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Taking the Pulse of Fiscal Distress: Inflation, Depreciation, and Crises

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Abstract

This study offers novel monthly estimates of the latent probability of fiscal crises for 163 countries, from January 1970 to December 2023. These indicators are constructed with minimal data requirements on prices and exchange rates and serve as a global early warning system for fiscal risk. The probabilities are estimated using a Random Forest model within a Mixed-Data Sampling (MIDAS) framework, trained on manually compiled fiscal crisis events. Using these indicators, we test nine hypotheses on the effects of country characteristics, time periods, and policy choices on the probability of fiscal crises. Countries with inflation-targeting regimes, on average, experience lower fiscal distress. Fiscal rules reduce the probability of crises while higher debt levels increase their likelihood. Our findings are particularly relevant for developing countries, where fiscal risk is higher than in advanced economies, even after controlling for policy choices and country-specific characteristics**.**

Keywords: Fiscal Crisis, Early Warning Systems, Inflation Targeting, Fiscal Rules, Openness, Machine Learning.

JEL Classification: E63, H87, O23, G01, H12

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1. Introduction

Fiscal distress and sovereign debt concerns have moved again to the forefront of both academic and policy discussions in recent years (see, Mitchener and Trebesch, 2023). Historically high debt levels across various economies—from low-income to advanced—have intensified the need for fiscal space, particularly to support the transformation of global production in response to environmental concerns (Bolton et al., 2022). This dynamic raises the prospect of new waves of sovereign-fiscal crises in the coming years (Gomez-Gonzalez et al., 2023, 2024).

In this context, developing new tools to monitor the evolution of macroeconomic pressures and fiscal imbalances, especially in developing countries, has become essential (e.g., Bordo and Meissner, 2016; Kose et al., 2022). We make two main contributions to literature. First, we provide and make public new estimates of fiscal distress for 163 countries from January 1970 to December 2023. Second, we use these novel indicators to test key hypotheses inferred from the extant literature, concerning the effect of various policy choices and country characteristics on fiscal distress[1].

Our first contribution enhances the coverage of previous research (e.g., Medas et al., 2018; Badia et al., 2022), primarily developed within the International Monetary Fund (IMF), in three important ways. First, we extend the estimation of fiscal crisis probabilities to include the pre-1990 period, enabling us to assess the long-term evolution of fiscal distress in an unprecedented manner. Second, we expand the fiscal distress indicators' coverage from 150 to 163 countries. Third, and most significantly, we increase the frequency of measurement, moving from annual to monthly assessments, and replacing the discrete classification of fiscal crisis episodes with a continuous probability measure.

This shift provides a valuable, globally applicable tool for real-time monitoring and managing of fiscal risk. Our indicators serve as an ideal complement to traditional fiscal monitoring exercises, which rely on detailed analysis of debt variables, long-term fiscal trends, and asset-liability management indicators (see Baldacci et al., 2011; Medas et al., 2018; Badia et al., 2022; Kose et al., 2022). Moreover, the continuous nature of our metrics aligns more closely

[1] We use the term "fiscal distress" rather than "fiscal crises" for our indicators because fiscal crises represent the actual realization of fiscal risk, whereas "fiscal distress" more accurately captures the probabilistic and latent nature of our indicators. Naturally, the two concepts are closely related, as persistent and elevated fiscal distress can eventually escalate into a fiscal crisis. Therefore, in the main text, the terms "fiscal distress" and "probability of fiscal crisis" will be used interchangeably.

with recent theoretical approaches to understand sovereign risk (e.g., Arellano et al., 2023; 2024), which view sovereign default as a partial rather than total event. In this framework, during partial defaults, sovereigns continue making some debt payments, take on new debt, and accumulate arrears, reflecting real-world sovereign distress episodes. In our view, a continuous-time indicator of fiscal or sovereign distress is more appropriate than a binary classification of fiscal crises, as it better reflects the underlying concept of partial events.

The comprehensive coverage of our indicators enables our second contribution: testing several central hypotheses derived from the existing literature regarding various policy frameworks and country characteristics and their effects on fiscal distress. Although our hypotheses are solidly linked to previous literature, mainly to conventional views on sovereign risk, financial integration and currency crises, such a comprehensive exercise is lacking in the field. This approach greatly enhances the understanding of fiscal crises by analyzing multiple explanatory factors simultaneously, offering a robust empirical foundation for identifying and assessing fiscal risks. Specifically, our models quantify the impact of various monetary regimes, exchange rate regimes, and different levels of financial and trade openness, among other factors, on the probability of experiencing a fiscal crisis.

Having a continuous variable also enables us to identify previously unknown clusters of nations that tend to comove when experiencing fiscal distress. This facet of our estimates, also novel to the literature, offers a fresh analysis that is particularly useful for international portfolio diversification strategies, in addition to regulators.

Our approach to constructing the latent probabilities of fiscal crisis is eclectic, as models in the first part of our contribution are primarily predictive. In other words, we do not need, for instance, to take a definitive stance on whether fiscal shocks induce asymmetric changes in real exchange rates or not, among other ongoing debates in the field (see Born et al., 2024). For our models, it suffices that both exchange rates and prices—our predictors—are statistically and economically related to fiscal outcomes. This perspective has long been supported by classical literature in macroeconomics and international economics (e.g., Sargent and Wallace, 1981; Mundell, 1963; Fleming, 1962—see Section 2).

Our empirical models have two features. First, they are grounded in the extensive literature that examines the close relationship between fiscal outcomes, inflation, and exchange rates, both on a pair-by-pair basis or the three variables simultaneously —see Ferrara et al. (2021); Kirchner and Rieth (2021); Jørgensen and Ravn (2022); Aizenman and Zheng (2023) for recent examples of this literature. Second, from a methodological standpoint, we advance

beyond traditional Mixed Frequency Models (MIDAS) —Ghysels et al. (2004; 2006)— by leveraging Machine Learning (ML), and in particular Random Forest (RF), to handle our mixed frequency data. This allows us to use monthly-sampled variables, such as inflation and nominal exchange rates, to *nowcast* annual fiscal crises. Compared to traditional MIDAS, our approach is more flexible, as it does not impose specific functional forms (e.g., splines or polynomials) on the low frequency variables. Instead, it lets the data speak freely on the underlying relationships via the construction of numerous weak classifiers and combining them through ensemble learning. Our model excels at handling correlated variables (such as the lags of exchange rate returns and inflation) which is a typical problem in the MIDAS literature. To the best of our knowledge, this is also a contribution of our study to the growing MIDAS framework.

Nevertheless, our primary contribution is to the literature focused on developing methodologies for predicting and understanding sovereign and fiscal distresses. These studies span classical works on leading indicators, such as those by Kaminsky et al. (1998), to the more recent applications of ML tools for the same purpose (e.g., Fioramanti, 2008; Hellwig, 2021; Jarmulska, 2022). Within this field, the most popular approach is based on the signaling technique to forecast currency crises due to Kaminsky et al. (1998). In this methodology, signal variables are computed using a wide range of economic data, and when a given indicator rises above an estimated critical threshold, a signal is generated. By combining relevant variables, this approach allows for the estimation of leading indicators to predict instances of sovereign debt concerns (e.g., Baldacci et al., 2011).

Unlike these studies, our contribution focuses on providing new estimates of fiscal distress using minimal data requirements, on a global basis. Indeed, our indicators can be seen as nowcasting the binary fiscal crisis variable developed by Medas et al. (2018) and Baldacci et al. (2011), which requires data collection and manual classification of fiscal distress episodes across four dimensions[2]: credit events, 2) substantial external official funding, 3) implied default on domestic public debt, 4) loss of market confidence; making our approach broader than solely focusing on sovereign risk. To construct our indicators, we concentrate on three primary predictors: inflation, energy price variation, and exchange rate returns. These variables not only demonstrate strong links to fiscal outcomes but are also consistently reported on a comparable cross-country basis, facilitating routine updates to our models, which is a definitive advantage on the manual approach followed by the previous literature.

[2] See the Data section for further details on the construction and update of the fiscal crises' variable.

Our models also account for the non-linear nature of fiscal and sovereign risks, implicit in the modeling assumptions of the threshold-methodologies. In this respect, we allow Random Forest to handle non-linearities in a more flexible and general manner.

In the second part of our contribution, we draw on consolidated knowledge in the field to propose nine hypotheses on how specific variables are expected to influence our estimates of fiscal distress. In some cases, this serves as a validation exercise for our indicators, confirming established expectations regarding the effects of inflation targeting, debt levels, and fiscal rules. However, other variables, such as natural resource abundance and trade openness, despite prior conjectures, show no clear association with the probability of fiscal crises once relevant policy choices are considered. Furthermore, according to our empirical results, a fixed exchange rate regime enhances fiscal resilience during favorable economic conditions but diminishes it in bad times, as expected. Interestingly, in post-1990 data and for advanced economies, we observe a small protective effect of fixed regimes regarding fiscal risk, highlighting the Euro's stabilizing role in the later part of the sample period, in conjunction with its classification as a fixed regime following Ilzetzki et al. (2019).

The case of financial integration is particularly intriguing, as its impact can be either positive or detrimental depending on whether we use a *de jure* or *de facto* measure as a proxy. This result echoes previous studies that highlight both the positive and negative effects of financial integration on financial stability (e.g., Devereux and Yu, 2020; Pierri and Quadrini, 2018; Giraldo et al., 2024) and productivity (Benigno et al., forthcoming). Our findings underscore the importance of clearly defining financial integration and specifying which countries are being evaluated, as our results also vary between advanced and developing nations.

While all the explanatory variables in our empirical model are widely recognized for their impact on inflation, sovereign risk and exchange rates, a systematic assessment of their role as potential determinants of fiscal distress is, to the best of our knowledge, novel to the field.

As anticipated, emerging and low-income countries consistently face higher probabilities of fiscal crises throughout our long sample. Thus, on the policy front, our findings highlight the role of fiscal rules, which are significant in explaining fiscal distress. These rules typically impose limits on budget deficits, debt levels (which are also significant independently), and spending growth. According to our results, countries that adopt fiscal rules generally experience lower probabilities of fiscal crises. Additionally, inflation targeting contributes to fiscal resilience over the course of our sample.

The rest of this document is organized as follows. Section 2 examines the theoretical links between inflation, exchange rates, and fiscal shocks, which underpins our ML-predictive approach in the first part. Section 3 reviews the literature on early warning systems, focusing particularly on studies that address sovereign debt outcomes. The fourth section outlines our methodology, while the fifth describes our data and sources. The sixth section presents our main hypotheses and results, and the concluding section wraps up the discussion and policy implications. The probabilities of fiscal crises for each country are plotted in the Appendix and publicly available online.

2. Relationship between inflation, exchange rates and fiscal outcomes

Fiscal outcomes have long been recognized as key determinants of inflation (e.g., Sargent, 1982; Sargent and Wallace, 1981; Leeper, 1991; Leeper and Leith, 2016). Expansionary fiscal policies can unintentionally create conditions that foster inflation, which can be understood through the lens of the Fiscal Theory of the Price Level- FTPL (Cochrane, 2022a, 2023; Bianchi et al., 2023; Barro and Bianchi, 2024). This theory, although observationally equivalent to traditional New Keynesian macroeconomic models (Woodford, 2003), emphasizes a more active role for fiscal authorities (e.g., Leeper and Leith, 2016; Cochrane, 2022b). It posits that the price level adjusts to ensure the real value of government debt matches the present value of future real primary surpluses. In its most basic form, it emphasizes that when fiscal deficits are financed through money creation rather than borrowing, the resulting increase in money supply relative to economic output leads to inflation (Sargent and Wallace, 1981).

The relationship between fiscal policy and inflation remains a vibrant area of academic research, with notable contributions from Ferrara et al. (2021), Kirchner and Rieth (2021), Jørgensen and Ravn (2022), and Aizenman and Zheng (2023), among others. Recently, Angeletos et al. (2024) demonstrated that, within the modern Heterogeneous Agent New Keynesian (HANK) paradigm, non-Ricardian households ensure that fiscal deficits drive inflation in a way consistent with the magnitudes predicted by the FTPL, provided there is sufficiently slow fiscal adjustment.

On their side, exchange rates are inherently connected to inflation, hence to fiscal outcomes, through multiple channels, with the most straightforward being the Purchasing Power Parity (PPP) theory. PPP posits that the nominal exchange rate between two currencies should be equivalent to the ratio of the aggregate price levels in the two countries, ensuring that a unit

of currency from one country maintains the same purchasing power in the other (e.g., Taylor and Taylor, 2004). While several variations of the original PPP theory exist, they all suggest a strong relationship between the nominal exchange rate and inflation, and thus, between the nominal exchange rate and fiscal policy shocks. Indeed, this connection between fiscal policy and exchange rates has been long exploited in international macroeconomics, at least since the development of the open economy version of the IS-LM framework due to Mundell (1963) and Fleming (1962).

When a country experiences higher inflation relative to its trading partners, its currency typically depreciates, resulting in increased import prices. Such depreciation can further exacerbate inflation, particularly in economies reliant on imported goods. Recent literature emphasizes the role of expectations, demonstrating how anticipated inflation can lead to currency depreciation even before inflationary pressures manifest.

In a related strand of the literature, understanding the government decision between issuing debt denominated in local or foreign currency also helps to establish a strong connection between prices, exchange rates and fiscal considerations. In general lines, we have that governments may issue debt that is either indexed to inflation or denominated in foreign currency. Unlike nominal debt, an increase in the price level does not reduce the real value of inflation-indexed debt, and a depreciation of the domestic currency does not lower the real burden of foreign currency debt. To repay such obligations, the government must generate budget surpluses or face the risk of default.

In a view advanced by Cochrane (2022a), foreign and indexed debt function similarly to corporate debt, which must be repaid to avoid default. Conversely, domestic currency and nominal (non-indexed) debt resemble corporate equity, where the value can adjust downward to reflect lower expected returns. Thus, the government's decision between issuing domestic versus foreign currency debt, or nominal versus indexed debt, is comparable to a firm's choice between debt and equity. Nominal debt, like equity, enables the government to share the risks of fiscal stress by allowing inflation or currency devaluation to alleviate the pressure of formal default. All in all, this view provides a clear mechanism that establishes a statistically and economically significant link between fiscal risks, inflation, and exchange rates.

Our work is also inspired by the recent literature on the 'Twin Ds' —default and devaluation— (Na et al., 2018; Augustin et al., 2018, 2020; Chernov et al., 2023; Della-Corte et al., 2023). This body of research has demonstrated that higher sovereign risk increases the likelihood of currency depreciation (Della-Corte et al., 2022). Conversely, strong

expectations of currency depreciation heighten the risk of default (Bernoth and Herwartz, 2021). Na et al. (2018) showed that it can be optimal for a government to devalue its domestic currency simultaneously with a debt default. They argue that when governments face a series of negative shocks leading to default (due to limited commitment), they often devalue the local currency to soften the impact on real wages. This approach helps offset the reduction in labor demand caused by a contraction in domestic absorption. The simultaneous occurrence of devaluation and default, first noted by Reinhart (2002), may then be explained by the optimality of such policy responses. In short, by directly linking depreciation to sovereign risk, these advances on the Twin Ds study also provide a foundation for using exchange rate fluctuations to predict fiscal crises, where sovereign spreads—and their sharp increases—are indeed one of their main components.

3. Monitoring Fiscal Distress

In their assessment of fiscal risk in low-income nations, Milesi-Ferretti and Lane (2017) employed a probit model and found that foreign income, risk premium, conflict dummy variables, global growth, and institutions were highly important predictors. Terms-of-trade volatility was shown to be able to forecast changes in spreads and default probabilities by Hilscher and Nosbusch (2007). Using a Bayesian averaging model, Maltritz and Molchanov (2014) report similar findings, highlighting the significance of governance and competitiveness factors including economic activity, property rights, and governance effectiveness.

Jarmulska (2021) compared RF models with binary choice logit models to predict fiscal distress events, showing evidence in favor of the latter during the sovereign debt crises that affected the Euro area. Regression-tree-based models were also employed by Savona and Vezzoli (2015) to study sovereign defaults. ML models have generally been found to perform better out-of-sample than conventional binary choice models (e.g., Dawood et al., 2017; Berg et al., 2005).

Badia et al. (2022) evaluate the importance of public debt as a precursor to fiscal crises. They use ML algorithms to take into consideration the associations between debt and macroeconomic variables, which are hard to quantify using conventional econometric techniques due to non-linearities. According to their findings, one of the most significant indicators of fiscal crises is the level of government debt. Furthermore, private lending, large current account deficits, and how they interact with the level of debt are important markers of fiscal trouble.

Bruns and Poghosyan (2018) contribute by highlighting the significance of non-fiscal factors in the forecasting of sovereign distress episodes. It is demonstrated that their vulnerability indicator, which is built using both fiscal and non-fiscal leading variables, has a higher predictive power than a conventional index that solely uses fiscal indicators.

Unlike all this literature, our contribution focuses on providing new estimates of fiscal distress, which connects us closely only with Medas et al. (2018) and Badia et al. (2022). Compared to these studies, our indicators offer higher frequency, are continuous variables, and cover a longer time span across more countries. Additionally, they are more easily updated, relying solely on inflation, energy prices and nominal exchange rate data, which makes them ideal to construct fiscal monitoring systems.

Naturally, our estimates are not intended to replace the approach by Moreno et al. (2018), as the manual classification of episodes remains a crucial input for our models in future updates of the training set. Rather, our method should be viewed as complementary, enabling real-time policy insights and offering a more complete understanding and timely evaluation of macroeconomic policies with an expected impact on fiscal distress.

4. Measuring Fiscal Distress with High Frequency Variables

Our methodology consists of two parts. We start by introducing the Mixed Data Sampling (MIDAS) framework, which allows us to use higher frequency variables such as prices and exchange rates to nowcast fiscal crises, which have a lower frequency. Then, we present our approach to estimate the MIDAS model, which leverages Random Forest (Breiman, 2001).

4.1. MIDAS Models

MIDAS is a regression framework designed to handle data with different frequencies, such as using high-frequency variables (e.g., daily, weekly, or monthly) to explain low-frequency outcomes (e.g., quarterly or yearly). In this study, we employ a MIDAS model to estimate the relationship between three high-frequency economic indicators (i.e., inflation, energy prices and exchange rates), and the realization of a fiscal crisis. This procedure allows us to estimate the monthly likelihood of observing a fiscal crisis, starting from the annual measure of the latter.

The MIDAS regression framework was introduced by Ghysels et al. (2004, 2006) to model relationships between variables sampled at different frequencies. The key advantage of MIDAS is its ability to capture the dynamic effects of high-frequency

variables over time using a relatively parsimonious structure, often employing polynomial lag functions, or splines, to control for the influence of lagged variables. Andreou, et al. (2010) extended this framework by exploring different model specifications that improve its predictive capabilities in a wide range of economic applications, such as forecasting and volatility modeling.

Recent literature in macro-econometrics has increasingly focused on refining the forecasting of key macroeconomic variables, such as inflation, by applying machine learning techniques to capture more complex relationships and better accommodate larger datasets (e.g., Bai et al., 2013; Mogliani and Simoni, 2021; Medeiros et al., 2021; Goulet-Coulombe et al., 2020). These advancements build on theoretical results, such as those by Davis et al. (2020), which establish consistency for RF in a time series context. However, despite the potential of RF, this literature has largely overlooked its natural advantages within the MIDAS framework. Our contribution represents a first step in bridging this gap.

Formally, let p_t represent the dependent variable, which is an indicator of fiscal crisis, measured at a lower frequency (i.e. yearly). Our regressors consist of three high-frequency variables: year-over-year monthly inflation π, the year-over-year monthly variation in the logarithm of energy prices e, and the monthly variation in the logarithm of exchange rates fx. Since these variables are available at a higher frequency (e.g., monthly), the MIDAS model allows us to incorporate multiple lags into the regression, thus capturing their dynamic effects on the low-frequency outcome p_t.

The general MIDAS model specification for our case is given by the following equation:

$$p_t = \alpha + \sum_{k=0}^{11} \beta_{1,k} \cdot \pi_{t-k/h} + \sum_{k=0}^{11} \beta_{2,k} \cdot e_{t-k/h} + \sum_{k=0}^{11} \beta_{3,k} \cdot fx_{t-k/h} + \epsilon_t, \qquad (1)$$

where: p_t is the dependent variable indicating the occurrence of a fiscal crisis at time t (low-frequency). $\pi_{t-k/h}$, $e_{t-k/h}$, $fx_{t-k/h}$ represent the lagged values of inflation, energy prices, and exchange rates, respectively, observed at high-frequency $t - k/h$, where h is the ratio of high-frequency periods to low-frequency periods. $\beta_{1,k}$, $\beta_{2,k}$, $\beta_{3,k}$ are the coefficients that measure the impact of the high-frequency variables at different lags k, up to 12 months (in our case). α is the intercept. ϵ_t is the error term.

Traditionally, MIDAS models are estimated using nonlinear least squares (NLS) or

other maximum likelihood techniques. The key challenge lies in selecting an appropriate lag structure for the high-frequency variables, which is often modeled by polynomial weighting functions that reduce the number of parameters. This helps avoid overfitting and multicollinearity that can arise from including a large number of high-frequency lags. In this context, a common approach is to use Almon or Beta polynomial functions to impose smoothness on the lag coefficients.

However, traditional MIDAS models have limitations, particularly when the relationship between the variables is nonlinear, which motivates the use of ML methods like RF to improve prediction accuracy and capture less obvious patterns in the data.

4.2. MIDAS Model Estimation Using Random Forest

To account for nonlinear relationships and potential interactions between lags and regressors, we propose estimating the MIDAS model using Random Forest, a widely used ensemble learning technique, particularly suited for tabular data, as in our case, with a panel of countries tracked over time. RF builds multiple decision trees from bootstrapped samples of the data and combines them to produce predictions. Each tree in the forest is trained on a random subset of both the data and the predictor variables, which helps to mitigate overfitting and enhance the generalization ability of the model.

The RF model for predicting p_t using our high frequency regressors can be written as:

$$p_t = f\left(\pi_{t-0/h}, \pi_{t-1/h}, \dots, \pi_{t-11/h}, e_{t-0/h}, e_{t-1/h,} \dots, e_{t-11/h}, fx_{t-0/h}, fx_{t-1/h}, \dots, fx_{t-11/h}\right) + \epsilon_t, \quad (2)$$

where $f(\cdot)$ represents the function learned by the RF algorithm.

4.3. Random Forest Algorithm

RF works by growing multiple decision trees, where each tree $T^{(i)}$ is built using a randomly selected subset of the training data and a random subset of predictors. The final prediction for p_t is the average prediction across all decision trees.

In this study, we employ the RF algorithm within a *regression framework* rather than a

classification framework. The goal is to construct a continuous predicted variable $\hat{p}_t$, which measures the likelihood or intensity of a fiscal crisis in each month, rather than classifying the episodes.

In our case, the RF model uses the high-frequency regressors — inflation π, e, fx— and their lags to predict the variable p_t. The prediction for p_t can be expressed as:

$$\hat{p}_t = \frac{1}{B}\sum_{i=1}^{B} T^{(i)}(X_t), \quad (2)$$

where: B is the number of decision trees in the forest. $T^{(i)}(X_t)$ is the prediction of the $i-th$ decision tree based on the input data X_t, which consists of the lagged values of the high frequency regressors π, e, and fx. $X_t = \left(\pi_{t-0/h}, \pi_{t-1/h}, \dots, \pi_{t-11/h}, e_{t-0/h}, e_{t-1/h,} \dots, e_{t-11/h}, fx_{t-0/h}, fx_{t-1/h}, \dots, fx_{t-11/h}\right)$.

Since we are predicting the probability of fiscal crisis, effectively treating it as a continuous outcome, the final prediction $\hat{p}_t$ is obtained by averaging the predictions from all the decision trees in the forest, resulting in a smooth estimate of the likelihood of a fiscal crisis or severity of fiscal distress.

4.4. Estimation Algorithm

First, we compile the high-frequency data on inflation, energy prices and exchange rates, including 12 lags for each variable. This creates the predictor matrix where each row contains the lagged values of these regressors. Then, our RF model is trained by growing multiple decision trees, where each tree is constructed using a bootstrapped sample of the data. At each node in the tree, a random subset of the predictor variables is selected, and the optimal split is chosen to minimize the mean squared error (MSE). The splitting criterion for each tree is based on the reduction in MSE, which helps ensure that each tree provides accurate predictions for the outcome. Once the trees are built, the RF model combines the predictions from all individual trees by averaging their outputs. This ensemble approach smooths out individual tree errors and results in a more robust prediction of the continuous probability of the crisis variable.

Key hyperparameters for the RF must be selected, such as the number of trees B, the maximum depth of each tree, and the number of predictors considered at each split. They are all set to default values in R. The number of trees is 500. The trees are allowed to grow very deep by default, which ensures that the model can capture complex

patterns in the data. The maximum depth of each tree is implicitly controlled via node size option, set at 5. The number of predictors considered at each step is defined as $p/3$, where p is the total number of predictors (36 in our case). These default values are chosen to introduce randomness into the tree-building process and to reduce the correlation between individual trees. The lower number of predictors considered at each split ensures diversity among trees, improving the overall performance of the ensemble. We also split the data in training and validation sets of 70% and 30% respectively. This helps prevent overfitting and ensures that the RF considers different combinations of variables across trees.

These defaults are widely used because they balance model complexity, performance, and computation time. For larger datasets, these values can be tuned for better performance through cross-validation or other tuning techniques. In our case, with a relatively small dataset, differences are imperceptible in the prediction task utilizing variations of the default hyperparameters.

In short, the key advantages of using RF to estimate a MIDAS model include its ability to capture complex, nonlinear relationships between the high-frequency predictors and the fiscal crisis indicator. Handle interactions between variables without requiring explicit modeling of those interactions. Provide robust predictions by averaging across multiple trees, which reduces the risk of overfitting that is prevalent in traditional MIDAS models with many regressors and lags.

5. Data

Given the low (annual) frequency of the fiscal crisis indicator provided by Medas et al. (2018), which serves as a main input for training our ML models, it is not feasible to estimate fiscal distress indicators using data from individual countries with variation solely over time. This occurs because a single country does not experience enough fiscal crises to allow for the estimation of a ML model using high-frequency indicators as regressors. Therefore, the selection of predictors needs to be done carefully and prioritizing a wide sample of countries during a long-time span to achieve reliable results.

For this reason, we rely on three key variables with good information for 163 countries: the exchange rate of each country with respect to the US dollar (sourced from the Bank of International Settlements Department of Statistics), the Headline Consumer Price Index, and

the Energy Price Index per country (both published by the World Bank and described in detail by Ha et al. (2023)).

These three variables were transformed to achieve stationarity before we conduct our estimations: year-over-year log differences for the price indexes, and monthly log differences for the foreign exchange rates. These variables were chosen due to the high-quality data available from as far back as the early 1970s and because they have a clear theoretical relationship with the occurrence of fiscal crises as detailed in section 2.

We present the descriptive statistics of the three high frequency variables in Table 1. Our sample runs from January 1970 to December 2023 (648 months). Originally the database consists of 163 countries for which information of exchange rates and prices exist. Summary statistics in Table 1 were constructed using the information for these countries.

Table 1 A. Summary Statistics

Panel A. High Frequency Predictors

Indicator	*Source*	*Mean*	*Median*	*Std.Dev*	*Max.*	*Min.*
Exchange rate with respect to USD	Bank of International Settlements	0.62	0	10.25	986.96	-2140.2
Headline Consumer Price Index	The World Bank	4.59	2.13	11.86	296.07	-16.61
Energy Price Index	The World Bank	2.94	1.76	9.86	419.62	-148.57

Panel B. Categorical Variables

Indicator	*Source*	*Mean*	*Median*	*Std.Dev*	*Ones*	*Zeros*
Emerging and Low-Income Economies	International Monetary Fund	0.63	1	0.48	0.63	0.37
Resource Rich Countries	International Monetary Fund	0.28	0	0.45	0.28	0.72
Financial Openness (De Jure)	Chinn and Ito Web Page	0.36	0	0.48	0.36	0.64
Financial Openness (De Facto)	World Bank	0.13	0	0.33	0.13	0.87
Trade Openness	World Bank	0.12	0	0.33	0.12	0.88
Exchange Rate Regime (Pegged)	Ilzetzki, Reinhart & Rogoff	0.82	1	0.29	0.82	0.18
Debt to GDP ratio	International Monetary Fund	0.11	0	0.31	0.11	0.89
Inflation Targeting	World Bank and IMF	0.1	0	0.3	0.1	0.9
Fiscal Rule	World Bank and IMF	0.56	1	0.5	0.56	0.44

Note: Panel A shows the summary statistics for the three high-frequency variables in our analysis, which are measured monthly. For the headline consumer price index and the energy price index, the log-differences are year-over-year. For the nominal exchange rates, the log-differences are monthly. The total number of countries included in the analysis is 163. Panel B shows summary statistics for the variables used to explain the fiscal crisis probabilities. The columns are like Panel A, but instead of the maximum and minimum, we have included the proportion of ones and the proportion of zeros in the sample. The sample period spans January 1970 (December 1975) to December 2023 in Panel A(B), covering a total of 648 (577) months.

5.1. Dependent Variable: Fiscal Crises

The original series constructed by Medas et al. (2018) go from January 1990 to December 2015 , and we manually update the fiscal crisis variable until December 2023 to estimate our models, following the same criteria of the original authors, namely: 1) Definition of Credit Events: A fiscal crisis occurs when a country fails to meet its debt obligations on time or when creditors face other types of financial losses, such as through debt restructuring. 2) Definition of Substantial External Official Funding: This happens when a nation receives considerable financial assistance from institutions like the International Monetary Fund (IMF) or the European Union. 3) Implied Default on Domestic Public Debt: This refers to situations where: (i) there is a period of high inflation, often linked to government deficits being financed by printing money; or (ii) the country accumulates significant internal payment delays. 4) Loss of Market Confidence: This is triggered by severe market pressures, including: (i) losing access to financial markets, sovereign default, or halting bond issuances; or (ii) a sharp rise in borrowing costs or sudden surges in sovereign yields. If one or more conditions are met a fiscal crisis is recorded in the year of occurrence.

