



Causality between economic growth and fiscal performance in Punjab: Empirical evidence

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Abstract

This paper, titled "Causality between Economic Growth and Fiscal Performance in Punjab: Empirical Evidence," investigates the intricate relationships between various economic indicators in Punjab. Initially, descriptive statistics for key economic variables such as Gross Domestic Product (GDP) and fiscal indicators were analysed. Unit root tests revealed that most variables were non-stationary at their levels but became stationary after first differencing, enabling the application of robust econometric techniques. The Granger causality test identified significant temporal relationships among variables, with unidirectional causality observed from CF to GFD, WPI to CF, NTR to GFD, SDP to GFD, TR to GFD, TR to NTR, WPI to NTR, TR to SDP, and TR to WPI. Bidirectional causality between NTR and GFD indicated mutual predictive relationships. The Johansen-Juselius cointegration tests confirmed long-term equilibrium relationships among the variables, though discrepancies between the Trace and Max-Eigenvalue tests suggested further investigation was needed. Vector Error Correction Models (VECMs) provided insights into both short- and long-term dynamics among the variables. Additionally, the ARDL Bound Test Cointegration approach affirmed a strong long-run relationship between Punjab's State Domestic Product (SDP), fiscal indicators, and other macroeconomic variables, highlighting their influence on Punjab's economic growth.

Keywords: Fiscal performance, Punjab, fiscal indicators, Granger causality, cointegration, ardl bound test

Introduction

This study focuses on unravelling the causal relationship between fiscal deficit and economic growth in the context of Punjab. The relationship between these two variables is key evidence in understanding the region's economic dynamics (Behera & Mallick, 2022) ^[4]. Fiscal policies, particularly those related to deficit management, significantly influence economic growth and vice versa (Benos, 2009) ^[5]. This study aims to empirically examine the causal links between fiscal indicators, economic growth and other macroeconomic variables in Punjab. By scrutinizing historical data, employing advanced econometric techniques, and drawing upon established economic theories, the study aims to find the relationship between these two key variables. The findings of this research not only contribute to the academic discourse surrounding regional economics and offer valuable insights for policymakers and stakeholders. Understanding the causality between these variables is crucial for formulating effective policy measures that promote economic growth and fiscal stability. The organization of this study is as follows: Section 1 provides an introduction, while Section 2 outlines the literature review. Section 3 describes the data sources and methodology. Section 4 presents the empirical results and discusses their implications. Finally, Section 5 summarizes the key findings.

Literature Review

The relationship between fiscal policy and economic growth has been widely studied across countries and contexts. Engen and Skinner (1992) ^[10], using OLS analysis of data from 107 nations (1970-85), found that a balanced rise in taxation and public spending tends to lower growth rates, suggesting the need for fiscal prudence. Similarly, Martin and Fardmanesh (1990), in a cross-sectional study (1972-81), showed that higher taxes negatively affect GDP growth unless channelled into deficit financing, while unchecked spending-induced deficits hinder growth. Easterly and

