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Measuring fiscal sustainability: A novel multidimensional index, a developed country perspective

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1. Introduction

Definition of Fiscal Sustainability (FS)

- Fiscal policy is often said to be sustainable or unsustainable for different reasons; however, there was not any specific definition to explain what “fiscal sustainability” actually means, e.g., Terzi, 2023; Krejdl, 2006; and World Bank GRI Index, 2022.

Working definition of Fiscal Sustainability

- This study identifies essential conditions to ensure fiscal sustainability: **The government must maintain public finances at a credible and manageable level, control excessive spending, reduce the national debt, and ensure consistent GDP growth**.

The requirement of a Fiscal Sustainability Index (FSI)

A weak fiscal position increases the risk of insolvency or, in more severe cases, bankruptcy in the future. As a result, it is essential to develop a comprehensive index to measure fiscal sustainability in order to restore public finances. Such indicators are crucial for identifying and predicting economic trends.

Problem Statement

- High levels of unproductive public expenditures, weak tax collection mechanisms, a spiralling debt situation, unstable price levels, low saving rates, and unpopular deficit financing policies—primarily involving money printing or asset depletion—along with exchange rate crises and stagnant economic growth have become significant concerns.

- These issues jeopardise fiscal sustainability and ultimately expose the country to a risk of insolvency.

Research Gap

- Current literature identifies various indices for measuring economic performance, including poverty (Alkire et al., 2022; Santos & Villatoro, 2020), human development (Biggeri & Ferrone, 2022; Lind, 2019; Lind, 1992), gender inequality and gender development (Schmid et al., 2023; Johns et al., 2022), and educational outcome (Kayal, 2023), as well as financial inclusion, financial stress, and financial development (Borhan et al., 2021; Monin, 2019; Svirydzenka, 2016).

- However, there is currently no comprehensive index available that specifically addresses fiscal sustainability.

2. Literature Review

What is fiscal sustainability: A theoretical perspective

Long-Run Fiscal Sustainability Condition (LRFSC) theory

The **LRFSC theory involves a country's current and capital accounts, as well as its external debt position**. When the government finances its initial debt by generating revenue through seigniorage and plans to run primary surpluses in the future, the present value of these future surpluses must equal the initial debt obligations. **This concept is known as the steady state.** A basic tool for analysing fiscal sustainability **uses a steady-state** approach (Burnside, 2005).

The Transversality Condition in Sustainability (TCS) theory

- The TCS theory states that while it is **possible to have an overall deficit in each period**, the **growth of debt must be slower than the interest rate**, which is essential for fiscal sustainability.
- Specifically, **it requires that the discounted present value of government debt equal zero**. This requirement is crucial as it prevents the accumulation of excessive public debt without addressing the initial debt.
- The key variables involved in developing this condition include the **primary deficit, interest rate, growth rate, and debt-to-GDP ratio** (Chalk & Hemming, 2000).

What is fiscal sustainability: Current Evidence

Index Literature

Author(s)	Index	Methodology	Findings
Alkire et al. (2022)	Multidimensional poverty index (MPI)	It uses the **Alkire-Foster (AF)** method across 105 countries from 2006 to 2016, impacting 1.3 billion people living in developing countries.	A leading tool for understanding the various aspects of poverty.
Lind (2019)	Human development index (HDI)	embodies the concept that **three dimensions—long life, knowledge, and a decent standard of living.**	All equally significant for human development.
Johns et al. (2022)	Gender development index (GDI)	It uses data from 2010 to 2019 in 57 countries, assessing the relationship with **fractional logistic regression models**.	Gender equality is positively associated with childhood immunisation coverage.
Schmid et al. (2023)	Gender inequality index (GII)	Employed **principal component analysis** to measure gender inequality in Great Britain.	Identifies the sub-national measure of gender inequalities.

