Asian Economic and Financial Review
ISSN(e): 2222-6737
ISSN(p): 2305-2147
DOI: 10.55493/5002.v13i11.4859
Vol. 13, No. 11, 738-755.
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URL: www.aessweb.com

Constructing an aggregate financial stability index for Botswana

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Article History
Received: 26 October 2022
Revised: 23 February 2023
Accepted: 7 August 2023
Published: 21 August 2023

Keywords
Aggregate index
Financial stability
Financial stress.

JEL Classification:
E0; E6; E60; E61.

ABSTRACT

This paper evaluates the likely benefits of adopting an aggregate financial stability index (AFSI) as an additional mechanism for monitoring the financial system in Botswana. Since the turn of the new century that brought a sequence of financial episodes, financial stability remains a topical issue among researchers and policymakers. To guard against financial instability, authorities continually look for mechanisms to effectively detect stress in the financial system. This paper builds on recent literature to develop an AFSI for Botswana constructed from sub-indices that reflect financial development, financial vulnerability, financial soundness, and external environment developments. To determine the existence, or absence, of effects from key macroeconomic variables on the AFSI, the autoregressive distributed lag (ARDL) model is used. The study found that the synthetic AFSI constructed is robust and able to track the impact of different macroeconomic events on the stability of the financial sector in Botswana. As such, gains can be expected from the use of an AFSI. In this regard, policy makers will be able to unambiguously interpret the prevailing level of financial stress and respond accordingly.

Contribution/Originality: This paper contributes to the policy debate on tracking and responding to events of financial stress by developing an aggregate financial stability index for Botswana (against the prevailing single indicator approach). The paper focuses on Botswana, on which very little empirical evidence on the subject exists.

1. INTRODUCTION

Stability of the financial system is indispensable. A stable financial system provides the basis for rational decision making about the allocation of resources and improves the climate for saving and investment (Crockett, 1996). The 2008 global financial crisis demonstrated how catastrophic financial instability can be (Braga, Pereira, & Reis, 2014). To safeguard financial stability, authorities must be vigilant and continuously look for ways to improve the ability to anticipate and avoid future spells of instability (Karanovic & Karanovic, 2015).

Botswana's financial sector has remained resilient, with sturdy capital and liquidity buffers and high profitability all sustained by accommodative monetary policy conditions. As part of the efforts to address and mitigate emerging or pertinent risks in the financial system, in 2019, Botswana established the Financial Stability Council (FSC). The macro-prudential policy framework, within which the FSC carries out its mandate, aims to limit systemic risk and any potential transmission to the rest of the economy. This framework, while useful, does not comprehensively capture potential risks in the financial system. In periods of no stress, the standard evaluation as per the framework

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suffices. In periods of economic distress, however, it is necessary to have a measure that helps authorities identify the level of financial stress and its source, which would assist them in adjusting strategies accordingly (Braga et al., 2014).

For this reason, this paper proposes the use of an aggregate financial stability index (AFSI) as an additional evaluation mechanism to the existing framework. In essence, the index attempts to grasp complex multi-dimensional phenomena by aggregating a set of indicators into a single quantitative measure whose value can reflect the multi-layered reality of the economy (Karanovic & Karanovic, 2015). This reality is captured by a collection of indicators which represent observable variables that quantify phenomena. Being based on observable variables that reflect the different aspects of financial stability, the AFSI enables policymakers to unambiguously interpret the level of financial stress in the financial sector (Kondratovs, 2014).

Various techniques for constructing an aggregate financial stability index are proposed in the literature. A number of studies relying on these techniques have been published in different settings with insightful policy implications (see (Karanovic & Karanovic, 2015; Kondratovs, 2014; Malega & Horváth, 2017; Manolescu & Manolescu, 2017)). However, none of the studies encountered in existing literature focus on Botswana. Against this background, the specific contribution of this paper is to construct and evaluate the efficacy of an aggregate financial stability index for Botswana. The index is constructed using quarterly data on financial soundness and macro-prudential indicators for the period from 2005 to 2020. The empirical analysis generates interesting policy implications.

The remainder of the paper is organized as follows: Section 2 gives an overview of the literature; Section 3 covers methodological considerations; Section 4 discusses the estimation results; and Section 5 provides the conclusion and policy implications based on the findings.

2. OVERVIEW OF THE LITERATURE: FINANCIAL STABILITY INDEX CONSTRUCTION

There have been many attempts to define financial stability, and Schinasi (2004) provides a comprehensive review of this literature. Since there is no widely accepted definition, this paper relies on the definition proposed by the World Bank. According to World Bank Group (2016), a financial system operates within a range of stability when it dissipates financial imbalances, absorbing the shocks (whether from exogenous sources or arising endogenously) via self-corrective mechanisms and preventing disruption in real economic or financial system activities. The paper leans on this definition because the ideal situation where financial stress is completely absent may not exist; in reality, the financial system is subjected to varying degrees of financial stress.

Advances in this literature, and indeed on the role of financial soundness indicators in the assessment of financial stability, have led to the development of quantitative methods to measure financial stability. The objective of these indicators is to provide users with a rough idea of the soundness of the financial sector as a whole (see Gersl and Hermanek (2007)). To allow for international comparison, the International Monetary Fund (IMF) and the World Bank in cooperation with national authorities have since developed a comprehensive set of indicators that reflect financial soundness, stability and structure. Gersl and Hermanek (2007) provide a comprehensive overview of this literature. Given the foregoing uses of financial indicator development, the literature has converged on the realization that the concept of financial stability is multifaceted. Notably, financial stability has to be consistent with the existence of complex relations among financial institutions and financial markets, the risks associated with financial market structure, and domestic and international macroeconomic developments (see Dumicic (2016)).

In terms of efforts to measure financial stability, research has expanded in different directions, resulting in stress testing, early warning systems and aggregate financial stability index techniques encountered in the literature today. With regard to aggregate index construction, on which this paper sharply focuses, the most primitive attempt at index aggregation concerns a non-parametric approach of the mechanical comparison of basic indicators hierarchically ordered as index components with equal weights given to the minimum differences between the indicator values (see Karanovic and Karanovic (2015)).

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Building on the existing literature, Albulescu (2010) developed an aggregate financial stability index for Romania by using a stochastic simulation model to provide a forecast for the country's banking system. A number of papers have since applied this technique and several others to examine financial stability in different contexts (see for example, (Braga et al., 2014; Ekinci, 2013; Kondratovs, 2014; Malega & Horváth, 2017; Morris, 2010)). Ekinci (2013) concluded that the public sector can be a significant contributor to financial stress, especially during periods of high stress. Malega and Horváth (2017) concluded that high levels of financial stress highly impact output, prices, and interest rates, with the greatest response occurring well over a year after the shock from the economic downturn. Morris (2010) showed that the index was highly sensitive to variations in major macroeconomic indicators. Kondratovs (2014) found that financial stability in Latvia began deteriorating in 2002, demonstrating the necessity of having an index to signal growing stress, permitting proper intervention by authorities. Akosah, Loloh, Lawson, and Kumah (2018) also found interesting results for Ghana using these techniques. To the best of our knowledge, no study has attempted the construction of an aggregate financial stability index for Botswana. This paper is critical to the extent that it provides empirical evidence from which authorities can draw inferences to enhance the current framework for evaluating financial stability in Botswana.

3. METHODOLOGY

Reflecting the conceptual issues of financial stability, the AFSI is constructed to capture the different dimensions of financial stability. The dimensions of financial stability comprise financial development, financial vulnerability, financial soundness and global economic condition (see Karanovic and Karanovic (2015)). In this regard, the AFSI is constructed by aggregating several sub-indices, the monitoring of which enables timely detection of vulnerabilities and potential systemic risks to financial stability. The sub-indices, in turn, are constructed by aggregating individual indicator variables that signify risks facing the banking system and reflect developments in financial infrastructure, as well as developments in macroeconomic conditions (including real and public sectors) (cf. Dumicic (2016)).

The criteria for selecting indicator variables used to construct the AFSI can be summarized as follows. The indicator variables that can provide a timely warning of eminent systemic risk must be selected; hence the choice of variables is often based on the broad framework of the core set of financial stability indicators recommended by the IMF for monitoring and assessing the soundness of the financial sector in its member countries (see Cheang and Choy (2011)). These variables should also reflect the structure of the financial system of the country under study (Botswana for this paper) and should have a set of variables from each of the important dimensions of financial stability (cf. Morris (2010)). Table A1 in the Appendix presents the selected indicator variables for Botswana and their grouping into the four broad categories. Most of the variables relate to the banking sector due to the dominance of this sector in the financial system of Botswana. The data[1] for the selected indicators cover the period from 2005:Q4 to 2020:Q4 to allow for the analysis of trends before and after the 2008 financial crisis.

For this study, the selection of variables and the methodology used followed, to some degree, the studies by Malega and Horváth (2017); Morris (2010); Kondratovs (2014); Yiu, Ho, and Jin (2010) and Manolescu and Manolescu (2017), which used equal weights in averaging the individual variables to form sub-indices corresponding to the four dimensions of financial stability. However, this study assigns unequal weights to the four sub-indices in computing the AFSI, depending on the level of risk captured in the sub-indices.

