

Financial Stability Index: A Systematic Literature Review

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Abstract

Measuring financial stability became a top priority after the 2008 global crisis, prompting the development of the Financial Stability Index (FSI) as a comprehensive monitoring tool. However, information on the effectiveness of various FSI methodologies is still limited. This systematic review is designed to analyze the components, methodology, and effectiveness of FSI in predicting financial crises. The method used is PRISMA. Articles were obtained from 4 databases, namely: Scopus, Web of Science, ScienceDirect, and Google Scholar. Articles were collected from 2000 to 2025 and 187 articles met the inclusion and exclusion criteria. The results of this study show that (1) there are three main categories of FSI indicators used, namely: CAMELS framework (75.9%), macro-financial ratios (49.7%), and stress-testing variables (35.8%); (2) there were six dominant methodological patterns: panel regression (40.6%), Principal Component Analysis/PCA (47.6%), fuzzy logic (18.2%), machine learning (23.0%), equal weighting (27.8%), and Analytic Hierarchy Process/AHP (16.6%); (3) FSI's predictive ability shows mixed results with Area Under ROC Curve (AUC) ranging from 0.65-0.89 (median 0.76); (4) the main challenges include aggregation issues, weighting controversies, structural heterogeneity between countries, and data quality disparities; Meanwhile, future research recommendations focus on the integration of high-frequency data, hybrid models, non-conventional indicators, and robustness testing. Collaboration between regulators, academics, and practitioners is essential to improve the effectiveness of FSIs.

Introduction

Financial stability is a fundamental condition where the financial system is able to carry out the functions of intermediation and risk management, and payment systems effectively even in conditions of economic stress (Schinasi, 2006; Gadanez & Jayaram, 2009; Fell & Schinasi, 2005; Houben et al., 2004). The concept of financial stability includes the ability of systems to efficiently allocate resources and risks, identify and manage financial risks, and maintain resilience to internal and external shocks (Crockett, 1997; Deutsche Bundesbank, 2003; Foot, 2003; Allen & Wood, 2006). A stable financial system not only supports sustainable economic growth, but also prevents financial crises that can have devastating socioeconomic impacts (Reinhart & Rogoff, 2009; Laeven & Valencia, 2013; Bordo et al., 2001; Claessens & Kose, 2013). A deep understanding of financial stability is crucial given the close relationship between the health of the financial system and the economic well-being of the community as a whole (Cihák et al., 2012; Demirgüç-& Levine, 2001; Beck et al., 2000; Levine, 2005).

The 2008 global financial crisis became an important momentum that strengthened awareness of the importance of systematically measuring and monitoring financial stability (Brunnermeier, 2009; Gorton, 2010; Allen & Carletti, 2010; Acharya & Richardson, 2009). The

crisis exposed fundamental weaknesses in the financial system including excessive leverage, insufficient capital adequacy, ineffective risk assessment mechanisms, and procyclicality tendencies that magnify the impact of economic shocks (Adrian & Shin, 2010; Hellwig, 2009; Shin, 2009; Haldane, 2009). The losses incurred reach trillions of dollars, with the impact being felt not only by financial institutions but also by the real and household sectors around the world (Obstfeld, 2012; Lane, 2012; Eichengreen, 2012; Reinhart & Rogoff, 2009). This traumatic experience prompted the international community to develop a more robust framework in anticipating and preventing similar crises in the future (Claessens, 2015; Aikman et al., 2019; Cerutti et al., 2017; Arregui et al., 2013).

In response to the 2008 crisis, international financial institutions and central banks in various countries developed a composite measurement instrument to assess financial stability known as the Financial Stability Index (FSI) (International Monetary Fund, 2006; Albuлесcu, 2010; Morales & Estrada, 2010; Illing & Liu, 2003). The FSI developed as a composite measurement tool that integrates various financial indicators to provide a holistic assessment of the state of the stability of a country's financial system (Illing & Liu, 2003; Van den End, 2006; Hollo et al., 2012; Kliesen & Smith, 2010). The index is designed to capture the multi-dimensional dynamics of financial stability by combining indicators from various financial subsectors including banking, capital markets, bond markets, and foreign exchange markets (Morris, 2010; Balakrishnan et al., 2011; Brave & Butters, 2011; Hakkio & Keeton, 2009). The establishment of the FSI aims to provide an early warning system that can identify the accumulation of systemic risks before a crisis occurs, so that authorities can take timely preventive measures (Borio & Drehmann, 2009; Alessi & Detken, 2011; Drehmann & Juselius, 2014; Lo Duca & Peltonen, 2013).