Author(s)	Index	Methodology	Findings
Kayal (2023)	Educational outcome index (EOI)	Primary education evaluated through various indicators; enrolment, retention, and learning outcomes in India and utilises **principal component analysis.**	Primary education vary significantly across different regions of India.
Svirydzenka (2016)	Financial development index (FDI)	A total of nine variables related to financial institutions and financial markets. Employs **principal component analysis** and spans 183 countries from 1980 to 2013.	Variation in FD across different income groups: advanced, emerging, and low-income developing countries.
Borhan et al. (2021)	Multidimensional Financial Inclusion Index (FII)	incorporates five indicators—ATMs, banks, deposits, loans, and financial institutions—period from 2013 to 2019 and employs **factor analysis.**	The results indicate a lower level of financial inclusion in developing countries compared to developed economies.
Monin (2019)	Financial Stress Index (FSI)	This study utilises daily data from global financial markets from 2000 to 2018 in the **USA** and **employs principal component analysis**.	The findings suggest that increases in financial stress can help predict declines in economic activity.

3.Data

This study analyses **annual secondary data** from **37 selected OECD** countries*. The dataset includes **nine variables**: government expenditure, external debt stock, revenue, real GDP growth rate, inflation rate, gross domestic savings, interest rate, broad money supply, and exchange rate. The data covers a period of **29 years**, from **1995 to 2023**, and comprises a total of **1,044** data points.

*The sample countries are Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Chile (CL), Colombia (CO), Costa Rica (CR), Czech (CZ), Denmark (DNK), Estonia (EE), Finland (FIN), France (FRA), Greece (GRC), Hungary (HU), Iceland (ISL), Ireland (IRE), Israel (IL), Italy (ITA), Japan (JPN), Korea, Rep. (KOR), Latvia (LV), Lithuania (LT), Luxemburg (LUX), Mexico (MEX), Netherlands (NLD), New Zealand (NZL), Norway (NOR), Poland (PL), Portugal (PRT), Slovak, Rep. (SK), Slovenia (SI), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), United Kingdom (UK), United States (US).

Data Sources

Table 1: Data Sources

Category	Indicator	Data Source
Expenditure	Government expenditure (% of GDP)	WDI, FRED
	External debt stock (% of GDP)	WDI, FRED
Revenue	Tax revenue, excluding grants (% of GDP)	WDI, FRED
Others	GDP growth rate (annual %)	WDI, FRED
	Gross domestic savings (annual %)	WDI, FRED
	Inflation rate (annual %)	WDI, FRED
	Real interest rate (annual %)	WDI, FRED
	Broad money growth (% of GDP)	WDI, FRED
	Exchange rate (US dollar exchange rate index)	WEO, FRED

WDI -World Bank's World Development Indicators
FRED - Federal Reserve Economic Data—St. Louis FED
WEO- IMF World Economic Outlook database

4. Methodology

- The **FSI** will be constructed using **three** main dimensions:
  1) expenditure, 2) revenue, and 3) others.

- These three dimensions were further narrowed to selected **nine** variables.