1 Data on these indicators was sourced from Bank of Botswana and the Organization of Economic Co-Operation and Development (OECD) data website. It is worth noting that the choice of data for the study varies in frequency: financial data is oftentimes compiled on a monthly basis, while real sector data is quarterly. For data comparability, the monthly financial data was converted to quarterly data. According to Vermeulen et al. (2015), quarterly data is the best frequency for obtaining historical trends related to financial crises.

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Following the construction of the AFSI, the relevance of the synthetic index was tested through an econometric model. Specifically, the autoregressive distributed lag (ARDL) model was used to determine the existence, or absence, of effects from key macroeconomic variables on the AFSI.

3.1. Construction of the Indexes

3.1.1. Construction of the Sub-Indexes

The process of constructing the AFSI entails three steps. First, the selected individual indicator variables are standardized. The reason for this is that the variables are measured in different units and scales – some variables are measured in percent, while others are in billions of Pula. This makes it difficult to compare and aggregate the variables into a single synthetic index. Hence, the variables must be normalized. The study followed the method of empirical normalization (see Morris (2010)). Once normalized, all the indicators' values fall within the same range of [0, 1]. The lower bound represents the weakest value of the indicator and the upper bound shows the strongest value. These values, in turn, suggest situations of potential instability (or stress) and stability in the financial system, respectively. The normalization formula is specified as:

$$nX_{it} = \frac{X_{it} - \min X_i}{[\max(X_i) - \min(X_i)]}$$

$_nX_{it}$ = the normalized indicator i at time t.

X_{it} = the indicator value at time t.

$\max(X_i)$ captures the largest value of each individual indicator in the 2005–2020 period.

$\min(X_i)$ captures the smallest value of each individual indicator in the study period.

Second, the standardized individual variables are aggregated into sub-indices that indicate conditions relating to financial development, financial vulnerability, financial soundness and external economic environment. This aggregation was achieved through Equations 1 to 4.

$$\overline{FDI}_t = \frac{\sum_{i=1}^{6} XD_{it}}{6} \qquad (1)$$

$$\overline{FVI}_t = \frac{\sum_{i=1}^{9} XV_{it}}{9} \qquad (2)$$

$$\overline{FSI}_t = \frac{\sum_{i=1}^{4} XS_{it}}{4} \qquad (3)$$

$$\overline{WI}_t = \frac{\sum_{i=1}^{2} XW_{it}}{2} \qquad (4)$$

Where:

- XD_{it} is the i[th] indicator at time t under the financial development index.
- XV_{it} is the i[th] indicator at time t under the financial vulnerability index.
- XS_{it} is the i[th] indicator at time t under the financial soundness index.
- XW_{it} is the i[th] indicator at time t under the world economic environment index.

Third, the AFSI is computed by combining the four sub-indices using a weighted average method, as shown in Equation 5. The largest weight is assigned to the financial vulnerability index, as it constitutes the greatest number of indicators that carry a wide array of risks.

$$AFSI_t = \frac{6\overline{FDI}_t + 9\overline{FVI}_t + 4\overline{FSI}_t + 2\overline{WI}_t}{21} \qquad (5)$$

Consistent with interpretation of the magnitude of normalized individual indicator values, low values of the AFSI, particularly between the half mark and the lower bound, indicate deterioration in financial stability. Similarly, large values of the index, particularly between the half mark and the upper bound, indicate improvement in financial stability in the economy.

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3.2. Testing the Efficacy of the Aggregate Financial Stability Index (AFSI)

The efficacy test employed an empirical assessment using an ARDL model to ascertain the presence of short- and/or long-run relationships between the AFSI and select key macroeconomic variables. Therefore, the AFSI was regressed against the real effective exchange rate (REER), gross domestic product (GDP), interest rate spread, government budget balance, inflation, current account balance, liquidity ratio, and the lagged values of the index. The choice of variables is informed by the impact with which crisis events affect the indicators, and quite often, much earlier than other indicators.

The general specification of the ARDL model (ARDL (p,q)) is specified as:

$$AFSI_t = \gamma + \beta_j \sum_{j=1}^{p} AFSI_{t-j} + \theta_i \sum_{i=0}^{q} X_{t-i} + \varepsilon_t \qquad (6)$$

Where AFSI is explained by autoregressive terms and lags of the vector of covariates, denoted by X_t and ε_t as disturbances. The order of the model is determined by the standard criteria.

The unrestricted error correction version of the ARDL model specification for analysis of the impact of the regressors on the AFSI is:

$$\Delta AFSI_t = \gamma_0 + \beta_j \sum_{j=1}^{p} \Delta lnAFSI_{t-j} + \theta_{1i} \sum_{i=0}^{q-1} \Delta lnGBB_{t-i} + \theta_{2i} \sum_{i=0}^{q-1} \Delta lnCA\_GDP_{t-i} + \theta_{3i} \sum_{i=0}^{q-1} \Delta lnGDP_{t-i} + \theta_{4i} \sum_{i=0}^{q-1} \Delta lnInflation_{t-i} + \theta_{5i} \sum_{i=0}^{q-1} \Delta IRS_{t-i} + \theta_{6i} \sum_{i=0}^{q-1} \Delta lnLR_{t-i} + \theta_{7i} \sum_{i=0}^{q-1} \Delta REER_{t-i} + \alpha_1 lnAFSI_{t-1} + \alpha_2 lnGBB_{t-1} + \alpha_3 lnCA\_GDP_{t-1} + \alpha_4 lnGDP_{t-1} + \alpha_5 lnInflation_{t-1} + \alpha_6 IRS_{t-1} + \alpha_7 lnLR_{t-1} + \alpha_8 REER_{t-1} + \varepsilon_t \quad (7)$$

Using Equation 7, cointegration is investigated by testing the null hypothesis of no level relationships against the alternative hypothesis of the existence of level relationships between variables. Thus, the test hypotheses become:

$$H_0: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8$$
$$H_1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq \alpha_6 \neq \alpha_7 \neq \alpha_8$$

The hypotheses are evaluated using the F-statistic against a set of critical values, as computed by Narayan (2005). Narayan's critical values for the bounds F-statistic are more suitable for the small sample size used in this study, unlike the critical values in Pesaran, Shin, and Smith (2001), which apply to larger sample sizes of more than 100 observations.

After establishing the existence of cointegration, a level relationship equation can be specified using Equation 6, which is then solved for long-run coefficients. The optimal lag length was established as previously indicated.

The short-run dynamics are derived from estimation or re-parameterization of the ARDL model into an error correction model, as specified in Equation 8:

$$\Delta AFSI_t = \gamma_0 + \beta_j \sum_{j=1}^{p-1} \Delta lnAFSI_{t-j} + \theta_{1i} \sum_{i=0}^{q-1} \Delta lnGBB_{t-i} + \theta_{2i} \sum_{i=0}^{q-1} \Delta lnCA\_GDP_{t-i} + \theta_{3i} \sum_{i=0}^{q-1} \Delta lnGDP_{t-i} + \theta_{4i} \sum_{i=0}^{q-1} \Delta lnInflation_{t-i} + \theta_{5i} \sum_{i=0}^{q-1} \Delta lnIRS_{t-i} + \theta_{6i} \sum_{i=0}^{q-1} \Delta lnLR_{t-i} + \theta_{7i} \sum_{i=0}^{q-1} \Delta lnREER_{t-i} + \delta ECT_{t-1} + \varepsilon_t \quad (8)$$

Where δ is the coefficient of the error correction term, which measures the speed of adjustment to equilibrium; β and θ are short-run coefficients; ECT_{t-1} is the error correction term; and ε_t is the error term.

4. EMPIRICAL RESULTS

4.1. Interpretation of the Indexes

4.1.1 Interpretation of the Sub-Indexes

An interpretation of the four sub-indices was carried out to draw inference from the dynamics of each and their individual impact on the AFSI. The trends of the sub-indexes are consistent with three major macroeconomic events observed in the period of study; the 2007–2008 global financial crisis, the 2015 domestic liquidity crisis, and the 2020 Covid-19 pandemic. Figure 1 plots the AFSI and the contributions of the four sub-indices to the AFSI.