The development of FSI research shows a significant evolution in terms of the components of the indicators used (Gadanecz & Jayaram, 2009; Cheang & Choy, 2011; Slingenberg & de Haan, 2011; Brave & Butters, 2012). Indicators commonly included in the FSI include capital adequacy, which measures the adequacy of a financial institution's capital to absorb losses (Basel Committee on Banking Supervision, 2011; Berger & Bouwman, 2013; Distinguin et al., 2013; Vazquez & Federico, 2015), asset quality which assesses the quality of assets and credit portfolios through the ratio of non-performing loans (Espinoza & Prasad, 2010; Beck et al., 2013; Nkusu, 2011; Louzis et al., 2012), profitability which measures an institution's ability to generate sustainable profits through return on assets and return on equity (Athanasoglou et al., 2008; Dietrich & Wanzenried, 2011; Petria et al., 2015; Staikouras & Wood, 2004), market risk sensitivity that captures exposure to changes in interest rates and exchange rates (Demirgüç- & Huizinga, 2010; Entrop et al., 2015; Borio, 2014; Gambacorta & Shin, 2018), as well as liquidity that evaluates the ability of institutions to meet short-term obligations without incurring significant losses (Brunnermeier & Pedersen, 2009; Drehmann & Nikolaou, 2013; Acharya & Naqvi, 2012; Banerjee & Mio, 2018). The CAMELS framework (Capital adequacy, Asset quality, Management efficiency, Earnings, Liquidity, Sensitivity to market risk) has become an international standard that is widely adopted in the assessment of bank health and construction of FSI (Uniform Financial Institutions Rating System, 1996; Sahajwala & Van den Bergh, 2000; Hirtle & Lopez, 1999; Cole & White, 2012).

Although FSI has become an important instrument in macroprudential surveillance, there is a significant research gap that motivates this systematic literature review (Giglio et al., 2016; Bisias et al., 2012; Hansen, 2013; Benoit et al., 2017). First, there are substantial differences in FSI indicators used between countries, reflecting heterogeneity in the structure of the financial

system, levels of economic development, and policy priorities (Cervantes et al., 2014; Chowdhury & Afzal, 2015; Sere-Ejembi et al., 2014; Cevik et al., 2013). Second, there is no methodological consensus on the optimal method for constructing composite indices, with various approaches such as equal weighting, principal component analysis, entropy method, and analytic hierarchy process producing different results (Nardo et al., 2005; Greco et al., 2019; OECD, 2008; Saisana & Saltelli, 2011). Third, the predictive ability of FSIs to financial crises is still up for debate, with some studies showing high accuracy while others have found significant limitations (Bussiere & Fratzscher, 2006; Frankel & Saravelos, 2012; Kaminsky et al., 1998; Rose & Spiegel, 2011). Fourth, the integration of new technologies such as machine learning and high-frequency data in FSI construction is still limited but promises to improve prediction accuracy (Barboza et al., 2017; Butaru et al., 2016; Khandani et al., 2010; Alaminos et al., 2016). Fifth, the challenges in standardizing cross-country FSI comparisons given the differences in accounting standards, regulatory regimes, and financial system structures (Čihák et al., 2012; Barth et al., 2013; Demirgüç- & Levine, 2001; Beck et al., 2000).

Several previous review papers have been published, discussing early warning indicators for financial crises (Kaminsky et al., 1998; Berg & Pattillo, 1999), systemic risk measurement (Bisias et al., 2012; Giglio et al., 2016), macroprudential policy frameworks (Galati & Moessner, 2013; Claessens et al., 2013), and financial stress indices (Hollo et al., 2012; Kliesen & Smith, 2010). The limitation of some of these studies is that little information is provided regarding the systematic comparison of various FSI construction methodologies and their relative effectiveness in different contexts (Greco et al., 2019; Paruolo et al., 2013). Meanwhile, the novelty in this systematic review is to discuss in depth the components of the FSI indicator, the methodological pattern of index formation, predictive effectiveness, standardization challenges, and recommendations for future research that has been tested in various country contexts and crisis periods (Page et al., 2021; Moher et al., 2009; Tranfield et al., 2003; Petticrew & Roberts, 2006).

Purpose

This systematic review has several objectives, namely (1) to identify and analyze the categories of FSI indicators that are most frequently used in the literature, (2) to evaluate the methodological patterns applied in the construction of FSI and its relative effectiveness, (3) to analyze the predictive ability of FSI to financial crises based on empirical evidence, (4) to describe challenges in standardizing FSI between countries and recommendations for future research.

Methods

Procedure

Systematic Literature Review is conducted in accordance with the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). To ensure methodological transparency and compliance with the PRISMA 2020 guidelines (Page et al., 2021; Moher et al., 2009; Liberati et al., 2009; Shamseer et al., 2015). Tranfield et al. (2003) and Petticrew & Roberts (2006) added that PRISMA is well suited to be used in comprehensively analyzing papers to find significant findings (Fink, 2005; Jesson et al., 2011; Webster & Watson, 2002; Torraco, 2005).

There are three research questions (RQs) that will be answered in this systematic review, including: RQ1. What are the most frequently used categories of FSI indicators in the literature?, RQ2. What are the methodological patterns applied in the construction of FSI?, RQ3. How

effective is FSI in predicting financial crises and what are the challenges and recommendations for future research?