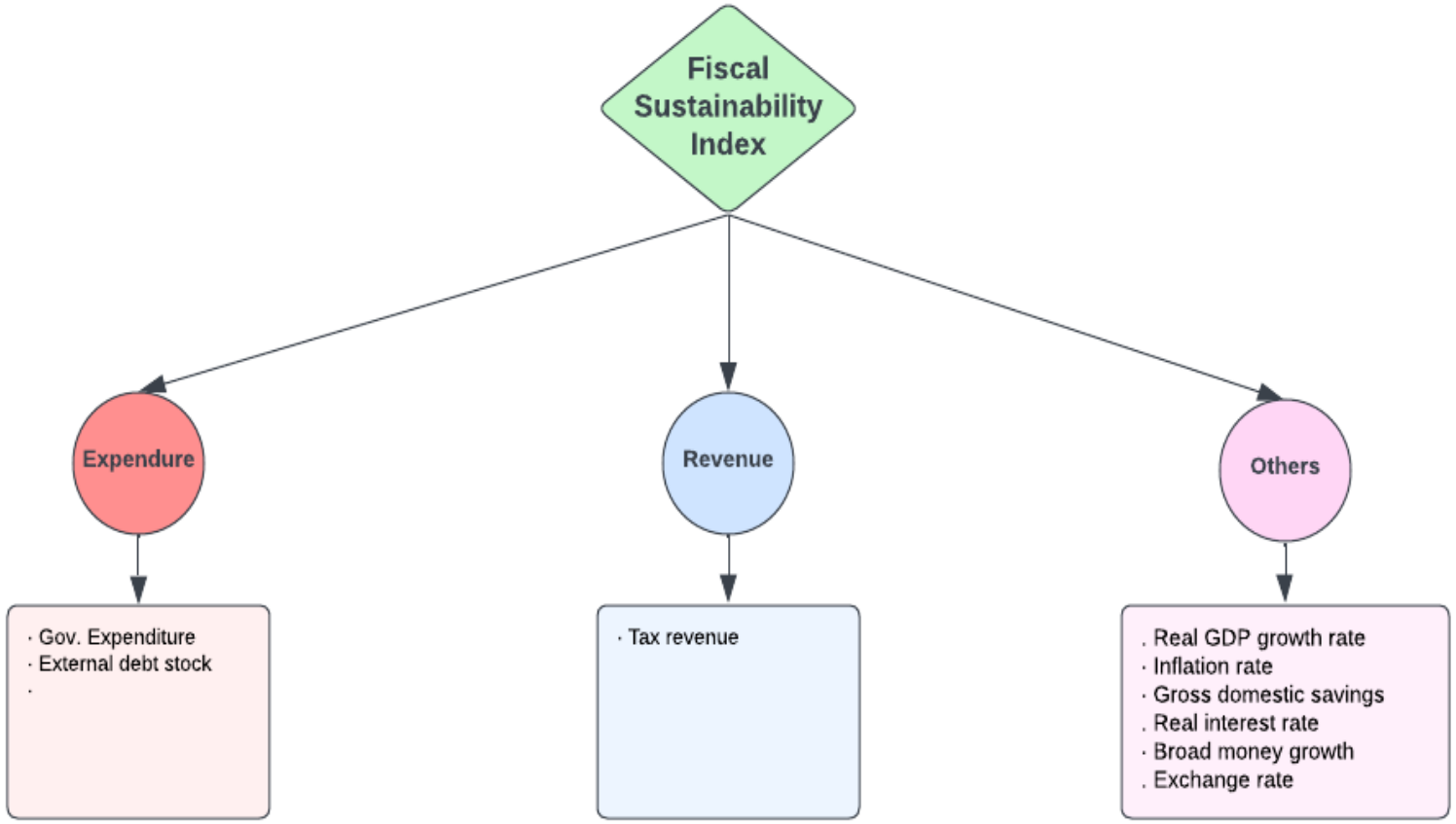


Figure 1: Fiscal Sustainability Index Pyramid

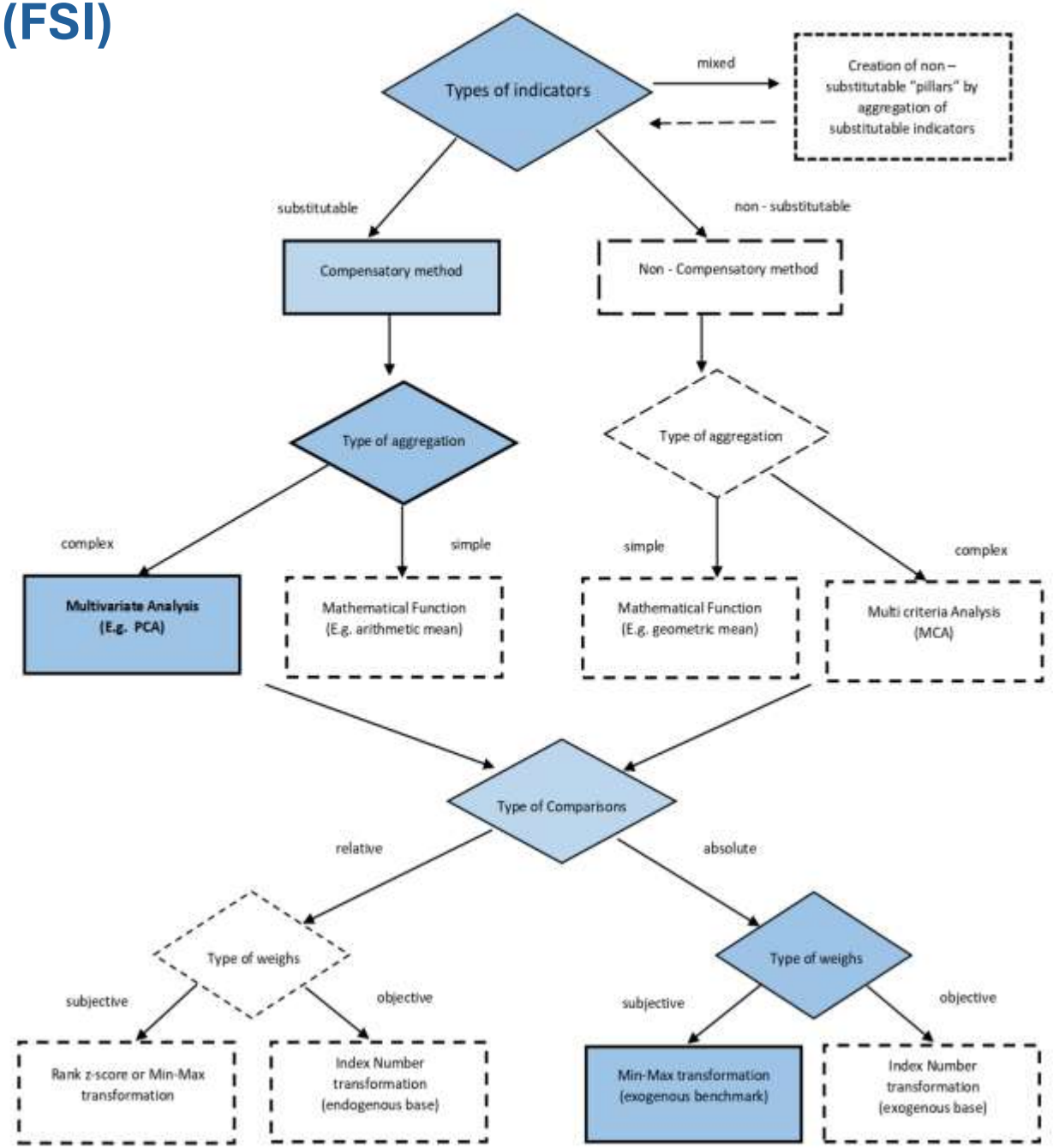
The ‘path’ of the Fiscal Sustainability Index (FSI)

- This study employed a **quantitative** research method, specifically **principal component analysis**, to construct the **FSI** (Nardo et al., 2008).

- The process of constructing composite indicators, follows a multidimensional approach of five steps: 1) treatment of outliers, 2) ensuring adequate correlation, 3) normalisation, 4) weight assignment, and 5) aggregation (Nardo et al., 2008).

- The path of the FSI:
  1) type of indicators (**substitutable**/non-substitutable);
  2) type of aggregation (simple/**complex**); 3) type of comparisons (**absolute**/relative); 4) type of weights (objective/**subjective**) (Mazziotta & Pareto, 2013).

Figure 2: The path of the Fiscal Sustainability Index (FSI)



Model Specification

- The principal component analysis of a linear equation can be developed as the n-th principal component (n=1, 2...9) of a data vector X_i and w_i is eigenvalue in Equation 1.

$$PC_n = \sum_{i=1}^{9} w_i . X_i \text{----------} (1)$$

- The n-th principal component (PCn) in Equation 2 will be identified as a linear combination of the selected nine variables.

$$PC_n = w_{n1}.Exp + w_{n2}.Eds + w_{n3}.\mathrm{Re}v + w_{n4}.GDP + w_{n4}.Sav + w_{n6}.Inf + w_{n7}.Int + w_{n8}.Exr + w_{n9}.Msb$$

---------- (2)

For developing the index, an average component score (ACS) is calculated as in Equation 3 (Svirydzenka, 2016).