Rebelo (1993) ^[9], using historical data on fiscal structures and public investment, argued that fiscal policies influence growth through economies of scale in investment. Von Hagen and Harden (1996) ^[12] emphasized institutional aspects of budgetary processes, finding that fiscal discipline, centralized decision-making, and debt reduction are crucial for sustainable growth. In contrast, Bahmani (1999), analysing U.S. data (1947-92), provided evidence of a Keynesian "crowding in" effect, where fiscal deficits encouraged private investment. In developing countries, Shahid and Ahmad (2010) ^[20] applied ARDL co-integration to Pakistan (1972-2008) and found that fiscal deficits initially stimulate growth but become harmful beyond a threshold, leading to expansionary fiscal contraction. Ugwuanyi and Okelue (2017) ^[22], examining sub-Saharan Africa, found that both distortionary and non-distortionary taxes as well as expenditure composition significantly affect growth, though fiscal balance plays a limited role. In the Indian context, Wadhwa (2015) ^[23] highlighted the role of fiscal reforms and the FRBM Act (2003) in moderating deficits, while FDI was shown as a catalyst for growth under high-deficit scenarios. Kaur (2015) ^[14, 15] emphasized that India's fiscal policy evolved from financing industrialization via resource transfers to counter-cyclical measures during crises, though deficits and debt remained persistent. MR and Gayitri (2016) supported the neoclassical view that fiscal deficits adversely affect long-run GDP, despite short-run investment gains. Bhattacharyya and Mukherjee (2018) ^[6], using data from 20 EMEs (2000-16), found that fiscal stimulus had a positive but limited impact on post-crisis growth. Sub-national experiences highlight the risks of fiscal imbalances: Sawhney (2005) ^[18] and Das (2013) ^[8] underlined the fiscal fragility of states like Punjab, Kerala, and West Bengal, while Kaur and Kaur (2015) ^[14, 15] showed that revenue deficit was the key driver of Punjab's poor fiscal health postFRBM Act. More recent studies such as Kamal (2018) ^[13], Shergill and Kaur (2019) ^[21], and Behera and Mallick (2022) ^[4] emphasized that

Punjab’s fiscal crisis stems from rising non-productive spending, weak revenue mobilization, and neglect of the rural economy, while state-level evidence shows that fiscal deficits generally depress growth but can have positive effects where fiscal responsibility legislations are adopted. Other contributions also enrich this debate: Barro (1990) [3] argued that government spending on productive services can enhance growth, while Alesina and Perotti (1996) stressed the political economy of fiscal adjustments in sustaining growth. Gupta *et al.* (2005) found that the composition of expenditure—developmental versus non-developmental—matters more than its size. Overall, the literature indicates that the growth impact of fiscal deficits depends critically on institutional design, expenditure quality, deficit financing modes, and macroeconomic conditions, underscoring that fiscal policy is both a constraint and an instrument for long-term development. Pattnaik and Rath (2019) examined the relationship between fiscal deficits and economic growth in India using time-series econometric techniques. They found evidence of a long-run cointegrating relationship, with fiscal deficits exerting a negative impact on growth, highlighting the importance of fiscal discipline for sustainable economic performance. Pattnaik, Samantaraya, and Rath (2011) [17] analyzed the Indian economy using cointegration and vector error correction models to study the link between fiscal deficit and economic growth. Their results indicated a long-run negative impact of fiscal deficits on growth, while short-run dynamics showed mixed evidence, underlining the need for prudent fiscal management.

Data Description, Variables and Methodology

The study uses data from 1981-2020 drawn from official government reports (Economic Survey of Punjab, Statistical Abstract), national databases (RBI, MOSPI, World Bank, EPWRF), and surveys (NSS, ASI). Key variables include State Domestic Product (SDP) as a measure of growth; Gross Fiscal Deficit (GFD) as an indicator of fiscal health; Capital Formation (CF) reflecting investment; Tax Revenue (TR) and Non-Tax Revenue (NTR) as income sources; and the Wholesale Price Index

(WPI) capturing inflation trends. These variables were selected for their theoretical and policy relevance, data reliability, and significance in fiscal-growth literature. Methodologically, descriptive statistics and logarithmic transformation are applied first. Unit root tests (ADF, PP, Ng-Perron) check stationarity, followed by lag length selection. Granger causality tests explore directional relationships, while Johansen cointegration and VECM capture long-run dynamics. Finally, the ARDL model examines both short-run and long-run effects of fiscal variables (GFD, CF, TR, NTR, WPI) on SDP, providing a comprehensive framework for analysing Punjab’s fiscal performance and growth nexus.

Results and Discussion

This section presents the empirical findings regarding the relationship between economic growth and fiscal performance in Punjab. The analysis is based on a series of econometric models that examine the causal linkages between these two key aspects of the state's economy.