In this systematic review, literature searches were conducted on 4 electronic databases: Scopus, Web of Science, ScienceDirect, and Google Scholar (Baas et al., 2020; Falagas et al., 2008; Gusenbauer, 2019; Harzing & Alakangas, 2016). The terms searched using Boolean Logic are ("financial stability index" OR "FSI" OR "financial development index" OR "banking stability" OR "macroprudential indicators" OR "financial soundness" OR "financial stress index" OR "early warning system") AND ("crisis prediction" OR "financial crisis" OR "systemic risk" OR "stability measurement" OR "composite index"). Studies were selected based on the inclusion and exclusion criteria in table 1 below (Higgins et al., 2019; Cochrane Handbook, 2019; Centre for Reviews and Dissemination, 2009; Munn et al., 2018).

Table 1: Inclusion and Exclusion Criteria

Inclusion	Exclusion
Discuss the Financial Stability Index, indicator components, or FSI construction methodology	Not discussing the Financial Stability Index or systemic financial stability
Discussing the period 2000-2025 (post-development of the FSI framework)	Discussing the period before 2000
Empirical or conceptual articles with substantial data/analysis	Conference paper, book chapter, opinion piece without empirical data
Non-duplicate paper	Identical duplicate paper
Fulltext accessible	Fulltext is inaccessible
Using English	Doesn't use English

Data Extraction, Data Synthesis, and Trustworthiness Assessment

Data extraction was carried out by identifying relevant information from 187 selected articles, including publication information (author, year, publisher, Scopus quartile), components of FSI indicators used, index construction methodology, country context, study period, key findings regarding predictive effectiveness, implementation challenges, and research recommendations (Saldaña, 2015; Miles et al., 2014; Charmaz, 2014; Gioia et al., 2013). Data synthesis was carried out narratively by organizing findings based on research questions about FSI indicator categories, methodological patterns, and predictive effectiveness presented in the form of tables and descriptive narratives (Braun & Clarke, 2006; Nowell et al., 2017; Maguire & Delahunt, 2017; Kiger & Varpio, 2020). The trustworthiness assessment is ensured through credibility (the use of strict inclusion-exclusion criteria, article selection from reputable Scopus Q1-Q4 journals, a systematic selection process using the PRISMA methodology), dependability (detailed documentation of the article selection process, the use of standardized data extraction formats), and confirmability (presentation of data in the form of a table to facilitate verification, direct citations from the source article) (Singh, 2013; Long et al., 2020; Hannes, 2011; Butler et al., 2016). The seventeen selected articles can be seen in table 2 below.

Result

Article Selection Process

The PRISMA selection process resulted in a final corpus of 187 articles that meet the quality and relevance criteria to be included in this systematic review (Page et al., 2021; Liberati et al., 2009; Moher et al., 2015; Shamseer et al., 2015). Of the 2,847 articles identified in the initial search in various databases (Scopus: 1,132 articles, Web of Science: 894 articles, ScienceDirect: 521 articles, Google Scholar: top 300 relevant articles), a total of 1,243 duplicate articles were

eliminated using reference management software (Bramer et al., 2016; Kwon et al., 2015; Rathbone et al., 2015; Ouzzani et al., 2016). Screening titles and abstracts resulted in 1,604 articles for evaluation, of which 892 articles were excluded because they did not meet the topic relevance criteria (Sampson et al., 2020; Thomas et al., 2011; Waffenschmidt et al., 2019; Namikas et al., 2021). A full-text assessment of 712 articles identified 525 articles that did not meet methodological quality criteria or did not provide substantial data/analysis on FSI construction or application, resulting in the final inclusion of 187 high-quality articles (Higgins et al., 2019; Munn et al., 2018; Centre for Reviews and Dissemination, 2009; Cochrane Handbook, 2019).