$$ACS = \left(\frac{\lambda_1}{\lambda_1 + \lambda_2 + \ldots + \lambda_n}\right)PC_1 + \left(\frac{\lambda_2}{\lambda_1 + \lambda_2 + \ldots + \lambda_n}\right)PC_2 + \ldots\ldots + \left(\frac{\lambda_n}{\lambda_1 + \lambda_2 + \ldots + \lambda_n}\right)PC_n$$

---------- (3)

$\lambda_1, \lambda_2, \lambda_3, \ldots\ldots, \lambda_n$ are eigen values

Indicators are then normalized between zero and one, using min-max transformation (Nardo et al., 2008).

$$FSI_i = \frac{ACS_i - ACS_{\min}}{ACS_{\max} - ACS_{\min}} \qquad \text{------ (4)}$$

FSI_i = Normalized value of FSI indicator i
ACS_i = Actual value of ACS indicator i
$ACS_{\min i}$ = Observed minimum value of ACS indicator i
$ACS_{\max i}$ = Observed maximum value of ACS indicator i

Where $i = 1, 2, 3 \ldots 29$

Next, the indicator will be generated for 29 years from 1995 to 2023.

$$FSI = \begin{bmatrix} FSI_1 \\ FSI_2 \\ . \\ . \\ . \\ FSI_{29} \end{bmatrix} = \begin{bmatrix} FSI_{1995} \\ FSI_{1996} \\ . \\ . \\ . \\ FSI_{2023} \end{bmatrix}$$

- The generated FSI = 0 indicates a higher level of FS

  FSI = 1 signifies a lower level of FS

- The variation in strength use for the absolute value of the FSI.

$0 < FSI < 0.4$ = Strong FS level

$0.4 < FSI < 0.6$ = Moderate weak FS level

$0.6 < FSI < 0.8$ = Substantial weak FS level

$0.8 < FSI < 1.0$ = Weak FS level

5. Empirical Analysis and Discussion of Results

Constructing FSI: Australian Evidence

Suitability of data set: Bartlett test sphericity

- We used **Bartlett's test of sphericity** to determine the appropriateness of a data set for PCA. The analysis identified that the **null hypothesis (H_0): variables are not intercorrelated**, and the **Kaiser-Meyer-Olkin (KMO) value is 0.695**.

- Since variables are uncorrelated and the KMO value is above 0.6 (Hair et al., 2010), this implies the **suitability of the selected data set for PCA**.

Identify the number of PCs that should be retained.

Kaiser's criterion:

Table 2 shows that **Kaiser's criterion, only components with an eigenvalue of one or above** are to be retained. Our study retained two PC's (Hair et al., 2010).

Table 2: Principle Components/ correlation

Principal components/correlation Rotation: (unrotated = principal)			Number of obs Number of comp. Trace Rho Number of obs	= 29 = 6 = 6 = 1.0000 = 29
Component	Eigenvalue	Difference	Proportion	Cumulative
Comp 1	3.10888	1.12754	0.4441	0.4441
Comp 2	1.98134	1.31781	0.2830	0.7272
Comp 3	.663535	.133939	0.0948	0.8220
Comp 4	.380485	.209479	0.0544	0.9520
Comp 5	.171006	.005855	0.0244	0.9764
Comp 6	.165151	.	0.0236	1.0000

Catell's scree test:

Figure 3 displays how the eigenvalues plot against the number of components (Tabachnick & Fidell, 2018)