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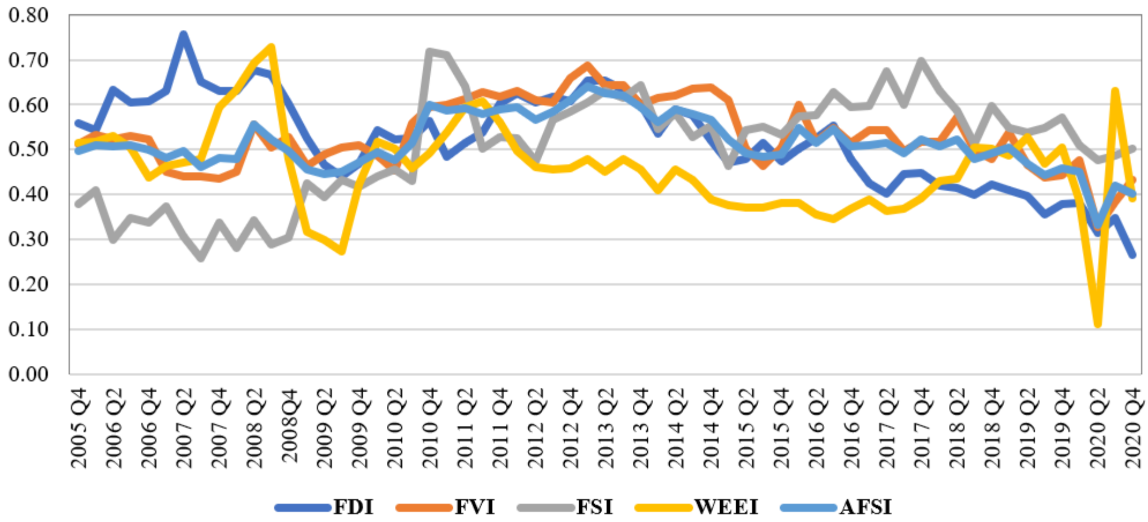

Figure 1. Decomposition of AFSI.

The Financial Vulnerability Index (FVI) had the greatest fluctuations, decreasing sharply in the first few quarters of the review period (December 2005–June 2010), with the lowest index value recorded as 0.43. The downward trajectory was on account of a sharp deterioration in the government budget, intermediation ratio, REER and the reserve to deposits ratio. Figures 1A and 1B in the Appendix show a plot of the FVI and a decomposition of the sub-index, respectively. A deterioration in the government budget balance means that the share of investment opportunities taken up by the government declined, leading to a drawdown on deposits held by banks for the government. This likely led to the deterioration of the intermediation ratio (loans to deposit ratio) given the drawdown on deposits, leaving banks with more loans than deposits, as the government is the largest deposit account holder with commercial banks. Meanwhile, the deterioration of the reserves to deposits ratio shows the banking sector's capacity to meet bank runs in the event of looming financial uncertainties, hence the negative impact on the AFSI. The decline in the REER indicates an improvement in trade competitiveness as exports become cheaper due to the domestic currency trading cheaper against trading partner countries, ultimately translating to inflationary pressures that negatively impact the AFSI.

In the same period, the Financial Development Index (FDI) recorded its highest index value of 0.76 in June 2007 on the back of high GDP, market capitalization and return on equity (ROE) recordings. Figures 1C and 1D in the Appendix show a plot of the FDI and a decomposition of the sub-index, respectively. Statistics show a growth of 11.9% in GDP in June 2007, which translated to looser credit conditions, as would be expected when the real sector growth is positive, giving a significant boost to the stock market. As anticipated, the Financial Soundness Index (FSI) recorded its lowest index values as the real economy deteriorated due to the impacts of the global financial crisis, recording index values under 0.5 in the period between December 2005 and September 2010. This was due to a deteriorated capital adequacy ratio and z-score. Figures 1E and 1F in the Appendix illustrate a plot of the FSI and a decomposition of the sub-index, respectively. Meanwhile, the World Economic Environment Index (WEEI) performed relatively well, having shown a steady trend before taking a sharp decline after a peak of 0.73 in September 2008 to a low of 0.27 in September 2009. The WEEI remained resilient, in part, given the strong capacity of G20 countries to mitigate external shocks. Figures 1G and 1H in the Appendix show a plot of the WEEI and a decomposition of the sub-index, respectively.

In the recovery phase following the global financial crisis, the values of the FVI peaked, showing an improvement in financial stability, peaking at an index value of 0.69 in March 2013. However, the index dips in June 2015, consistent with the domestic liquidity crisis experienced that year. The greatest contributors to the sharp decline in the FVI were a deteriorating government budget balance, the deposits to M2 ratio, and the reserves to deposits ratio. Following the domestic liquidity crisis, the index steadily recovers, reflecting improved financial stability. Similarly,

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the FDI showed improved financial stability, peaking at 0.63 in March 2013, before portraying a downward trend for the rest of the study period. The downward pull on the FDI was due to deterioration in the interest rate spread, ROE and ROA, but was smoothed out by higher recordings of the market capitalization to GDP ratio, GDP growth and total credit as a share of GDP. Meanwhile, following the global financial crisis, the FSI maintained an upward trend with index values greater than 0.5, except for a dip in March 2015 to an index value of 0.46 due to the domestic liquidity crisis. The stable trend in the FSI was due to macroprudential reforms put in place after the 2007–2008 financial crisis in an effort to create a resilient banking system.

With the onset of the Covid-19 pandemic and the subsequent global recession, the FVI shows a sharp deterioration in June 2020 to the lowest recorded index value of 0.33 in the study period. The decline corresponds to the subdued economic activity in the country resulting from the nationwide lockdown implemented to mitigate the spread of the virus. The main contributors to the sharp decline were a government budget deficit, a fall in the reserves to deposits ratio, the current account and the REER. Meanwhile, the computed FDI seems to have begun a downward trajectory in September 2019, recording its lowest index value in the entire study period of 0.31 in June and December 2020. This was against the backdrop of a decline in GDP growth, interest rate spread, ROE and ROA. The FSI remained resilient during the 2020 Covid-19 global recession as banks, in conjunction the Bank of Botswana, have put measures in place to remain adequately capitalized and liquid to withstand macroeconomic shocks since the 2007–2008 global financial crisis. The WEEI is also consistent with expectations in this period, sharply deteriorating to record a low of 0.11, culminating from subdued economic growth across the globe as countries went into lockdown to mitigate the dire effects of the coronavirus.

Figure 2 illustrates the computed AFSI for Botswana's financial sector in accordance with Equation 5 in section 3.

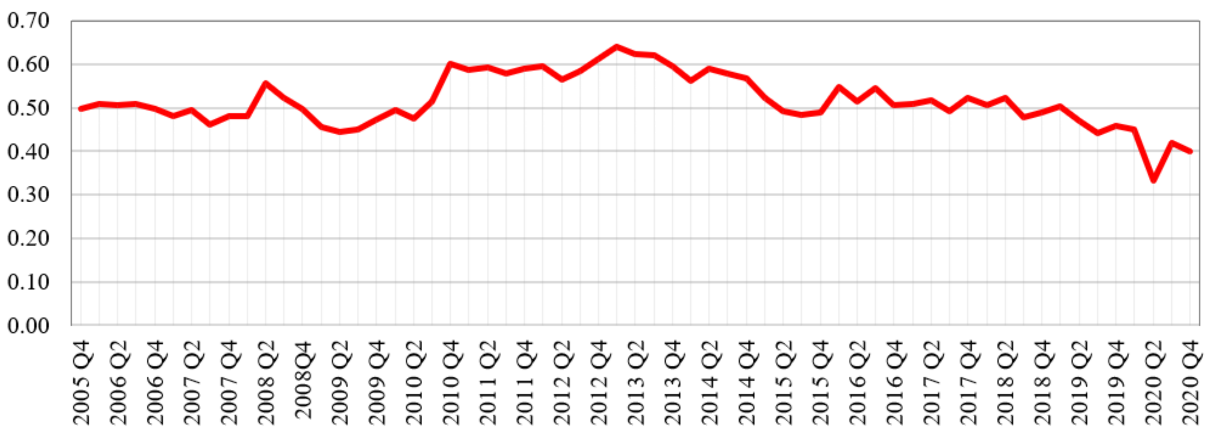

Figure 2. Aggregate financial stability index (AFSI).

4.1.2. Interpretation of the Aggregate Financial Stability Index (AFSI)

The trend of the AFSI has several peaks and troughs, depicting impacts of macroeconomic events on the stability of the financial sector as they unfolded across the period of study. The trend of the AFSI is also consistent with the three major macroeconomic events[2] observed in the period of study; the 2007–2008 global financial crisis, the 2015 domestic liquidity crisis, and the 2020 COVID-19 pandemic.

The evolution of the AFSI shows that, prior to the 2007–2008 global financial crisis, financial stability began deteriorating in March 2007 as the strain on the banking and financial market sectors from the rest of the world came into effect. The deterioration was largely informed by a greater decline in the FVI relative to the other sub-indices,

2 The quality of such a composite index is tied to its capacity to identify periods of stress, and the easiest way is a visual comparison of the index with known periods of stress (Braga et al., 2014).

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which declined from 0.52 to 0.45. The downward trajectory of the FVI stemmed from a greater decline in the REER due to financial crises often being anticipated to shock the exchange rate and stock markets earlier than other indicators. Deterioration was observed in the AFSI and its sub-indices in the period between June 2007 and June 2010, with the index averaging below 0.5. This was against the backdrop of deterioration in all sub-indices. There was, however, in that same period, a spike in the AFSI in June 2008 to an average of 0.52. This was in part due to monetary and fiscal policy reforms implemented by the government to mitigate recessionary pressures on the economy. Moreover, the spike was underpinned by an upward trajectory of all sub-indices June 2008. The AFSI appears to have taken a slight dip in June 2015, during the domestic liquidity crisis, in response to the varied movements of the sub-indices. Following the 2015 liquidity crisis, the AFSI remained relatively stable before embarking on a downward trajectory in June 2019 and deteriorating sharply at the peak of the Covid-19 pandemic in June 2020, recording its lowest index value in the entire study period of 0.33.