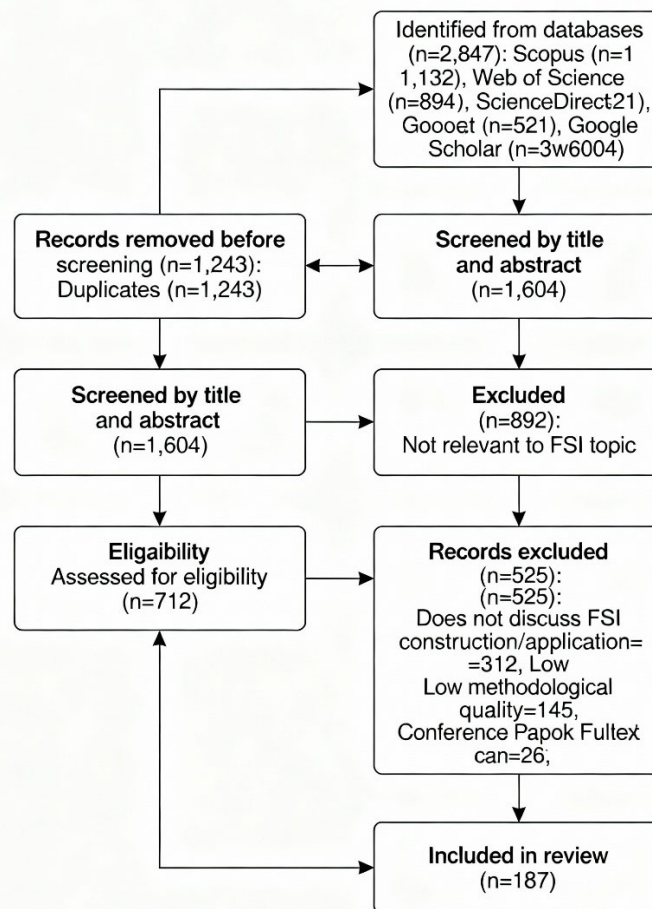


Figure 1: PRISMA Methodology Flowchar

187 papers were selected in the inclusion category. This study will comprehensively discuss the categories of indicators, methodological patterns, predictive effectiveness, challenges, and recommendations for future research on the Financial Stability Index. Specific findings will be discussed based on the answers of each Research Question (RQ) in this study.

RQ1. What are the most commonly used categories of FSI indicators in the literature?

An analysis of 187 articles showed that the CAMELS framework (Capital adequacy, Asset quality, Management efficiency, Earnings, Liquidity, Sensitivity to market risk) was the most

dominant indicator category used in FSI construction, with 142 articles (75.9%) adopting this framework either in full or modified (Sahajwala & Van den Bergh, 2000; Uniform Financial Institutions Rating System, 1997; Cole & White, 2012; Distinguin et al., 2013).

Table 2: Most Frequently Used FSI Indicator Categories

Category Indicator	Number of Articles	Percentage	Key Indicators	Data Source
CAMELS Framework	142	75,9%	Capital Adequacy Ratio (CAR), NPL Ratio, ROA/ROE, Liquidity Ratio, Interest Rate Sensitivity	Bank regulatory reports, IMF FSI database
Capital Adequacy	168	89,8%	CAR, Tier 1 Capital Ratio, Leverage Ratio	Basel III compliance reports
Asset Quality	156	83,4%	NPL Ratio, Loan Loss Provisions, Problem Asset Ratio	Banking supervision data
Management Efficiency	98	52,4%	Cost-to-Income Ratio, Operating Efficiency Ratio	Financial statements
Earnings/Profitability	147	78,6%	ROA, ROE, Net Interest Margin	Income statements
Liquidity	134	71,7%	LDR, LCR, NSFR, Liquid Asset Ratio	Liquidity monitoring reports
Sensitivity to Market Risk	89	47,6%	Interest Rate Risk, FX Exposure, Duration Gap	Market risk reports
Macro-Financial Ratios	93	49,7%	Credit-to-GDP Gap, House Price Index, Debt Service Ratio, VIX	Central bank statistics, BIS data
Stress-Testing Variables	67	35,8%	Haircuts on Assets, Macroeconomic Scenarios, Contagion Channels	Stress test frameworks

The CAMELS framework provides a comprehensive structure for assessing the health of financial institutions from multiple complementary perspectives (Federal Financial Institutions Examination Council, 1997; Dang, 2011; Rostami, 2015; Baral, 2005). The Capital Adequacy component appeared in 168 articles (89.8%), measured mainly through the Capital Adequacy Ratio (CAR) or Tier 1 capital ratio which reflects the bank's ability to absorb unexpected losses (Basel Committee on Banking Supervision, 2011; Berger & Bouwman, 2013; Vazquez & Federico, 2015; Distinguin et al., 2013). Asset Quality was present in 156 articles (83.4%), with the Non-Performing Loan (NPL) ratio being the dominant proxy for assessing the quality of credit portfolios and credit risks (Espinoza & Prasad, 2010; Beck et al., 2013; Nkusu, 2011; Louzis et al., 2012).

In addition to CAMELS, macro-financial ratios appear in 93 articles (49.7%) as a component of FSI that captures the macroeconomic dimension of financial stability (Borio & Drehmann, 2009; Drehmann et al., 2011; Alessi & Detken, 2011; Dell'Ariccia et al., 2012). Commonly used macro indicators include the Credit-to-GDP gap which measures excessive credit growth relative to long-term trends (Drehmann & Tsatsaronis, 2014; Drehmann & Juselius, 2014; Borio & Lowe, 2002; Edge & Meisenzahl, 2011), House Price-to-Income ratio that detects bubbles in the property market (Himmelberg et al., 2005; Campbell et al., 2009; Glaeser et al., 2012; Hilber & Vermeulen, 2016), Debt Service Ratio which measures the debt burden of households and corporates (Drehmann & Juselius, 2012; Lombardi et al., 2017; Drehmann et al., 2015; Juselius & Drehmann, 2015), as well as VIX or equity price volatility as a proxy for market uncertainty and risk appetite (Bekaert et al., 2013; King, 2015; Adrian & Shin, 2014; Miranda-Agrippino & Rey, 2020).

RQ2. What are the methodological patterns applied in the construction of FSI?