Regarding our fiscal crisis indicator, the occurrence of fiscal crises is relatively high in our dataset, with 52% of the sample falling into this category and 48% not. This is due to the broad criteria used by Medas et al. (2018) to define fiscal crises, which include triggers such as high inflation, elevated spreads, debt restructuring or renegotiation, and support from multilateral institutions, among others.

5.2. Predictor Variables in The MIDAS Framework

According to Table 1, the average monthly exchange rate variation is close to zero (0.62), while the median is zero. The extreme values recorded in the maxima and minima columns reflect significant fluctuations captured by our extensive dataset. The dispersion in our price indicators is also considerable, while their average values are 4.59 for year-over-year inflation and 2.94 for year-over-year energy price variation, the standard deviations of these variables are 11.86 and 9.86, respectively, which coincides with large maxima and low minima, especially concerning energy price variations.

5.3. Explanatory Variables in The Regression Framework

Panel B of Table 2 presents the descriptive statistics for the categorical variables used to characterize the fiscal distress indicators in the second part of our analysis. To ensure

meaningful comparisons, we dichotomized all those variables that were originally continuous. This is important because, as highlighted in the machine learning literature, binary variables tend to dominate early splits in models by dividing variance into only two groups, whereas continuous variables offer multiple potential splits. To prevent this bias, which could also arise in traditional regressions frameworks, we opted to dichotomize all variables. Naturally, we provide explanations for the associated effects in accordance with this transformation.

Our explanatory variables include a binary indicator that classifies economies as either emerging/low-income or advanced. In our dataset, 63% of the countries fall into the former category, while 37% belong to the latter (see the last two columns of Panel B). Additionally, 28% of the economies in our sample are classified as resource-rich, based on the IMF classification provided by Mlachila and Ouedraogo (2020).

For financial openness, we use a de jure measure from Chinn and Ito (2006), which we obtained from the authors' website. This originally continuous variable, ranging from 0 to 1, was dichotomized by assigning a value of 1 for countries with scores above 0.5 and 0 for others. According to this threshold, 36% of countries are classified as "more open", while 64% are "less open", as higher values indicate greater openness.

For the de facto measure, we used the sum of foreign assets and liabilities as a percentage of GDP in current U.S. dollars. To convert this into a binary variable for better comparisons, we selected the top 20 countries with the highest indicator values each month, assigning them a value of 1, with the remaining countries assigned a 0. This allows us to compare the most open economies with the rest. Thus, we have 13% of top-open economies and the rest of the sample is assigned a zero.

Our trade openness indicator is constructed as the sum of exports and imports of goods and services as a percentage of GDP. We used IMF data to update this indicator, following the same procedure used for financial openness (de facto). Naturally, again we have 12% of top-open economies and the rest is assigned a zero.

We also have information on the monetary policy framework of countries. In this case information from The IMF's Areaer is used as it offers country-specific details on inflation targeting frameworks starting in 2010, outlining the de jure monetary policy regime as declared by national monetary authorities (see Caceres et al., 2016). For countries that have adopted inflation targeting, the dataset specifies the month and year of adoption. We

complement the data with Haa et al. (2019). As a result, 10% of country periods had inflation targeting as the monetary regime, while in 90% of cases, it was not in place.

The exchange rate variable was sourced directly from Ilzetzki et al. (2019). The classification includes 15 categories: "1" No separate legal tender or currency union, "2" Pre announced peg or currency board agreement, "3" Pre announced horizontal (narrower than or equal to +/- 2%), "4" De facto peg, "5" Pre announced crawling peg and de facto moving band (narrower than or equal to +/-1%), "6" Pre announced crawling peg or horizontal band (+/- 2%), "7" De facto crawling peg, "8" De facto crawling band (narrower than or equal to +/- 2%), "9" Pre announced crawling band (wider than or equal to +/-2%), "10" De facto crawling band (narrower than or equal to +/-5%), "11" Moving band (narrower than or equal to +/-2%), "12" De facto moving band +/-5%/ and Managed floating, "13" for freely floating currencies; "14" for freely falling and, "15" for dual market in which parallel market data is missing. A dummy variable was created to represent a pegged exchange rate regime, assigned a value of 1 for countries classified from 1 to 11, and a value of 0 for flexible exchange rates, classified as 12 to 15. As a result, 82% of the countries in our sample are classified as having a pegged (or fixed) exchange rate regime.

Finally, we include a dummy variable to indicate whether a country has a fiscal rule in place. A fiscal rule imposes a long-term constraint on fiscal policy by setting numerical limits on budgetary aggregates. The IMF Fiscal Rules Dataset, initially developed by Schaechter et al. (2014), provides comprehensive information on fiscal rule implementation across 96 countries, covering budget balance, debt, expenditure, and revenue rules. In our sample, 56% of countries have some form of fiscal rule, while 44% do not. We also include a variable for the top ten most indebted economies in each month, assigning a value of 1 to these countries (representing 11% of the sample), while the remaining countries are assigned a value of 0 (89% of the sample). This variable is labeled 'debt' in both the table and the empirical section.

5.4. Countries in Our Sample

The number of countries with available data varies across indicators, and we also report the values of our fiscal distress indicators for these "NA" cases. Due to the low variability of our indicators, we used the same values (1 or 0) within each year, since monthly data is required for our fiscal distress indicators. We also updated the dataset using the sources listed in Panel B of Table 1, and when recent data was unavailable, we extrapolated the latest available values until the end of our sample. We do not anticipate significant variations in these characterization variables in last years, as they depict low variation over the sample.

Table 2 lists our sample of countries and highlights whether our indicators differ from those used in previous studies on fiscal crises, particularly Medas et al. (2018). For training our model, matching the exchange rate and price data with the fiscal crisis indicators resulted in the loss of 39 countries (listed in Panel B of Table 2), leaving a training sample of 124 countries (listed in Panel A of Table 2). Additionally, there are 27 countries listed in Panel C of Table 2 for which we have fiscal crisis data but lack exchange rate and inflation data, preventing us from constructing a fiscal crisis indicator for these countries. However, extending our findings to these countries would be straightforward once the necessary data becomes available, likely from domestic statistical sources.

Table 2 Countries Including

	1	2	3	4	5	6
	Panel A: Countries in the training set (with information for both fiscal crisis, inflation and exchange rates)					
1	Albania	Chad	Greece	Madagascar	Philippines	Thailand
2	Algeria	Chile	Grenada	Malawi	Poland	Togo
3	Argentina	Colombia	Guatemala	Maldives	Portugal	Trinidad and Tobago
4	Armenia	Congo, Dem. Rep.	Guinea	Mali	Russian Federation	Tunisia
5	Azerbaijan	Congo, Rep.	Guinea-Bissau	Mauritania	Rwanda	Turkey
6	Bahamas	Costa Rica	Haiti	Mauritius	St. Toma & Princ	Uganda
7	Bangladesh	Croatia	Honduras	Mexico	Samoa	Ukraine
8	Barbados	Cyprus	Hungary	Moldova, Rep.	Senegal	United Kingdom
9	Belarus	Czech Republic	India	Mongolia	Serbia	Uruguay
10	Belize	Djibouti	Indonesia	Montenegro	Seychelles	Uzbekistan
11	Benin	Dominica	Iran, Islamic Rep.	Morocco	Sierra Leone	Venezuela, RB
12	Bolivia	Dominican Republic	Iraq	Mozambique	Slovenia	Vietnam
13	Bosnia and Herzegovina	Egypt,Arab Rep.	Ireland	Myanmar	Solomon Islands	Zambia
14	Botswana	El Salvador	Jamaica	Namibia	South Africa	Zimbabwe
15	Brazil	Equatorial Guinea	Jordan	Nepal	South Sudan	
16	Bulgaria	Eswatini	Kenya	Nicaragua	Sri Lanka	
17	Burkina Faso	Ethiopia	Kyrgyz Republic	Niger	St. Lucia	
18	Burundi	Fiji	Lao, PDR	Nigeria	St. Vincent & Grenadines	
19	Côte d'Ivoire	Gabon	Latvia	Pakistan	St. Kitts and Nevis	
20	Cabo Verde	Gambia, The	Lebanon	Panama	Sudan	
21	Cambodia	Georgia	Lesotho	Paraguay	Suriname	
22	Cameroon	Ghana	Liberia	Peru	Tanzania, United Rep.	
	Panel B: Countries in the prediction set (with information only for inflation and exchange rates)					
1	Aruba	Denmark	Israel	Luxembourg	Oman	Switzerland
2	Austria	Estonia	Italy	Macao SAR, China	Qatar	Taiwan, China
3	Bahrain	Finland	Japan	Malaysia	Saudi Arabia	United Aran Emirates
4	Belgium	France	Kiribati	Malta	Singapore	United States
5	Brunei Darussalam	Germany	Korea, Rep.	Netherlands	Slovakia	
6	Canada	Hong Kong SAR, China	Kuwait	North Macedonia	Spain	
7	China	Iceland	Lithuania	Norway	Sweden	
	Panel B: Countries excluded (with information only for fiscal crises)					
1	Afghanistan	Comoros	Kosovo	Puerto Rico	Tajikistan	West Bank and Gaza
2	Angola	Ecuador	Libya	Romania	Tonga	Yemen
3	Antigua and Barbuda	Eritrea	Nauru	Somalia	Turkmenistan	
4	Bhutan	Guyana	Palau	St. Vincent and the Grenadi	Tuvalu	
5	Central African Republic	Kazakhstan	Papua New Guinea	Syria	Vanuatu	

Note: Panel A lists the countries included in our training set, which have data for both the predicted variable (fiscal crisis) and the predictors (inflation, energy price variation, and exchange rates). Panel B displays countries with data only in the prediction set. Together, the countries in Panels A and B form the whole prediction set, for which we can estimate the fiscal distress indicator. Lastly, Panel C shows the countries excluded from our dataset due to having fiscal crisis data but lacking high-frequency predictor data from BIS and the World Bank.

6. Results

Our main findings on the characterization of fiscal distress indicators are presented in Figures 1 to 12 and Table 3, with the actual probabilities for each country detailed in the Appendix. Figures 1 to 9 explore fiscal crisis probabilities across eight dimensions, which are linked to specific hypotheses inspired by previous literature. In general lines these dimensions are whether a country is emerging/low-income, resource-rich, or highly indebted; its levels of financial openness (both de jure and de facto); and its trade openness. Additional figures compare countries with inflation-targeting regimes versus others, those with pegged exchange rate agreements, and those with fiscal rules in place. The main analysis focuses on the period running from January 1990 to December 2023. Figure 10 offers a visual comparison between the pre-1990 and post-1990 periods, along the lines of the 9 characterization variables. We provide statistical evidence of these results using various panel data specifications, with the outcomes summarized in Table 3. The section concludes with Figures 11 and 12, which show clusters of countries exhibiting high synchronization of fiscal pressures in the post-1990 period.

6.1. Contrasting Hypotheses for the Characterization of Fiscal Distress

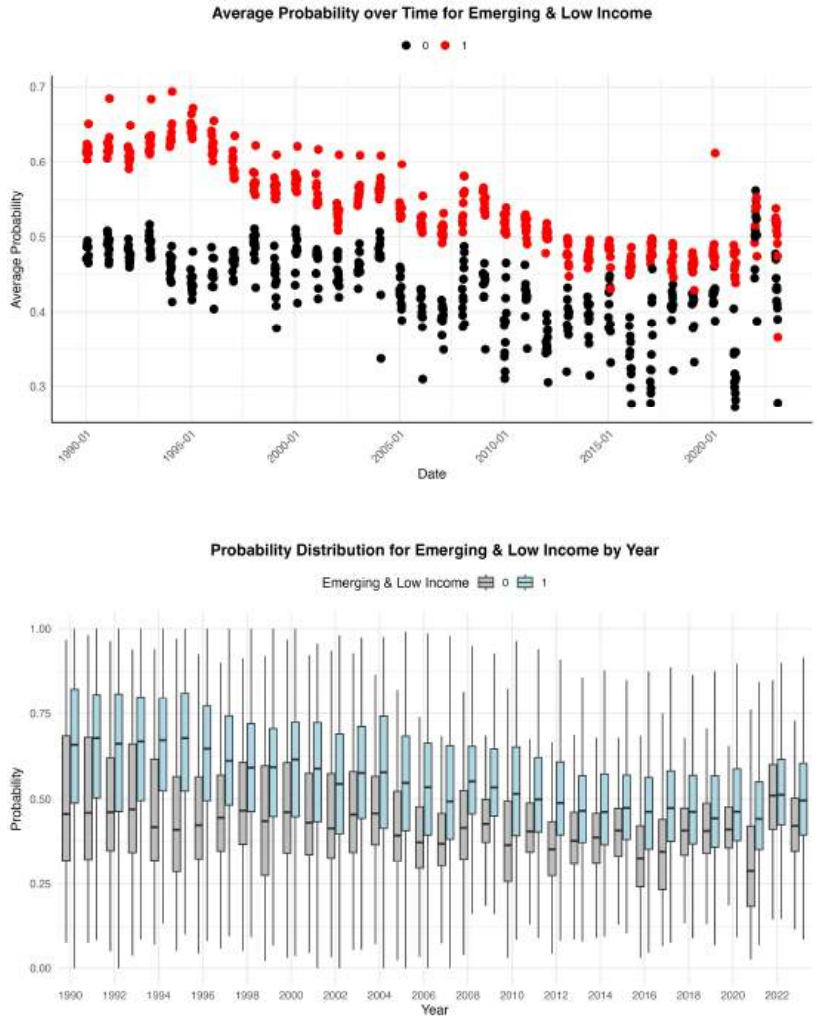
H1: *Developed countries are less likely to experience fiscal crises compared to developing countries.*

Developed countries are generally considered to have more robust institutions, stronger fiscal policies, and greater access to international capital markets, which lowers the likelihood of fiscal crises. Additionally, developed economies often have diversified revenue sources, better public finance management, and lower default risk perceptions compared to developing countries.

The literature provides several examples linking fiscal crises to development. For instance, fluctuations in terms of trade serve as a significant driving force behind business cycles in developing countries (Mendoza, 1995; Broda, 2004). Similarly, business cycles in emerging markets are influenced by changes in global interest rates (Uribe and Yue, 2006). Many developing economies heavily rely on commodity taxation for public revenue and depend on imported intermediate goods with few close substitutes. As a result, this volatility in business cycles may lead to a higher likelihood of sovereign defaults and, consequently, an increased probability of fiscal crises. Additionally, events that negatively impact a country's productivity—such as wars or civil conflicts, which are more common in developing countries—can also trigger sovereign risk perceptions (Sturzenegger and Zettelmeyer, 2006).

In Figure 1, we present the estimated probabilities of fiscal crises for our sample of 163 countries. The top panel (A) displays the monthly average probabilities for two distinct groups: emerging and low-income developing countries on one hand, and advanced economies on the other, covering the period from January 1990 to December 2023. The bottom panel (B) illustrates the same probabilities using a box plot, aggregated by year, for the same groups. This panel highlights the yearly distributions of the probability of fiscal crises.

Figure 1: Fiscal Distress Indicator Grouped by Level of Development



Note: The top panel displays the evolution of the average estimated monthly probability of a fiscal crisis over time for advanced economies and non-advanced economies (including emerging and low-income developing countries). The bottom panel presents the same probability, but shows the full distribution grouped by year.

From the figures, we observe that fiscal distress, as measured by the latent probability of a fiscal crisis, is consistently higher for developing economies. The year 2022 stands out as the

period with the most similar probabilities across both groups, likely due to the global surge in inflation. Notably, the distribution of probabilities has narrowed over time. This may be indicating that conditional on high debt levels, fiscal distress is also a concern for advanced economies. Indeed, the probability has increased for the last month in the sample, equalizing the levels in the aftermath of the global financial crisis (GFC). In general, the probabilities are larger in the earlier periods of the sample for both groups.

It is worth noting that the average estimates, and even the box plots, conceal significant heterogeneities at the country level (see the Appendix). For instance, Argentina has consistently exhibited probabilities above 0.5, with the only exception being in the second half of the 1990s, when probabilities dropped below 0.5 for several months. In fact, Argentina's probabilities follow a sine-like pattern, oscillating in cycles throughout the sample period. Currently, the probability stands at around 0.90. In contrast, Brazil, also part of the emerging nations group, presents a different trajectory. At the beginning of the sample period, its probability was significantly higher, fluctuating between 0.75 and 0.90, whereas by the end, it had decreased to between 0.45 and 0.70, though with an uptick toward the sample's end. Greece, meanwhile, shows a clear spike in probabilities between 2012 and 2015, when sovereign debt concerns were acute, and risks materialized. Interestingly, the probability for Greece remains relatively elevated toward the end of the sample, oscillating between 0.5 and 0.75. This stands in contrast to Germany, where probabilities consistently stayed below 0.5 throughout the period, except toward the sample's end, when they briefly and slightly increased above this threshold.

Overall, the divisions provide evidence supporting the indicators, as emerging and low-income developing countries are known to face higher probabilities of sovereign default. Consequently, these countries are typically required to pay higher premiums in international sovereign debt markets. They also house higher inflation rates and endure more volatile exchange rates.

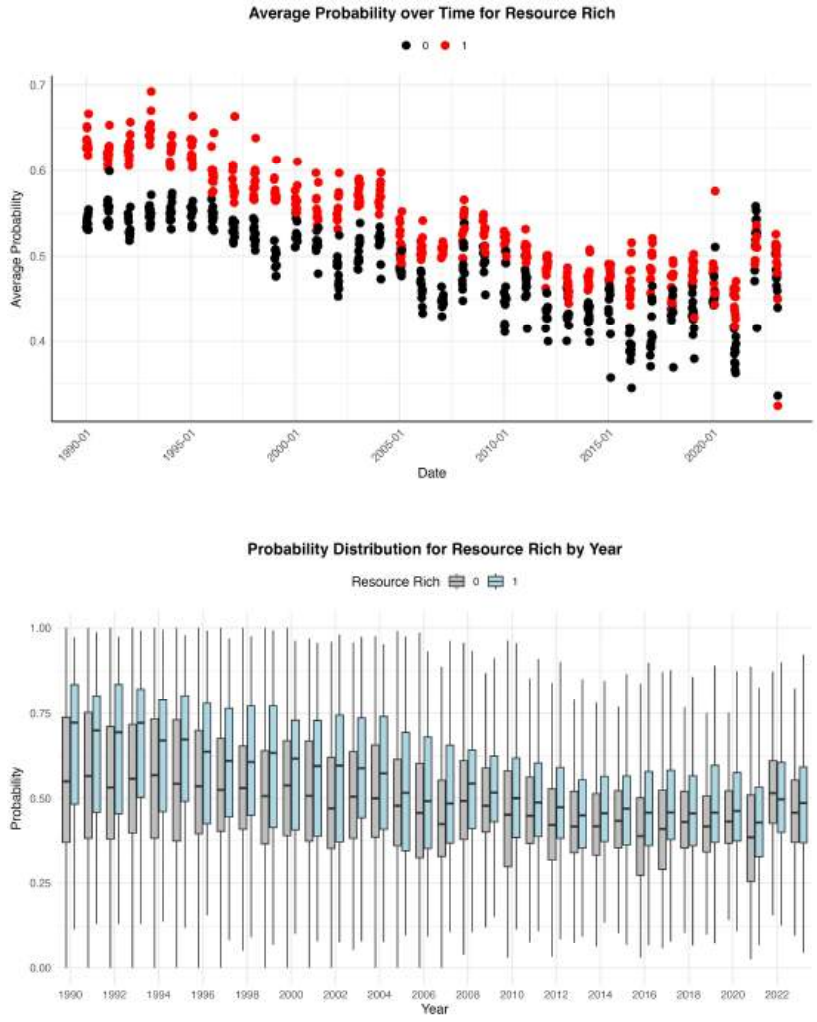
H2: *Resource-rich countries are more likely to experience fiscal crises compared to non-resource-rich countries.*

It is commonly believed that resource-rich countries are more vulnerable to sovereign debt or fiscal pressures because their economies are often highly dependent on volatile commodity prices. This commodity dependence leads to fiscal instability, especially when commodity prices drop, causing revenue shortfalls and increasing the debt burden, as highlighted by the literature on the 'natural resource curse' (Krugman, 1987; Van der Ploeg,

2011). Historically, many resource-dependent nations have struggled with boom-and-bust cycles, leading to fiscal mismanagement and increased risk of crisis (Sachs & Warner, 1995).

In Figure 2, we present the probabilities, distinguishing between resource-rich countries and others, following the classification by Mlachila and Ouedraogo (2020) at IMF. The plot structure is the same as before. This time, resource-rich countries consistently exhibit higher probabilities than other countries. This can be attributed to the fact that these countries' fiscal revenues are closely tied to the large fluctuations of commodity prices, which, in turn, creates greater uncertainty around their government's ability to meet debt obligations or rollover debt on favorable terms when necessary (Gomez-Gonzalez et al., 2023).

Figure 2: Fiscal Distress Indicator Grouped by Abundance of Natural Resources



Note: The top panel displays the evolution of the average estimated monthly probability of a fiscal crisis over time for resource-rich countries (1s) and non-resource rich countries (0s), classified according to Mlachila and Ouedraogo (2020) from the IMF. The bottom panel presents the same probability, but shows the full distribution grouped by year.

Once again, the distribution of probabilities has narrowed over time, reflecting the convergence of both inflation and energy prices throughout the period of analysis. Interestingly, while the probability of fiscal crises has clearly decreased for resource-rich countries, it has remained relatively stable for non-resource-rich countries.

H3: *Highly indebted countries are more likely to experience fiscal crises compared to low-debt countries.*

Highly indebted countries are more prone to sovereign debt or fiscal crises due to their increased vulnerability to debt servicing difficulties, especially when facing external shocks or economic downturns. High debt burdens often lead to unsustainable fiscal trajectories, triggering crises when markets lose confidence in a country's ability to repay. As the debt ratio increases, so does the probability of default or fiscal collapse (Reinhart and Rogoff, 2009).

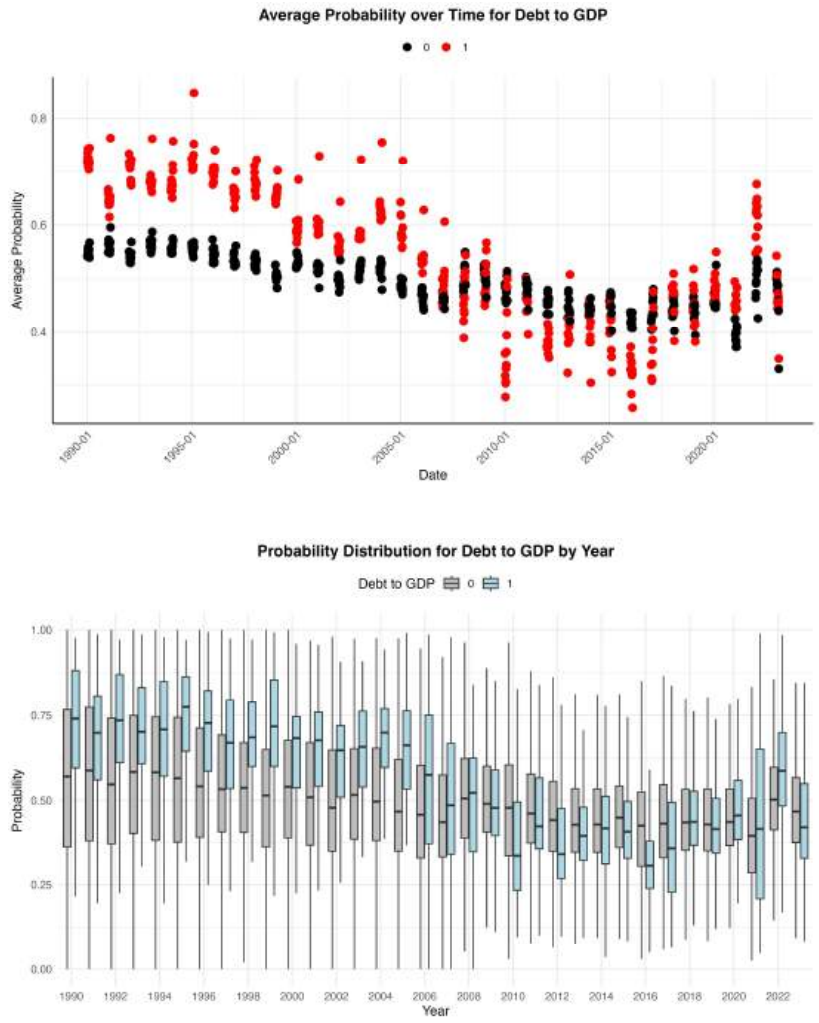
Figure 3 presents the probabilities distinguishing between countries with the highest debt-to-GDP ratios monthly during the sample period and other countries. As expected, highly indebted nations tend to exhibit a higher probability of fiscal crises, although this trend does not hold consistently across the entire sample period. Notably, from the end of the Global Financial Crisis (around 2009) until the onset of the COVID-19 pandemic in 2020, this pattern attenuated, with both groups enduring similar levels of distress. A sharp spike in the probability of fiscal distress is evident among highly indebted economies during the pandemic. Interestingly, despite the steady global increase in debt levels relative to output during this period, a decreasing trend in fiscal crisis probabilities is observed over time.

In general, as countries accumulate debt, the obligation to service that debt—through interest payments and principal repayments—grows. A high debt-to-GDP ratio can limit a government's fiscal space, making it more challenging to allocate resources to essential services and economic development. Amid controversies, literature has documented that high levels of debt are often associated with lower growth (Reinhart and Rogoff, 2010) and higher risks of default (Reinhart and Rogoff, 2009). As debt servicing consumes a larger portion of government revenues, it can lead to austerity measures that further hinder economic growth and social stability, increasing the likelihood of a crisis.

Highly indebted countries are also more vulnerable to economic shocks, such as sudden declines in commodity prices, currency devaluations, or global financial crises. According to Kaminsky and Reinhart (1999), countries with substantial external debt are more susceptible to capital flight and investor panic during periods of economic instability, leading to liquidity crises. This vulnerability can erode investor confidence, raising the probability of default and

signaling the onset of a fiscal crisis. This line of reasoning is also connected to the more recent literature of the Twin Ds, default and devaluation (e.g., Na et al., 2018; Chernov et al., 2023; Giraldo et al., 2024b).

Figure 3: Fiscal Distress Indicator Grouped by the Level of Debt



Note: The top panel displays the evolution of the average estimated monthly probability of a fiscal crisis over time for two groups: 1) the top 20 countries each month according to gross public debt as a percentage of GDP. 2) All other countries. The bottom panel presents the same probability, but shows the full distribution grouped by year.

When a country's debt levels are perceived as unsustainable, it may face higher borrowing costs or even exclusion from international financial markets. Eichengreen and Mody (1998) argue that a high debt burden can lead to rising risk premiums, making it more expensive for countries to refinance their obligations. This situation creates a vicious cycle where increased borrowing costs exacerbate fiscal stress and elevate default risk.

High levels of public debt can also lead to the crowding out of essential public investment. Governments facing substantial debt repayments may prioritize servicing their debt over funding critical infrastructure or social programs, which can stifle economic growth and development. This is emphasized by Berg et al. (2012), who found that high levels of debt can limit public investment, further weakening economic performance and increasing the likelihood of crises. Additionally, market perceptions of a country's creditworthiness can shift rapidly in response to changes in debt levels. According to Ostry et al. (2010), as debt levels rise, investors may perceive a higher risk of default, leading to increased volatility in bond markets and potential capital outflows. This sentiment can create a self-fulfilling prophecy, where the expectation of default triggers financial instability.

In summary, higher indebtedness is closely linked to a range of factors that collectively increase the probability of sovereign default and fiscal crises.

H4: *Financially open countries are more prone to fiscal crises compared to financially closed countries.*

Financial openness can increase the likelihood of fiscal crises as it exposes countries to global financial shocks and capital flight. The liberalization of capital flows allows for greater international consumption risk-sharing through increased international borrowing, but it also makes countries more vulnerable to sudden reversals in investor sentiment, leading to liquidity problems and increased debt burdens (Kaminsky & Reinhart, 1999). Countries with less regulated capital flows are often more exposed to external vulnerabilities.

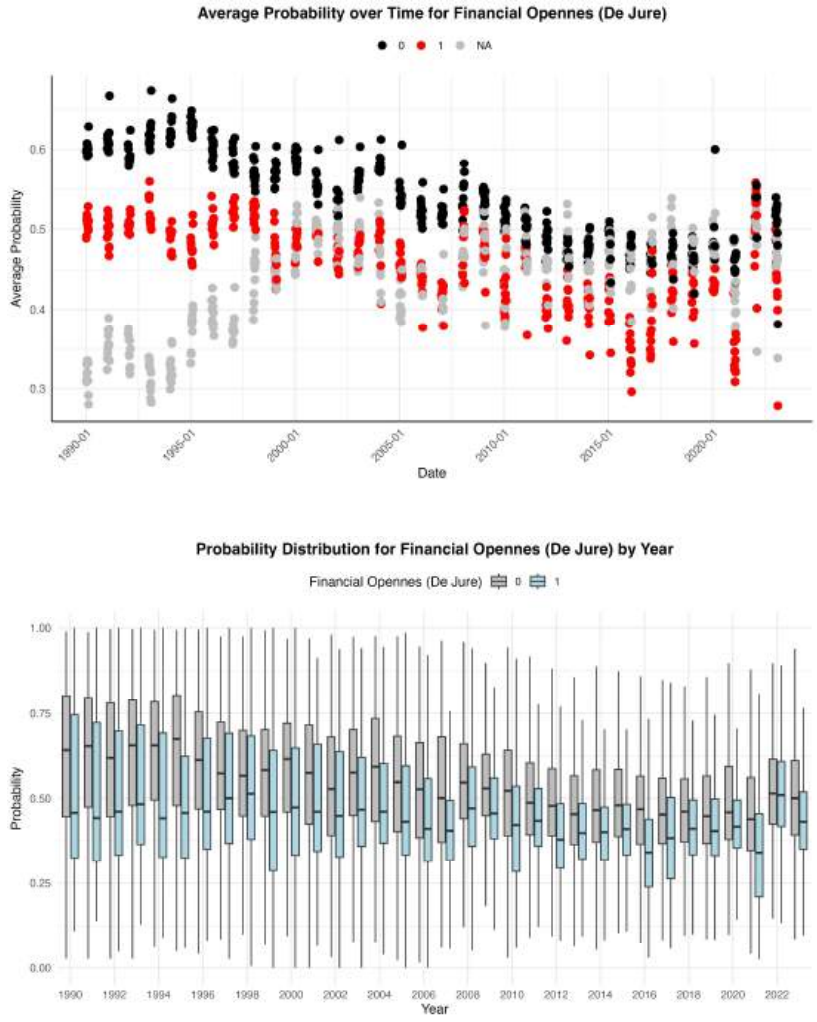
Despite our working hypothesis, it is important to highlight that the literature has not yet reached a consensus regarding Hypothesis 4. Moreover, this hypothesis is related to broader discussions in the field that link financial integration with financial stability—a concept broader than the fiscal stability analyzed here.