4.2. Interpretation of Econometric Results

On the back of the efficacy of the AFSI in tracking the effects of macroeconomic events on Botswana's financial system, the ARDL model is employed to examine the dynamic and long-run influence of key macroeconomic variables – REER, GDP, interest rate spread (IRS), government budget balance as a share of GDP (GBB), inflation, current account as a share of GDP (CA_GDP), and liquidity ratio (LR) – on the index.

4.2.1. Descriptive Statistics

Table 1 presents the descriptive statistics of the variables. Each variable had 61 observations. It is observed that the liquidity ratio, REER and interest rate spread had the greatest variations compared to the other variables.

Table 1. Descriptive statistics of the variables.

Variable	Observations	Mean	Median	Std deviation	Minimum	Maximum	Skewness
AFSI	61	0.517	0.507	0.059	0.332	0.641	-0.115
GBB	61	0.634	0.688	0.229	0.000	1.000	-0.924
CA_GDP	61	0.479	0.469	0.177	0.000	1.000	0.145
GDP	61	0.740	0.755	0.168	0.000	1.000	-1.712
Inflation	61	0.377	0.360	0.255	0.000	1.000	0.809
IRS	61	0.503	0.441	0.275	0.000	1.000	0.204
LR	61	0.383	0.183	0.334	0.000	1.000	0.634
REER	61	0.610	0.733	0.289	0.000	0.933	-0.639

Table 2. Breakpoint unit root test.

Variable	Levels		First difference		Integration
	ADF statistic	Critical value*	ADF statistic	Critical value*	
AFSI	-2.815	-4.194	-10.874	-4.194	I (1)
REER	-2.716	-4.607	-10.867	-4.607	I (1)
GDP	-5.254	-4.194	-	-	I (0)
GBB	-6.544	-4.194	-	-	I (0)
Inflation	-3.894	-4.607	-7.809	-4.607	I (1)
CA_GDP	-9.154	-4.194	-	-	I (0)
IRS	-4.224	-4.607	-7.021	-4.607	I (1)
LR	-5.653	-4.607	-	-	I (0)

Note: (*) 10% critical value for the ADF statistic.

4.2.2. Unit Root Test Results

The selected variables were subjected to a non-stationarity test using the breakpoint unit root test, which can overcome the power problem of standard unit root tests emanating from structural breaks. Standard unit root tests may be biased toward non-rejection of the unit root hypothesis. Before testing for unit root, a graphical depiction of

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the variables was undertaken to guide the modelling of deterministic terms in the unit root testing equation. Figure A1 in the Appendix presents the graph of the model variables.

The unit root test results are based on the augmented Dickey–Fuller (ADF) test statistic (Table 2). Using the 10% level, given the sample size, the ADF statistic indicates that the variables do not have unit roots, except the REER, interest rate spread, and inflation, which are stationary at first difference.

4.2.3. Lag Length and Optimal Model Selection

The lag order selection criteria were used to determine the lag length. From the results presented in Table 3, the Akaike Information Criterion (AIC) indicates a lag order of 4, while the Schwartz Information Criteria (SIC), supported by the rest of the information criteria, suggests a lag order of 2. For the study, the lag order suggested by the AIC was chosen, as the AIC imposes a less harsh penalty for adding more regressors compared to the SIC (Gujarati & Porter, 2009). Moreover, running the ARDL model with a lag order of 2 gave unsatisfactory diagnostic results compared to an ARDL model with a lag order of 4.

Table 3. Lag order selection.

Endogenous variable: AFSI						
Exogenous variables: C Government Budget Balance GBB CA_GDP GDP inflation IRS LR REER						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	126.820	NA	0.001	-4.169	-3.882	-4.058
1	135.654	14.883*	0.001	-4.444	-4.122	-4.319
2	137.895	3.690	0.001*	-4.488	-4.129*	-4.348*
3	138.850	1.542	0.001	-4.486	-4.092	-4.333
4	139.963	1.756	0.001	-4.490*	-4.060	-4.323

Note: * indicates lag order selection by the criterion.
LR: Sequential modified LR test statistic.
FPE: Final prediction error.
AIC: Akaike information criterion.
SC: Schwarz information criterion.
HQ: Hannan–Quinn information criterion.

When running the ARDL, to select the best model, five trend specification cases were alternated and the outcomes were compared. These trend specification cases are:

- Case 1: No Constant and No Trend.
- Case 2: Restricted Constant and No Trend.
- Case 3: Unrestricted Constant and No Trend.
- Case 4: Unrestricted Constant and Restricted Trend.
- Case 5: Unrestricted Constant and Unrestricted Trend.

The ARDL trend specifications will either restrict the constant and/or trend to affect the long-run relationship or unrestrict them so they feature only in the short-run (Pesaran et al., 2001). In instances where no constant or trend is included in the model, the software makes use of the t-Bounds test to determine which hypothesis gives greater inference. Against this backdrop, the best model is selected based on the smallest AIC and SIC estimates, small standard errors and high adjusted R-squared values. The results of the five cases are presented in Table 4.

Table 4. Optimal model selection output.

Case	AIC	SIC	Standard error	Adjusted R-squared	Significant LR coefficient
1	-5.120	-4.518	0.016	0.934	Yes
2	-5.206	-4.381	0.016	0.936	No
3	-5.206	-4.381	0.016	0.936	No
4	-5.392	-4.389	0.014	0.948	Yes
5	-5.392	-4.389	0.014	0.948	Yes

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From the data in Table 4, cases 4 and 5 had the smallest AIC, standard errors and higher adjusted R-squared values. To narrow down the model selection, the ARDL outputs from both cases were subjected to a cointegration test and the adjusted R-squared values compared. The case 4 model had a greater adjusted R-squared (0.871175) compared to that of case 5 (0.867597) (not reported in Table 4). The adjusted R-squared, as a model selection criterion, penalizes the addition of extra regressors, which in case 5, by unrestricting the constant and trend, are added to the short-run model, thus rendering a lower adjusted R-squared (Gujarati & Porter, 2009). Against this background, an ARDL model with an unrestricted constant and a restricted trend (case 4) was preferred for this study.

4.2.4. Diagnostic Tests of the ARDL Model

Diagnostic tests on the selected optimal ARDL model are presented in Table 5. The model was tested for serial correlation using the Breusch–Godfrey Lagrange multiplier (LM), heteroskedasticity, normality and stability tests. The test results showed that there is no serial correlation and that the residuals are homoscedastic and normally distributed.

The estimation model was also subjected to a stability test. Figure A2 reports the stability test outcome from the cumulative sum (CUSUM) of squares test. The results showed that the model coefficients are stable.

Table 5. Model diagnostic tests.

Serial correlation	**Heteroskedasticity**	**Normality**
Breusch–Godfrey LM test (Prob F)	Breusch–Pagan–Godfrey (Prob F)	Jarque–Bera (Prob)
0.704	0.818	0.853

4.2.5. Cointegration Test Results

Existence of the long-run relationship was tested in terms of the bounds F-test statistic, whose critical values are presented in Table 6. The results confirm a long-run influence of key macroeconomic variables on the index.

Table 6. F-Statistics for cointegration test.

Critical value bounds of the F-statistic						
10%		**5%**		**1%**		**(Test statistic)**
Lower	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**F-statistic**
2.28	3.50	2.73	4.16	3.86	5.69	8.95

Source: Narayan (2005).

4.2.6. Model Estimation Results

This sub-section presents the model estimation results. First, the empirical analysis establishes the variables that have long-run effects on the AFSI. This is achieved by the estimation of the level relationship part of the ARDL model. The second part of the empirical analysis investigates the response of the AFSI to short-run movements in the selected macroeconomic variables.

4.3. Results of the ARDL Long-Run Estimation

Table 7 presents the long-run coefficient estimates, which were obtained from an ARDL (3, 4, 4, 0, 2, 0, 4, 2) model specification. The results show a good model fit, with an adjusted R-squared of 0.95.

The empirical results indicate that, in the long run, the AFSI is influenced by the current account balance, GDP, domestic inflation and real effective exchange rate. The influence of the current account balance on the AFSI has a significant but negative impact. A 1 bps increase in the current account balance leads to deterioration in financial stability by 0.18 bps, partly due to the external shock exposure that comes with being a net lender (Bank of Botswana, 2020) to other countries, where in the event of a shock, there would be financial losses (cf. Dunn and Mutti (2000)).

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Thus, the results seem to suggest that, in the long run, large current account surpluses are undesirable for the stability of the financial system.

Table 7. ARDL long-run estimation results.