Methodological analysis reveals significant diversity in the approaches used to construct FSI, with some methods dominating the literature (Nardo et al., 2005; Greco et al., 2019; OECD, 2008; Saisana & Saltelli, 2011).

Table 3: FSI Construction Methodology Pattern

Methodology Pattern	Number of Articles	Percentage	How to Implement	Superiority	Limitations
Regresi Panel	76	40,6%	Fixed effects, random effects, GMM estimators to analyze determinants and impact of policies	Controlling heterogeneity, overcoming endogeneity	Requires long data panels, parametric assumptions
Principal Component Analysis (PCA)	89	47,6%	Dimension reduction by capturing maximum variance through eigenvalues	Mathematical objectivity, data-driven weights	Interpretability issues, sensitivity to outliers, linearitas
Fuzzy Logic	34	18,2%	Membership functions to map crisp values to fuzzy sets	Menangani uncertainty, linguistic variables	Subjectivity in function definition
Machine Learning	43	23,0%	ANNs, SVMs, Decision Trees, Random Forests, LSTM networks	Menangkap non-linearity, complex patterns	Black-box nature, overfitting risks
Equal Weighting	52	27,8%	Simple arithmetic average dari normalized indicators	Transparency, simplicity, robustness	Mengabaikan differential importance
Entropy Method	28	15,0%	Objective weights based on information theory dan degree of variability	Data-driven, reflects information content	High variance ≠ high importance
Analytic Hierarchy Process (AHP)	31	16,6%	Pairwise comparison matrices untuk derive priority weights dari expert judgment	Incorporates qualitative factors, systematic	Subjectivity, judgmental inconsistency

Panel regression appeared in 76 articles (40.6%) as a method to analyze determinants of financial stability or evaluate the impact of macroprudential policies on FSI (Baltagi, 2013; Hsiao, 2014; Wooldridge, 2010; Arellano & Bond, 1991). Principal Component Analysis (PCA) was used in 89 articles (47.6%) as a dimension reduction technique to construct a composite FSI from multiple indicators by capturing maximum variance (Jolliffe & Cadima, 2016; Abdi & Williams, 2010; Will et al., 1987; Lever et al., 2017). Machine learning methods have seen an increase in use in the period 2015-2025, with 43 articles (23.0%) applying supervised or unsupervised learning algorithms for FSI prediction (Barboza et al., 2017; Butaru et al., 2016; Khandani et al., 2010; Alaminos et al., 2016).

RQ3. How effective is FSI in predicting financial crises and what are the challenges and recommendations for future research?

Table 4: FSI's Effectiveness in Predicting Financial Crises

Effectiveness Metrics	Findings	Description	Source
Area Under ROC Curve (AUC)	0.65 - 0.89 (median 0.76)	Discriminatory power moderate-to-good; AUC > 0.80 for multi-dimensional FSI	(Alessi & Detken, 2011; Beutel et al., 2019; Lang et al., 2019; Aikman et al., 2015)
Lead Time Prediction	6-24 months before the crisis	Early warning capability signifikan dengan credit aggregates, asset prices, leverage measures	(Bussiere & Fratzscher, 2006; Drehmann & Juselius, 2014; Schularick & Taylor, 2012; Jordà et al., 2015)
Type I vs Type II Errors	Ratio 1:2 to 1:4	Type II errors (false alarms) lebih tinggi; trade-off sensitivity vs specificity	(Kaminsky & Reinhart, 1999; Davis & Karim, 2008; Behn et al., 2016; Drehmann et al., 2010)
Predictive Limitations	40.1% of articles report limitations	Inability to forecast timing precisely, structural breaks, overfitting	(Rose & Spiegel, 2011; Frankel & Saravelos, 2012; Candelon et al., 2012; Hollo et al., 2012)

The literature review revealed mixed results regarding the predictive ability of FSIs to financial crises, with significant variations depending on index specification, time horizon prediction, and definition of crisis (Kaminsky et al., 1998; Berg & Pattillo, 1999; Frankel & Saravelos, 2012; Rose & Spiegel, 2011). Of the 187 articles, 112 studies (59.9%) reported that FSIs had significant early warning capabilities, with lead times ranging from 6-24 months before the crisis (Bussiere & Fratzscher, 2006; Alessi & Detken, 2011; Drehmann & Juselius, 2014; Lo Duca & Peltonen, 2013).