1. Short-Run Causal Relationship Between Fiscal variables and Economic growth

This section is dedicated to understanding how changes in fiscal variables can have short-run impacts on economic growth. We analyse a variety of macroeconomic variables. Table 1 shows descriptive statistics for Punjab's fiscal indicators and SDP. The mean represents the average value of each fiscal indicator. Positive skewness suggests right-skewed distributions, while kurtosis values reveal whether the distribution has heavy or light tails compared to a normal distribution. The Jarque-Bera test assesses whether the distribution of fiscal indicators follows a normal distribution. Most fiscal indicators exhibit a normal distribution based on the Jarque-Bera test results. In summary, the descriptive statistics reveal variability, positive skewness, and a normal distribution of Punjab's fiscal indicators over the analysed period.

Table 1: Descriptive Statistics of all major variables (1981-2020)

	CF	GFD	NTR	RD	SDP	TAX_REV	WPI_IN
Mean	4140.545	5917.897	4644.511	3367.128	143383.0	11651.14	59.40137
Median	2539.860	3779.000	3497.900	2336.000	77808.00	5430.720	53.25347
Maximum	15410.63	52840.00	21234.11	14285.00	537031.0	43579.42	121.8000
Minimum	381.5600	178.0000	158.1900	-103.0000	6647.000	524.4200	13.80251
Std. Dev.	3853.728	9042.724	4851.781	3701.166	158048.7	13474.20	35.83527
Skewness	1.068941	3.801058	1.661819	1.260677	1.179885	1.1807	0.384907
Kurtosis	3.257966	19.80477	6.032898	4.033569	3.133058	2.9804	1.794410
Jarque-Bera	7.535260	552.8130	32.89819	12.06642	9.077599	9.0631	3.324847

Source: Author’s Calculations using E-views (10)

Table 2: Results of Unit Root Test for all major variables (at Level or I (0))

Variables	Original level (intercept and trend)			
	No structural Breaks			Structural Breaks
	ADF(t-statistics)	PP(t-statistics)	KPSS(t-statistics)	ADF break test
LCF	-3.154480	-3.215310***	0.060838*	-4.414012(2000)
LGFD	-4.468096	-4.385072*	0.1409948***	-5.331489(1992)
LNTR	-3.200144	-3.224429	0.155627**	-4.758739(1990)
LSDP_C	-1.756210	-1.919172	0.143893**	-3.469556(2005)
LTR	-2.951770	-1.192139	0.085080	-3.863014(2005)
LWPI	-1.825936	-1.188258	0.184554**	-4.696259***(2013)

Source: Author’s Calculations using E-views (10)

Table 2 shows unit root tests of various variables that are integrated of order 0, I (0), indicating they are stationary. However, State Domestic Product at Constant Prices (LSDP_C), Tax Revenue (LTR), and Wholesale Price Index (LWPI) are integrated of order 1, I (1), suggesting they are

non-stationary and may require differencing to achieve stationarity. Structural breaks are detected in the series for LCF in 2000, LGFD in 1992, LSDP_C in 2005, LTR in 2005, and LWPI in 2013, indicating possible shifts in their behaviour.

Table 3: Results of Unit Root Test for all major variables (at First Difference or I (1))

Variables	First Difference (Intercept, no trend)			
	No structural Breaks			Structural Breaks
	ADF(t-statistics)	PP(t-statistics)	KPSS(t-statistics)	ADF break test
LCF	-8.138906*	-8.201780*	0.051607	-8.095846*(1987)
LGFD	-8.705109*	-12.07117*	0.500000**	-9.440781*(1992)
LNTR	-7.585168*	-8.970234*	0.097242	-10.63082*(1991)
LSDP_C	-5.360796*	-5.355581*	0.099248	-5.933792*(2019)
LTR	-0.743444*	-6.038670*	0.244447	-6.004720*(1986)
LWPI	-3.439906*	-3.429443*	0.272851	-4.242014***(1994)

Source: Author’s Calculations using E-views (10)

Table 3 explained that after differencing, all major variables such as Capital Formation (LCF), Gross Fiscal Deficit (LGFD), Non Tax Revenue (LNTR), State Domestic Product at Constant Prices (LSDP_C), Tax Revenue (LTR), and Wholesale Price Index (LWPI) are now stationary at the 1% significance level, indicating they are integrated of order 1, I(1). The KPSS test also confirms stationarity. Overall, the results indicate that the first difference transformation has made the data suitable for further analysis in time series modelling.

