorial control	Expert-assessed estimate of share of territory controlled by the central state	V-Dem
Urban population growth	Urban population growth (annual %)	WB/WDI
Women's representation in parliament	Proportion of seats held by women in national parliaments (%)	WB/WDI

Notes: This table reports the variables used in the analysis, together with their definitions and data sources. All variables are measured at the country–year level unless otherwise noted.
Sources: Authors' elaboration.