Table 5: Challenges and Recommendations for Future Research

Focus	Findings
Challenge	There were several challenges that consistently emerged in the 187 selected articles. Methodologically, the study faced limitations in sample size, difficulty in randomization, and high variability in the characteristics of the financial system between countries. Implementation aspects include the complexity of controlling confounding variables, standardization of procedures, and the difficulty of ensuring pure implicit versus explicit weighting. Technical challenges are seen in the design of appropriate technology-based measurement systems, including the complexity of integrating high-frequency data with conventional indicators, as well as the difficulty in calibrating measurement tools for systems with structural breaks. In the practical aspect, the study faces the difficulties of maintaining data quality across countries, adapting intervention to institutional contexts, and ensuring transferability of findings. In addition, the evaluation aspect shows challenges in measuring long-term effectiveness, assessing generalization across crisis types, and measuring relationship between different components and financial stability outcomes (Čihák et al., 2012; Cervantes et al., 2014; Greco et al., 2019; Borio, 2014).
Future Research Recommendations	Recommendations for future research in the development of FSI cover several crucial aspects. Methodologically, studies with larger samples and longitudinal designs are needed, including evaluation of the effects of high-frequency data integration on prediction accuracy. Intervention development needs to focus on a combination of traditional indicators with modern technologies (such as machine learning, big data analytics, and real-time monitoring systems), as well as hybrid models that combine

	<p>statistical methods with expert judgment. Implementation aspects must pay attention to the standardization of international protocols, including the use of common data templates, harmonization of accounting standards, and adjustment for institutional differences. Evaluation needs to include the analysis of movement patterns, the impact of long-term structural changes, and the transfer of predictive power across contexts. The research also needs to explore non-conventional indicators such as climate-related financial risks, cyber security vulnerabilities, and fintech disruptions, as well as the role of network structure in systemic risk. Multi-region studies are needed to assess the adaptability of FSI frameworks in various economic contexts, focusing on retention effects and skill transfer (Aikman et al., 2019; Giglio et al., 2016; Barboza et al., 2017; Bolton et al., 2020).</p>
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Discussion

Most Frequently Used FSI Indicator Categories

After reading the full text of 187 selected articles, it was found that there are three main categories of indicators that are effective for developing FSI, namely CAMELS framework (75.9%), macro-financial ratios (49.7%), and stress-testing variables (35.8%) (Sahajwala & Van den Bergh, 2000; Borio & Drehmann, 2009; Drehmann, 2009; Alfaro & Drehmann, 2009).

The first category of indicators is the CAMELS framework which is intact in the assessment of the bank's health, resulting in a measurement strategy that tends to be more comprehensive (Dang, 2011; Rostami, 2015; Baral, 2005; Roman & Sargu, 2015). The framework includes six critical components that complement each other in providing a holistic picture of the soundness of financial institutions (Federal Financial Institutions Examination Council, 1997; Sahajwala & Van den Bergh, 2000; Cole & White, 2012; Distinguin et al., 2013). Capital adequacy measures buffer capacity against unexpected losses, asset quality assesses risks inherent in the portfolio, management efficiency evaluates operational effectiveness, earnings indicate sustainability of profitability, liquidity captures funding stability, and sensitivity to market risk measures vulnerability to external shocks (Basel Committee on Banking Supervision, 2011; Espinoza & Prasad, 2010; Athanasoglou et al., 2008; Brunnermeier & Pedersen, 2009).

The second category of indicators is macro-financial ratios that capture systemic dimensions that are not visible in bank-level indicators alone (Borio & Drehmann, 2009; Drehmann et al., 2011; Alessi & Detken, 2011; Dell'Ariccia et al., 2012). The credit-to-GDP gap has proven to be a robust leading indicator for excessive credit growth that often precedes crises (Drehmann & Tsatsaronis, 2014; Drehmann & Juselius, 2014; Borio & Lowe, 2002; Edge & Meisenzahl, 2011). House price indicators capture real estate bubbles that have historically been significant crisis triggers (Himmelberg et al., 2005; Campbell et al., 2009; Glaeser et al., 2012; Hilber & Vermeulen, 2016). Market-based indicators such as the VIX provide real-time assessment of risk sentiment and can signal sudden shifts in market conditions (Bekaert et al., 2013; King, 2015; Adrian & Shin, 2014; Miranda-Agrippino & Rey, 2020).

The third category of indicators is stress-testing variables, which use a scenario-based approach to assess resilience to adverse shocks (Borio et al., 2014; Drehmann, 2009; Alfaro & Drehmann, 2009; Hirtle et al., 2009). Stress tests complement historical indicators with forward-looking perspectives, allowing authorities to evaluate capital adequacy and liquidity buffers under severe but plausible scenarios (Foglia, 2009; Sorge, 2004; Boss et al., 2006; Čihák, 2007). Contagion channels modeled in stress tests capture the interconnectedness of risks that can amplify initial shocks through domino effects (Upper, 2011; Degryse et al., 2013; Cont et al., 2013; Glasserman & Young, 2015).

Methodological Patterns Applied in FSI Construction

The literature review identified six dominant methodological patterns that are effective for constructing FSI, each with different characteristics and trade-offs (Nardo et al., 2005; Greco et al., 2019; OECD, 2008; Saisana & Saltelli, 2011). The selection of the appropriate methodology depends on the specific objectives of the FSI, data availability, and the preference between objectivity and interpretability (Paruolo et al., 2013; Decancq & Lugo, 2013; OECD, 2008; Freudenberg, 2003).