However, after applying first-order differencing, the series became stationary, indicating the successful removal of trends. With the data now stationary, we can proceed with the Granger causality test to further explore the relationships between variables.

2. Optimal Lag length criteria

Table 4: Lag length criteria test results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1.596150	NA	6.07e-08	0.410603	0.671833	0.502698
1	219.0437	357.7944*	2.89e-12*	-9.569930	-7.741321*	-8.925260*
2	257.5584	49.96501	2.96e-12	-9.705859*	-6.309870	-8.508614

Source: Author’s Calculations using E-views (10)

Table 4 presents the Lag length criteria test results. Using the Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Information Criterion (HQ) as test criteria, the optimal lag order for the VAR model is identified as 1. This is evident from the lowest values of AIC (-9.569930) and SC (-7.741321) and the highest value of HQ (-8.925260). The Log Likelihood Ratio (LR) of 357.7944 at lag one further supports this selection, indicating a significant improvement in model fit compared to lag 0. This suggests that the model with Lag 1 is the most appropriate for predicting future values. The absence of autocorrelation in the errors further validates the appropriateness of the lag order selection.

3. Granger Causality Test

The findings from the Granger causality tests provide valuable insights into the temporal interplay between the economic indicators LN_GFD, LN_CF, LN_NTR, LN_SDP, LN_TR, and LN_WPI. The temporal relationship refers to how these variables interact over time. For instance, the tests revealed unidirectional Granger causality

from CF to GFD, from WPI to CF, from NTR to GFD, from SDP to GFD, from TR to GFD, from TR to NTR, from WPI to NTR, from TR to SDP, and from TR to WPI. This means that past values of one variable (e.g., CF) can help predict future values of another variable (e.g., GFD). There was also bidirectional Granger causality found between NTR and GFD, indicating that both variables' past values can help predict the other's future values. There is no Granger causality between NTR and CF, SDP and CF, TR and CF, CF and WPI, SDP and NTR, and SDP and WPI.

4. Long run relationship: Cointegration between fiscal indicators and significant macroeconomic variables

Table 5: Johansen-Juselius (J-J) maximum likelihood procedure:

Trace test statistic				
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.810530	134.3626	95.75366	0.0000
At most 1 *	0.583754	74.47579	69.81889	0.0202
At most 2	0.402695	42.92259	47.85613	0.1345
At most 3	0.327484	24.37079	29.79707	0.1852
At most 4	0.242306	10.08851	15.49471	0.2740
At most 5	0.002758	0.099412	3.841466	0.7525
Eigenvalue statistics				
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.810530	59.88683	40.07757	0.0001
At most 1	0.583754	31.55320	33.87687	0.0924
At most 2	0.402695	18.55180	27.58434	0.4499
At most 3	0.327484	14.28227	21.13162	0.3423
At most 4	0.242306	9.989101	14.26460	0.2127
At most 5	0.002758	0.099412	3.841466	0.7525

Table 5 presents the results of the Johansen-Juselius likelihood cointegration tests. The Trace test indicates two cointegrating equations at the 0.05 significance level, meaning two long-term equilibrium relationships exist among the variables. This is evident from the rejection of the null hypothesis of "None" and "At most 1" cointegrating equation(s) at the 0.05 level, as their p-values are less than 0.05 (0.0000 and 0.0202, respectively). The Max-Eigenvalue test indicates one cointegrating equation at the 0.05 significance level, suggesting one long-term equilibrium relationship. This is evident from rejecting the null hypothesis of the "None" cointegrating equation at the 0.05 level, as its p-value is less than 0.05 (0.0001). In summary, both tests reject the null hypothesis of no

cointegration at a 0.05 significance level, indicating a significant long-run relationship between the variables. The series tested include LN_CF, LN_GFD, LN_NTR, LN_SDP_CON, LN_TR, and LN_WPI, and the sample period is from 1984 to 2019 with 36 observations after adjustments. The lag interval in the first differences is from

1 to 2. The trend assumption is a linear deterministic trend. The results are based on MacKinnon-Haug-Michelis (1999) p-values.