For instance, two recent studies present contrasting views in this respect. On the one hand, Devereux and Yu (2020) argue that while international financial integration diversifies risk, it also facilitates the spread of crises across countries. Their model presents a trade-off between the probability and severity of crises, as financial integration increases global leverage, reduces consumption risk, and encourages risk-taking among investors, ultimately raising the likelihood of financial crises. In contrast, Pierri and Quadrini (2018) suggest that greater financial integration reduces the probability of crises, but when they do occur, the effects are more severe and synchronized across countries. Their model indicates that financial frictions can lead to good equilibria with high expected resale prices for defaulted assets, which encourages borrowing. However, shifts in these expectations can result in bad

equilibria. Financial integration equalizes collateral prices across countries, creating more homogeneous credit conditions and making crises more global. As markets integrate, the likelihood of self-fulfilling crises decreases, as a larger market size necessitates coordination among more agents for a crisis to occur.

In Figures 4 and 5, we test Hypothesis 4 using two different proxies for financial integration. Specifically, these figures present the probabilities of fiscal crises, differentiating between countries with higher and lower levels of financial openness.

Figure 4: Fiscal Distress Indicator Grouped by Level of Financial Openness (De Jure)

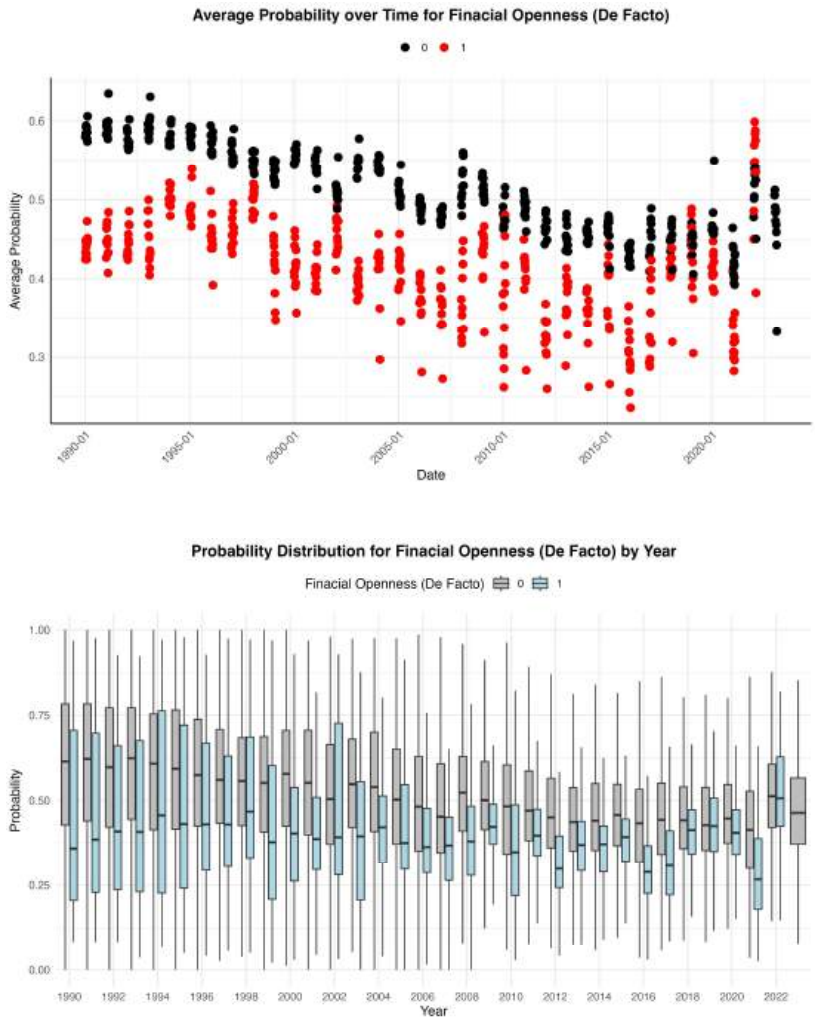


Note: The top panel displays the evolution of the average estimated monthly probability of a fiscal crisis over time for two groups: 1) countries with greater than 0.5 openness indicators according to Chinn and Ito (2006). 2) All other countries. The bottom panel presents the same probability, but shows the full distribution grouped by year.

Figure 4 evaluates financial openness using a *de jure* classification, while Figure 5 employs a *de facto* indicator. In both cases, countries with lower financial openness seem to exhibit

higher probabilities of experiencing fiscal crises. However, both indicators show that over time, these probabilities have been converging between the two groups. By the end of the period, it becomes difficult to distinguish the effect (refer to Table 3 for a more precise regression analysis). These results align with the intuition developed by Pierri and Quadrini (2018), although their framework does not directly address fiscal crises.

Figure 5: Fiscal Distress Indicator Grouped by Level of Financial Openness (De Facto)

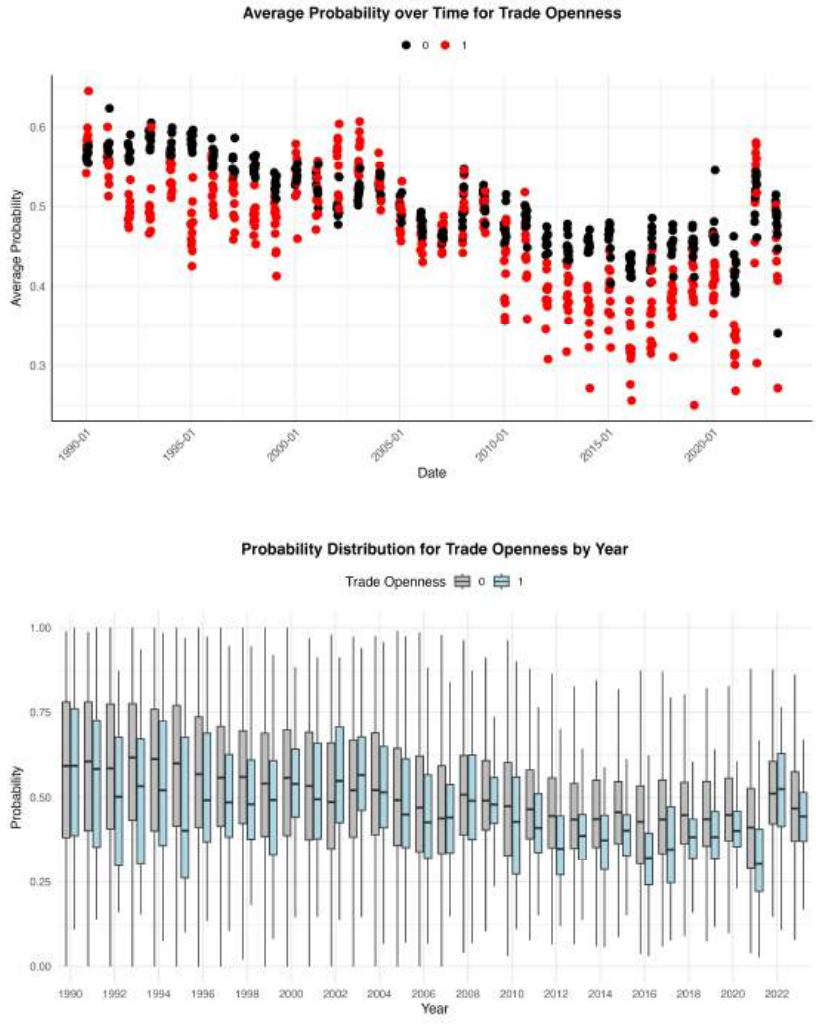


Note: The top panel displays the evolution of the average estimated monthly probability of a fiscal crisis over time for two groups: 1) the top 20 countries each month according to the sum of foreign assets and liabilities as a percentage of GDP in current U.S. dollars. 2) All other countries. The bottom panel presents the same probability, but shows the full distribution grouped by year.

H5: *Countries that are more open to trade are less likely to experience fiscal crises*

Countries that are more open to trade should be more resilient to fiscal crises. Trade openness often boosts economic growth and diversification, which leads to more stable revenues and lower fiscal imbalances. Additionally, trade helps reduce dependency on volatile domestic demand and makes countries more competitive internationally, reducing the likelihood of crises (Frankel and Romer, 1999). We test H5 in figure 6.

Figure 6: Fiscal Distress Indicator Grouped by the Level of Trade Openness



Note: The top panel displays the evolution of the average estimated monthly probability of a fiscal crisis over time for two groups: 1) the top 20 countries each month according to the sum of exports and imports of goods and services as a percentage of GDP. 2) All other countries. The bottom panel presents the same probability, but shows the full distribution grouped by year.

Focusing on trade openness rather than financial openness in Figure 6 reveals a similar pattern to that observed in Figures 4 and 5. In general, more open economies tend to experience lower fiscal distress, with notable exceptions between 2000 and 2005 and in the

aftermath of the COVID-19 pandemic, preliminary confirming the beliefs of conventional wisdom in the field.

H6: *Countries with fixed exchange rate regimes are more prone to fiscal crises due to the constraints these regimes impose on monetary policy, especially when external shocks occur.*

In theory, a fixed exchange rate limits a country's ability to adjust the value of its currency in response to external shocks, making it harder to absorb them. Without the option to devalue the currency, fiscal pressures may intensify, leading to higher sovereign risk and a heightened probability of fiscal crisis. All in all, fixed exchange regimes often exacerbate sovereign debt crises by limiting policy options.

According to the moral hazard argument outlined by Eichengreen and Hausmann (1999), pegged exchange rates act as an implicit guarantee, creating moral hazard. These regimes encourage unhedged borrowing in foreign currencies and, due to their lack of credibility over longer time horizons, skew financial flows toward shorter-term borrowing. These unhedged, short-term, foreign-currency-denominated liabilities become problematic and may lead to instability. Consequently, more flexible exchange rates are preferable, as they help limit short-term capital inflows and enhance the stability of the financial system and, by extension, the fiscal stability of a nation. Moreover, the perceived stability of fixed exchange regimes can encourage excessive borrowing and fiscal indiscipline, further increasing sovereign risk concerns. Lastly, the collapse of a fixed exchange rate often triggers a currency crisis, sharply raising the local value of foreign debt and worsening fiscal balances, a phenomenon explored by Kaminsky and Reinhart (1999).

Previous literature suggests that fixed exchange rate regimes may increase a country's vulnerability to fiscal crises and sovereign default. However, the options available to a monetary union like the Eurozone differ significantly from those faced by smaller countries like Panama with currencies pegged to the US dollar. This observation has sparked a debate on the appropriate way to measure the rigidity of exchange rate regimes—whether at the regional level, as done by the IMF or at the country level, as in Ilzetzki et al. (2019). We adopt the latter perspective.

According to Ilzetzki et al. (2019) the Eurozone lacks the flexibility of a cohesive sovereign entity, as its member countries do not possess individual currencies that could adjust to local economic shocks to inflation, output, or unemployment. The currency union operates at the rigid end of the exchange rate flexibility spectrum, similar to a *de jure* peg, where Eurozone countries are bound to a single currency without separate legal tender. Even the largest

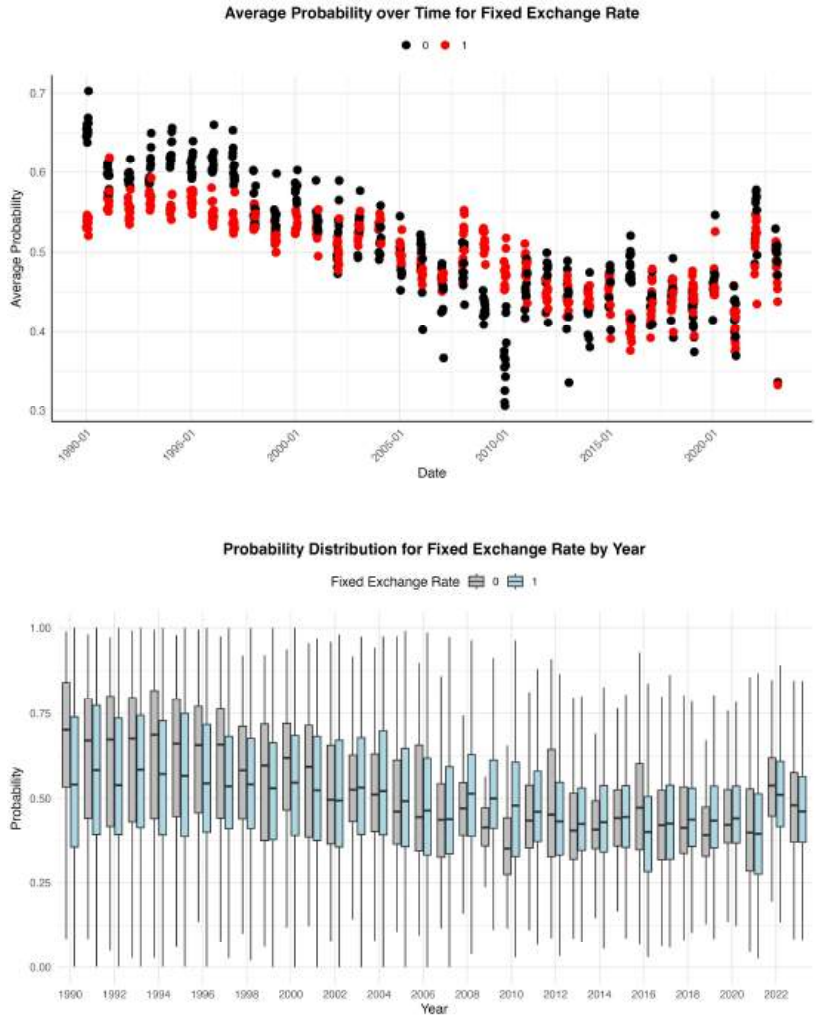
Eurozone economies, such as Germany or France, wield limited de jure influence over European Central Bank policy, holding only minimal voting rights. Consequently, ECB interest rate policy restricts member states' capacity to tailor monetary responses to national economic conditions, a stark contrast to the flexibility a floating exchange rate would afford under a rule like the Taylor rule, where interest rate adjustments respond to domestic inflation or output gaps.

Therefore, contrasting H6 is important in policy terms to understand which view prevails in the aggregate and how different fixed exchange rate contexts impact fiscal stability over different regimes of economic activity. One relevant mechanism, in the current context of historically high debt levels, is that sovereign debt crises, and consequently fiscal crises, often occur when a country accumulates high levels of external debt in foreign currency. Fixed exchange rate regimes can exacerbate this vulnerability, as countries may borrow more in foreign currency to maintain the peg. In the event of a crisis, maintaining the fixed exchange rate becomes unsustainable, potentially triggering a currency crisis that can spill over into a fiscal crisis. Figure 7 compares the probabilities of fiscal distress for countries with fixed exchange rate regimes and those with other exchange rate arrangements.

The figure can be divided into two distinct periods. From 1990 to 2004, both groups exhibited similar probabilities of fiscal distress, with slightly higher risks for countries with flexible regimes. Starting in 2005, the probabilities for countries with pegged exchange rates increased significantly, likely reflecting these economies' reduced ability to respond during crises due to the loss of monetary policy flexibility to counteract negative shocks.

Notably, the red dots, indicating fiscal crisis probabilities for pegged regimes, rise above the black dots (flexible regimes) during the Global Financial Crisis (2008-2009) and to a lesser extent in the 2020-2021 pandemic. This further highlights the transmission mechanism by which countries with fixed exchange rates lack the ability to use monetary policy as a tool for economic adjustment, exacerbating fiscal pressures and increasing the risk of sovereign default.

Figure 7: Fiscal Distress Indicator Grouped by Exchange Rate Regime



Note: The top panel displays the evolution of the average estimated monthly probability of a fiscal crisis over time for two groups: countries with a pegged exchange rate with a value of 1 and countries with a flexible regime with a value of 0. The bottom panel presents the same probability, but shows the full distribution grouped by year.

H7: *Inflation-targeting regimes are associated with lower likelihoods of fiscal crises.*

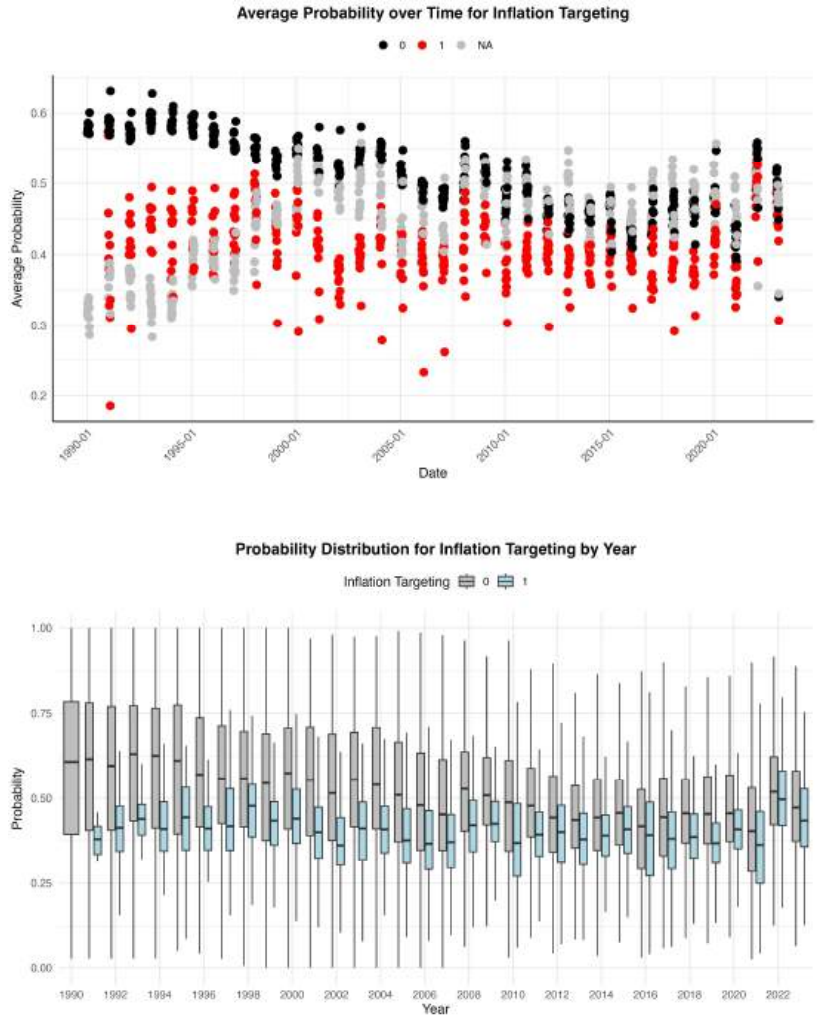
Inflation targeting typically reflects a commitment to macroeconomic stability, which enhances investor confidence and reduces borrowing costs. By controlling inflation, these countries prevent the erosion of debt sustainability, thus lowering the likelihood of debt crises. This can be rationalized by the fact that inflation targeting represents a stronger commitment to systematic and optimizing monetary policy compared to other regimes (Svensson, 1999). Moreover, inflation-targeting regimes often encourage fiscal discipline as a complement to achieving monetary stability.

Focusing on Figure 8, we observe that countries with Inflation-Targeting regimes consistently experience lower fiscal distress probabilities throughout the entire sample

period. As more countries adopt Inflation-Targeting, the variation within this group has also increased. This regime appears to have played a crucial role in keeping fiscal distress probabilities low, particularly during the pandemic and in the months that followed.

Our results align with those of Balima et al. (2017), who provide evidence of improvements in sovereign debt risk in emerging market economies following the adoption of inflation targeting regimes. Among other things, we extend their findings to a broader set of countries and examine the effects over time, while focusing on fiscal crises, a broader phenomenon than sovereign risk.

Figure 8: Fiscal Distress Indicator Grouped by Monetary Policy Regime



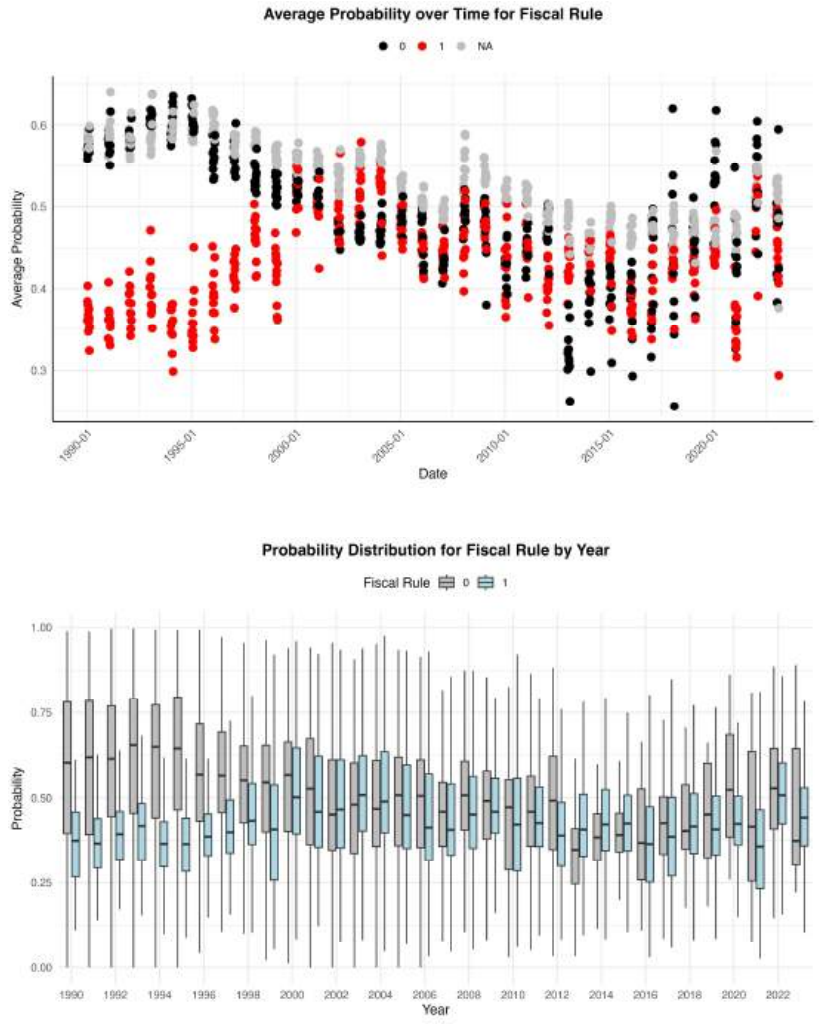
Note: The top panel displays the evolution of the average estimated monthly probability of a fiscal crisis over time for two groups: 1) countries with a declared inflation target with a value of one in the indicator and 2) All other regimes. The bottom panel presents the same probability, but shows the full distribution grouped by year.

H8: *Countries with fiscal rules in place are less likely to experience fiscal crises compared to countries without.*

Countries with fiscal rules, such as balanced-budget requirements or debt brakes, are less likely to experience sovereign debt or fiscal crises. Fiscal rules constrain government spending and borrowing, promoting fiscal discipline and sustainability (Grembi et al., 2016). By limiting the ability to accumulate unsustainable debt, these rules reduce the risk of fiscal mismanagement, which can lead to crises (Debrun et al., 2008). According to this view, effective fiscal governance is key to maintaining macroeconomic stability.

Figure 9 compares the probabilities of fiscal crises between countries with and without enacted fiscal rules. As anticipated, countries lacking a fiscal rule demonstrate a higher probability of fiscal distress, which underscores the intended purpose of these rules.

Figure 9: Fiscal Distress Indicator Grouped by Fiscal Rule



Note: The top panel displays the evolution of the average estimated monthly probability of a fiscal crisis over time for countries with an enacted fiscal crisis at a given month and the rest of countries. The bottom panel presents the same probability, but shows the full distribution grouped by year.

However, this distinction was more pronounced before January 2000. Since then, the probabilities for the two groups have been converging over time. Specifically, during the intervals from 2002 to 2005 and from 2010 to 2015, countries with fiscal rules exhibit higher fiscal distress than those without. From 2015 to the end of the sample period, the probabilities are relatively homogeneous, although countries without fiscal rules tend to have slightly higher probabilities. Additionally, there are some observations in the sample that we were unable to classify into either group from our sources (NAs), which show a relatively consistent probability over time with a modest downward trend.

6.2. Comparison of pre-1990 versus post-1990 eras

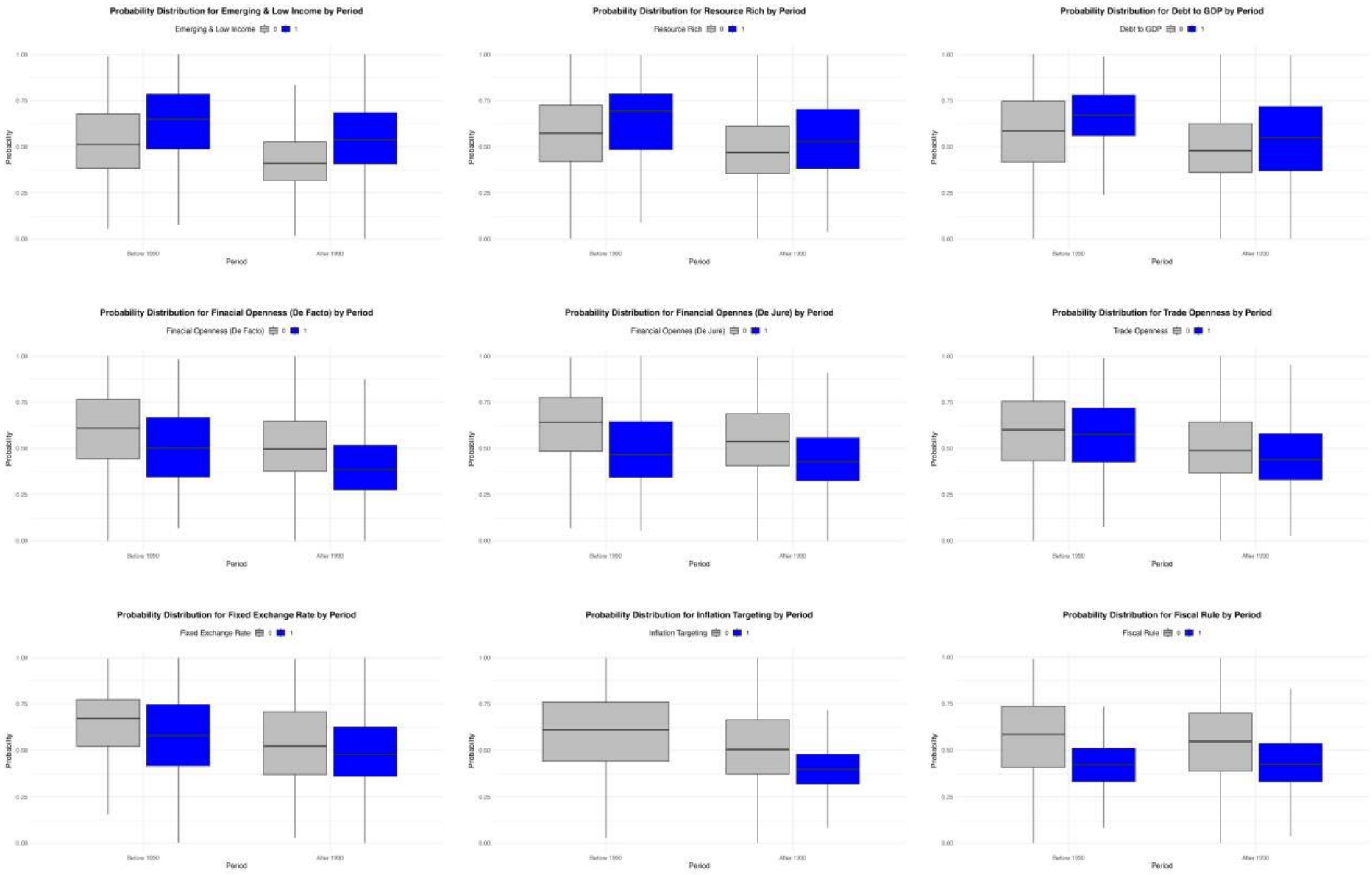
Although our main analysis focuses on the period from 1990 to 2023—years for which fiscal crisis estimates exist based on previous literature—our predictive models allow us to estimate unobserved probabilities prior to 1990. We postulate H9 to set the stage for this exploration:

H9: *The probability of experiencing sovereign debt or fiscal crises has decreased in the post-1990 era compared to the pre-1990 era.*

The likelihood of sovereign debt or fiscal crises may have decreased in the post-1990 era compared to earlier periods due to the widespread adoption of more prudent fiscal policies, better governance, and improved access to international financial institutions. The pre-1990 era was characterized by numerous debt crises, especially in emerging markets such as Latin America. In contrast, the post-1990 era has seen a reduction in crises due to increased economic globalization, multilateral financial cooperation, and stronger institutional frameworks.