Long-run model results				
Variable	**Coefficient**	**Std. error**	**T-statistic**	**Probability**
GBB	0.052	0.044	1.180	0.250
CA__GDP	-0.180	0.053	-3.382	0.002
GDP	0.136	0.033	4.091	0.000
Inflation	0.069	0.039	1.751	0.090
IRS	0.050	0.040	1.245	0.223
LR	-0.034	0.071	-0.486	0.631
REER	0.299	0.083	3.623	0.001
Trend	-0.005	0.001	-7.087	0.000
R-squared	0.973	Adjusted R-squared		0.948
F-statistic	38.728	Prob (F-statistic)		0.000
Durbin–Watson statistic	2.272	Akaike info criterion		-5.392

Meanwhile, GDP significantly and positively influences the AFSI, as per expectations. A 1 bps increase in GDP leads to a 0.14 bps increase in the AFSI, partly due to economic growth leading to growth in incomes, which translates to greater credit uptake by individuals and companies for investment opportunities, creating overall economic growth which positively impacts financial stability in the long run. Inflation, in the long run, is shown to be significant at the 10% level of significance, where a 1 bps increase in inflation leads to an improvement in the AFSI by 0.069 bps. This outcome, however, goes against expectations, as an increase in inflation indicates deterioration in price stability and, consequently, a deterioration in financial stability. Lastly, the long-run results indicate that the REER positively and significantly impacts the AFSI. An increase in the REER indicates that a country's exports have become more expensive, translating to a loss in trade competitiveness. However, in the long run, there is exchange rate parity, wherein as economic conditions of respective countries change, the purchasing power of the foreign currencies eventually become equal (Romer, 1996). Therefore, in the long run, a 1 bps increase in the REER would improve the AFSI by 0.3 bps on account of purchasing power parity.

On the other hand, the long-run results indicate that the government budget balance, interest rate spread, and liquidity ratio are insignificant in influencing movement of the AFSI at the 10% level of significance.

After observing the variables with possible long-run effects on financial stability, it is instructive to also investigate the variables to which the AFSI responds in the short run.

4.4. Results of the ARDL Short-Run Estimation

Table 8 presents the dynamic results. The error correction term (CointEq(-1)) is correctly signed and indicates that any deviation of the AFSI from the mean will be fully eliminated over a period of two quarters.

The short-run results show that the AFSI coefficients for the lagged terms of the last two quarters are statistically significant at 10% and negatively affect the current period's AFSI. The negative signs of the lagged AFSI growth terms are required for stability purposes. Given the non-stationarity of the variable, a positive sign of its lagged terms would result in the synthetic index being characterized by explosive properties. The negative sign, however, implies that currently observed financial stability (or instability) will later taper off and may be followed by less stable (or more stable) conditions.

Meanwhile, the government budget balance terms for the current period and three quarters back all significantly and positively influence the AFSI, thereby contributing to financial stability. The current account balance as a share of GDP in the current period proves to be insignificant in influencing the AFSI. However, the one, two and three period lags significantly and positively impact the AFSI in the short run. This is because a positive current account

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balance means the country is a net lender to other countries and, as payment receipts come in, the government could take up investment opportunities that would ultimately positively impact financial stability (Dunn & Mutti, 2000).

Table 8. ARDL short-run estimation results.

Variable	Coefficient	Std. error	T-statistic	Probability
D(AFSI (-1))	-0.283	0.092	-3.065	0.005
D(AFSI (-2))	-0.306	0.077	-3.960	0.001
D(GBB)	0.060	0.008	7.161	0.000
D(GBB (-1))	0.056	0.013	4.321	0.000
D(GBB (-2))	0.052	0.012	4.473	0.000
D(GBB (-3))	0.028	0.009	3.066	0.005
D(CA__GDP)	0.021	0.013	1.610	0.118
D(CA__GDP (-1))	0.121	0.018	6.661	0.000
D(CA__GDP (-2))	0.078	0.017	4.519	0.000
D(CA__GDP (-3))	0.036	0.011	3.167	0.004
D(Inflation)	0.170	0.024	7.105	0.000
D(Inflation (-1))	0.081	0.027	3.043	0.005
D(LR)	-0.027	0.031	-0.865	0.394
D(LR (-1))	-0.093	0.033	-2.859	0.008
D(LR (-2))	-0.029	0.032	-0.909	0.371
D(REER)	-0.049	0.022	-2.241	0.033
D(REER (-1))	0.095	0.030	3.218	0.003
C	0.325	0.032	10.085	0.000
CointEq(-1)	-0.820	0.081	-10.135	0.000

The short-run results indicate that the inflation rate in the current period and one period lag positively and significantly influence the AFSI. Perhaps this seemingly counterintuitive outcome was obtained because of the general price stability that has prevailed in the economy. With general price stability, a moderate rise in inflation may promote financial stability instead of generating instability.

Meanwhile, the liquidity ratio is shown to have a negative impact on the AFSI, with only the one period lag being significant. This goes against the a priori expectation that an increase in liquidity would improve financial stability, as it reflects the banking sector's resilience to meeting financial obligations in the event of cashflow distress. This may be partly due to an increase in liquidity translating to increased money supply, which tends to be inflationary and may deteriorate financial stability (Morris, 2010).

Lastly, the REER was found to be statistically significant in impacting the AFSI in the short run, albeit in varying directions. The current period REER shows a positive impact on the AFSI, while the one period lag has a negative impact. An increase in the REER indicates that a country's exports have become more expensive, translating to a loss in trade competitiveness. Against this backdrop, as our results indicate, an increase in the REER in the previous quarter is detrimental to financial stability due to the loss of trade competitiveness but is beneficial in the current quarter from the currency gain from the export sales as currencies reach purchasing power parity (Mankiw, 2003).

5. CONCLUSION AND POLICY IMPLICATIONS

On the basis of the foregoing discussion, it seems reasonable to conclude that the existing financial stability monitoring framework can be complemented by the use of an aggregate financial stability index (AFSI). This approach should provide authorities with a more comprehensive and timely warning system of potential risks, which is essential to prevent the onset and/or minimize the impact of financial crises. An important feature of tracking an AFSI is that it permits policymakers to monitor movements of the sub-indices that make up the AFSI. Information in the sub-indices is useful in determining potential risks to the different dimensions of financial stability. In this context, policy makers and market participants could more effectively supervise financial system stability with the ability to unambiguously interpret the prevailing level of financial stress. Future studies, with the benefit of more

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comprehensive data on a wider array of macroeconomic variables, could widen the scope of the variables considered in the computation of the AFSI in this study, with potentially insightful results.

Funding: This study received no specific financial support.
Institutional Review Board Statement: Not applicable.
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Data Availability Statement: Upon a reasonable request, the supporting data of this study can be provided by the corresponding author.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Akosah, N., Loloh, F., Lawson, N., & Kumah, C. (2018). *Measuring financial stability in Ghana: A new index-based approach*. Retrieved from Munich Personal RePEc Archive, Paper No. 86634.

Albulescu, C. T. (2010). Forecasting the Romanian financial system stability using a stochastic simulation model. *Romanian Journal of Economic Forecasting, 13*(1), 81-98.

Bank of Botswana. (2020). *Botswana financial statistics*. Retrieved from https://www.bankofbotswana.bw/botswana-financial-statistics?page=1

Braga, J. P., Pereira, I., & Reis, T. B. (2014). *Composite indicator of financial stress for Portugal*. Retrieved from Economic Bulletin and Financial Stability Report Articles and Banco De Portugal Economic Studies.

Cheang, N., & Choy, I. (2011). Aggregate financial stability index for an early warning system. *Macao Monetary Research Bulletin, 21*(1), 27-51.

Crockett, A. (1996). The theory and practice of financial stability. *De Economist, 144*(4), 531-568.

Dumicic, M. (2016). Financial stability indicators - the case of Croatia. *Journal of Central Banking Theory and Practice, 5*(1), 113-140. https://doi.org/10.1515/jcbtp-2016-0006

Dunn, R. M., & Mutti, J. H. (2000). *International economics* (5th ed.). London: Routledge.

Ekinci, A. (2013). Financial stress index for Turkey. *Doğuş University Magazine, 14*(2), 213-229. https://doi.org/10.31671/dogus.2018.107

Gersl, A., & Hermanek, J. (2007). *Financial stability indicators: Advantages and disadvantages of their use in the assessment of financial system stability*. Retrieved from CNB Financial Stability Report 2006.

Gujarati, D. N., & Porter, D. C. (2009). *Basic econometrics* (5th ed.). New York: McGraw-Hill.

Karanovic, G., & Karanovic, B. (2015). *Developing an aggregate index for measuring financial stability in the Balkans*. Paper presented at the 7th International Conference, the Economies of Balkan and Eastern Europe Countries in the Changed World, EBEEC.

Kondratovs, K. (2014). Modelling financial stability index for Latvian financial system. *Regional Formation and Development Studies, 8*(3), 118-129. https://doi.org/10.15181/rfds.v7i2.2368

Malega, J., & Horváth, R. (2017). Financial stress in the Czech Republic: Measurement and effects on the real economy. *Prague Economic Papers, 26*(3), 257-268. https://doi.org/10.18267/j.pep.608

Mankiw, G. N. (2003). *Principles of macroeconomics* (3rd ed.). Ohio: South-Western.

Manolescu, C. M., & Manolescu, E. (2017). The financial stability index-An insight into the financial and economic conditions of Romania. *Theoretical & Applied Economics, 24*(4), 5-24.