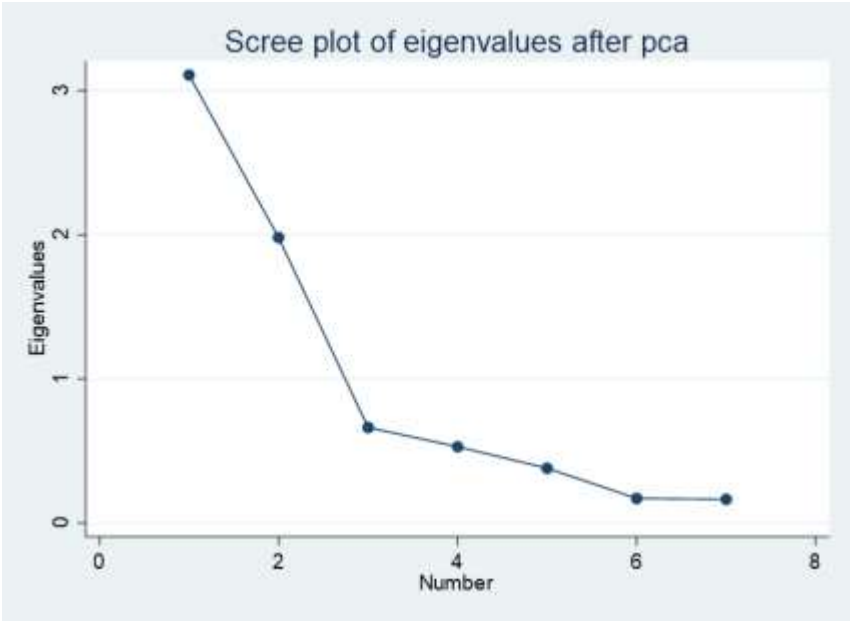


Figure-3: Catell's scree test

Table 3: Simplified rotated factor-loadings matrix (Hair et al., 2010).

Variable	Expenditure	Other
Exp	0.8044	
GDP		0.7346
Eds	0.7328	

Generate FSI

- To construct the FSI, the next step is to develop the ACS.

$$ACS_i = \left(\frac{0.4441}{0.7272}\right) * pc_1 + \left(\frac{0.2830}{0.7272}\right) * pc_2 \quad \text{------ (5)}$$

Where: i = 1, 2, 3... 29

ACSmin = -2.170549

ACSmax = 2.728777

- Finally, we developed the FSI using the min-max transformation, as described in Equation 4.

- Table 4 represent the FSI values for Australia from 1995 to 2023.

Table 4: Australia FSI values: 1995-2023

Time	FSI	Time	FSI	Time	FSI	Time	FSI
1995	0.0000	2003	0.3139	2011	0.5611	2019	0.7284
1996	0.0388	2004	0.2799	2012	0.5541	2020	1.0000
1997	0.1641	2005	0.3192	2013	0.6034	2021	0.9357
1998	0.1080	2006	0.4173	2014	0.6353	2022	0.7900
1999	0.1276	2007	0.3790	2015	0.6695	2023	0.6240
2000	0.1367	2008	0.3469	2016	0.5909		
2001	0.2701	2009	0.6923	2017	0.6696		
2002	0.2602	2010	0.5515	2018	0.6206		

- According to this study, in **1998**, the FSI indicator was **zero**, representing a **better fiscal sustainability** level in Australia. The reasons behind this situation were **lower government expenditure, lower external debt stock,** and a **higher GDP growth rate.**

- In **2020**, the FSI indicator was **one** and recorded a **lower fiscal sustainability** level in Australia. The factors leading to this were **higher government expenditure,** a **higher external debt stock,** and a **low GDP growth rate.**

- Moreover, we can argue that the circumstances leading to a higher FSI situation in 2020 were **higher government expenditures and debt financing circumstances to combat the COVID-19 outbreak** (RBA annual report, 2021).

The Evidence from Australia: The GFC and the COVID-19 Pandemic

- The FSI value was reported at **1.0000 in 2020**, a significant increase from **0.6923 in 2009**. The COVID-19 crisis weakened fiscal sustainability in Australia, surpassing the decline seen in the Global Financial Crisis (GFC).

- Table 5 shows that FSI has fluctuated between **0.197 and 0.689**, ranging from **stronger to substantially weak levels**.

- This trend reflects a positive outlook for the Australian economy, despite the challenges posed by two major crises.

Table 5: Descriptive Statistics of FSI in Australia

Descriptive Statistics	AUS
Mean	0.443
Standard Error	0.046
Median	0.417
Std. Dev.	0.247
Sample Variation	0.061
Kurtosis	0.073
Skewness	0.566
Minimum	0
Maximum	1
Count	29
Confidence Level (95%)	0.094

Evidence of FSI construction in OECD countries
The GFC and COVID-19 pandemic

The GFC's impact on OECD countries in 2009

In 2009, the study revealed that **Denmark, Ireland, New Zealand, Estonia, Latvia, Iceland, and the United States** (7) demonstrated a weaker level of fiscal sustainability.