In Figure 10, we provide a visual comparison of these probabilities, disaggregated across the nine categories discussed in Section 6.1. In most cases, the probabilities are higher before 1990, while maintaining the same inter-group rankings for each category. Interestingly, not only has the average value of the probabilities decreased between the two periods, but the entire distribution has also contracted in most instances, indicating a less volatile set of probabilities over time. A notable exception is the probability for highly indebted countries, which is now more dispersed among countries than it was before, due to the ever-growing debt in advanced economies during the last part of our sample period.

Figure 10: Distribution of the Probability of Fiscal Crisis Before and After 1990



Note: The figure depicts the evolution of the fiscal distress indicator across two periods, pre-1990 and post-1990. Each subplot corresponds to a different classification.

Our findings can be rationalized by recognizing the distinct macroeconomic regimes during two key periods. From 1970 to 1990, economic performance was characterized by high inflation, volatility, and the transition from the Bretton Woods system to floating exchange rates (Frieden, 2006). This era was defined by significant economic shocks, such as the oil crises of 1973 and 1979, which triggered widespread inflation across advanced economies. These supply-side disruptions (see Shapiro, 2024), combined with sluggish economic growth, led to stagflation. In many countries, inflation surged to double digits, prompting central banks to prioritize price stability.

6.3. Regression results

We present our regression results in Table 3. Overall, most of the effects described in Section 6.1 remain significant even when considered simultaneously across all estimators (i.e., Random Effects, Two-Way Fixed Effects, Pooled OLS, and GLS). However, certain effects warrant further consideration, as they either change sign or lose significance when incorporated into the comprehensive regression framework.

Consider columns 2 to 5 in Table 3, which present models estimated in order by POLS, TWFE, RE, and GLS. We can observe that the positive effect of natural resource abundance and the negative effect of trade openness become non-significant when moving from the POLS specification to the Random Effects and GLS models. It is important to note that this does not imply resource dependence and trade openness are unimportant determinants of fiscal crises, as both variables are clearly associated with fiscal crisis probabilities (see Figure 6). Rather, it suggests that the effects of these variables likely operate through intermediate mechanisms that are already captured in our regression framework by other variables. This is akin to how trade ceases to be a key determinant of growth, once a country's institutional framework is considered (Rodrik et al., 2004).

Notably, when analyzed together, the two indicators of financial openness—de jure and de facto—exhibit opposite signs: de jure openness has a negative (protective) effect, while de facto openness shows a positive effect, indicating higher risk. This contradictory relationship aligns with previous literature, which has highlighted that the measures of financial integration available in the field capture very different underlying forces, resulting in varied impacts on financial stability and economic stability. Indeed, consistent with Giraldo et al. (2024a), which emphasizes banking stability, we also find that de jure financial openness positively contributes to fiscal stability, while de facto measures—particularly those based on foreign direct investment (FDI) flows—have a detrimental effect on fiscal risk. This result is

also consistent with the hypothesis proposed by Benigno et al. (forthcoming), which suggests that increased financial integration is typically directed toward financing investments in non-tradable sectors. In their model, these sectors do not contribute as much to productivity growth, leading to a misallocation of resources from tradable to non-tradable sectors, ultimately hindering innovation investments in technological leaders like the US. In developing countries, the effects of financial integration can also be detrimental. Initially, while technology adoption may rise, over time, a decline in innovation activities at the technological frontier reduces the productivity gains that developing countries can achieve by absorbing knowledge from that frontier. In this context, *de facto* capital flows, which contribute to the so-called "savings glut", are negatively associated with productivity and growth, potentially increasing fiscal pressures.

Taken together, the most substantial effects are observed for countries classified as emerging or low-income economies. Being a developing country results in a penalty of 10 to 13 percentage points (pp), depending on the specification. This classification is largely time-invariant in our sample, so the analysis is limited to the RE, POLS, and GLS models.

Key policy choices also have significant impacts, notably the presence of inflation-targeting regimes, which reduce the probability of crises by 4 to 7 pp, depending on the specification. Similarly, fiscal rules are associated with a reduction of 2 to 7 pp in crisis probability, which is always statistically significant. Conversely, being among the 20 most indebted economies significantly increases the likelihood of fiscal distress by 4 to 6 pp.

On average, fixed exchange rate regimes slightly decrease fiscal distress probabilities by 1 to 2 percentage points. Broda (2004) previously noted that flexible exchange rate regimes provide better insulation against real shocks. However, our results—controlling for other policy variables and using an extended sample—do not show a clearly attenuating effect of flexible exchange rates on fiscal distress rates. The significant effect we observe likely stem from classifying Eurozone countries as fixed exchange rate regimes, consistent with Ilzetzki et al. (2019).

In columns 6 and 7, we present two interaction models with two-way fixed effects. Column 6 includes an interaction with the dummy variable that takes the value of one before 1990 and zero from 1990 onward, while column 7 introduces an interaction between the dummy representing emerging and low-income developing countries and all other variables.

Table 3. Regression Results: Predicted Variable Fiscal Distress Indicator

	POLS	TWFE	RE	GLS	Inter. Before 1990	Inter. Emerging
Predictors	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*
(Intercept)	0.52 *** (0.52 – 0.53)		0.46 *** (0.44 – 0.49)	0.45 *** (0.42 – 0.48)		
Emerging and Low Income Countries	0.09 *** (0.09 – 0.10)		0.12 *** (0.08 – 0.16)	0.13 *** (0.09 – 0.16)		
Resource Rich Countries	0.02 *** (0.01 – 0.02)		0.02 (-0.02 – 0.06)	0.01 (-0.03 – 0.06)		
Financial Opennes (De Jure)	-0.05 *** (-0.05 – -0.04)	-0.03 *** (-0.03 – -0.02)	-0.03 *** (-0.04 – -0.03)	-0.03 *** (-0.03 – -0.02)	-0.02 *** (-0.03 – -0.02)	-0.04 *** (-0.05 – -0.04)
Financial Opennes (De Facto)	-0.04 *** (-0.04 – -0.03)	0.03 *** (0.02 – 0.03)	0.02 *** (0.02 – 0.03)	0.03 *** (0.02 – 0.03)	0.03 *** (0.02 – 0.03)	0.02 *** (0.01 – 0.03)
Trade Openness	0 (-0.00 – 0.01)	0 (-0.00 – 0.01)	0 (-0.00 – 0.01)	0 (-0.00 – 0.01)	-0.01 * (-0.01 – -0.00)	0.03 *** (0.02 – 0.03)
Inflation Targeting	-0.07 *** (-0.08 – -0.07)	-0.03 *** (-0.04 – -0.03)	-0.04 *** (-0.05 – -0.04)	-0.04 *** (-0.04 – -0.03)	-0.03 *** (-0.04 – -0.02)	0 (-0.01 – 0.01)
Fixed Exchange Rates	-0.02 *** (-0.02 – -0.01)	-0.01 * (-0.01 – -0.00)	-0.01 *** (-0.01 – -0.00)	-0.01 ** (-0.01 – -0.00)	0.01 * (0.00 – 0.01)	-0.02 *** (-0.03 – -0.02)
Largest 20 Debt to GDP Ratio	0.04 *** (0.04 – 0.05)	0.04 *** (0.04 – 0.05)	0.04 *** (0.03 – 0.04)	0.04 *** (0.04 – 0.05)	0.04 *** (0.03 – 0.05)	0.06 *** (0.05 – 0.06)
Fiscal Rule	-0.07 *** (-0.07 – -0.06)	-0.03 *** (-0.03 – -0.02)	-0.05 *** (-0.05 – -0.04)	-0.04 *** (-0.04 – -0.03)	-0.03 *** (-0.04 – -0.03)	0 (-0.01 – 0.00)
Period Before 1990	0.02 *** (0.02 – 0.03)		0.05 *** (0.04 – 0.06)	0.05 *** (0.04 – 0.07)		
Emerging&LowIncome:Before1990					0 (-0.01 – 0.01)	
ResourceRich:Before1990					0.02 ** (0.01 – 0.03)	
FinOpen_DeJure:Before1990					-0.06 *** (-0.07 – -0.05)	
FinOpenDeFacto:Before1990					0 (-0.02 – 0.01)	
TradeOpen:Before1990					0.06 *** (0.04 – 0.07)	
FixedER:Before1990					-0.07 *** (-0.08 – -0.06)	
Debt2GDP:Before1990					0.02 *** (0.01 – 0.04)	
FiscalRule:Before1990					0.02 (-0.00 – 0.03)	
Emerging&LowIncome:FinOpen.						0.01 (-0.00 – 0.02)
Emerging&LowIncome:FinInt.						-0.02 (-0.03 – 0.00)
Emerging&LowIncome:Trade						-0.07 *** (-0.08 – -0.06)
Emerging&LowIncome:InfTarget						-0.06 *** (-0.07 – -0.05)
Emerging&LowIncome:PegFX						0.03 *** (0.02 – 0.04)
Emerging&LowIncome:Debt						-0.03 *** (-0.04 – -0.02)
Emerging&LowIncome:FiscalRule						-0.04 *** (-0.05 – -0.03)
Random Effects						
σ^2				0.02		
τ_{00}				0.00 $_{Date}$ 0.01 $_{Country}$		
ICC				0.3		
N				88 $_{Country}$ 468 $_{Date}$		
Observations	47268	47,268	47,268	47,268	47,268	47,268
R^2 / R^2 *adjusted*	0.238 / 0.238	0.019 / 0.007	0.039 / 0.039	0.190 / 0.437	0.026 / 0.014	0.031 / 0.019
AIC	-34438.107	-49639.834	-48530.649	-47357.86	-49953.085	-50197.03
log-Likelihood	17231.054	24827.917	24277.325	23692.93	24992.542	25113.515

** p<0.05 ** p<0.01 *** p<0.001*

Note: The table presents the regression results from a predictive model of fiscal distress using data from January 1970 to August 2023. Six models are included: POLS; TWFE; RE; GLS, and two models incorporating interactions with a dummy for before 1990 and for developing economies.

In relation to the results reported in Section 6.2 and our ninth working hypothesis, we confirm that fiscal distress probabilities were statistically higher before 1990. Before 1990, being a developing country was not as penalizing, as the interaction between the pre-1990 dummy and the emerging/low-income dummy has a negative sign. During that period, resource-rich economies faced greater fiscal pressures, as indicated by the positive interaction between the resource-rich dummy and the pre-1990 dummy.

In general, for most variables we conclude that the main effects intensify in the period 1970-1990, and remain largely consistent across the two sample periods, which is coherent with larger fiscal crisis probabilities before 1990. Nonetheless, three interactions warrant further consideration: fixed exchange rates, trade openness, and fiscal rules.

Specifically, the protective effect of fixed exchange rates effectively disappears after 1990; in fact, it reverses, as the interaction is larger in absolute value than the pre-1990 effect. This suggests that the reduction in fiscal crisis probabilities due to fixed exchange rate regimes is not a current phenomenon. Furthermore, trade openness is significant and positive when interacted with the dummy before 1990, and the magnitude is larger than for the base category (after 1990), indicating that greater openness to trade was associated with higher fiscal distress in that period. Finally, countries with fiscal rules before 1990 were more prone to crises than today, when fiscal rules appear to play a protective role, as evidenced by their now-negative effect on fiscal crisis probabilities.

In the second interaction model shown in the last column, we observe that the protective role of financial openness is primarily driven by advanced economies; for emerging and low-income countries, the protective impact of financial openness is considerably smaller. The increase in de facto financial integration is similar across both groups of countries. However, in the case of trade openness, we see that greater openness in emerging market economies indeed translates into enhanced fiscal resilience. This is evidenced by a reduction in the effect of trade openness when interacted with the emerging countries dummy, yielding an interaction coefficient of -0.07, which is larger, in magnitude, than the risk increasing effect observed for advanced economies.

Moreover, inflation targeting and fiscal rules have a more pronounced and significant protective effect for emerging and low-income countries compared to advanced economies. Interestingly, the interaction effect for pegged exchange rate regimes is positive, suggesting that the protective role of fixed exchange rate regimes is significantly reduced for emerging

and low-income countries, which again underlies the role of the Euro in driving the main results. Finally, while high debt-to-GDP ratios remain positively associated with the probability of fiscal crises, this effect is notably smaller for emerging and low-income countries compared to advanced economies.

6.4. Commonalty and clusters in fiscal distress

In this section, we present an analysis of the clusters of probabilities for our main analysis period, January 1990 to December 2023. In Figure 11 the correlation matrix between the probabilities of fiscal crisis for 163 countries are presented. The figure also contains five squares which delimit the main five clusters in the sample according to the hierarchical clustering algorithm. As can be seen in this figure, the size of the cluster varies significantly, with one big square in the middle, which virtually contains half of the sample. Interestingly, there is also a marked negative correlation between the countries in the first block (the first box to the left) and those in the second and third clusters.

In Figure 12 we present the same information but this time the schematic structure allows us to include the name of the countries. Based on the estimated clusters of countries, it is possible to conjecture common grounds in terms of economic, political, and geographical characteristics.

Cluster 1: *Resource-Rich and Transitioning Economies (16 countries)*: Argentina, Bahamas, St. Thomas, Côte d'Ivoire, Tanzania, Iraq, Kiribati, Liberia, Montenegro, Namibia, Qatar, South Sudan, North Macedonia, Tunisia, Uzbekistan, Kyrgyzstan.

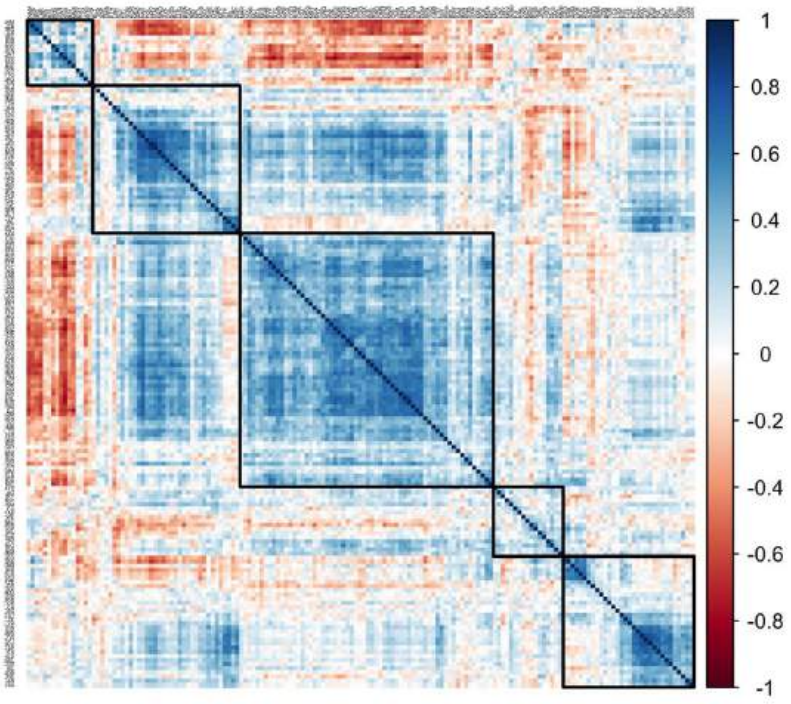
Countries in this cluster often have significant natural resource wealth (e.g., oil in Iraq and Qatar) and may face economic challenges due to volatility in global commodity prices. Others, like Argentina, have large agricultural sectors. In all cases, they are very dependent on natural resources. Many of these nations in this cluster are in transitional phases politically, with some experiencing conflict or instability (e.g., South Sudan and Iraq). They may also face governance challenges. This cluster includes countries from diverse regions, including Africa, the Middle East, and Latin America, with varied geographical challenges, from landlocked nations to island states. Notably, the fiscal dynamics of these countries are negatively correlated with those of clusters 2 and 3 and show little to no relationship with clusters 4 and 5.

Cluster 2: Middle-Income and Developing Nations with Established Institutions (39 countries): Algeria, Belize, Botswana, Bulgaria, Chile, Colombia, Croatia, Cyprus, Dominica, El Salvador,

Ethiopia, Greece, Haiti, Hungary, India, Ireland, Jordan, Korea, Rep., Lebanon, Malta, Mauritius, Mexico, Nepal, Equatorial Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Slovakia, Slovenia, South Africa, Sudan, Sweden, Russia, United Kingdom.

Countries in this cluster typically have more developed institutional frameworks than those in Cluster 1, with diverse industrial sectors and higher GDP per capita. Many have stable middle-income status and are characterized by diversified economies. These nations have stronger institutions, more established democracies, and better governance practices. However, some still experience political challenges like corruption (e.g., in Mexico and Russia). This cluster includes countries from Europe, Latin America, and parts of Asia, reflecting a range of developmental paths. Many have access to international markets and are relatively open to trade. Fiscal distress in these countries is negatively associated with that in cluster 1 and 4, while it has a positive association with that in cluster 3 and cluster 5.

Figure 11. Cluster of Countries According to The Probability of Fiscal Crisis



Note: The figure shows the correlation between the probability of experiencing fiscal crises across 163 countries from January 1990 to December 2023. Using hierarchical clustering, we identify five main clusters, highlighted with black squares.

Cluster 3: Emerging Markets and Transitional Economies (72 countries) : Albania, Bahrain, Benin, Bolivia, Brazil, Burkina Faso, Burundi, Cambodia, Cameroon, Chad, China, Macao, Congo, Rep., Costa Rica, Egypt, Djibouti, Hong Kong, Bosnia and Herzegovina, Eswatini, Gabon, St. Vincent and the Grenadines, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau,

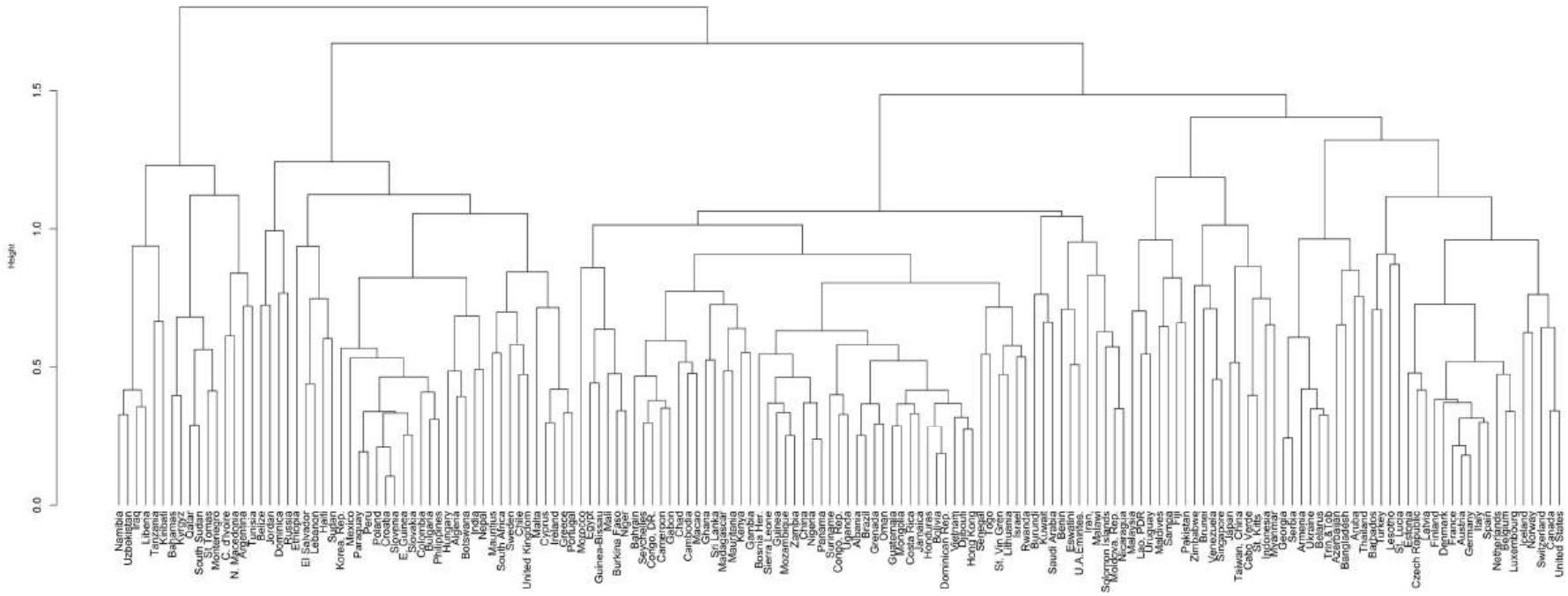
Honduras, Israel, Jamaica, Kenya, Kuwait, Lithuania, Madagascar, Malawi, Mali, Mauritania, Moldova, Mongolia, Morocco, Mozambique, Nicaragua, Niger, Nigeria, Oman, Panama, Dominican Republic, Rwanda, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Solomon Islands, Sri Lanka, UAE, Iran, Suriname, Congo, DR, Gambia, Togo, Uganda, Vietnam, Zambia.

This is the largest cluster in the sample, comprising roughly half of the countries. Many of these nations are characterized by rapid economic growth or emerging market status, often transitioning from low- to middle-income developing markets. They tend to rely heavily on natural resources (e.g., oil in Bahrain and Nigeria), agriculture (e.g., Guatemala and Kenya), and tourism services (e.g., Costa Rica and Jamaica), leading to greater fiscal revenue volatility. Politically, these countries exhibit a range of systems, from stable democracies (e.g., Costa Rica) to more authoritarian regimes (e.g., Sudan), with political instability sometimes affecting economic development. Geographically, this cluster spans diverse regions, including Latin America, Africa, the Middle East, and parts of Asia. Common challenges for these countries include vulnerability to external shocks and heightened exposure to the impacts of climate change. This cluster exhibits negative associations with cluster 1 and positive association with cluster 2, while the association is close to zero with both, cluster 4 and 5.

Cluster 4: Diverse Economies of Southeast Asia and the Pacific (19 countries): Venezuela, Cabo Verde, Fiji, St. Kitts and Nevis, Indonesia, Japan, Lao PDR, Brunei, Malaysia, Maldives, Myanmar, Pakistan, Samoa, Singapore, Taiwan, China, Uruguay, Zimbabwe.

This cluster includes either resource-rich countries (e.g., Venezuela and Brunei) or highly developed (e.g., Japan and Singapore). They vary significantly in economic performance, ranging from developing economies to global financial hubs like Singapore. Governance styles also differ, with stable democracies (e.g., Singapore and Uruguay) alongside more authoritarian regimes (e.g., Venezuela). This cluster serves as a catch-all or residual category, primarily comprising countries from Asia and the Pacific, many of which are small island nations or have unique geographical features that shape their economies, such as tourism and fisheries. The association among countries within this cluster is weak, as is the relationship between this cluster and the other four, indicating that the countries in this group face highly idiosyncratic fiscal pressures, preventing their classification into one of the other four clusters.

Figure 12. Cluster of Countries According to The Probability of Fiscal Crisis



Note: The figure presents the clusters of countries using the correlation between the probability of experiencing fiscal crises from January 1990 to December 2023.

Cluster 5: Developed and High-Income Countries (30 countries): Armenia, Aruba, Austria, Azerbaijan, Bangladesh, Barbados, Belarus, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Iceland, Italy, Trinidad and Tobago, Latvia, Lesotho, Luxembourg, Netherlands, Norway, Serbia, Spain, St. Lucia, Switzerland, Thailand, Turkey, Ukraine, United States

This cluster consists primarily of developed economies with high GDP per capita, advanced technological sectors, and diversified industries. Countries like Canada and Germany are known for their strong service sectors and solid fiscal positions relative to each other. Many of these countries enjoy stable democracies, strong institutions, and robust rule of law, though some, like Turkey and Ukraine, have recently faced important political challenges. Predominantly from Europe and North America, this cluster includes a mix of large and small economies, all with well-established infrastructure and high living standards. This is also evident in the presence of two sub-clusters within the main cluster, which tends to show a positive association with the second cluster

7. Conclusions

Fiscal crises have regained prominence in both academic and policy discussions, especially following the European debt crises of the mid-2010s. The intersection of historically high debt levels across economies, from low-income nations to advanced economies, with the pressing need for fiscal resources to support a global transition toward sustainable production raises concerns about potential new waves of fiscal distress in the coming years.

Thus, the necessity of developing new tools to monitor macroeconomic pressures and fiscal imbalances, particularly in developing countries, is growing. In our study, we contribute by providing a novel fiscal monitoring tool and actual estimates of fiscal distress for 163 countries from January 1970 to December 2023. These tools are easy to update on a regular basis and use only limited information of inflation, energy prices, and exchange rates.

Our analysis confirms established expectations about the relationship between various economic variables and policy choices on the one hand and fiscal outcomes on the other. Specifically, findings here highlight that emerging and low-income countries consistently face higher probabilities of fiscal crises. Resource-rich economies are also at increased risk, likely due to the volatility associated with commodity price variations, although this association loses its significance toward the end of the sample.

Countries with fixed exchange rate arrangements faced lowered probabilities of fiscal distress, but this association reverts especially during economic shocks such as the Global Financial Crise, and it is largely driven by the effect of the Euro toward the end of our sample period, as evidenced by our interaction models.

Countries adhering to inflation-targeting regimes consistently exhibited lower probabilities of fiscal crises, emphasizing the effectiveness of this framework in fostering price and macroeconomic stability. Our analysis also indicated that trade openness is positively correlated with fiscal health, especially for developing countries, but the association loses significance, on average, when other factors are considered simultaneously.

Furthermore, lower financial openness is associated with more significant risks of fiscal distress when both de jure and de facto measures of financial integration are considered separately, but the association reverts for de facto measures when considered in the general framework.

Fiscal rules have emerged as a significant factor influencing fiscal outcomes. These rules impose constraints on budget deficits and debt levels, which contribute to lower probabilities of fiscal crises. One likely mechanism through which fiscal rules positively impact fiscal stability is by keeping on track the debt-to-GDP ratio. This ratio is itself significant in predicting increased fiscal distress, particularly when examining the most indebted economies each month throughout the sample period. Nevertheless, we emphasized that this ratio can be reduced by both reducing the numerator or increasing the denominator, on which we do not conduct any formal analysis. In short, implementing fiscal rules and committing to price stability are effective measures for addressing fiscal turbulence, as expected.

Our clustering exercise provides key insights, particularly regarding the international diversification of sovereign risk. To diversify sovereign portfolios, it would be beneficial to balance holdings between countries in Cluster 3, which shows a high within-cluster correlation of fiscal crisis probabilities, and countries from Cluster 1. The most idiosyncratic risks are found in Cluster 4 and certain countries in Cluster 5. Due to the low correlation of fiscal crisis probabilities of countries in these clusters, they still offer potential for effective diversification strategies in global portfolios.

While estimating the actual diversification gains in terms of Sharpe ratios by comparing portfolios across different clusters with those concentrated in a single cluster is beyond the scope of this study, it represents a promising avenue for future research. This could be

pursued by using our monthly probabilities as pricing factors in sovereign debt markets. Such an approach would also allow for a more refined analysis, enabling monthly portfolio rebalancing to extract more relevant information from the continuous probabilities we generate.