Morris, V. C. (2010). Measuring and forecasting financial stability: The composition of an aggregate financial stability index for Jamaica. *Bank of Jamaica, 6*(2), 34-51.

Narayan, P. K. (2005). The saving and investment nexus for China: Evidence from cointegration tests. *Applied Economics, 37*(17), 1979-1990. https://doi.org/10.1080/00036840500278103

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Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics, 16*(3), 289-326. https://doi.org/10.1002/jae.616

Romer, D. (1996). *Advanced macroeconomics*. New York: McGraw-Hill.

Schinasi, G. J. (2004). *Defining financial stability*. Retrieved from IMF Working Papers 2004/187, International Monetary Fund.

Vermeulen, R., Hoeberichts, M., Vašíček, B., Žigraiová, D., Šmídková, K., & De Haan, J. (2015). Financial stress indices and financial crises. *Open Economies Review, 26*(3), 383-406. https://doi.org/10.1007/s11079-015-9348-x

World Bank Group. (2016). *Financial stability*. Retrieved from https://www.worldbank.org/en/publication/gfdr/gfdr-2016/background/financial-stability

Yiu, M. S., Ho, W.-Y. A., & Jin, L. (2010). *A measure of financial stress in Hong Kong financial market–the financial stress index*. Retrieved from Hong Kong Monetary Authority Research, Note02/2010.

APPENDIX

Table A1. Financial Stability Index indicators.

Indicator	Impact on the AFSI	Sub-index
Gross domestic product (GDP)	+	Financial Development Index
Market capitalization/GDP	+	
Total credit/GDP	+	
Interest rate spread (IRS)	+/-	
Return on assets (ROA)	+	
Return on equity (ROE)	+	
Inflation rate	-	Financial Vulnerability Index
Government budget balance (GBB) (%GDP)	+	
Current account (CA) balance (%GDP)	+	
Real effective exchange rate (REER) (Change)	+/-	
Private sector credit/Total credit	+	
Loans (% Deposits)	-	
Household credit/Total credit	-	
Deposits/M2	+	
(Reserves/Deposits)/(Note and Coins/M2)	+	
Non-Performing Loans (NPLs)/Total loans	-	Financial Soundness Indicator
Capital adequacy ratio (CAR)	+	
Z-Score	+	
Liquidity ratio (LR)	+	
Economic growth in G20	+	World Economic Environment Index
Inflation rate in G20	-	

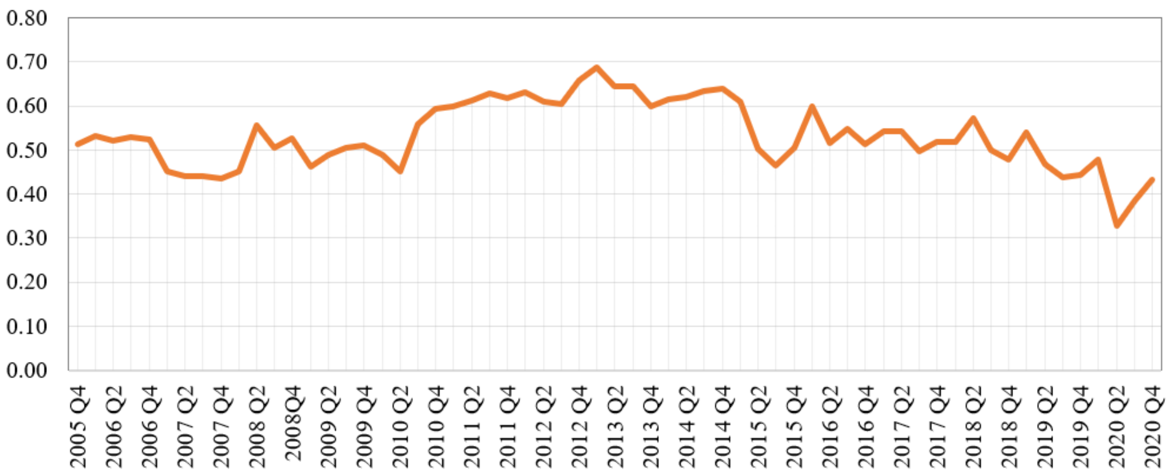

Figure 1A. Financial Vulnerability Index.

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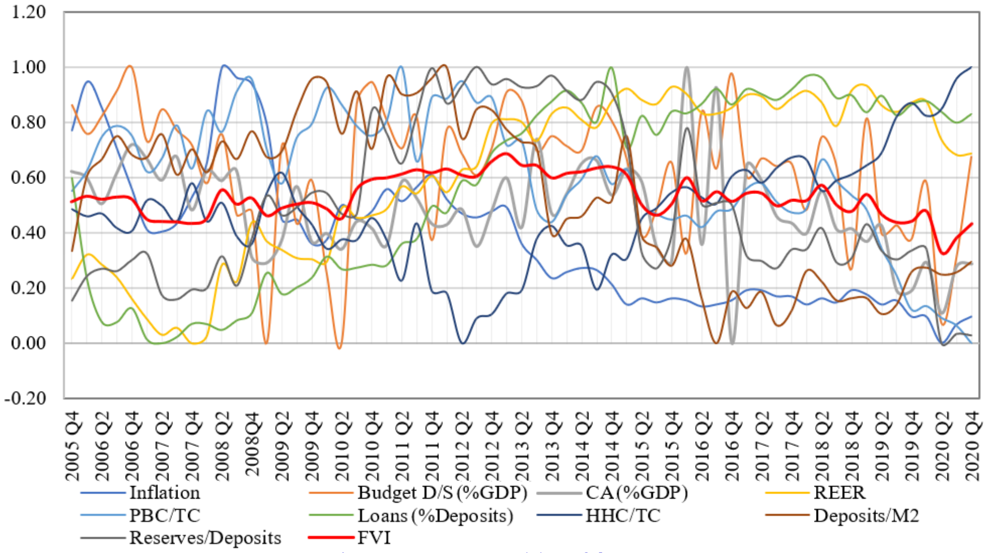

Figure 1B. Decomposition of the FVI.

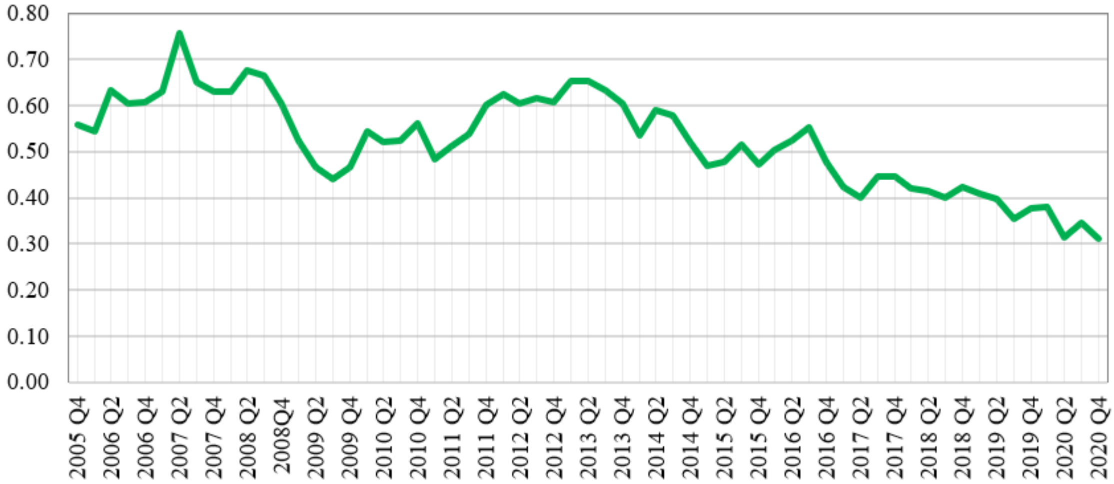

Figure 1C. Financial Development Index.

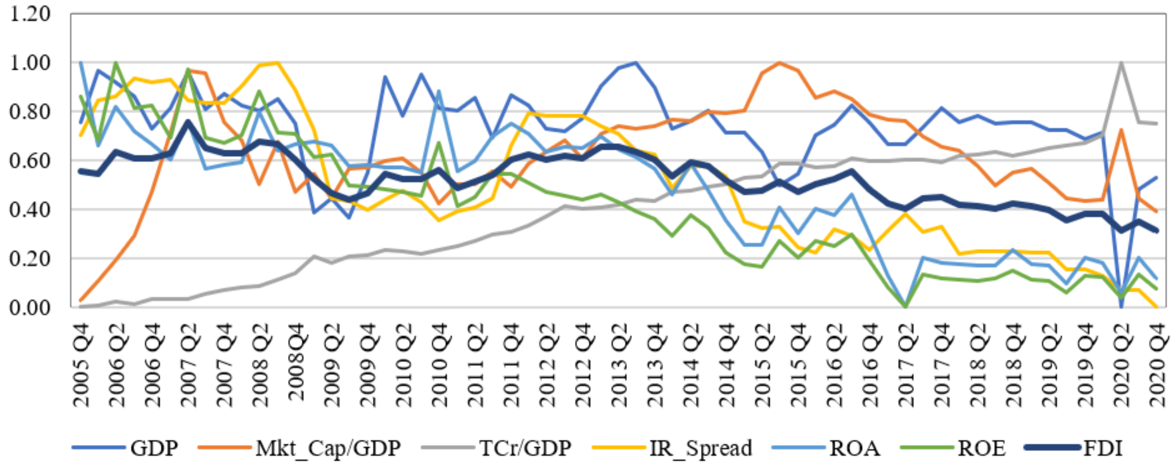

Figure 1D. Decomposition of the FDI.