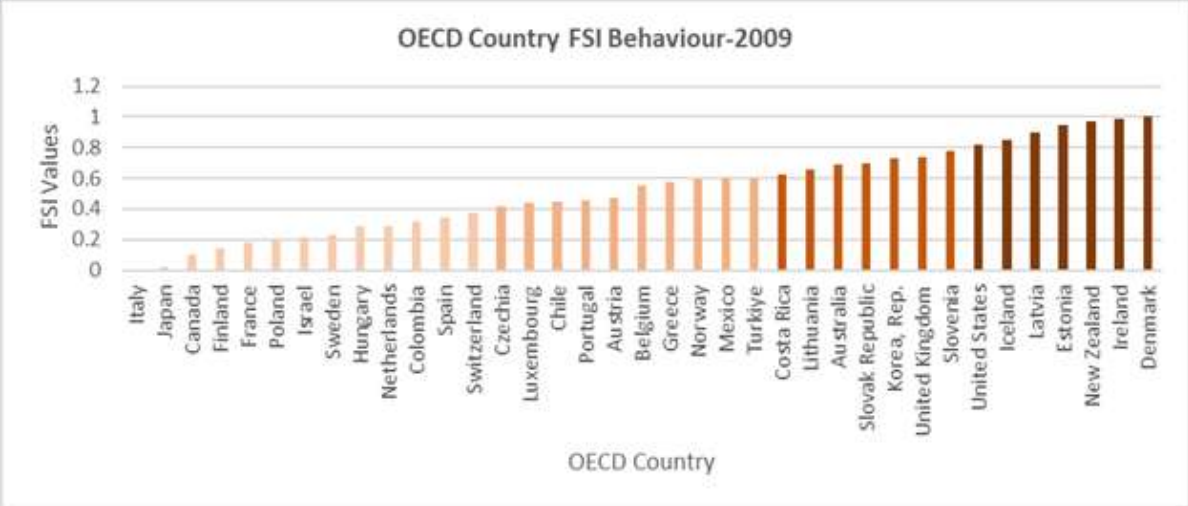


Figure 4: OECD Country FSI in a Column Chart: 2009

Table 6: OECD Country FSI Values in 2009

Country	FSI	Country	FSI	Country	FSI	Country	FSI
Italy	0.0000	Colombia	0.3196	Norway	0.5963	United States	0.8201
Japan	0.0196	Spain	0.3412	Mexico	0.5978	Iceland	0.8482
Canada	0.1003	Switzerland	0.3716	Turkiye	0.5994	Latvia	0.8954
Finland	0.1371	Czechia	0.4171	Costa Rica	0.6236	Estonia	0.9442
France	0.1846	Luxembourg	0.4407	Lithuania	0.6560	New Zealand	0.9694
Poland	0.1949	Chile	0.4488	Australia	0.6923	Ireland	0.9864
Israel	0.2124	Portugal	0.4580	Slovak Rep.	0.6974	Denmark	1.0000
Sweden	0.2287	Austria	0.4727	Korea, Rep.	0.7309		
Hungary	0.2839	Belgium	0.5550	UK	0.7355		
Netherlands	0.2903	Greece	0.5759	Slovenia	0.7784		

The COVID-19 Pandemic effects on OECD countries in 2020

- Our study found that the following countries exhibited weaker fiscal sustainability: **the United States, Slovenia, Norway, Mexico, Lithuania, Greece, France, Estonia, Czechia, Costa Rica, Colombia, and Australia. In contrast, a significantly weaker level of fiscal sustainability was noted in the Slovak Republic, Spain, Portugal, South Korea, Chile, the United Kingdom, Luxembourg, Hungary, Turkey, Latvia, Austria, the Netherlands, Denmark, and New Zealand (26).**