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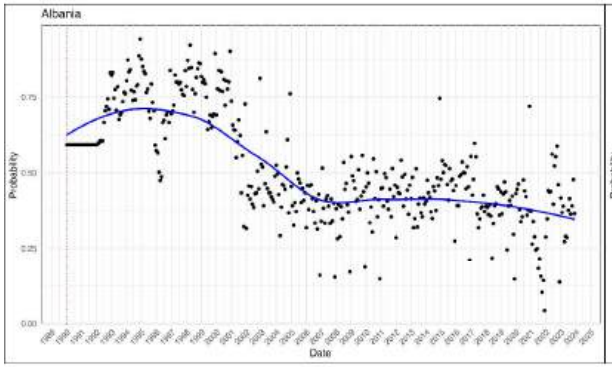
Online Appendix

Country Probabilities of Fiscal Crises: January 1990- December 2023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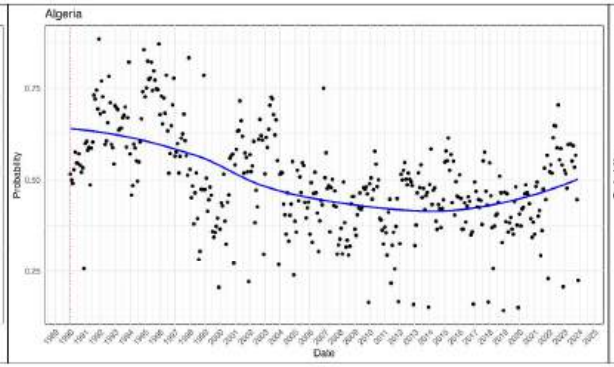
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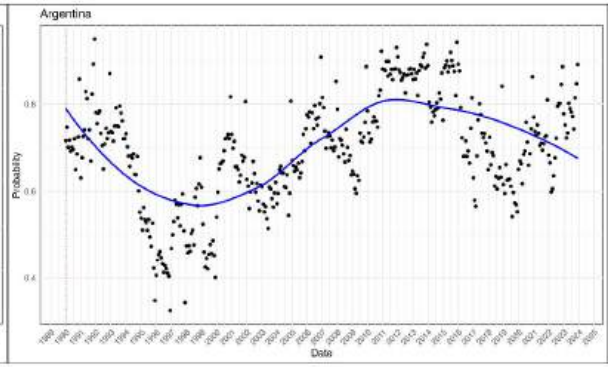
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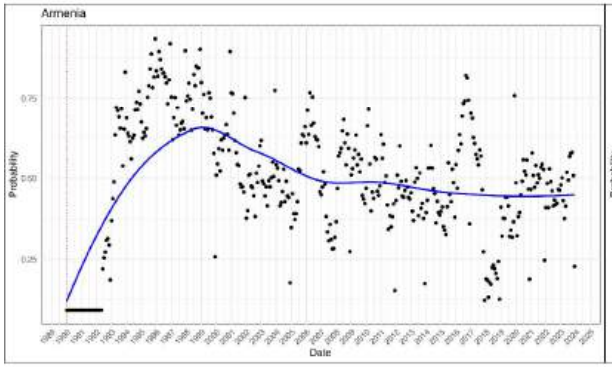
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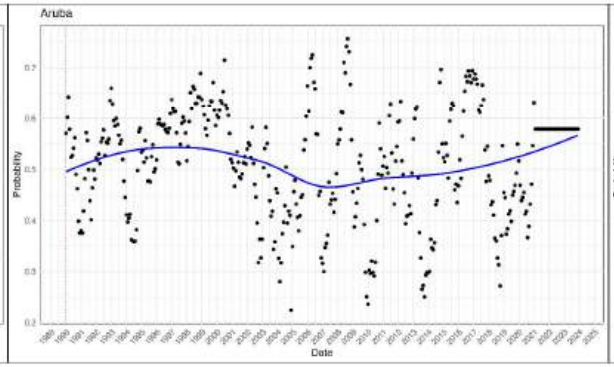
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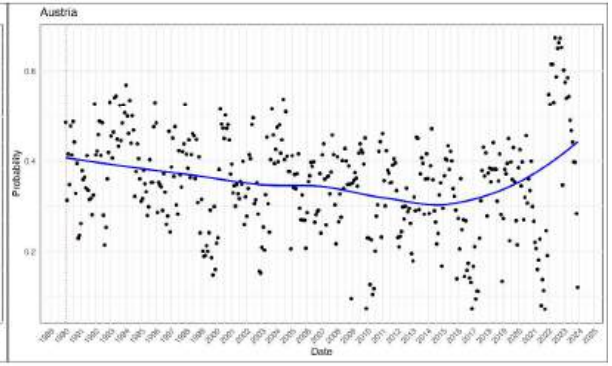
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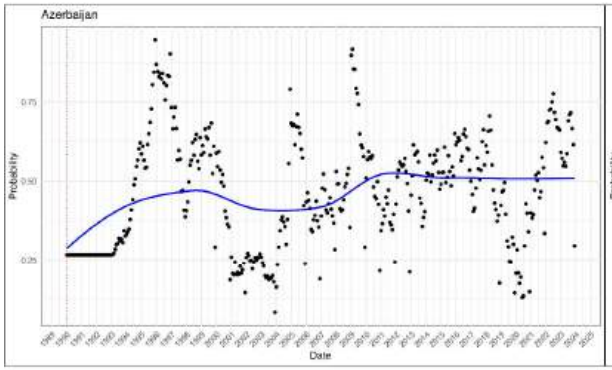
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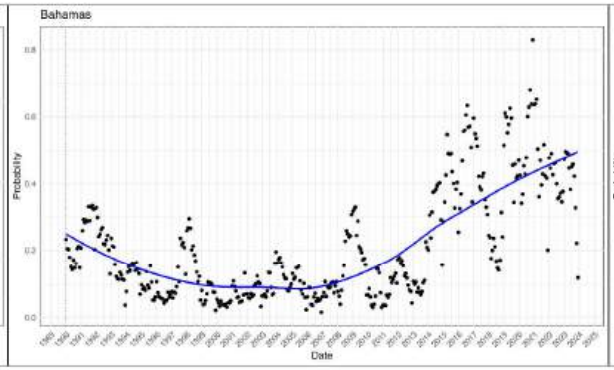
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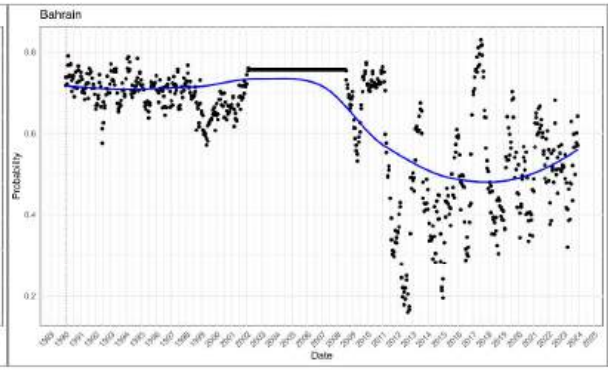
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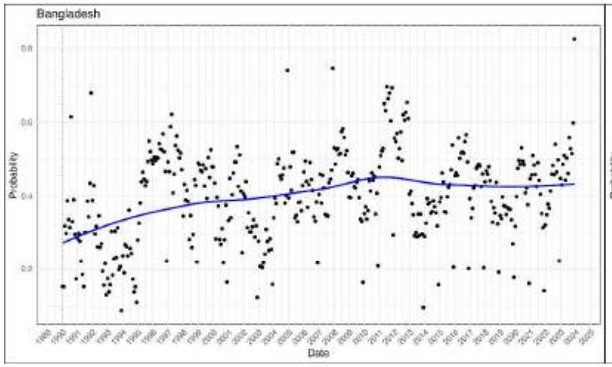
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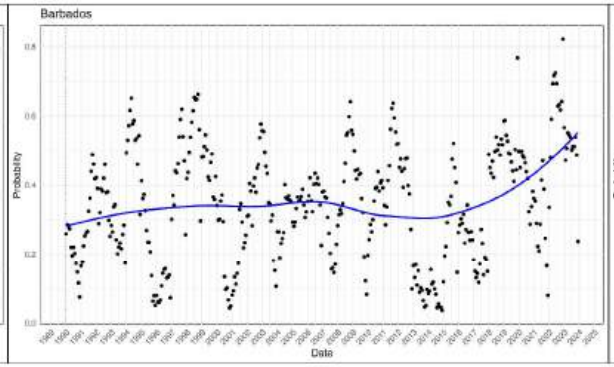
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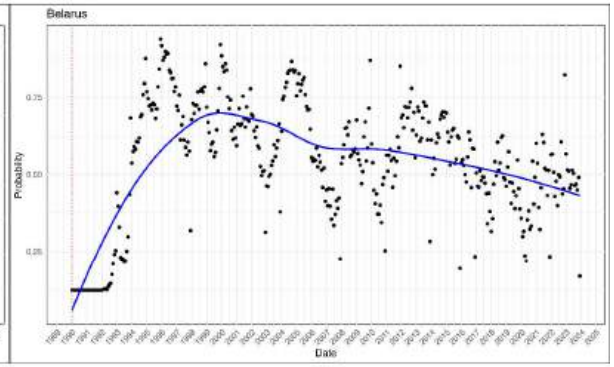
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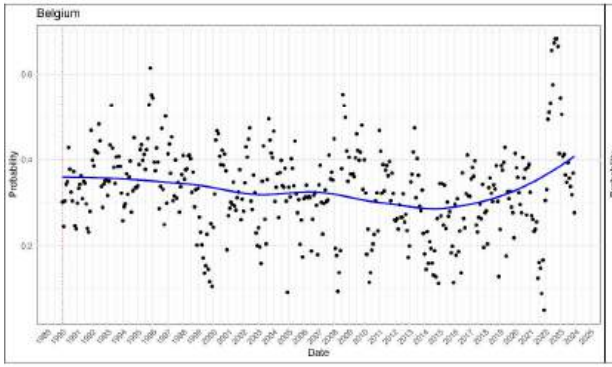
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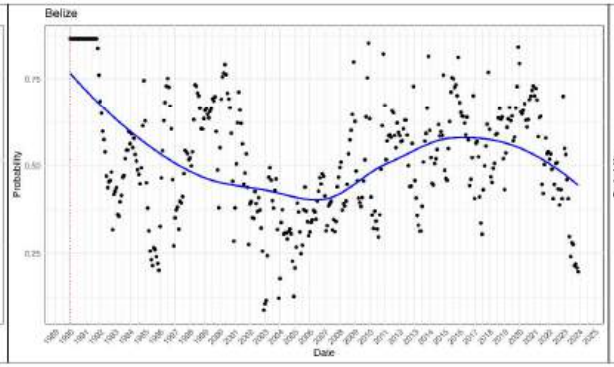
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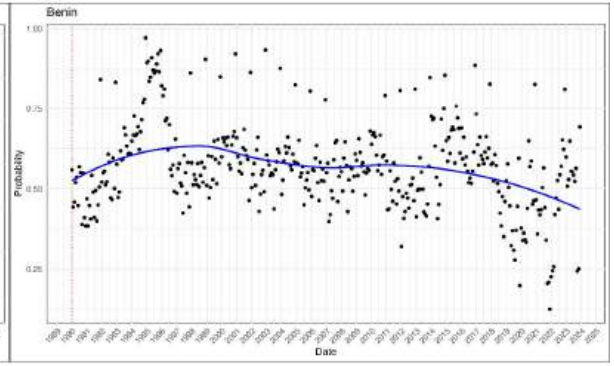
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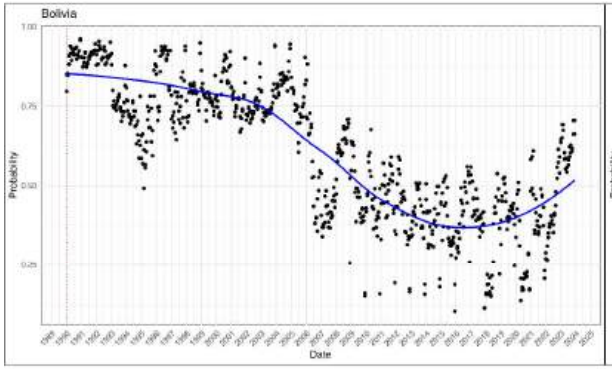
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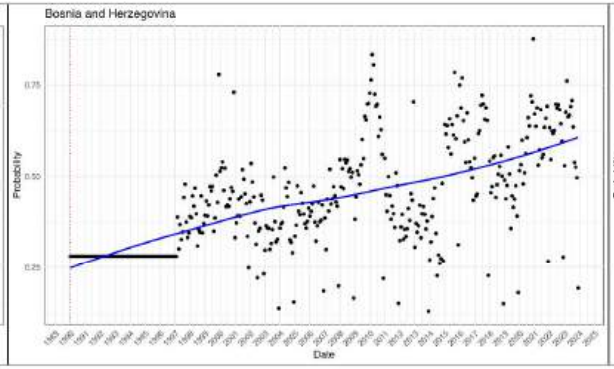
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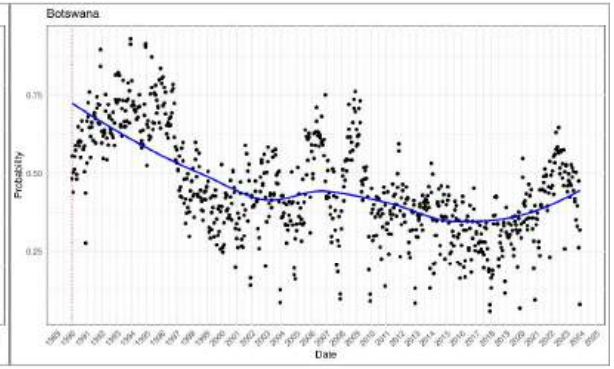
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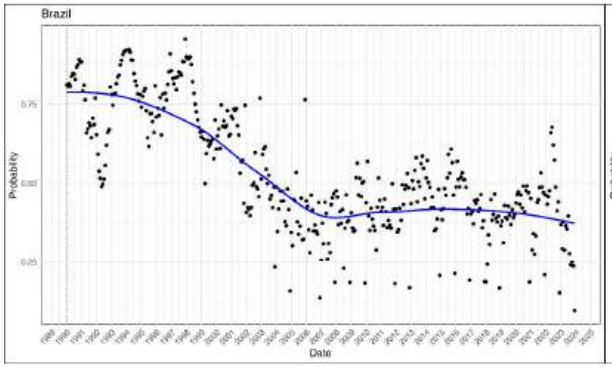
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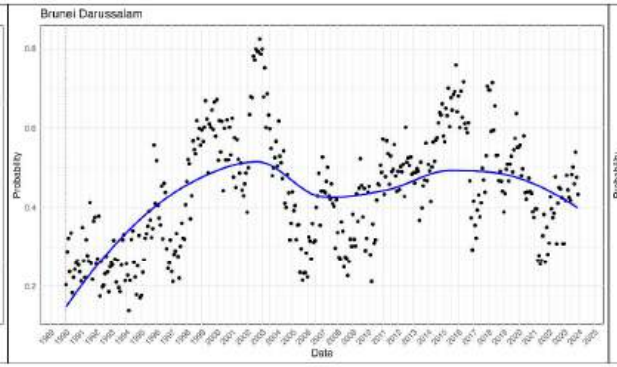
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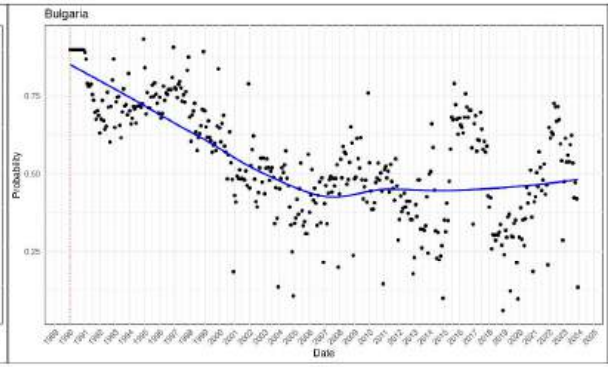
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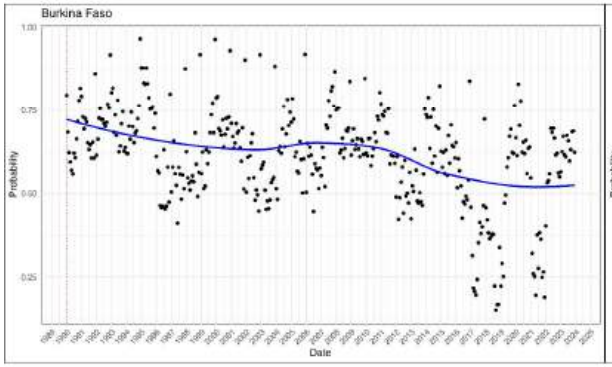
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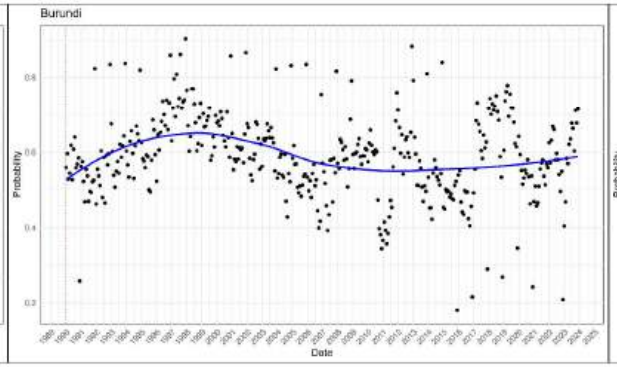
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Probability
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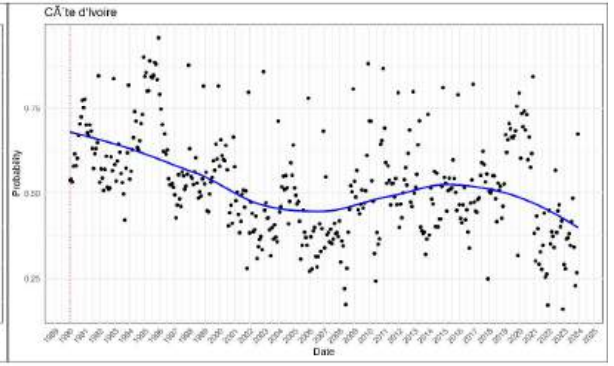
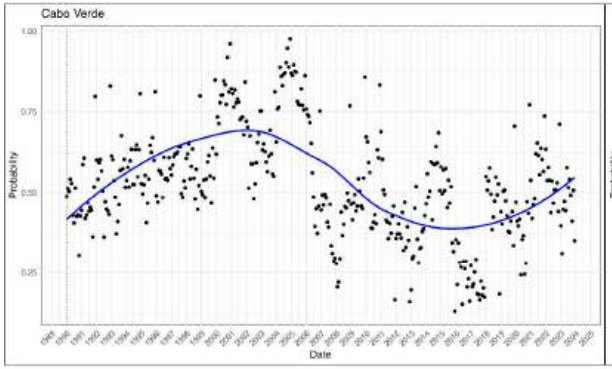
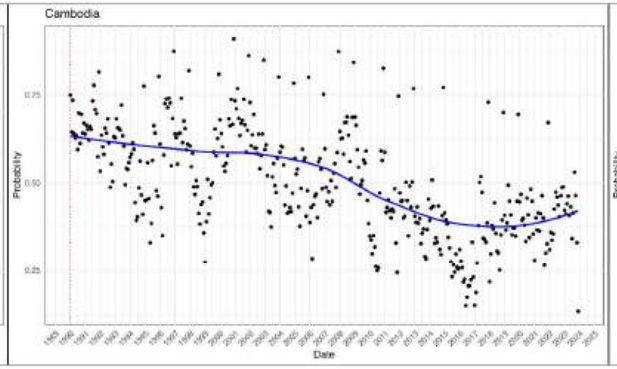
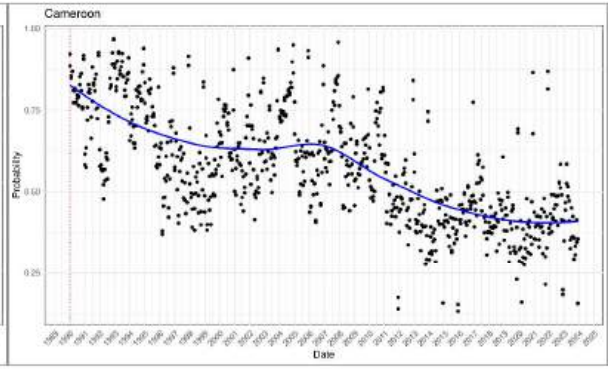
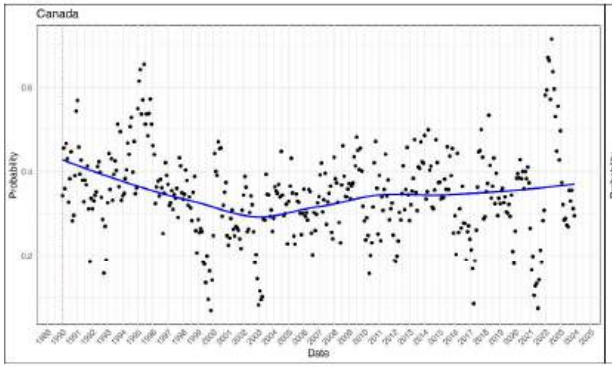
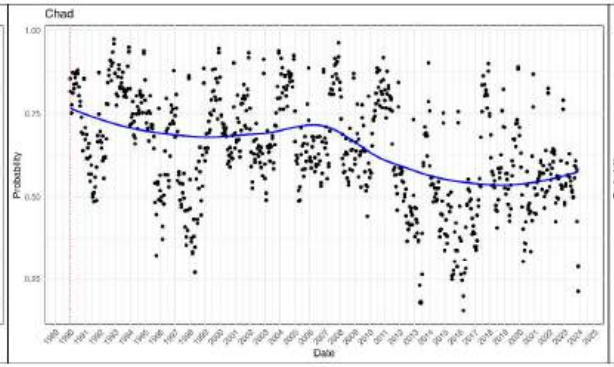

CÃ´te d'Ivoire
Probability
Date

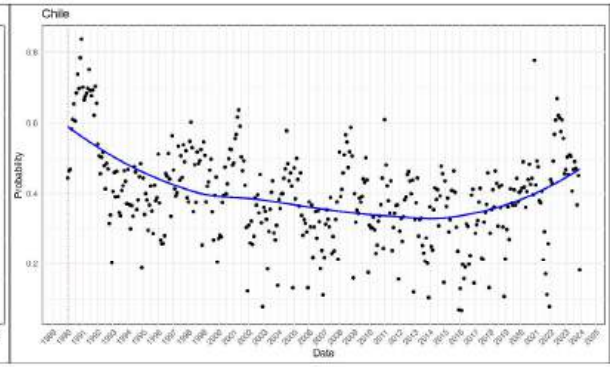

Cabo Verde
Probability
Date

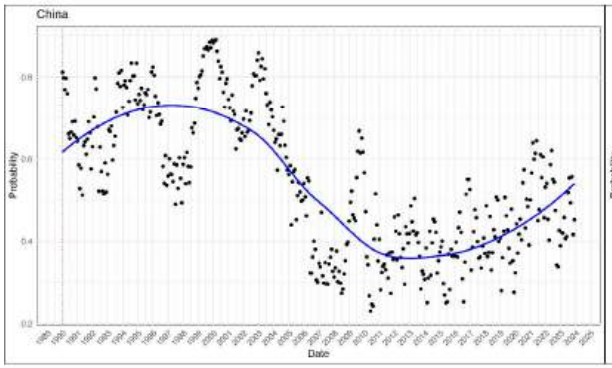

Cambodia
Probability
Date

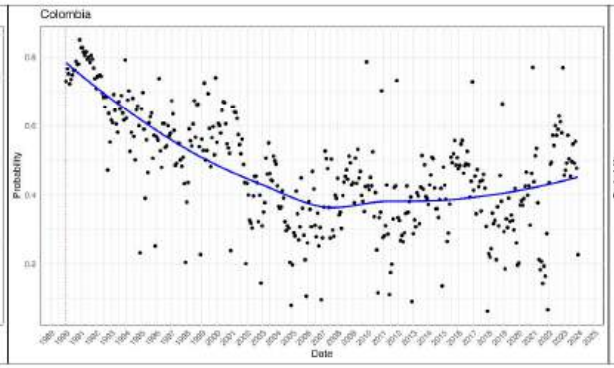

Cameroon
Probability
Date

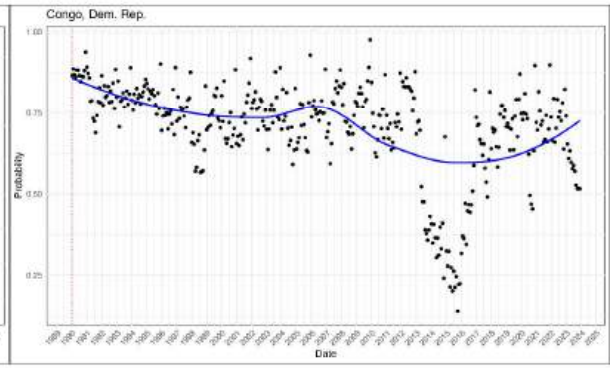

Canada
Probability
Date

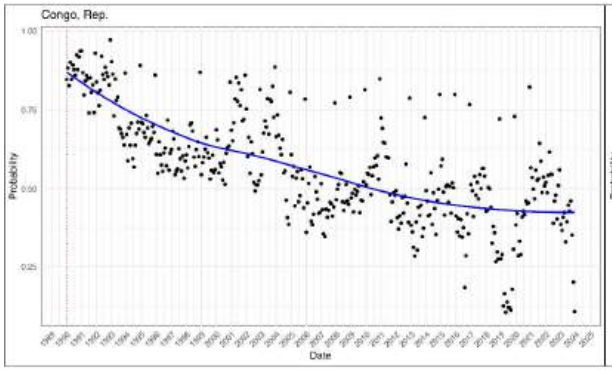

Chad
Probability
Date

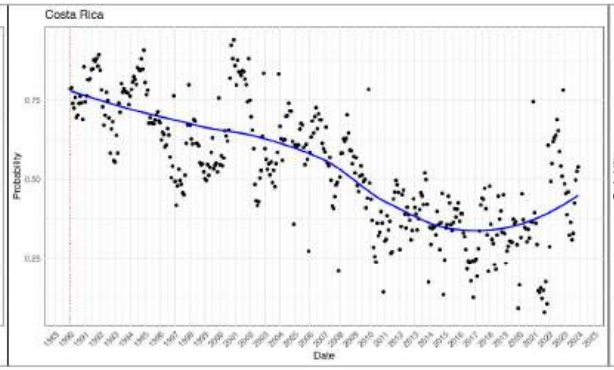

Chile
Probability
Date


China
Probability
Date


Colombia
Probability
Date


Congo, Dem. Rep.
Probability
Date


Congo, Rep.
Probability
Date


Costa Rica
Probability
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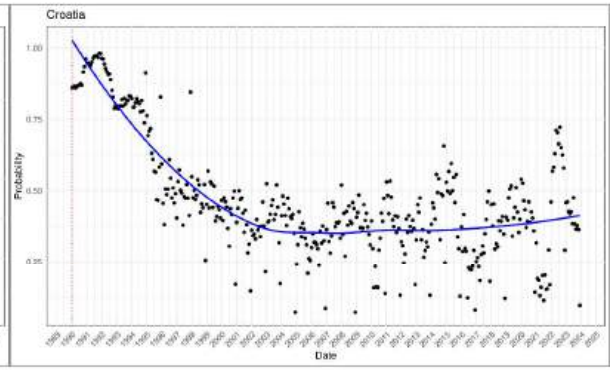
Croatia
Probability
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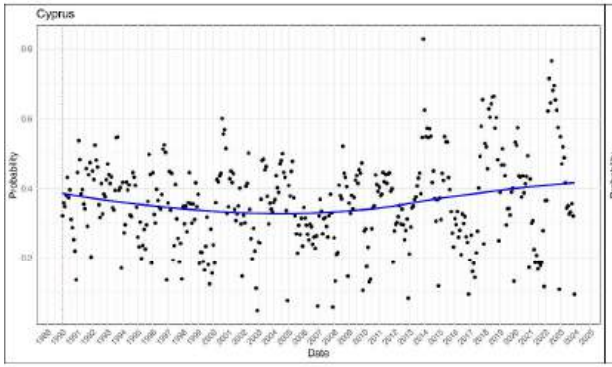
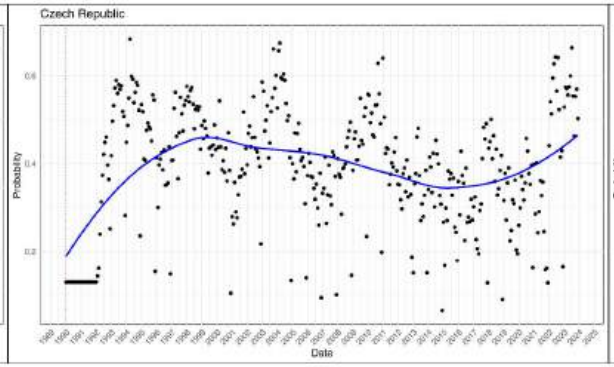
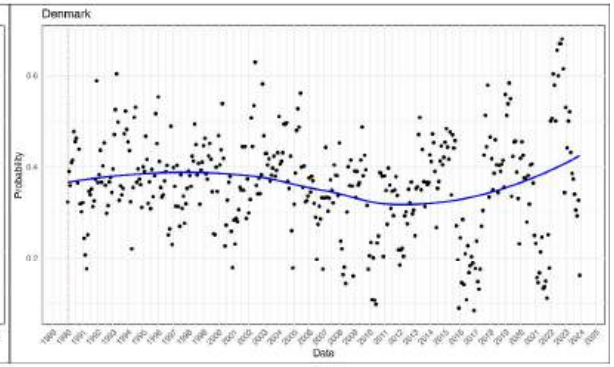
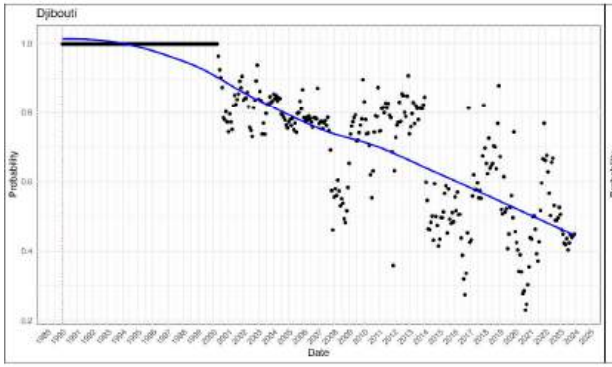
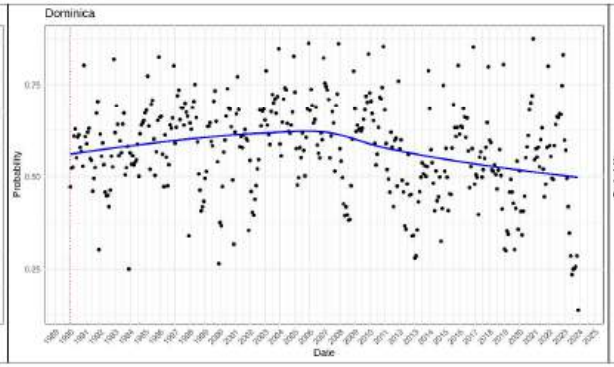
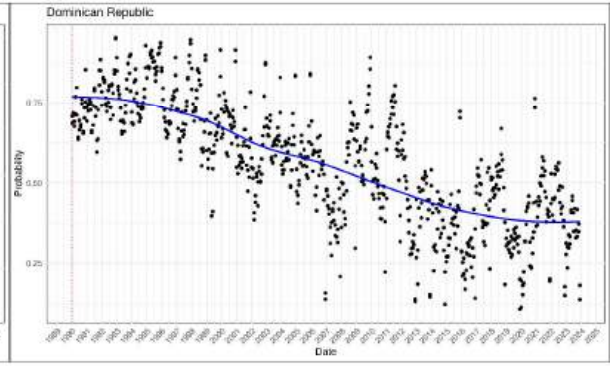