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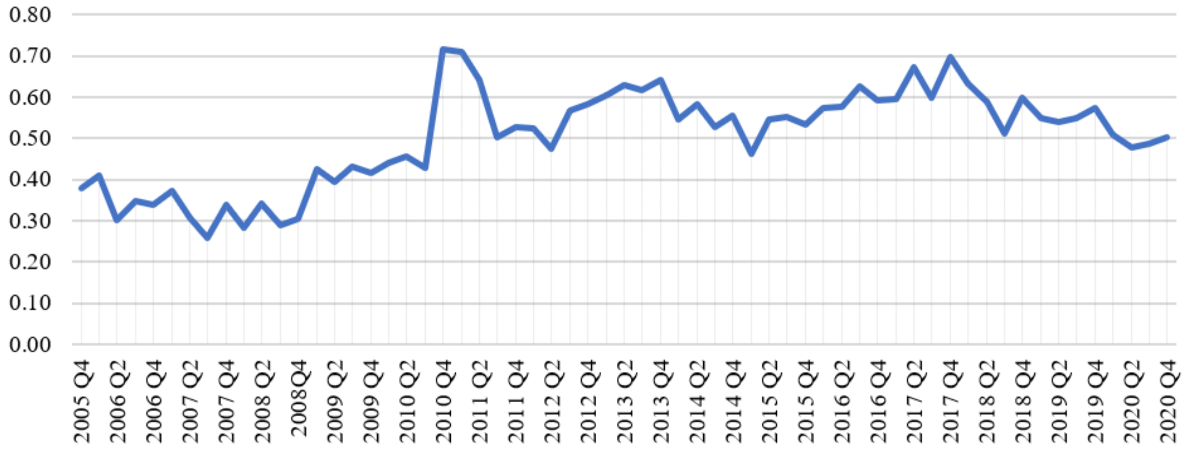

Figure 1E. Financial Soundness Index.

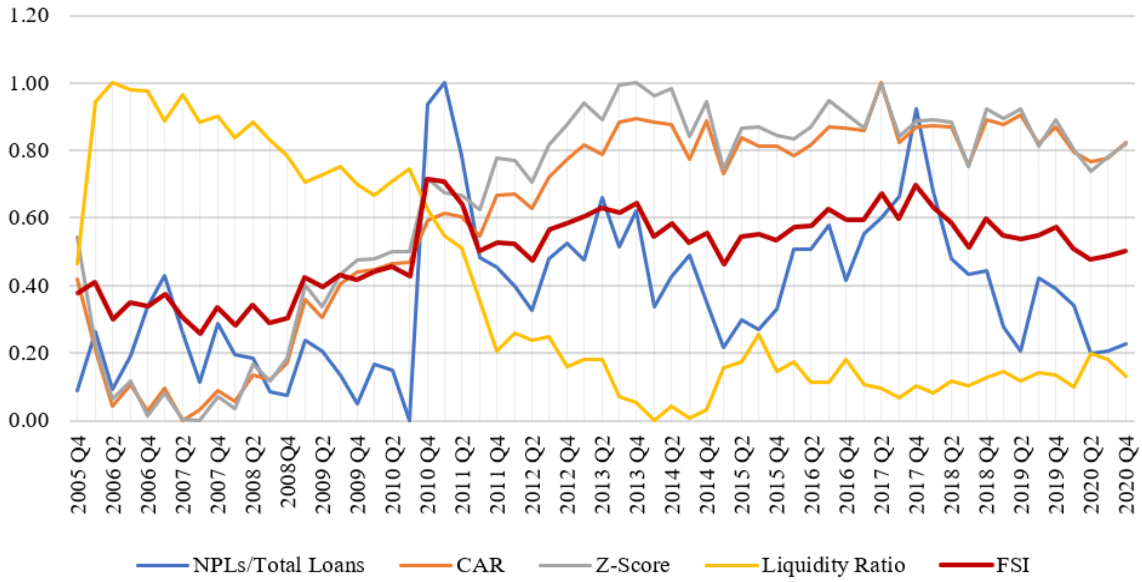

Figure 1F. Decomposition of the FSI.

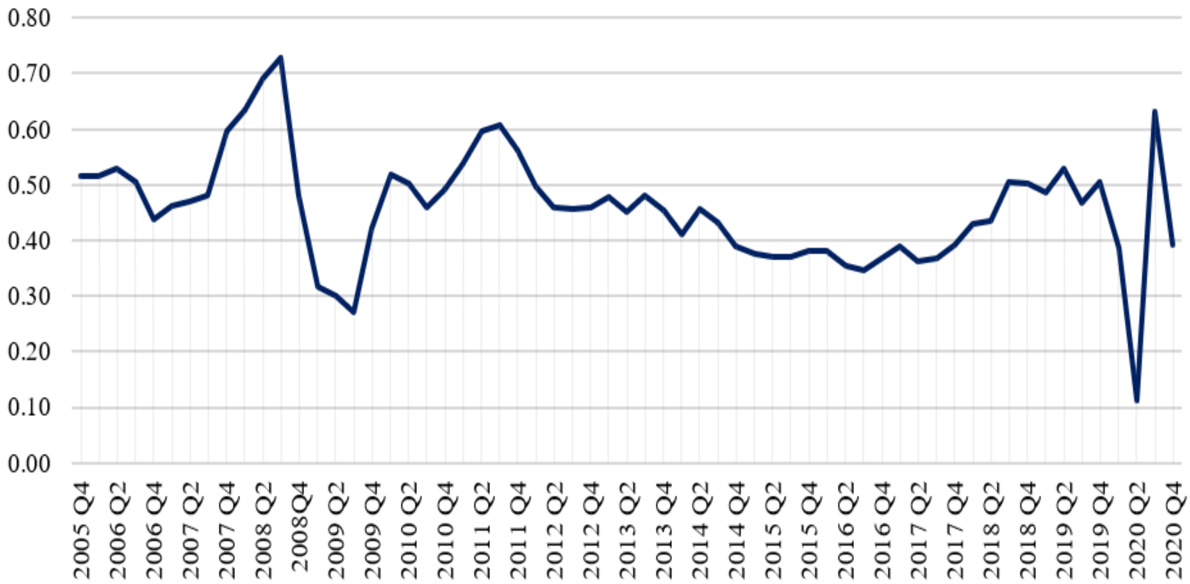

Figure 1G. World Economic Environment Index.

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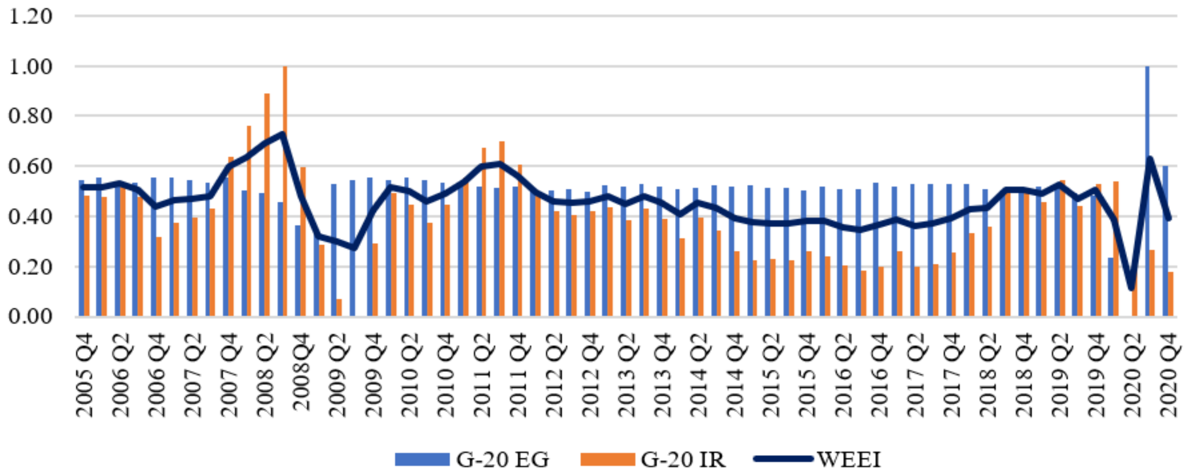
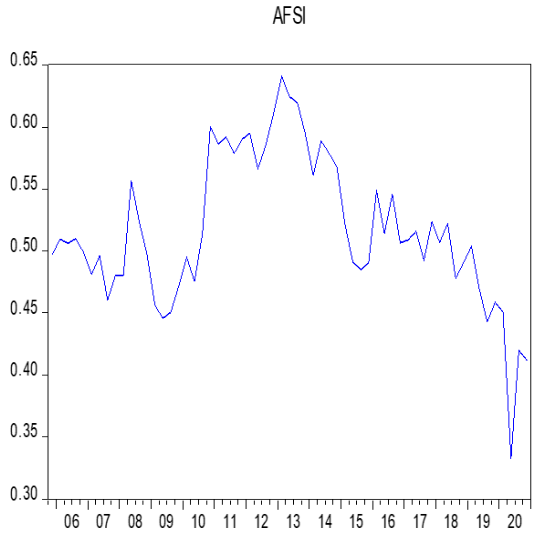
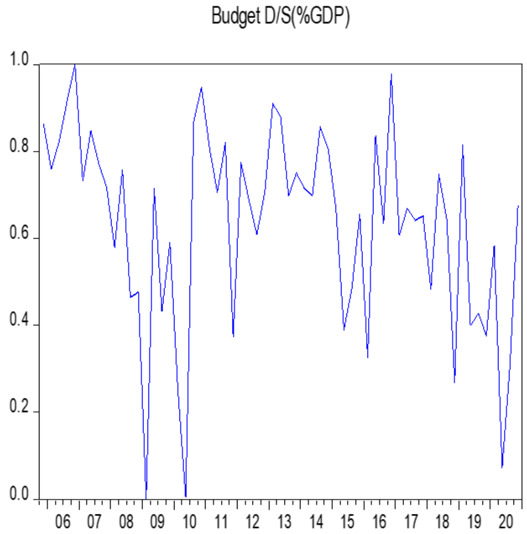