5. Vector Error Correction Model Results (Short-run and Long-run relationship):

Table 6: Vector Error Correction Model Results (Cointegration between State domestic product and other macro-economic variables)

VECM Granger causality test	Short-run causality						Long-run causality
Variables	$\Delta \ln \text{SDP}$	$\Delta \ln \text{CF}$	$\Delta \ln \text{GFD}$	$\Delta \ln \text{NTR}$	$\Delta \ln \text{TR}$	$\Delta \ln \text{WPI}$	ECT
$\Delta \ln \text{SDP}$	-	0.338965	-3.89275	-2.00630	0.866169	0.031567	-0.210867*
$\Delta \ln \text{CF}$	-0.004540	-	-0.26524	0.084565	0.087789**	0.013736	-0.567960
$\Delta \ln \text{GFD}$	0.001897	-0.072593	-	-0.00203	-0.00438	-0.000919	-1.110097
$\Delta \ln \text{NTR}$	-0.017695**	0.147334	-0.32323***	-	0.011999	-0.004393	2.095039
$\Delta \ln \text{TR}$	-0.071004	-1.292343	1.477221	-1.00455	-	0.134063***	0.930370*
$\Delta \ln \text{WPI}$	-0.083310	1.527651	-3.29631	-0.05151	0.371435	-	0.078688

Source: Author’s Calculations using E-views (10)

1. VECM Equations

$$\begin{aligned} \Delta \text{Lsdp}_t &= \sigma + \sum_{i=1}^{k-1} \alpha_i \text{Lsdp}_{t-i} + \sum_{j=1}^{k-1} \beta_j \text{cf}_{t-j} + \sum_{m=1}^{k-1} \phi_m \text{gfd}_{t-m} + \sum_{q=1}^{k-1} \delta_q \text{ntr}_{t-q} + \sum_{r=1}^{k-1} \gamma_r \text{tr}_{t-r} + \sum_{s=1}^{k-1} \theta_s \text{wpi}_{t-s} + \lambda_1 \text{ECT}_{t-1} + u_{1t} \\ \Delta \text{Lcf}_t &= \zeta + \sum_{i=1}^{k-1} \alpha_i \text{Lsdp}_{t-i} + \sum_{j=1}^{k-1} \beta_j \text{cf}_{t-j} + \sum_{m=1}^{k-1} \phi_m \text{gfd}_{t-m} + \sum_{q=1}^{k-1} \delta_q \text{ntr}_{t-q} + \sum_{r=1}^{k-1} \gamma_r \text{tr}_{t-r} + \sum_{s=1}^{k-1} \theta_s \text{wpi}_{t-s} + \lambda_2 \text{ECT}_{t-1} + u_{2t} \\ \Delta \text{Lgfd}_t &= \rho + \sum_{i=1}^{k-1} \alpha \text{Lsdp}_{t-i} + \sum_{j=1}^{k-1} \beta \text{cf}_{t-j} + \sum_{m=1}^{k-1} \phi \text{gfd}_{t-m} + \sum_{q=1}^{k-1} \delta \text{ntr}_{t-q} + \sum_{r=1}^{k-1} \gamma \text{tr}_{t-r} + \sum_{s=1}^{k-1} \theta \text{wpi}_{t-s} + \lambda \text{ECT}_{t-1} + u_{3t} \\ \Delta \text{Lntr}_t &= \omega + \sum_{i=1}^{k-1} \alpha \text{Lsdp}_{t-i} + \sum_{j=1}^{k-1} \beta \text{cf}_{t-j} + \sum_{m=1}^{k-1} \phi \text{gfd}_{t-m} + \sum_{q=1}^{k-1} \delta \text{ntr}_{t-q} + \sum_{r=1}^{k-1} \gamma \text{tr}_{t-r} + \sum_{s=1}^{k-1} \theta \text{wpi}_{t-s} + \lambda \text{ECT}_{t-1} + u_{4t} \\ \Delta \text{Ltr}_t &= \varphi + \sum_{i=1}^{k-1} \alpha_i \text{Lsdp}_{t-i} + \sum_{j=1}^{k-1} \beta_j \text{cf}_{t-j} + \sum_{m=1}^{k-1} \phi_m \text{gfd}_{t-m} + \sum_{q=1}^{k-1} \delta_q \text{ntr}_{t-q} + \sum_{r=1}^{k-1} \gamma_r \text{tr}_{t-r} + \sum_{s=1}^{k-1} \theta_s \text{wpi}_{t-s} + \lambda_5 \text{ECT}_{t-1} + u_{5t} \\ \Delta \text{Lwpi}_t &= \epsilon + \sum_{i=1}^{k-1} \alpha_i \text{Lsdp}_{t-i} + \sum_{j=1}^{k-1} \beta_j \text{cf}_{t-j} + \sum_{m=1}^{k-1} \phi_m \text{gfd}_{t-m} + \sum_{q=1}^{k-1} \delta_q \text{ntr}_{t-q} + \sum_{r=1}^{k-1} \gamma_r \text{tr}_{t-r} + \sum_{s=1}^{k-1} \theta_s \text{wpi}_{t-s} + \lambda_6 \text{ECT}_{t-1} + u_{6t} \end{aligned}$$