Cyprus
Probability
Date

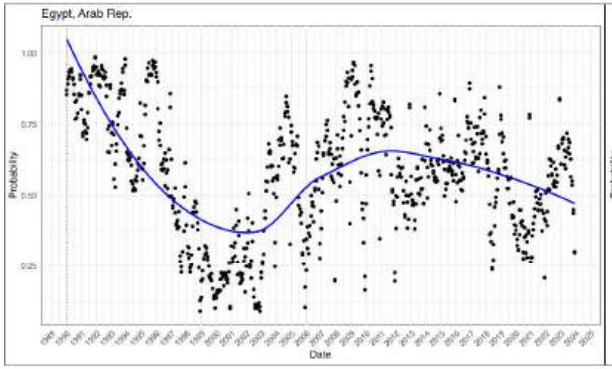

Czech Republic
Probability
Date

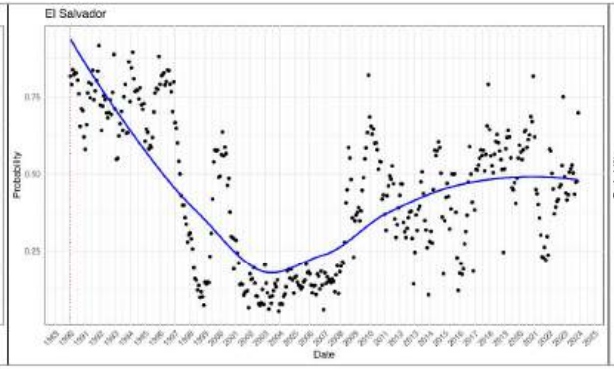

Denmark
Probability
Date

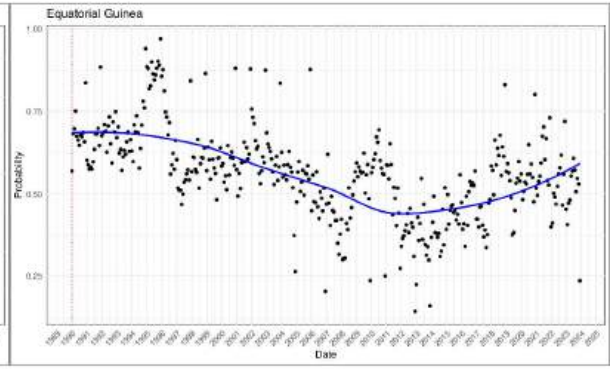

Djibouti
Probability
Date


Dominica
Probability
Date


Dominican Republic
Probability
Date


Egypt, Arab Rep.
Probability
Date


El Salvador
Probability
Date


Equatorial Guinea
Probability
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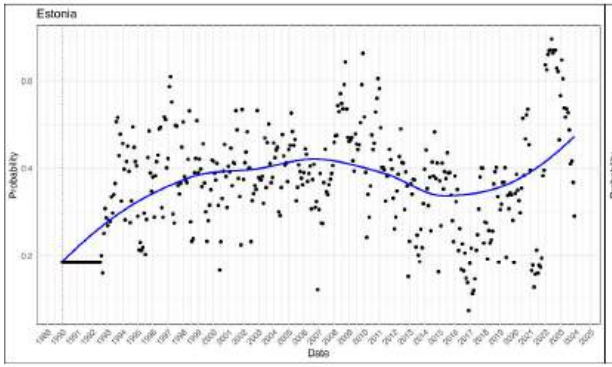
Estonia
Probability
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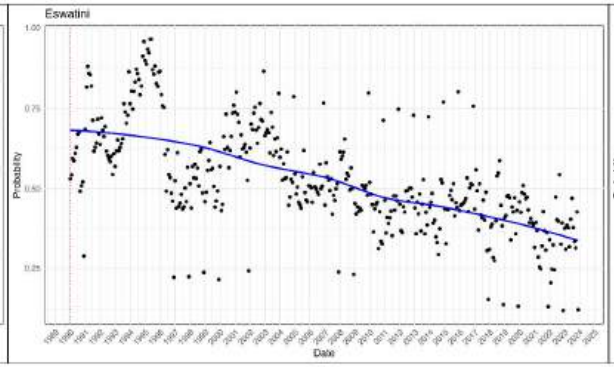
Eswatini
Probability
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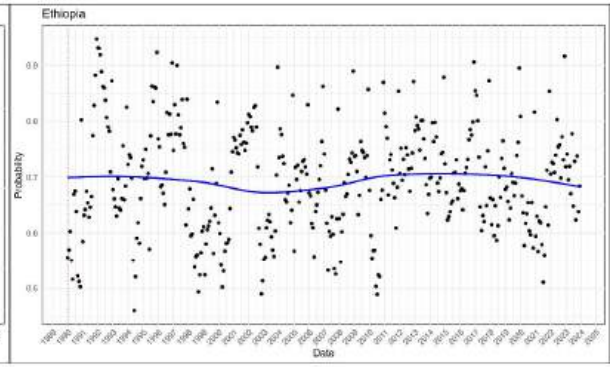
Ethiopia
Probability
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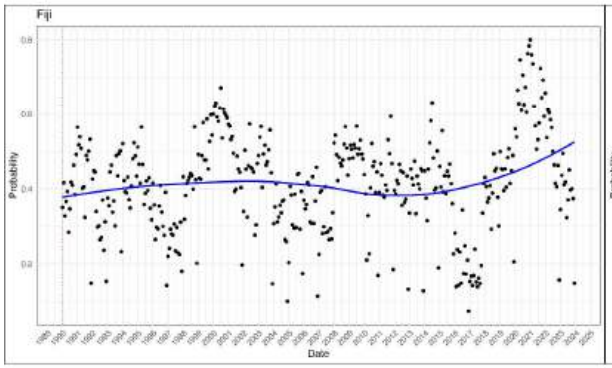
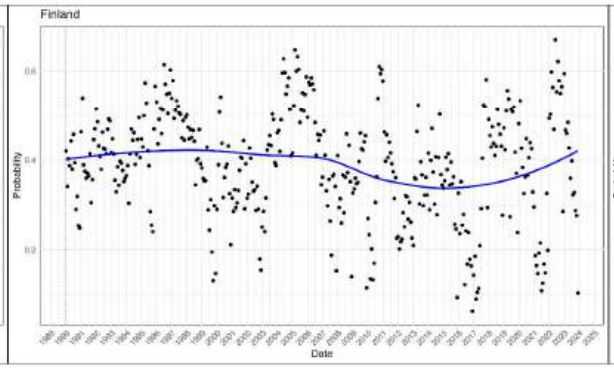
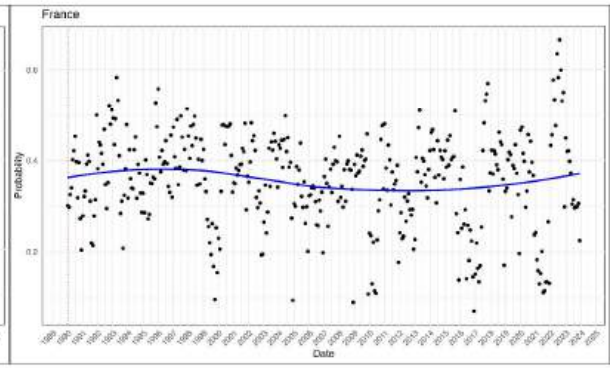
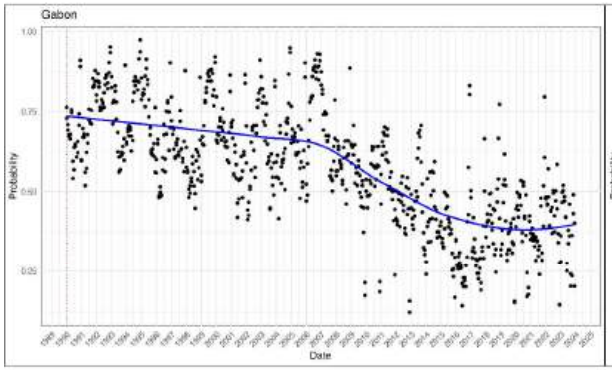

Fiji
Probability
Date


Finland
Probability
Date


France
Probability
Date


Gabon
Probability
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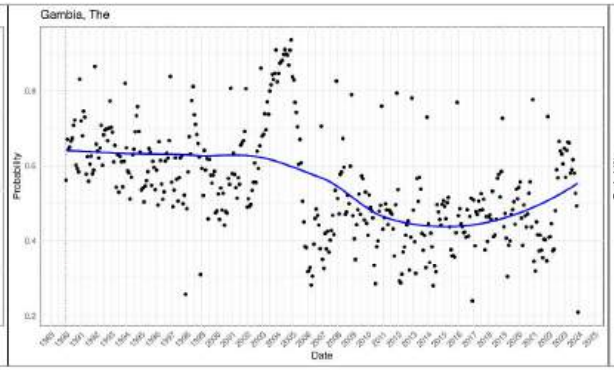
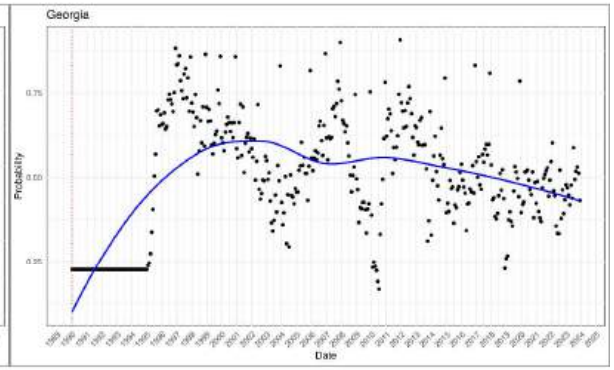

Gambia, The
Probability
Date


Georgia
Probability
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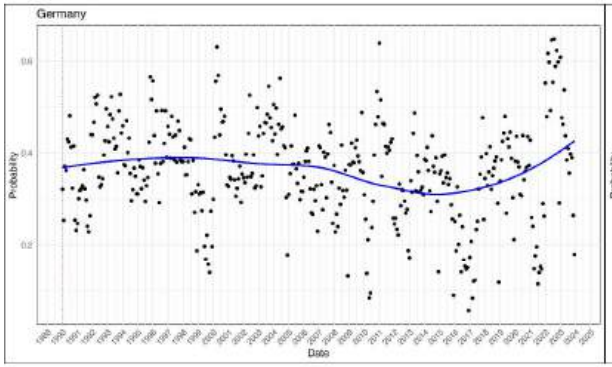
Germany
Probability
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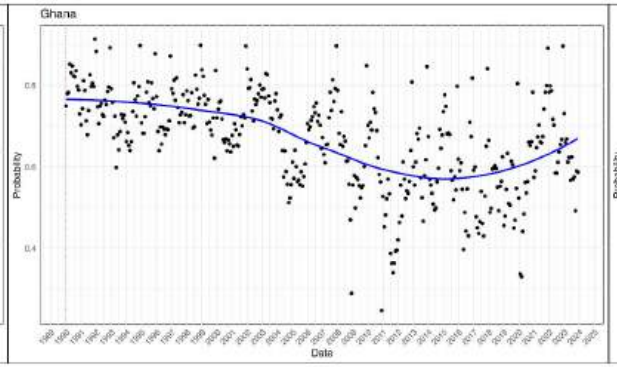
Ghana
Probability
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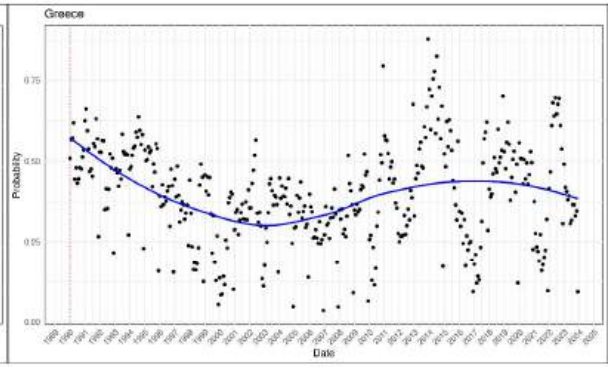
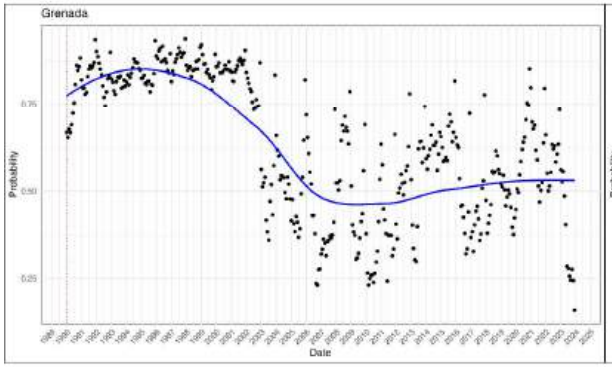

Greece
Probability
Date


Grenada
Probability
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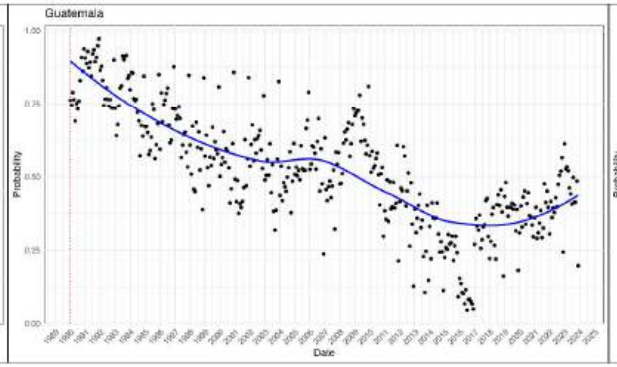
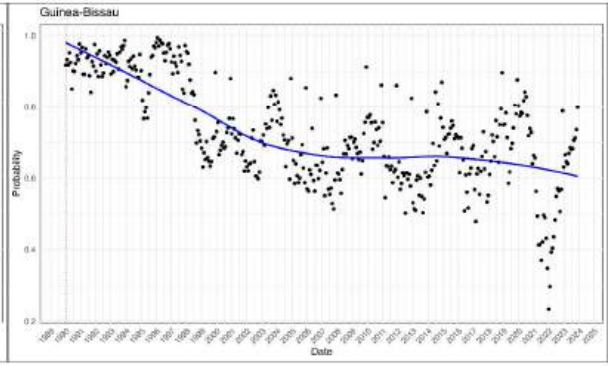
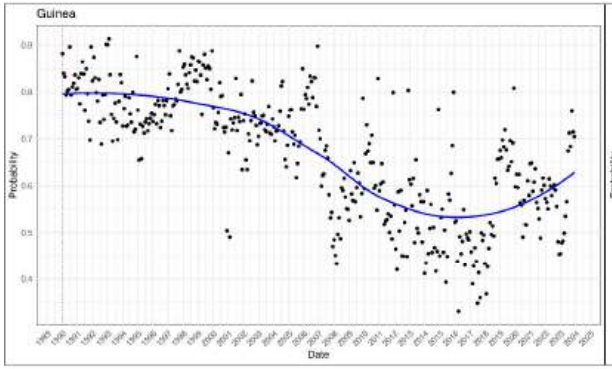

Guatemala
Probability
Date


Guinea-Bissau
Probability
Date


Guinea
Probability
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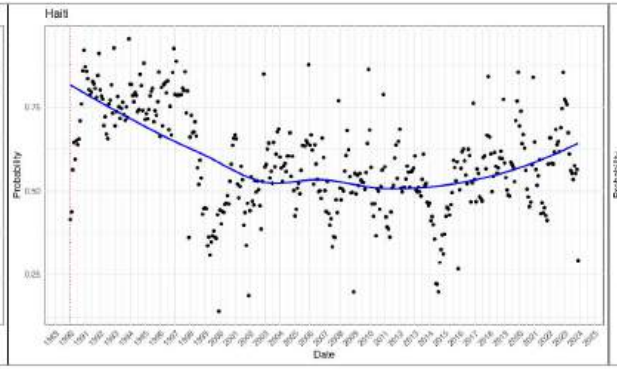
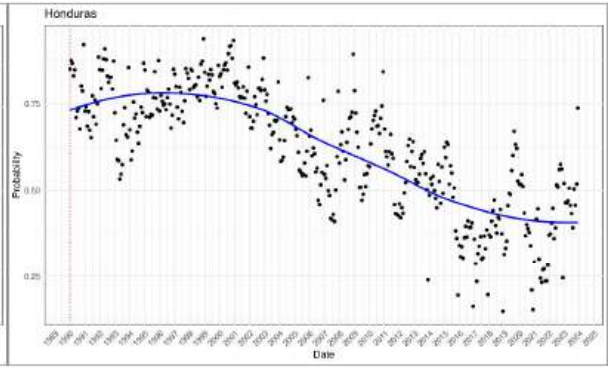
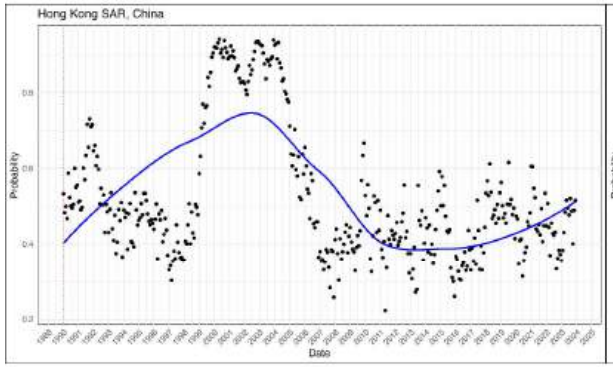
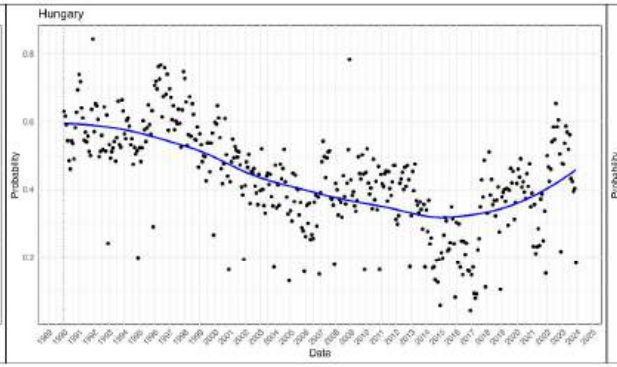
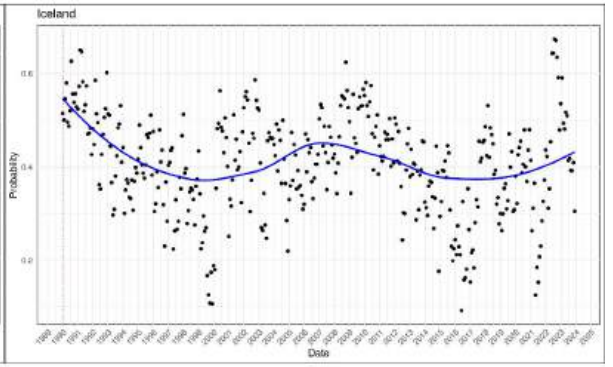
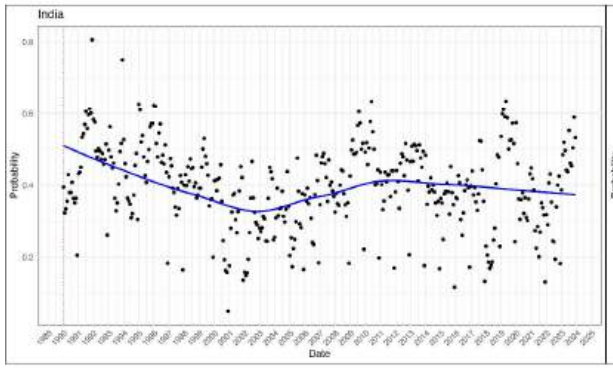

Haiti
Probability
Date


Honduras
Probability
Date


Hong Kong SAR, China
Probability
Date


Hungary
Probability
Date


Iceland
Probability
Date


India
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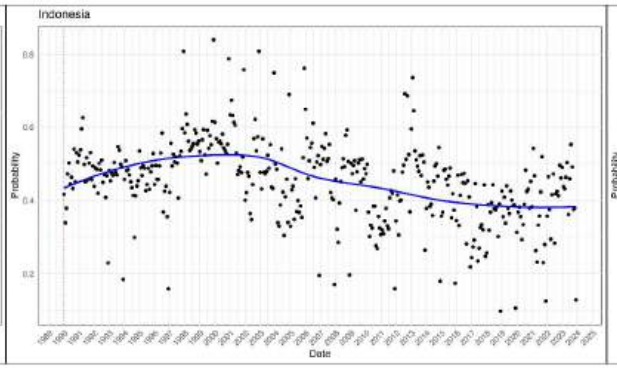
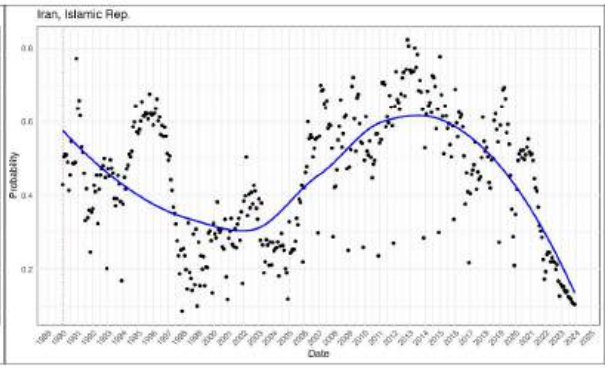
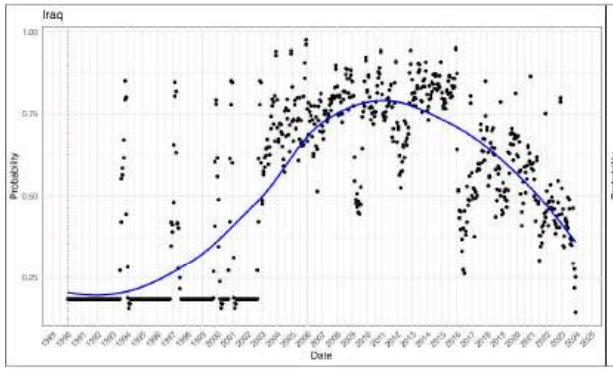
Date


Indonesia
Probability
Date


Iran, Islamic Rep.
Probability
Date


Iraq
Probability
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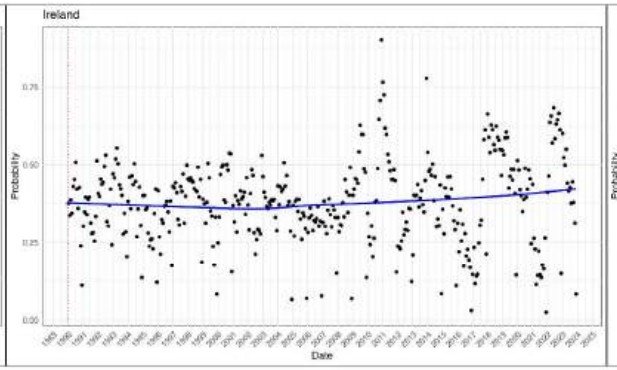
Ireland
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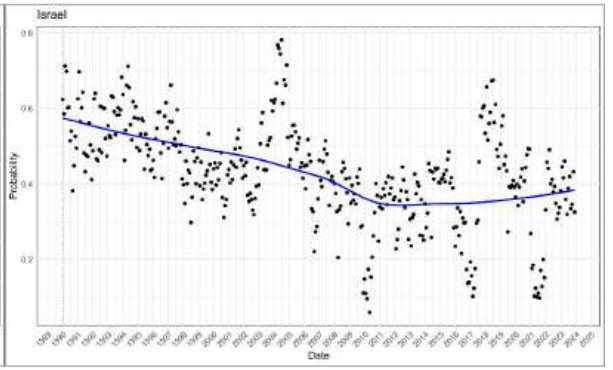
Israel
Probability
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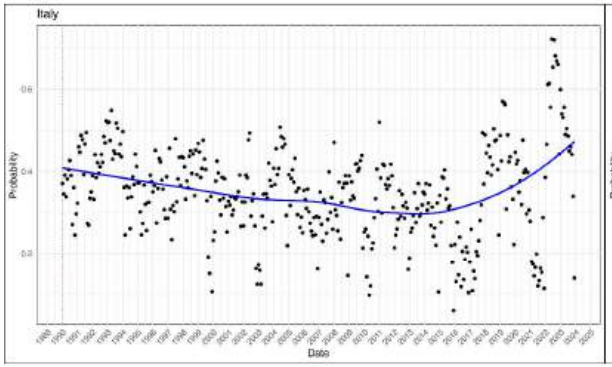
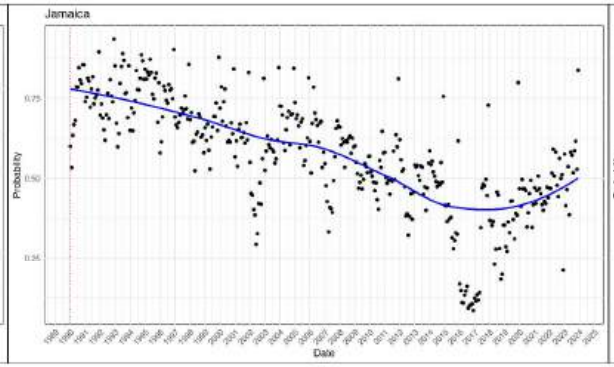
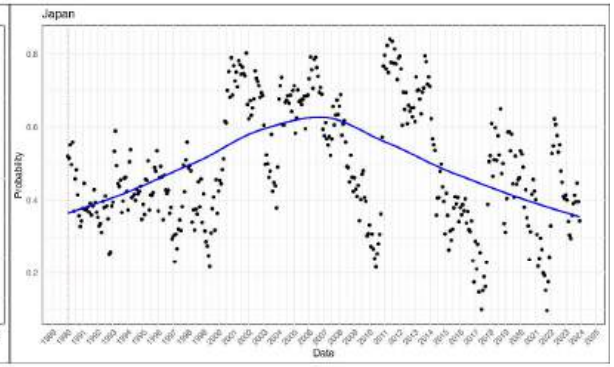
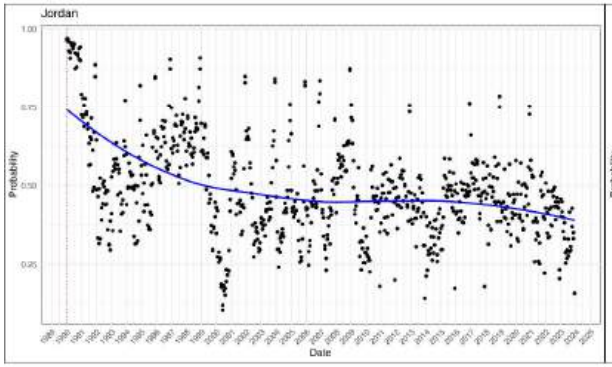
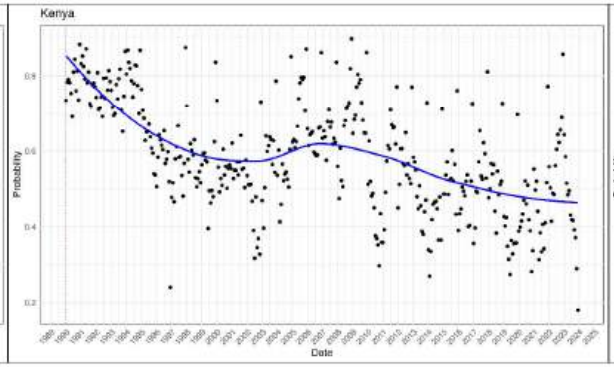
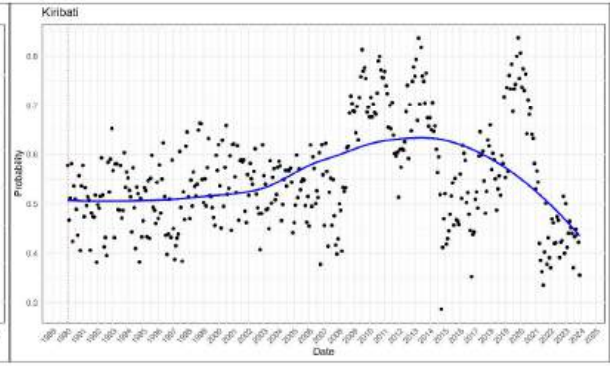