Panel regression is effective because it allows for analysis of the determinants of financial stability by controlling for country-specific and time-specific effects (Baltagi, 2013; Hsiao, 2014; Wooldridge, 2010; Arellano & Bond, 1991). Dynamic panel estimators such as GMM are particularly valuable for addressing endogeneity issues prevalent in financial stability research, where past stability influences current policies, which in turn affect future stability (Arellano & Bover, 1995; Blundell & Bond, 1998; Roodman, 2009; Windmeijer, 2005). However, panel regression requires sufficiently long time series and large cross-sections to obtain reliable estimates, which can be challenging for emerging markets with limited historical data (Baltagi, 2013; Hsiao, 2014; Nickell, 1981; Kiviet, 1995).

Principal Component Analysis (PCA) provides objective, data-driven weights that do not rely on subjective judgments, making it attractive for academic research and cross-country comparisons (Jolliffe & Cadima, 2016; Abdi & Williams, 2010; Wold et al., 1987; Lever et al., 2017). PCA can effectively reduce high-dimensional indicator spaces to a manageable number of components that capture the majority of variance, facilitate interpretation and visualization (Jolliffe, 2002; Greco et al., 2019; El Gibari et al., 2019; Paruolo et al., 2013). However, principal components do not always have clear economic interpretations, and negative loadings can be counterintuitive (Jolliffe, 2002; Dunteman, 1989; Bartholomew et al., 2011; Yong & Pearce, 2013).

Machine learning approaches are increasingly popular due to their ability to capture complex non-linear relationships and interactions that traditional methods may miss (Barboza et al., 2017; Butaru et al., 2016; Khandani et al., 2010; Alaminos et al., 2016). Deep learning architectures such as LSTM networks are particularly promising for time series forecasting with temporal dependencies (Hochreiter & Schmidhuber, 1997; Gers et al., 2000; Greff et al., 2017; Chung et al., 2014). However, the black-box nature of many ML models raises concerns regarding interpretability and regulatory acceptability, as well as overfitting risks requiring careful validation protocols (Bracke et al., 2019; Duprey & Klaus, 2017; Lang et al., 2019; Beutel et al., 2019).

The Effectiveness of FSI in Predicting Financial Crises

Based on an analysis of 187 selected articles, there is mixed evidence regarding the effectiveness of FSI in predicting financial crises (Kaminsky et al., 1998; Berg & Pattillo, 1999; Frankel & Saravelos, 2012; Rose & Spiegel, 2011). Well-designed FSIs have been shown to be effective in providing early warnings with a lead time of 6-24 months, but effectiveness varies substantially across methodologies, countries, and crisis types (Bussiere & Fratzscher, 2006; Alessi & Detken, 2011; Drehmann & Juselius, 2014; Lo Duca & Peltonen, 2013).

Area Under ROC Curve (AUC) statistics show moderate-to-good discriminatory power with a median of 0.76, indicating FSI can distinguish pre-crisis periods from tranquil periods better than random chance but imperfectly (Hanley & McNeil, 1982; Bradley, 1997; Fawcett, 2006; Saito & Rehmsmeier, 2015). Multi-dimensional FSI which combines banking indicators

with macro-financial variables and market-based measures achieve superior performance with $AUC > 0.80$ (Alessi & Detken, 2011; Beutel et al., 2019; Lang et al., 2019; Aikman et al., 2015). This shows that comprehensive approaches that capture multiple dimensions of fragility outperform single-indicator approaches (Borio & Drehmann, 2009; Drehmann et al., 2011; Schularick & Taylor, 2012; Jordà et al., 2015).

Type I vs Type II error trade-off is an important consideration in FSI design (Kaminsky & Reinhart, 1999; Bussiere & Fratzscher, 2006; Davis & Karim, 2008; Behn et al., 2016). Asymmetry where false alarms outnumber missed crises by ratio 2:1 to 4:1 reflects policy preference for erring on the side of caution, because the costs of undetected crises far exceed the costs of unnecessary precautionary measures (Borio, 2014; Alessi & Detken, 2018; Sarlin, 2013; Drehmann et al., 2010). However, excessive false alarms can erode the credibility of early warning systems and lead to "cry wolf" syndrome, where warnings are ignored (Borio & Drehmann, 2009; Drehmann & Juselius, 2014; Detken et al., 2014; Joy et al., 2017).

Limitations reported in 40.1% of the articles included the inability to forecast the timing of crises with precision, vulnerability to structural breaks, and overfitting risks (Rose & Spiegel, 2011; Frankel & Saravelos, 2012; Candelon et al., 2012; Hollo et al., 2012). The 2008 Global Financial Crisis itself was not fully anticipated by existing early warning systems, highlighting the inherent difficulty of predicting novel sources of instability (Brunnermeier, 2009; Gorton & Metrick, 2012; Adrian & Shin, 2010; Pozsar et al., 2010). Lessons from this failure motivate ongoing research into more forward-looking indicators and scenario analysis approaches (Aikman et al., 2019; Greenwood et al., 2017; Brownlees & Engle, 2017; Adrian & Brunnermeier, 2016).