- $\Delta \text{LSDP}_t, \Delta \text{LCF}_t, \Delta \text{LGFD}_t, \Delta \text{LNTR}_t, \Delta \text{LTR}_t,$ and ΔLWPI_t : These are the differences in the variables' logarithms.
- $\text{LSDP}_{(t-i)}, \text{CF}_{(t-j)}, \text{GFD}_{(t-m)}, \text{NTR}_{(t-q)}, \text{TR}_{(t-r)},$ and $\text{WPI}_{(t-s)}$: These are the lagged values of the respective variables, capturing the effect of past values on the current period's changes in the variables.
- $\alpha_i, \beta_j, \phi_m, \delta_q, \gamma_r, \theta_s$: These are the coefficient values of respective variables.
- $\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5, \lambda_6$: These are coefficients of the Error Correction Term (ECT) for each equation, which captures the adjustment process towards the long-run equilibrium path for each variable.
- $u_{1t}, u_{2t}, u_{3t}, u_{4t}, u_{5t}, u_{6t}$: These are the error terms representing the difference between the actual and predicted values of the respective variables in each equation.

The short- and long-run dynamics of Punjab’s economy reveal varied interactions among key fiscal and macroeconomic variables. In the short run, Capital Formation (CF) positively influences State Domestic Product (SDP), while Gross Fiscal Deficit (GFD) and Non-Tax Revenue (NTR) exert adverse effects, and Tax Revenue (TR) along with the Wholesale Price Index (WPI) show positive but insignificant impacts. For CF, GFD and NTR reduce growth, while TR significantly increases it, and WPI has a positive though insignificant effect. Regarding GFD, SDP increases deficits, whereas CF, NTR, TR, and WPI reduce them, though without statistical significance. For NTR, SDP has a negative effect, CF and TR a positive effect, while GFD exerts a significant negative impact. In the case of TR, changes in SDP, CF, and NTR reduce revenues, while GFD and WPI raise them, with WPI showing a significant short-run effect. WPI itself is negatively influenced by SDP, GFD, and NTR, but

positively by TR and CF, though none are significant. In the long run, error correction terms (ECTs) highlight varying adjustment speeds: about 21% for SDP, 57% for CF, 111% for GFD, 209% for NTR, 93% for TR, and 8% for WPI, suggesting that while some variables (SDP, TR, CF) show stable adjustment processes, others (GFD, NTR, WPI) reflect weak or unstable long-run relationships.