Italy
Probability
Date

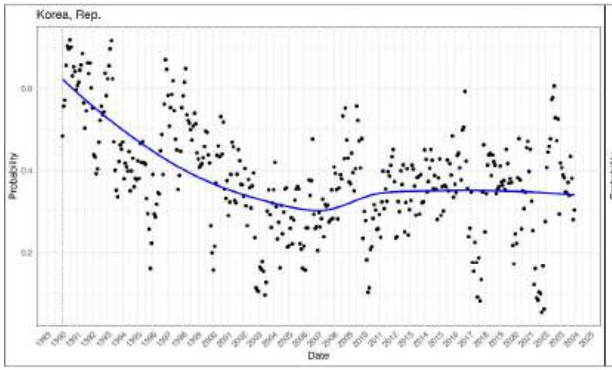

Jamaica
Probability
Date

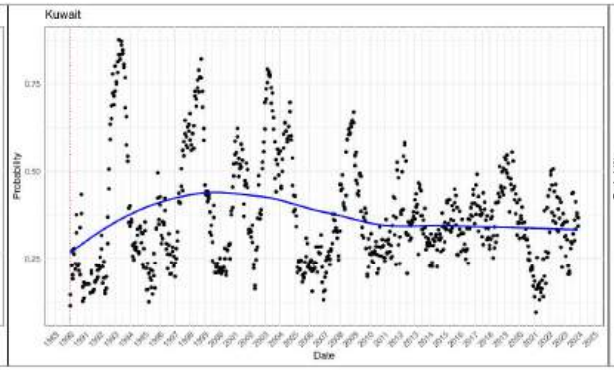

Japan
Probability
Date

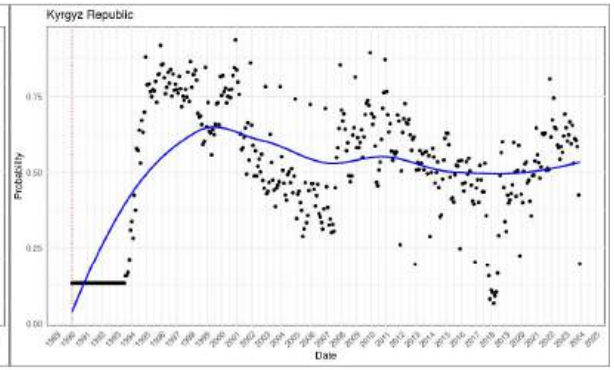

Jordan
Probability
Date

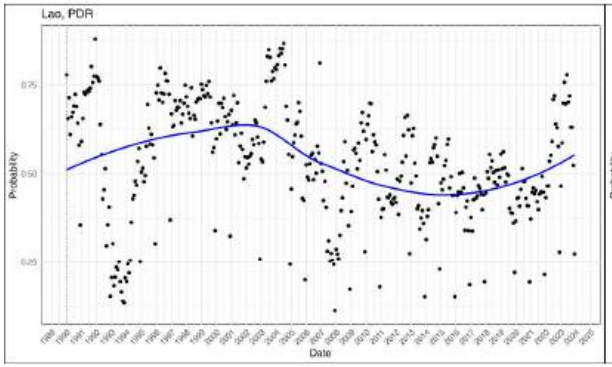

Kenya
Probability
Date

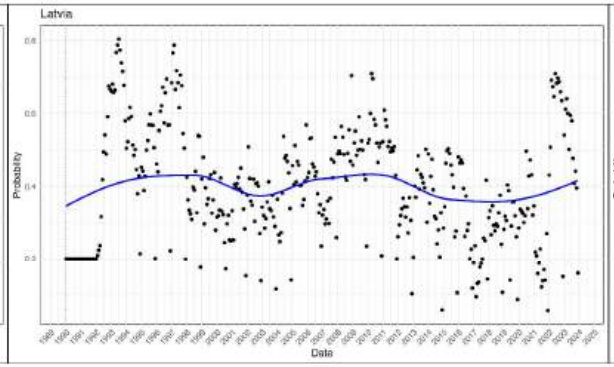

Kiribati
Probability
Date

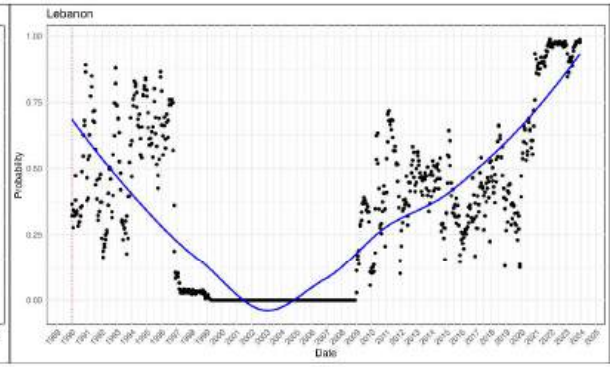

Korea, Rep.
Probability
Date

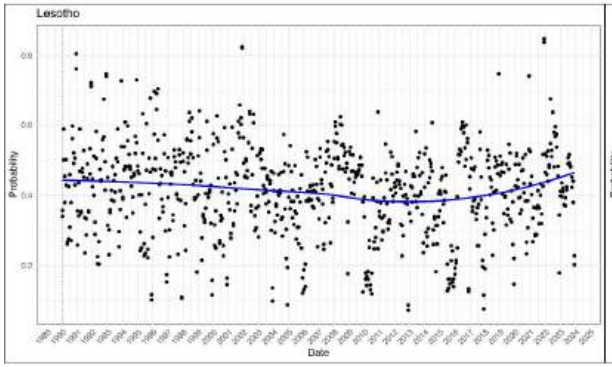

Kuwait
Probability
Date

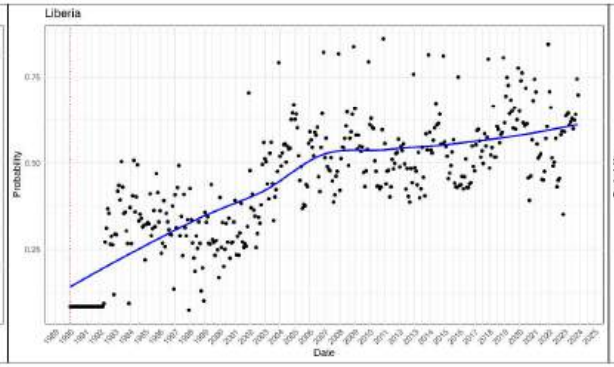

Kyrgyz Republic
Probability
Date

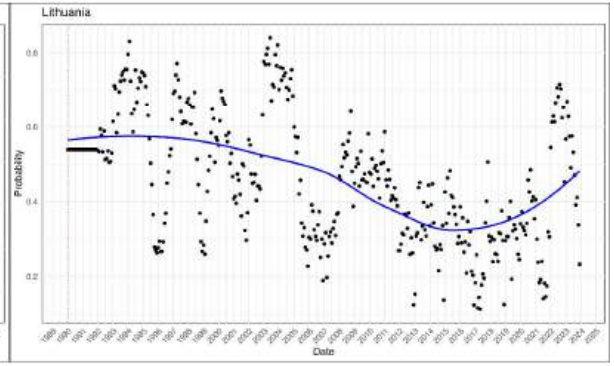

Lao, PDR
Probability
Date

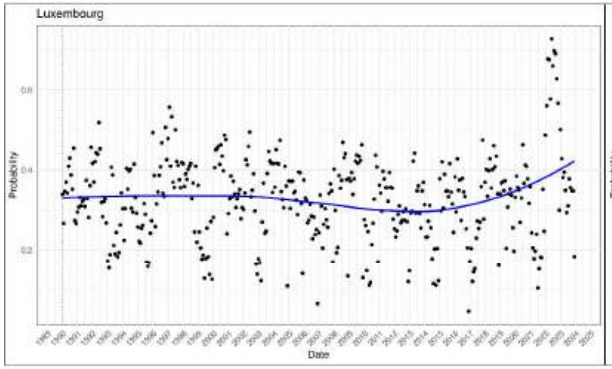

Latvia
Probability
Date

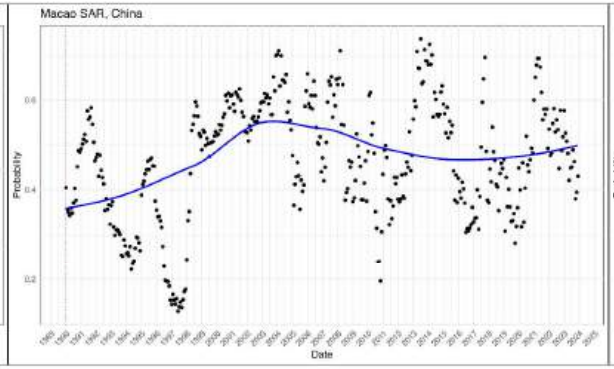

Lebanon
Probability
Date

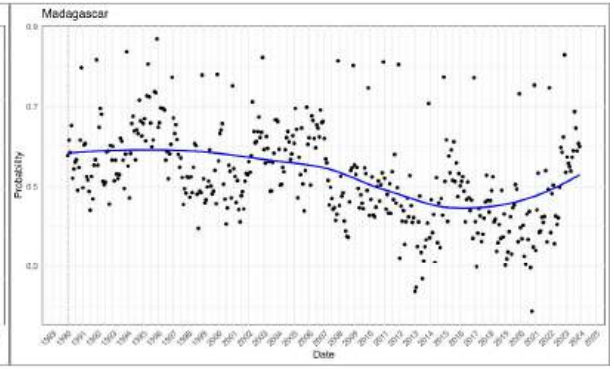

Lesotho
Probability
Date

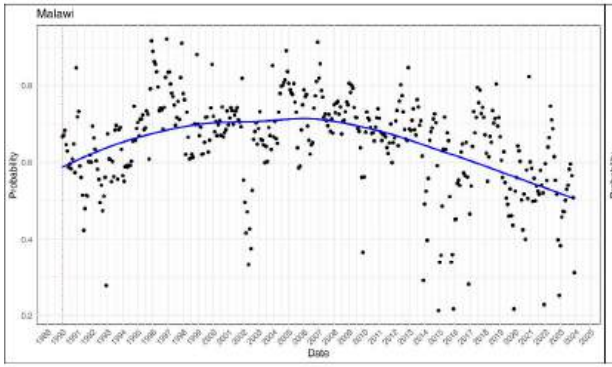

Liberia
Probability
Date

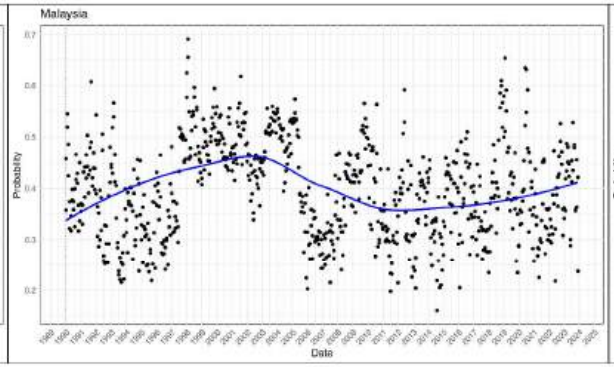

Lithuania
Probability
Date


Luxembourg
Probability
Date


Macao SAR, China
Probability
Date


Madagascar
Probability
Date


Malawi
Probability
Date


Malaysia
Probability
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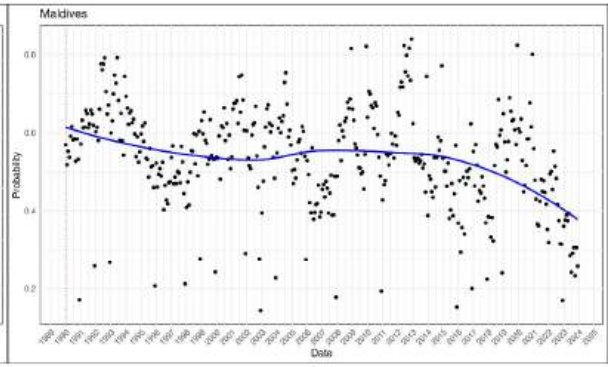
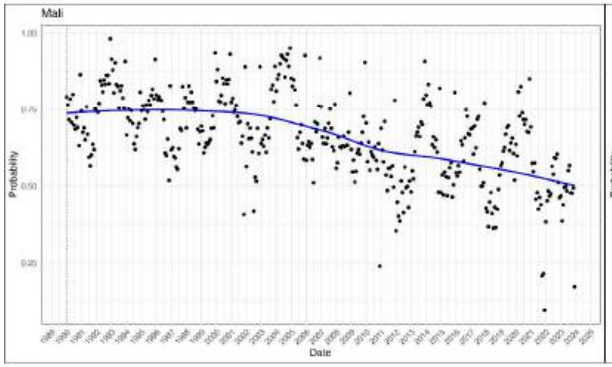
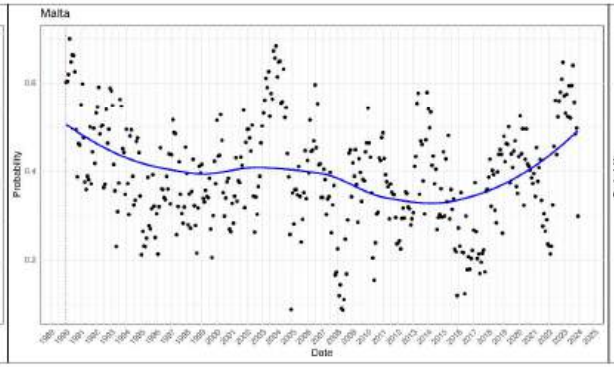
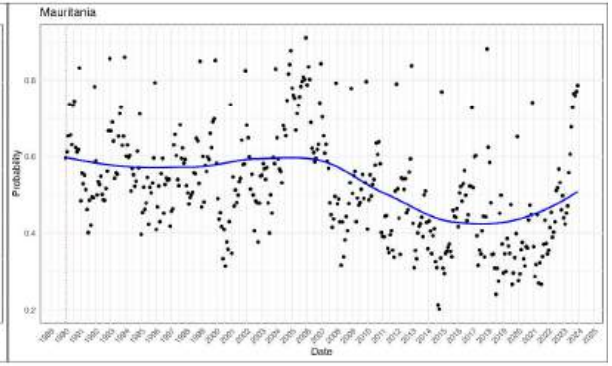
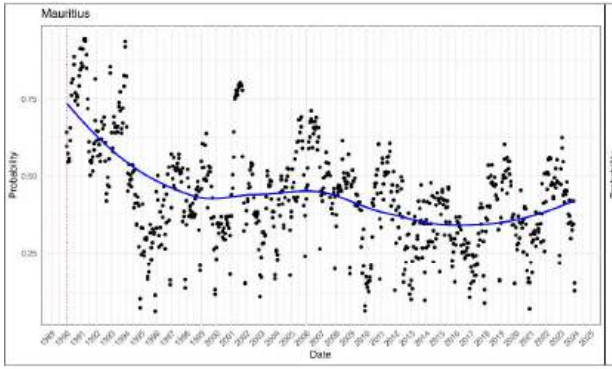
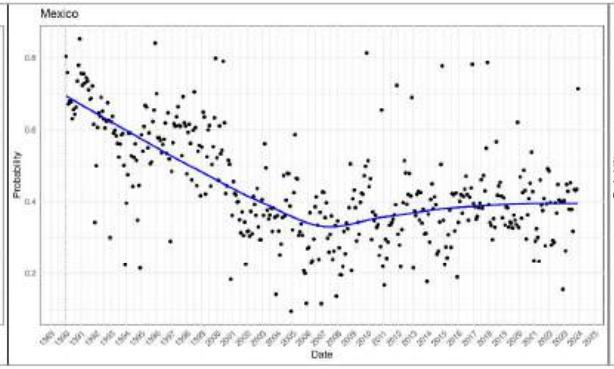

Maldives
Probability
Date

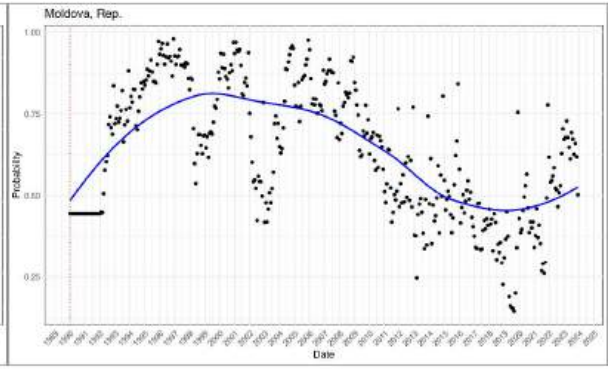

Mali
Probability
Date

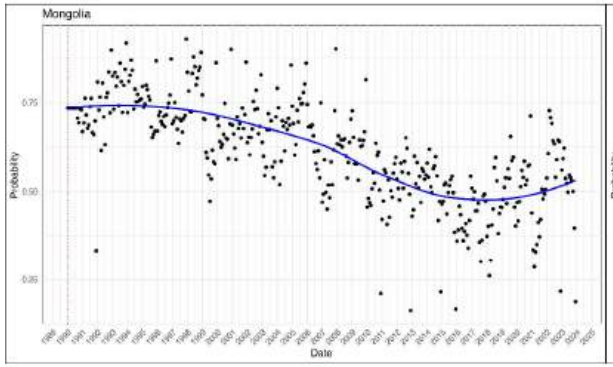

Malta
Probability
Date

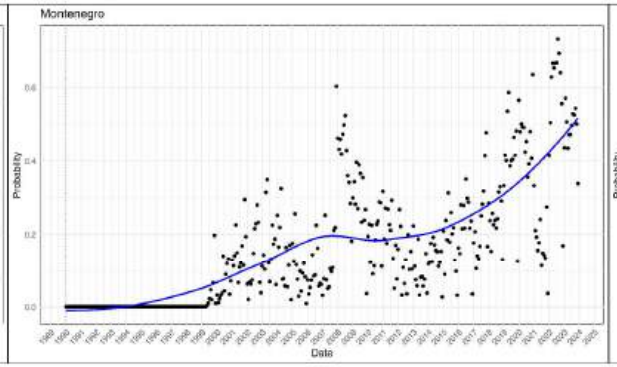

Mauritania
Probability
Date

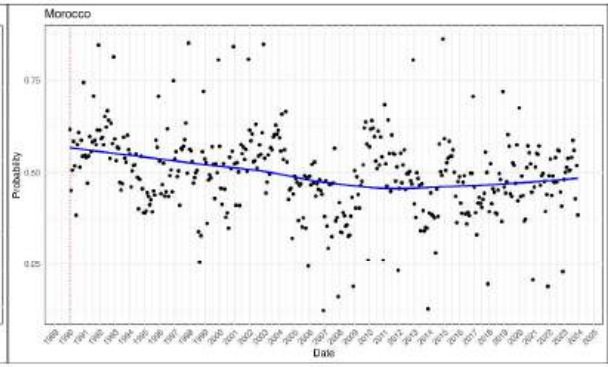

Mauritius
Probability
Date

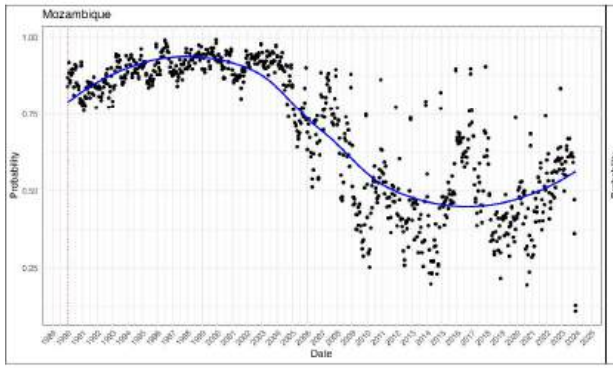

Mexico
Probability
Date

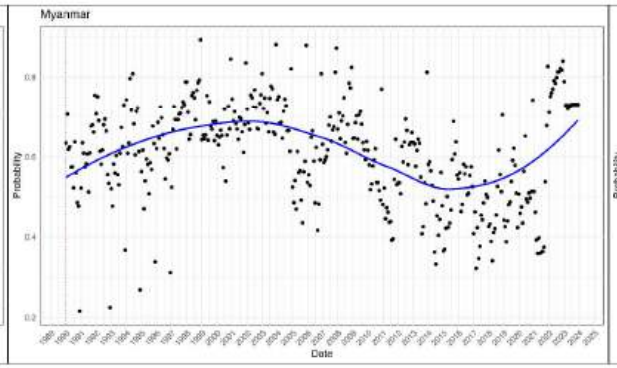

Moldova, Rep.
Probability
Date

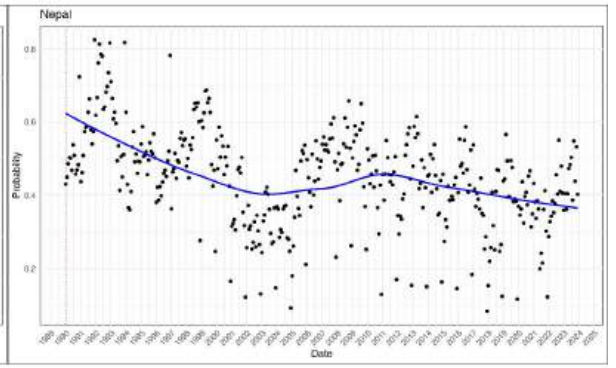

Mongolia
Probability
Date

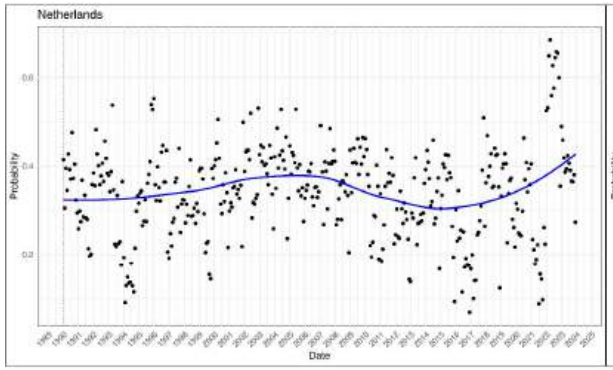

Montenegro
Probability
Date

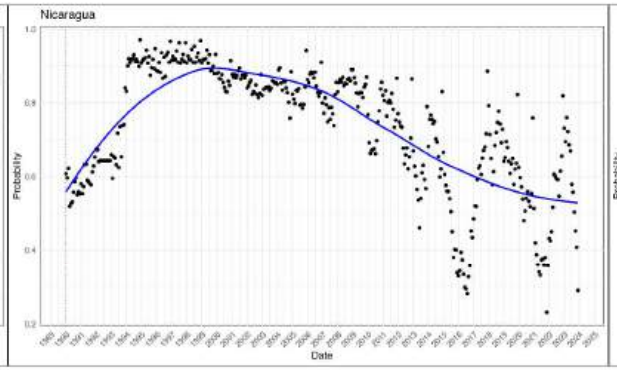

Morocco
Probability
Date

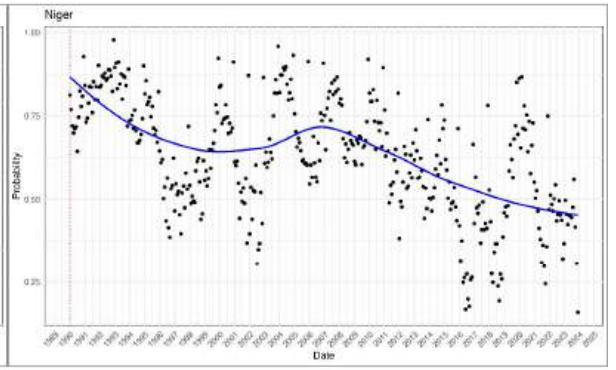

Mozambique
Probability
Date

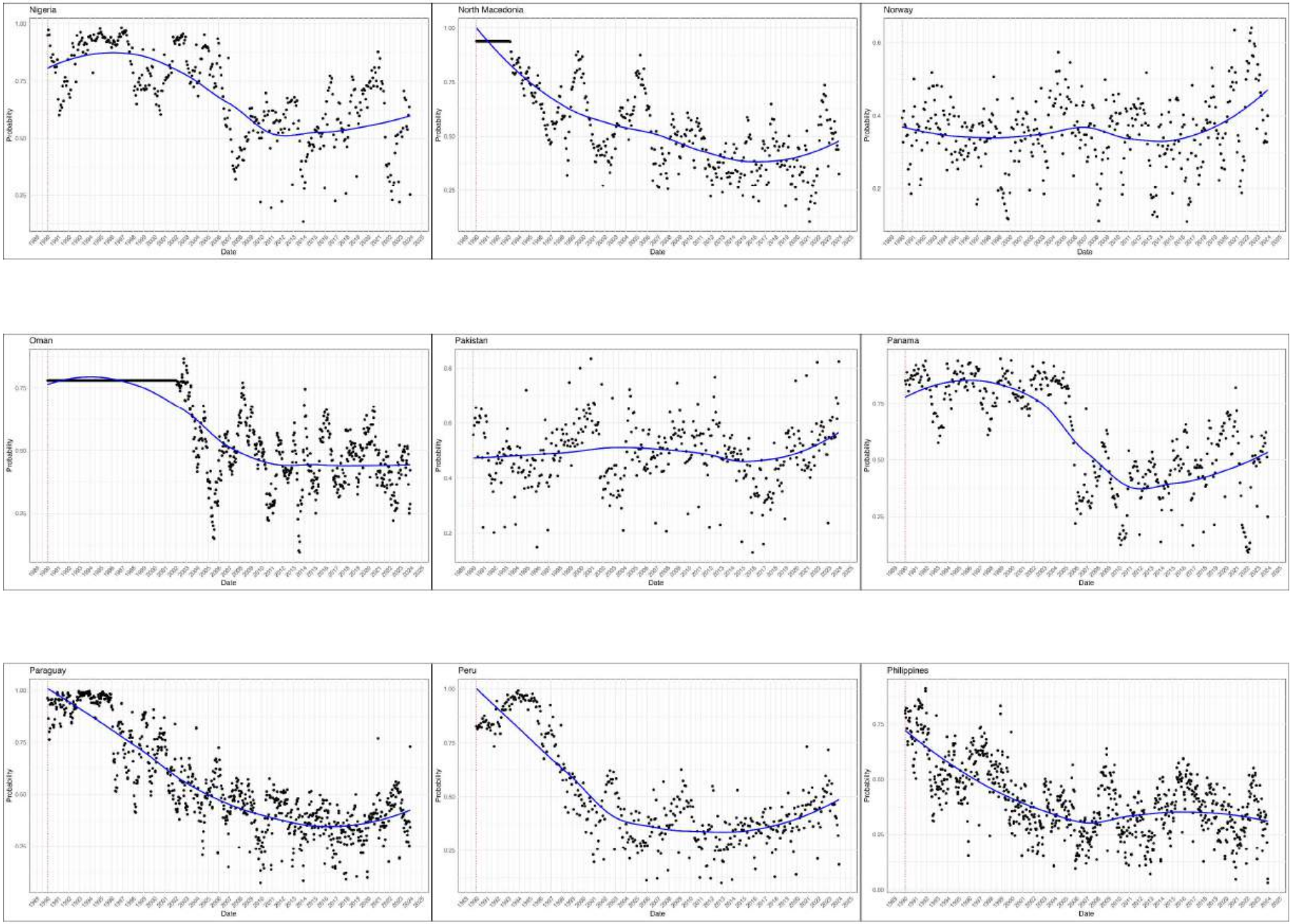

Myanmar
Probability
Date

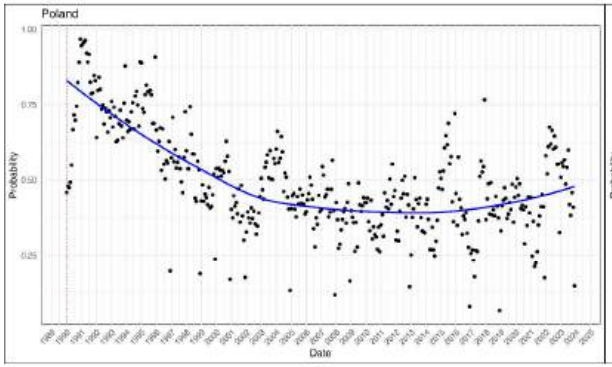

Nepal
Probability
Date

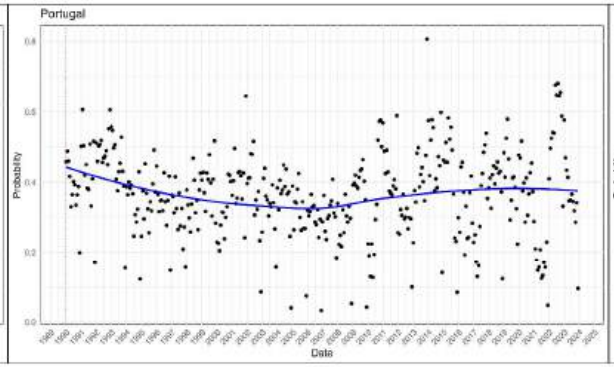

Netherlands
Probability
Date

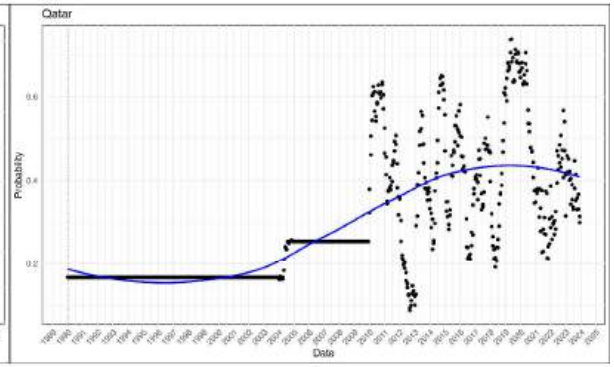

Nicaragua
Probability
Date

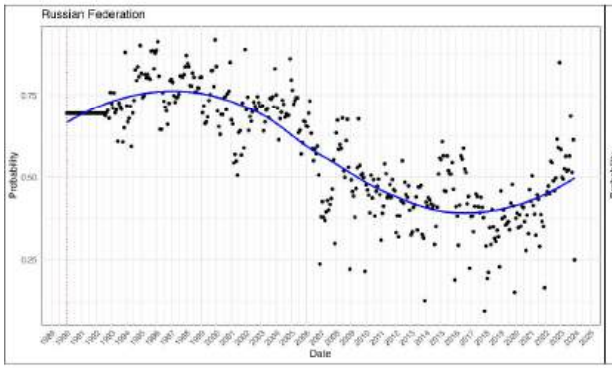

Niger
Probability
Date

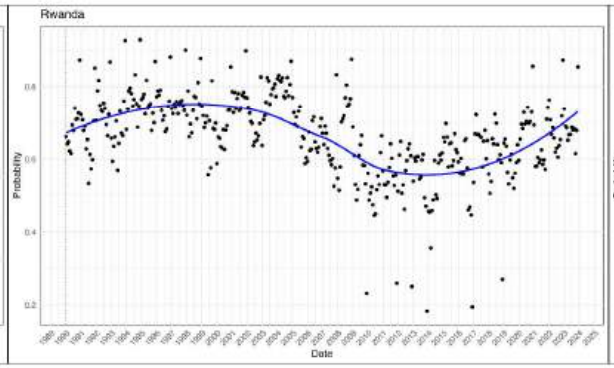

Nigeria
North Macedonia
Norway
Oman
Pakistan
Panama
Paraguay
Peru
Philippines
Probability
Date