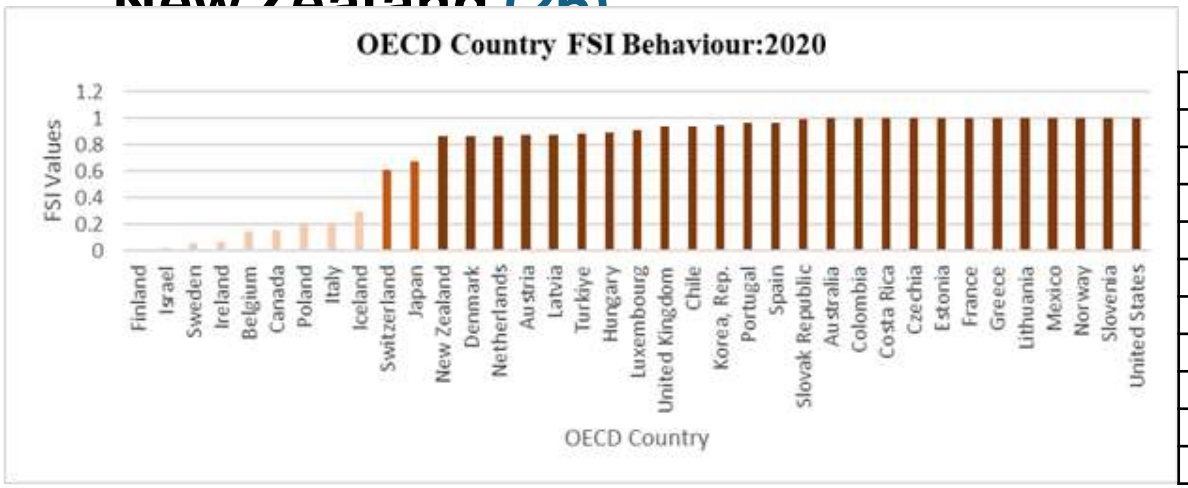


Figure 5: OECD Country FSI in a Column Chart in 2020

Table 7: OECD Country FSI Values in 2020

Country	FSI	Country	FSI	Country	FSI	Country	FSI
Finland	0.0000	Japan	0.6724	Chile	0.9418	France	1.0000
Israel	0.0194	New Zealand	0.8633	Korea, Rep.	0.9481	Greece	1.0000
Sweden	0.0620	Denmark	0.8717	Portugal	0.9675	Lithuania	1.0000
Ireland	0.0634	Netherlands	0.8718	Spain	0.9698	Mexico	1.0000
Belgium	0.1465	Austria	0.8750	Slovak Rep.	0.9944	Norway	1.0000
Canada	0.1551	Latvia	0.8760	Australia	1.0000	Slovenia	1.0000
Poland	0.2051	Turkiye	0.8851	Colombia	1.0000	USA	1.0000
Italy	0.2072	Hungary	0.8931	Costa Rica	1.0000		
Iceland	0.2937	Luxembourg	0.9124	Czechia	1.0000		
Switzerland	0.6131	UK	0.9415	Estonia	1.0000		

6. CONCLUSION

- This paper introduces a novel multidimensional FSI for **thirty-seven OECD countries**, with a particular focus on **Australia**. It specifically examines two major crises: the **GFC and the COVID-19 pandemic**, which occurred between 1995 and 2023.

- We first applied the newly developed FSI to Australia and found that the FSI value was **nearly zero in 1998**, indicating a strong level of fiscal sustainability. However, by **2020, the FSI had risen to nearly one**, which indicated a decline in fiscal sustainability. Notably, Australia's fiscal sustainability was significantly weaker during the COVID-19 pandemic compared to the GFC.

- Over the period from 1995 to 2023, Australia's fiscal sustainability fluctuated between **strong and substantially weaker levels**.

Second, we applied the FSI to thirty-seven OECD countries and found that **twenty-six countries** faced weaker fiscal sustainability during the COVID-19 crisis compared to the GFC. Many OECD countries have experienced **worsening fiscal sustainability** due to the **COVID-19 pandemic**.

The FSI relies on three key factors that affect fiscal sustainability: **government expenditure, levels of external debt, and the GDP growth rate.**

In conclusion, the FSI has proven to be a reliable tool for evaluating a country's fiscal sustainability, both in normal and crisis conditions. Additionally, it applies to any nation and can serve as a valuable administrative resource for monitoring fiscal stability, ultimately supporting the achievement of a country's sustainable development goals.

Thank You