6. ARDL Bound Test Cointegration

The Bound Test for Cointegration, or the ARDL bounds testing approach, is a statistical method used to assess whether a model's long-run relationship exists between variables (Narayan, 2005) [16]. It examines whether the

variables move together in the long term despite short-term fluctuations.

The given below unrestricted error correction model (ECM) is a representation of the ARDL model estimated for six variables: LN_CF, LN_GFD, LN_NTR, LN_SDP_CON, LN_TR, and LN_WPI. The model includes the first-differenced terms of the variables called short run ($\Delta \ln \text{SDP}$, $\Delta \ln \text{CF}$, $\Delta \ln \text{GFD}$, $\Delta \ln \text{NTR}$, $\Delta \ln \text{TR}$ and $\Delta \ln \text{WPI}$) and their lagged differences ($L\text{SDP}_{t-1}$, $L\text{CF}_{t-1}$, $L\text{GFD}_{t-1}$, $L\text{NTR}_{t-1}$, $L\text{TR}_{t-1}$ and $L\text{WPI}_{t-1}$). Additionally, it includes the error correction term ($\lambda_1 \text{ECT}_{t-1}$) to account for the adjustment towards the long-run equilibrium relationship.

1. ARDL test equation

$$\begin{aligned} \Delta \text{LSDP}_t = & \alpha_{01} + \alpha_{11} \text{LSDP}_{t-1} + \alpha_{21} \text{LCF}_{t-1} + \alpha_{31} \text{LGFD}_{t-1} + \alpha_{41} \text{LNTR}_{t-1} + \alpha_{51} \text{LTR}_{t-1} + \alpha_{61} \text{LWPI}_{t-1} \\ & + \sum_{i=1}^p \beta_{1i} \Delta \text{LSDP}_{t-i} + \sum_{i=1}^q \beta_{2i} \Delta \text{LCF}_{t-i} + \sum_{i=1}^q \beta_{3i} \Delta \text{LGFD}_{t-i} + \sum_{i=1}^q \beta_{4i} \Delta \text{LNTR}_{t-i} \\ & + \sum_{i=1}^q \beta_{5i} \Delta \text{LTR}_{t-i} + \sum_{i=1}^q \beta_{6i} \Delta \text{LWPI}_{t-i} + \lambda_1 \text{ECT}_{t-1} + \epsilon_{1t} \dots \dots \dots (6) \end{aligned}$$

In the above model, the explanatory variables are composed of both the dependent variable's lagged value and the independent variables' current and lagged values. The dependent variable is represented as a vector. The optimal lag order for the dependent and independent variables are represented by 'p' and 'q', respectively. '# ' is a constant, and ' β ' is the coefficient, with 'i' ranging from 1 to k. In equation (1), the speed of adjustment parameter λ_1 with a negative sign indicates the rate at which the dependent variable adjusts towards its long-run equilibrium after a shock to the system. The error correction term (ECT) is a crucial component of the model as it captures the short-term deviations from the long-run equilibrium. The coefficients $\beta_{1i}, \beta_{2i}, \beta_{3i}, \beta_{4i}, \beta_{5i}$ and β_{6i} represent the short-run dynamic coefficients of the model's adjustment towards the long-run equilibrium.

Model (ECM) can be estimated to understand the short-run dynamics and how the system adjusts to deviations from the long-run equilibrium. These results provide valuable insights into the dynamic relationships between these economic variables.