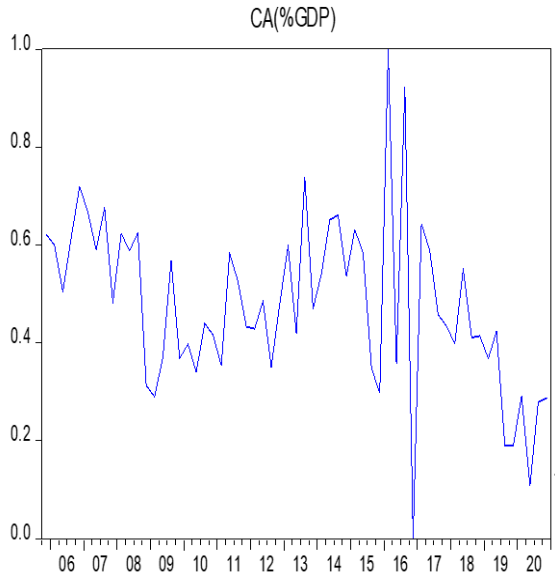
Figure 1H. Decomposition of the WEEI.



(a)



(b)



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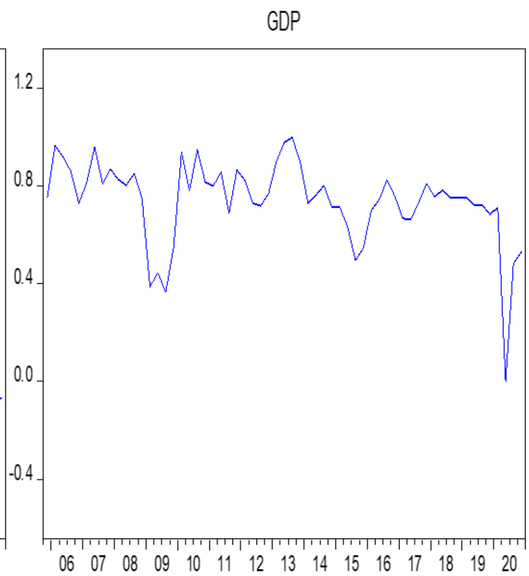

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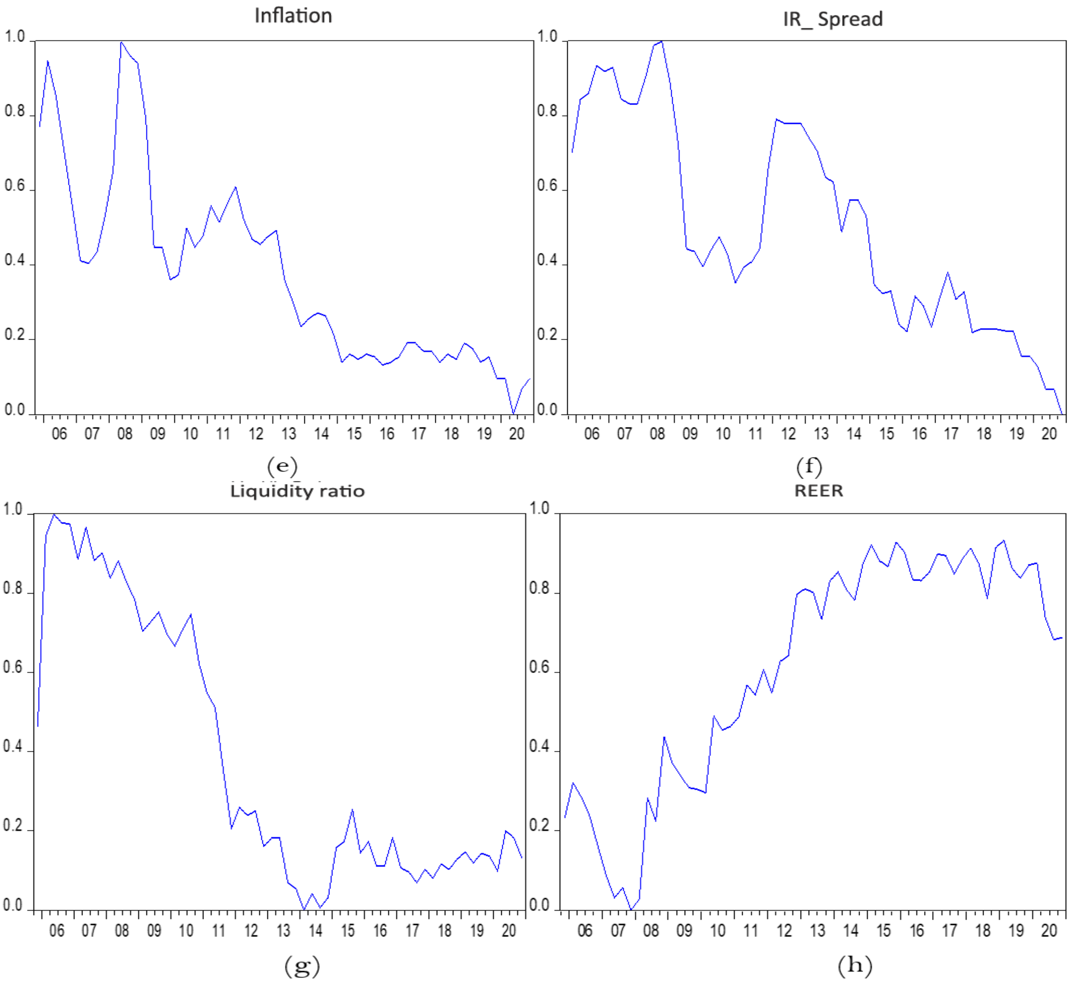

Figure A1. Graphical trends of the model variables.

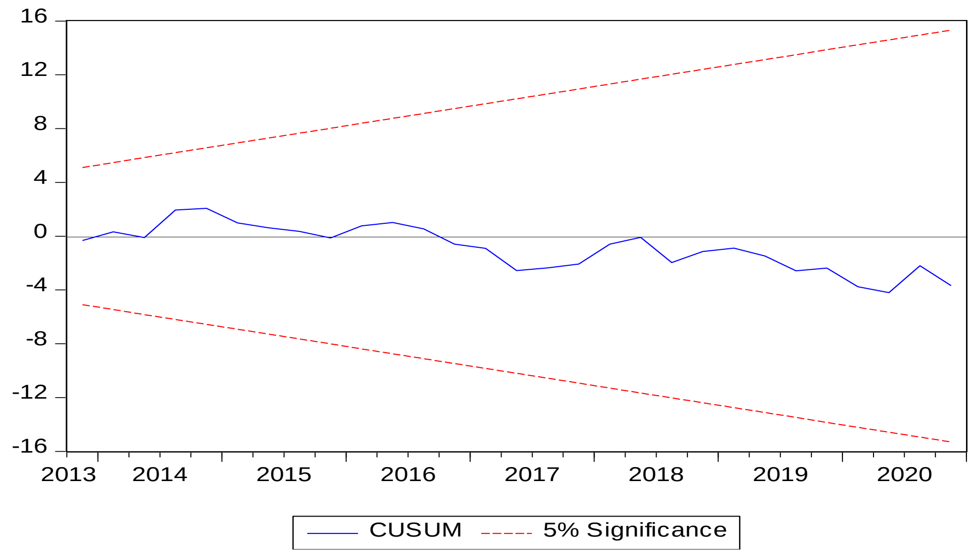

Figure A2. CUSUM stability test.

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