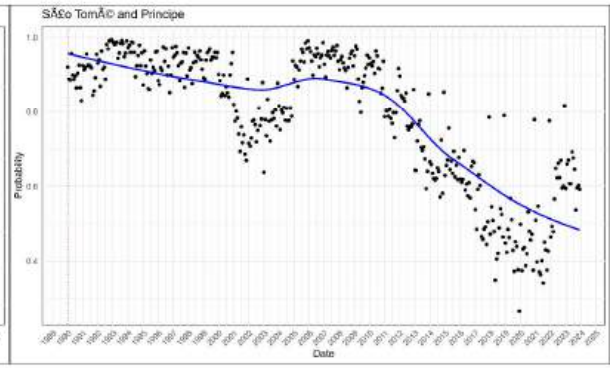

Poland
Probability
Date

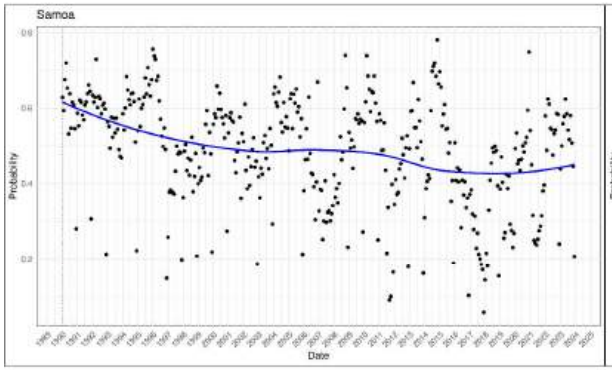

Portugal
Probability
Date

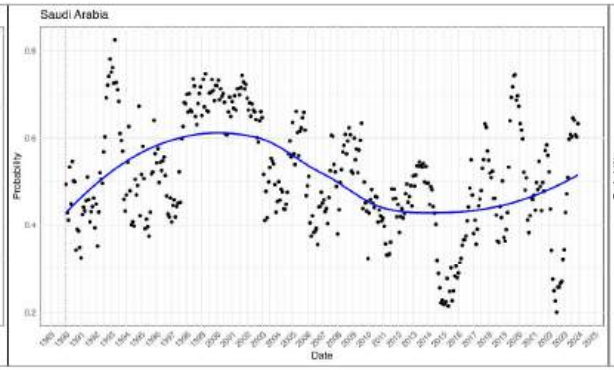

Qatar
Probability
Date

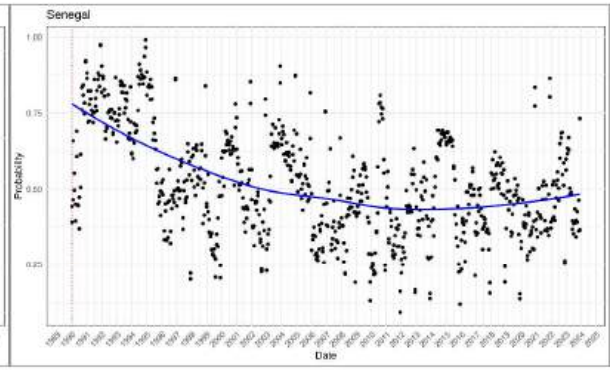

Russian Federation
Probability
Date

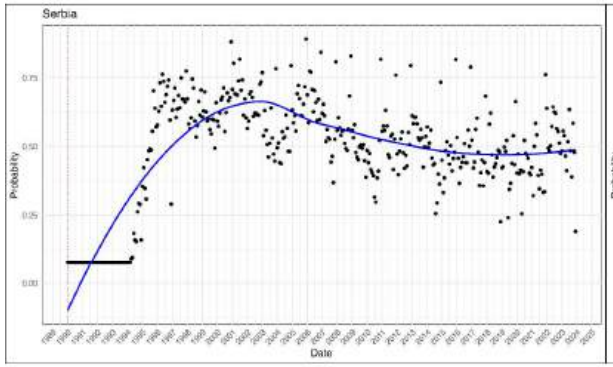

Rwanda
Probability
Date

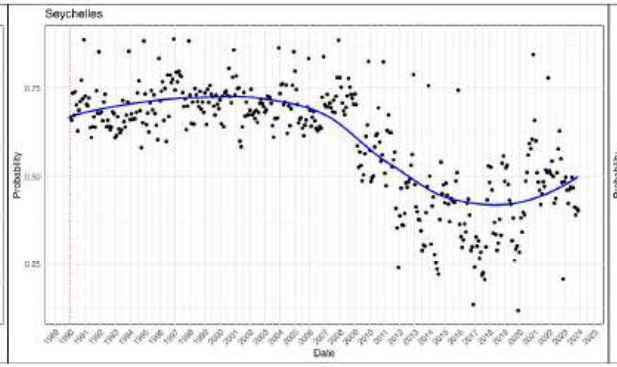

SÃ£o TomÃ© and Principe
Probability
Date

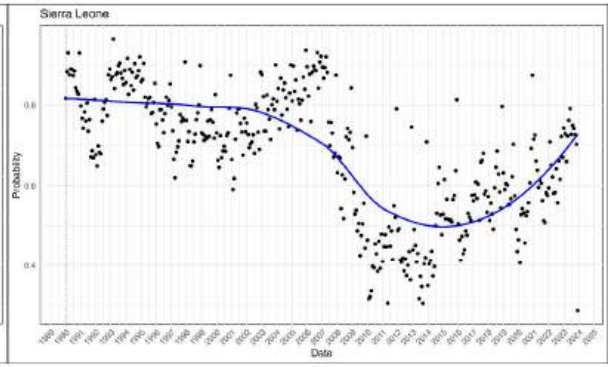

Samoa
Probability
Date

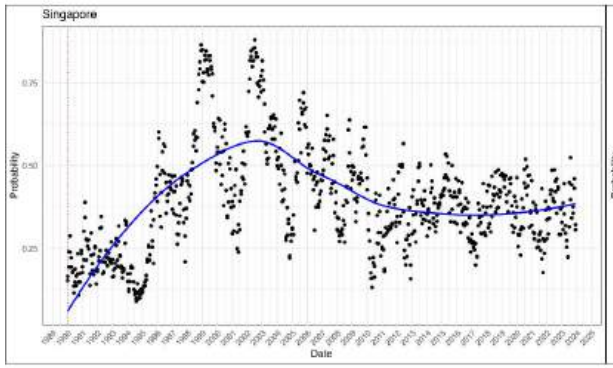

Saudi Arabia
Probability
Date

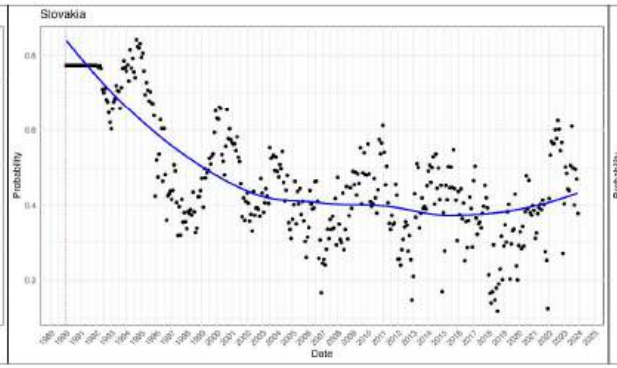

Senegal
Probability
Date

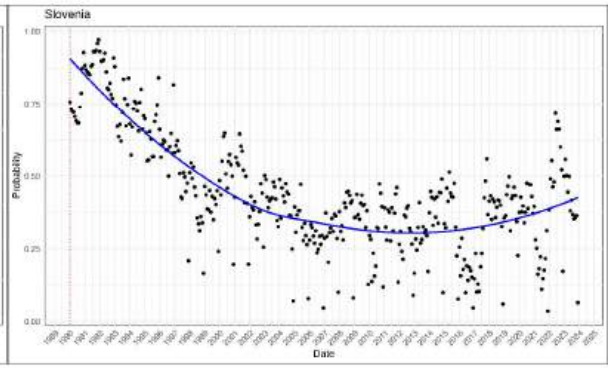

Serbia
Probability
Date

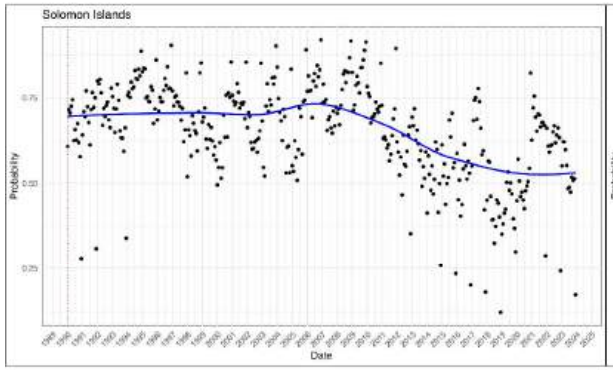

Seychelles
Probability
Date

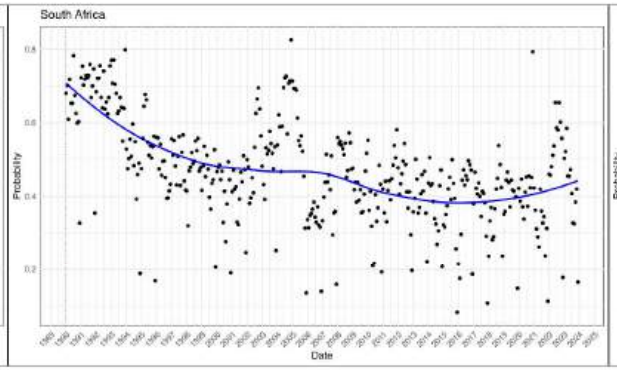

Sierra Leone
Probability
Date

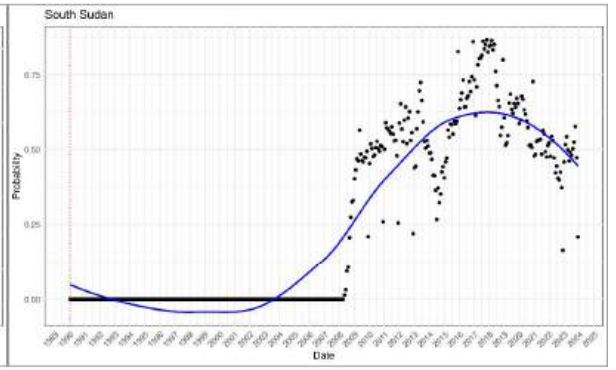

Singapore
Probability
Date

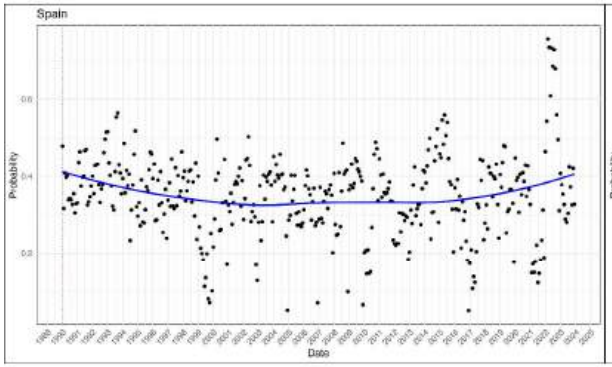

Slovakia
Probability
Date

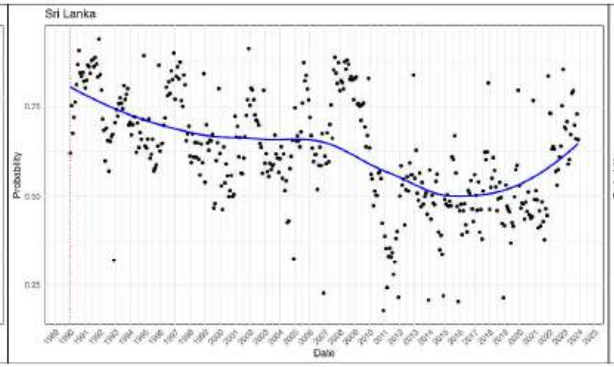

Slovenia
Probability
Date

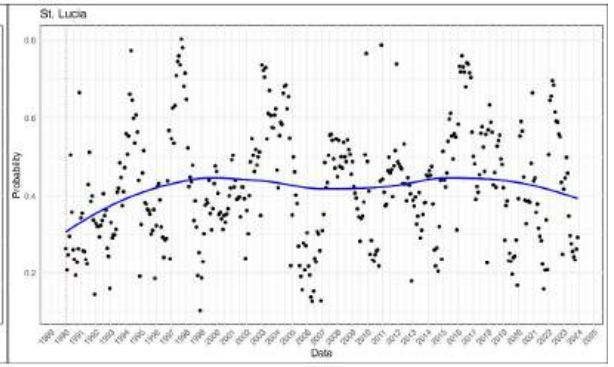

Solomon Islands
Probability
Date

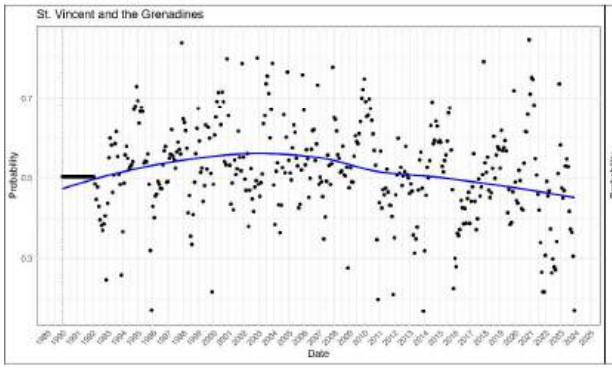

South Africa
Probability
Date

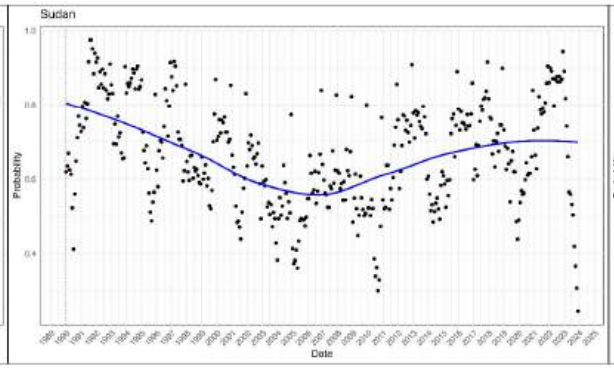

South Sudan
Probability
Date

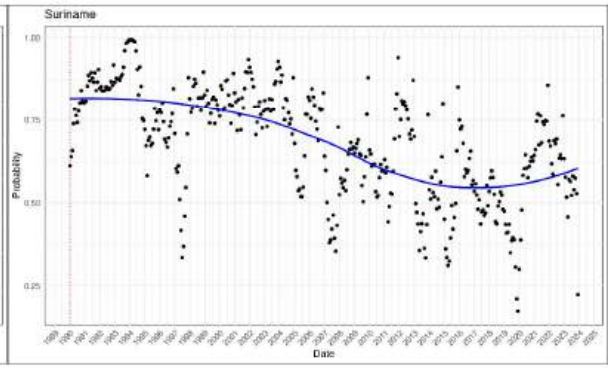

Spain
Probability
Date

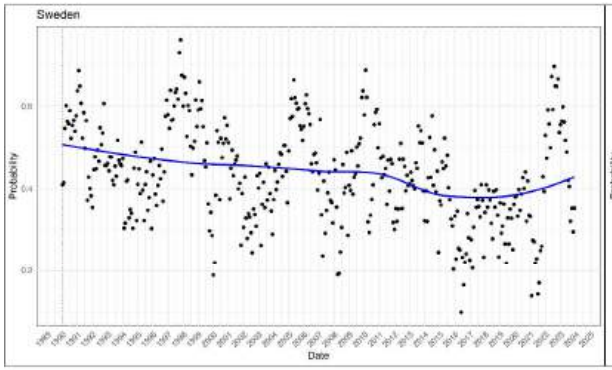

Sri Lanka
Probability
Date

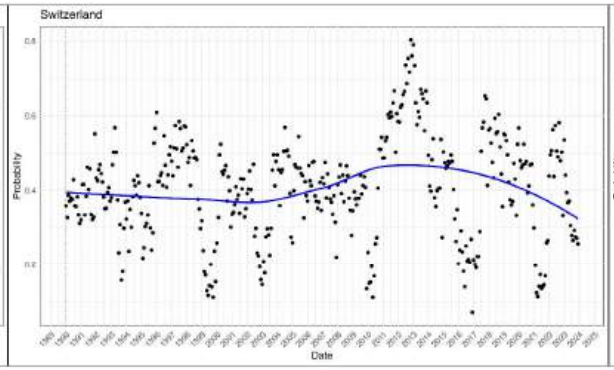

St. Lucia
Probability
Date

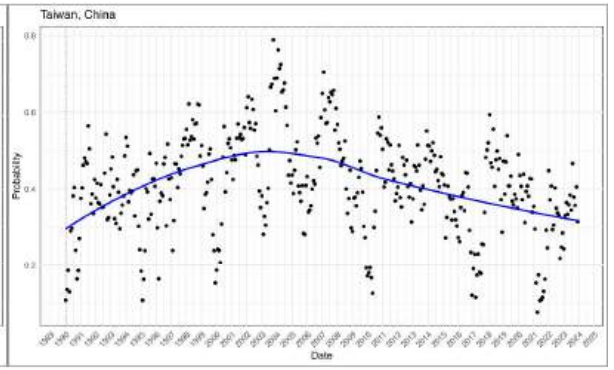

St. Vincent and the Grenadines
Probability
Date

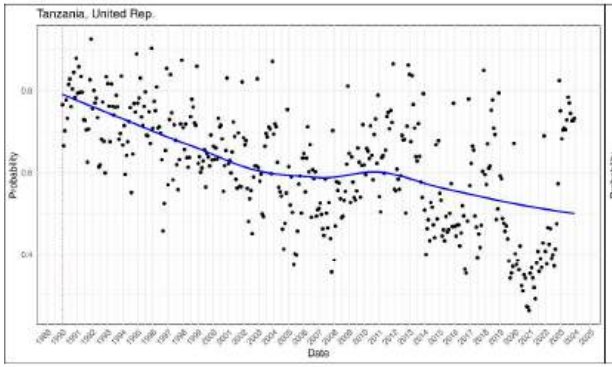

Sudan
Probability
Date

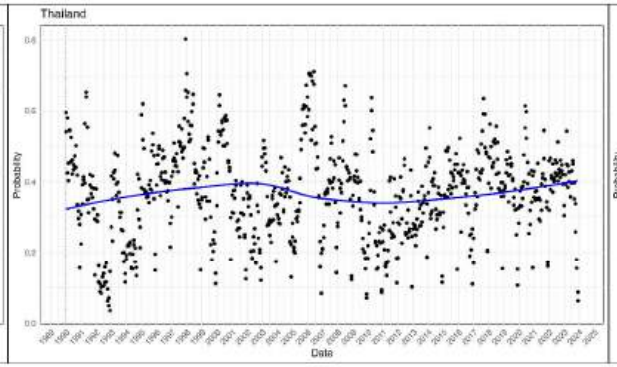

Suriname
Probability
Date

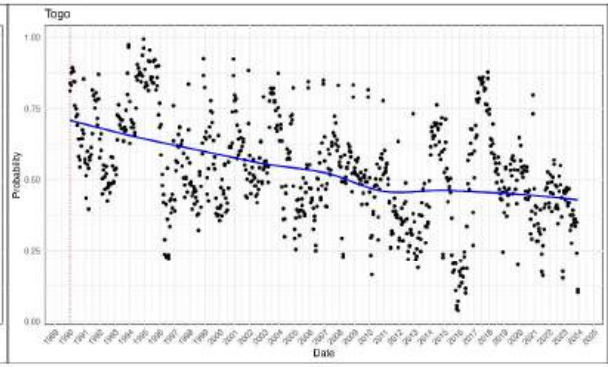

Sweden
Probability
Date

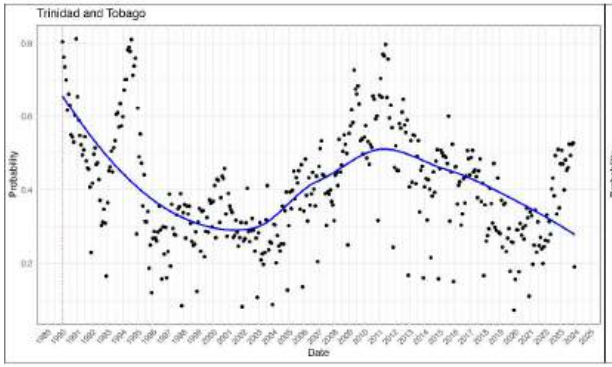

Switzerland
Probability
Date

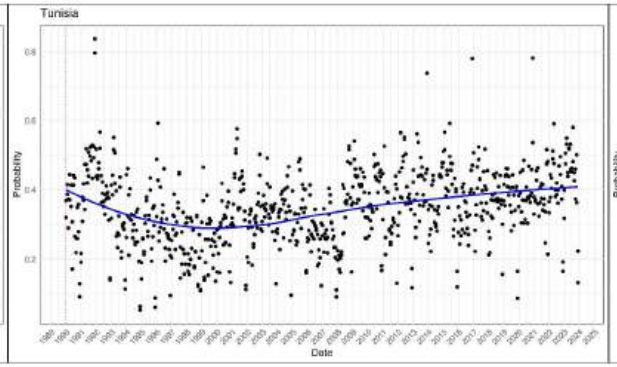

Taiwan, China
Probability
Date

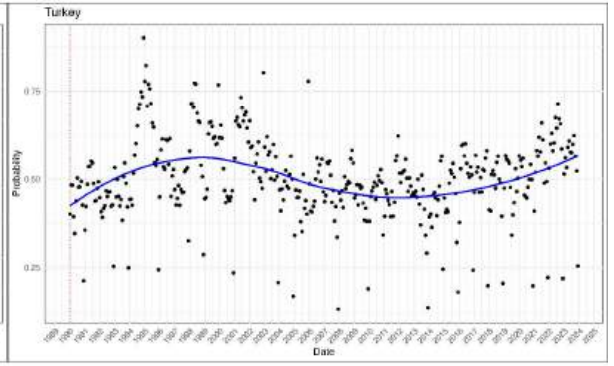

Tanzania, United Rep.
Probability
Date

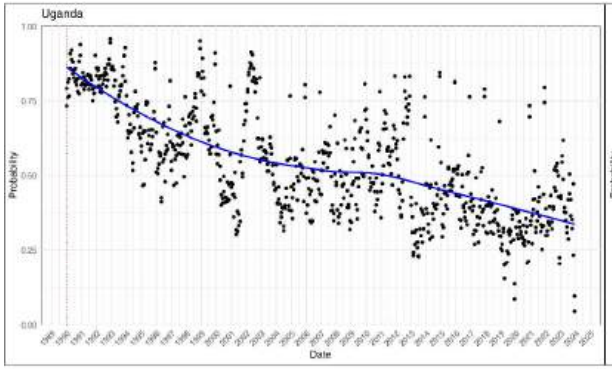

Thailand
Probability
Date

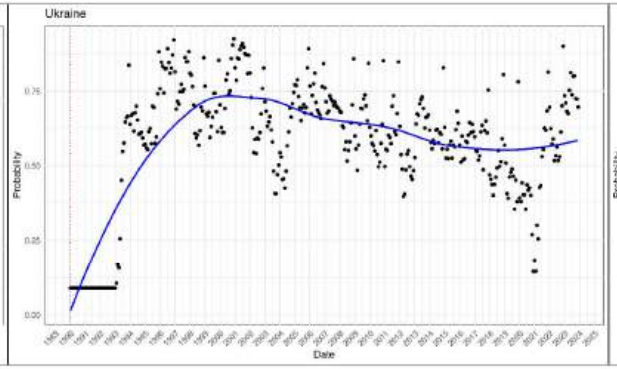

Togo
Probability
Date

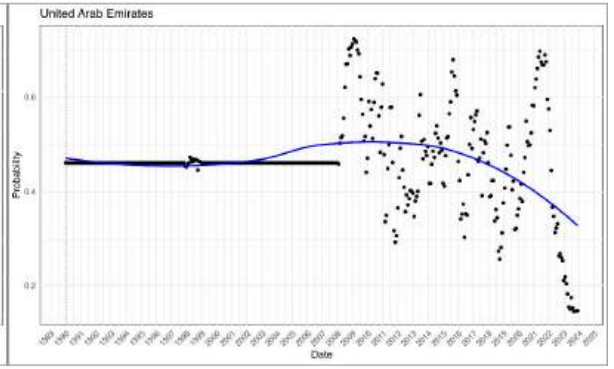

Trinidad and Tobago
Probability
Date

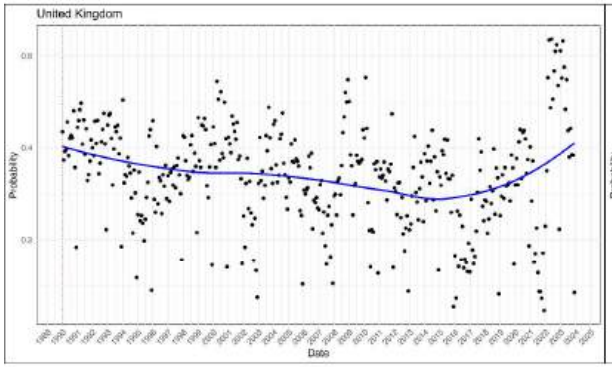

Tunisia
Probability
Date

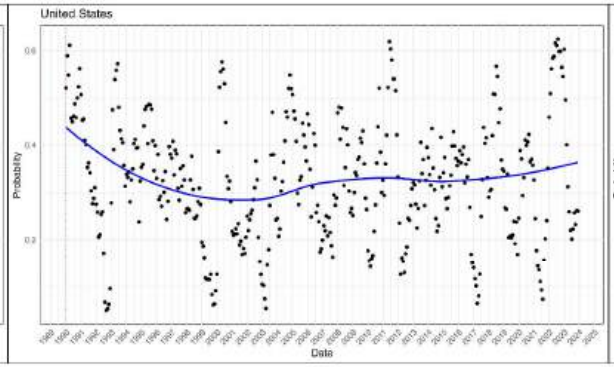

Turkey
Probability
Date

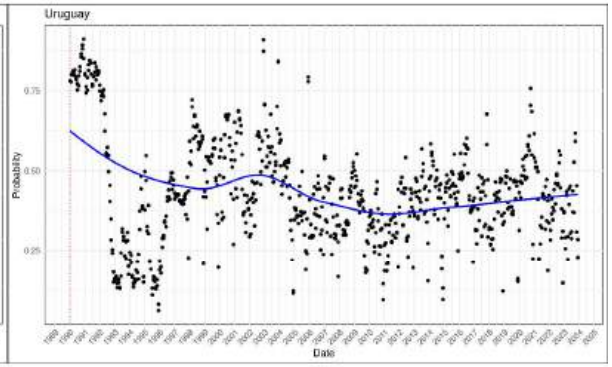

Uganda
Probability
Date

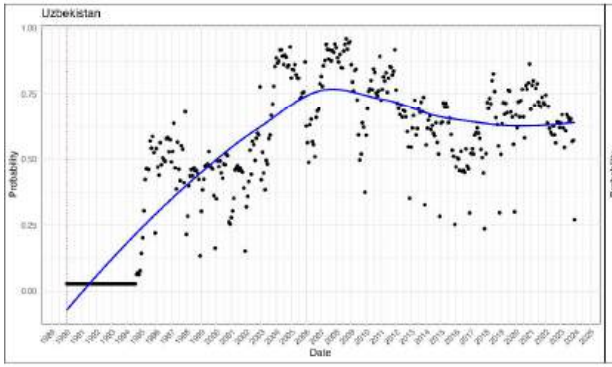

Ukraine
Probability
Date

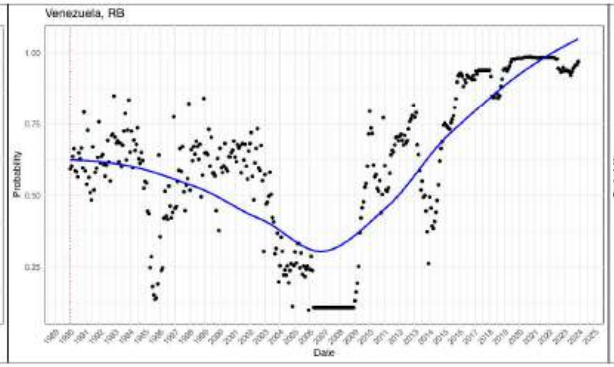

United Arab Emirates
Probability
Date

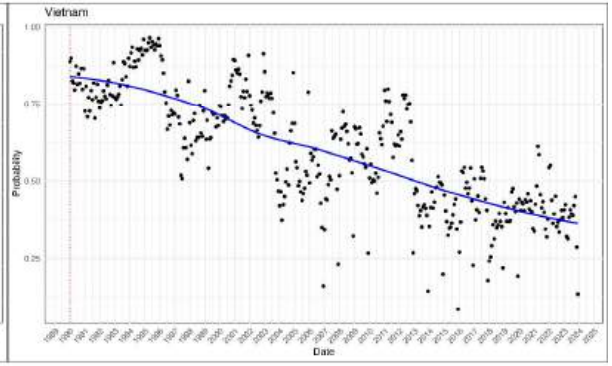

United Kingdom
Probability
Date

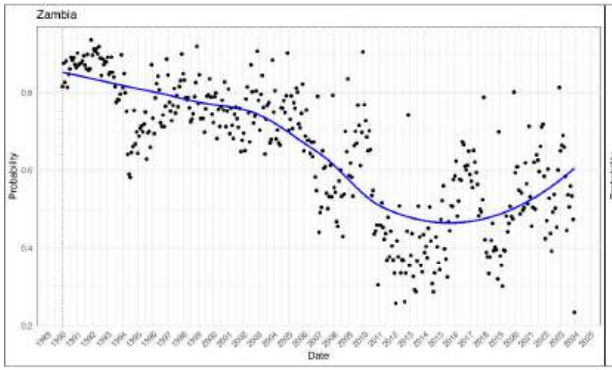

United States
Probability
Date

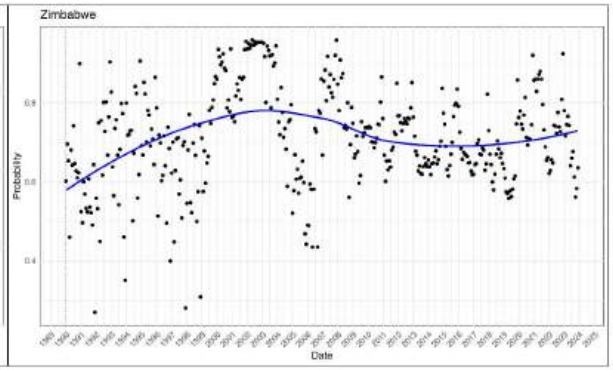

Uruguay
Probability
Date


Uzbekistan
Probability
Date


Venezuela, RB
Probability
Date


Vietnam
Probability
Date


Zambia
Probability
Date


Zimbabwe
Probability
Date

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