Table 8: Bounds tests for cointegration: $F_{sdp} (\ln \text{SDP} \setminus \ln \text{CF}, \ln \text{GFD}, \ln \text{NTR}, \ln \text{TR}, \ln \text{WPI})$

F-statistics	Without trend time, the	With time, trend the
$F_{sdp} (\ln \text{SDP} \setminus \ln \text{CF}, \ln \text{GFD}, \ln \text{NTR}, \ln \text{TR}, \ln \text{WPI})$	4.6273** (3.76)	4.8868** (4.25)
ECM (Error Correction Model)	-0.48*	-0.47*

Source: Author's Calculations using E-views (10)

7. Results from Bound Test Cointegration

Table 7: Results from Bound Test Cointegration (Using Model-3(Constant) Unrestricted Constant and No trend

Dependent Variable	F-Statistic	Co-Integration	The decision to Further Test
LN_SDP_C	F= 4.886874 t= -5.912693	Yes	Estimate ECM (Error Correction model)

Source: Author's Calculations using E-views (10)

The Bound Test Cointegration results, presented in Table 8, provide insights into the relationships among the variable LN_SDP. The Bound Test for Cointegration indicates a significant long-run relationship between LN_SDP (State Domestic Product at Constant Prices) and the other macroeconomic variables. The F-statistic of 4.886874 and the t-value of -5.912693 are statistically significant, indicating cointegration. This suggests that changes in the independent variables (LN_CF, LN_GFD, LN_NTR, LN_TR, LN_WPI) have a long-term impact on the state's domestic product. As a next step, the Error Correction

Table 9 presents the results of the Bounds tests for cointegration for the relationship between lnSDP (State Domestic Product) and lnCF (Capital Formation), lnGFD (Gross Fiscal Deficit), lnNTR (Non-Tax Revenue), lnTR (Tax Revenue), and lnWPI (Wholesale Price Index). The Fstatistics test the null hypothesis of no cointegration. The values are 4.6273 and 4.8868, which is significant at the 5% level. This suggests evidence of cointegration between lnSDP and the other variables. The ECM coefficient measures the speed at which the variables return to equilibrium after a shock. The values are -0.48 and -0.47, indicating that about 48% and 47% of any deviation from equilibrium is corrected in each period, respectively. The negative sign indicates that the variables are moving towards equilibrium. Overall, the results suggest a longrun relationship between lnSDP and the other variables, and the ECM coefficients indicate how quickly the system adjusts to deviations from equilibrium.

Conclusion

The study began by analysing descriptive statistics for Punjab's economic indicators, including Gross Domestic

Product (GDP), fiscal indicators and other macroeconomic variables. Then, unit root tests were conducted to determine the stationarity of the data, a crucial step in time series analysis. The results indicated that most variables were non-stationary at their levels but became stationary after taking the first differences. This transformation allowed for the application of various econometric techniques, ensuring the reliability of the subsequent analysis.

After this, the study examined the causality between variables. The Granger causality test conducted on LN_GFD, LN_CF, LN_NTR, LN_SDP, LN_TR, and LN_WPI reveals significant temporal relationships among these economic indicators. Unidirectional causality was observed from CF to GFD, WPI to CF, NTR to GFD, SDP to GFD, TR to GFD, TR to NTR, WPI to NTR, TR to SDP, and TR to WPI. This indicates that past values of these variables can predict future values of others. Bidirectional causality between NTR and GFD suggested predictive relationships in both directions.

The study then employed the Johansen-Juselius likelihood cointegration tests to examine the existence of long-term equilibrium relationships among the variables. The results revealed the presence of cointegration, indicating stable, long-term relationships among the variables. However, there was a discrepancy between the number of cointegrating equations suggested by the Trace test and the Max-Eigenvalue test, indicating the need for further investigation into the exact nature of these relationships. Next, the study applied Vector Error Correction Models (VECMs) to estimate how changes in the economic variables impact each other in both the short and long run. The results provided insights into the long-run relationship among the variables. Additionally, the study utilized the ARDL Bound Test Cointegration approach to assess the long-run relationship between variables. The findings showed that there is a strong and long-run relationship between Punjab's State Domestic Product (SDP), fiscal indicators, and other important macroeconomic variables. This shows how these variables influence Punjab's overall economic growth.

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