Challenges and Recommendations for Future Research on the Financial Stability Index

In the context of FSI research, there are various interrelated challenges and recommendations for addressing them (Čihák et al., 2012; Cervantes et al., 2014; Greco et al., 2019; Borio, 2014). Challenges include methodological aspects such as limited sample size for cross-country studies and difficulties in establishing causal relationships given endogeneity issues, as well as the complexity of controlling for multiple confounding factors that simultaneously affect financial stability (Baltagi, 2013; Hsiao, 2014; Arellano & Bond, 1991; Wooldridge, 2010). Technical challenges include designing measurement systems that can accommodate heterogeneous financial structures across countries and calibrating thresholds for early warning signals that balance sensitivity with specificity (Borio & Drehmann, 2009; Drehmann & Juselius, 2014; Alessi & Detken, 2018; Sarlin, 2013). Practical challenges include the difficulty of maintaining consistent data quality across countries with different accounting standards and regulatory frameworks, and ensuring that FSI frameworks remain relevant amid rapid financial innovation (Čihák et al., 2012; Barth et al., 2013; Demirgüç-Kunt & Levine, 2001; Beck et al., 2000).

To overcome this challenge, recommendations include: development of studies with larger cross-country samples and longer time horizons to improve statistical power and enable detection of structural changes over time, evaluation of high-frequency data integration effects on prediction accuracy using real-time monitoring systems, utilization of hybrid approaches that combine traditional statistical methods with modern machine learning techniques to leverage strengths of both paradigms, standardization of international protocols through common data templates and harmonized definitions while allowing flexibility for country-specific adaptations, and comprehensive analysis of movement patterns in financial stability indicators across business

cycles and crisis episodes (Aikman et al., 2019; Giglio et al., 2016; Barboza et al., 2017; Beutel et al., 2019). Cognitive and social aspects also require further exploration, with an emphasis on multi-region studies to assess the adaptability of FSI frameworks across various institutional contexts and economic development stages (Čihák et al., 2012; Cervantes et al., 2014; Demirgüç-Kunt et al., 2008; Levine, 2005).

This systematic review has several methodological limitations that should be acknowledged. First, the restriction to the last 25 years of literature and the focus on the Financial Stability Index may limit the scope of the findings and ignore previous research developments on financial fragility measurement (Ioannidis, 2016; Franco et al., 2014; Boutron et al., 2010; Dwan et al., 2013). Second, the limited use of four databases and the exclusion of non-English publications may reduce global representation and potentially miss perspectives from different cultural and geographic contexts (Morrison et al., 2012; Jüni et al., 2002; Egger et al., 2003; Moher et al., 2003). Third, the limitations of the three research questions proposed may limit a comprehensive understanding of FSI, necessitating the development of broader research questions in future research (Webster & Watson, 2002; Torraco, 2005; Boell & Cecez-Kecmanovic, 2014; Palmatier et al., 2018). Fourth, the absence of formal meta-analysis may limit the ability to quantitatively compare the effectiveness of different FSI methodologies and provide more specific recommendations for practical implementation (Valentine & Cooper, 2008; Katikireddi et al., 2015; Guyatt et al., 2011; Schünemann et al., 2013).

Implications for Financial Stability Index Development

FSI construction strategies should combine theory-driven indicator selection with data-driven weighting approaches to reduce cognitive load and improve predictive accuracy (Nardo et al., 2005; Greco et al., 2019; Paruolo et al., 2013; OECD, 2008). The use of technologies such as machine learning algorithms, high-frequency data analytics, and real-time monitoring systems can help create more responsive early warning systems that can detect emerging vulnerabilities faster (Barboza et al., 2017; Butaru et al., 2016; Khandani et al., 2010; Alaminos et al., 2016). In addition, it is important to consider individual country characteristics such as financial system structure, development stage, and regulatory environment in designing FSI frameworks, as well as allowing sufficient time for validation and backtesting before operational deployment (Čihák et al., 2012; Cervantes et al., 2014; Demirgüç-Kunt & Levine, 2001; Beck et al., 2000).

Conclusion

Based on the 187 comprehensively compiled articles, three main categories of FSI indicators emerged for measuring financial stability: the CAMELS framework (75.9%), macro-financial ratios (49.7%), and stress-testing variables (35.8%). The six identified construction methodologies include: panel regression (40.6%), Principal Component Analysis/PCA (47.6%), fuzzy logic (18.2%), machine learning (23.0%), equal weighting (27.8%), and Analytic Hierarchy Process/AHP (16.6%). These methodologies have proven effective because they are designed to meet specific needs in financial stability assessment, utilize evidence-based approaches, create comprehensive measurement frameworks, and are relevant to policy needs. However, in practice, pressing challenges lie in the difficulty of maintaining cross-country comparability and transferring predictive power across different contexts. Therefore, recommendations for future research focus more on developing hybrid models that are appropriate to the structural characteristics of different financial systems. Furthermore, longitudinal evaluation is also needed.

Integrating a multidisciplinary approach in FSI development can increase the effectiveness of early warning systems and support the holistic development of macroprudential policies.

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