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Research Article

A Comparative Study of the Association between Occupational Safety and Economic Growth in North Indian States of Punjab and Haryana

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ABSTRACT

Empirical studies in economics often overlook the association in relation to economic growth and occupational safety, specifically concerning the North Indian states of Punjab and Haryana. The present study empirically examines the linkages between occupational safety reflected through fatal accidents at workplace and economic growth represented by gross state domestic product (GSDP) per capita .This research uses annual time series data concerning the period from 1999 to 2022 retrieved from statistical abstract of respective states. The employment of the autoregressive distributed lag (ARDL) model comparatively analyzes the dynamic association among occupational safety and economic growth in both states. The research finds that economic growth represented by GSDP per capita significantly and negatively impacts fatal accidents at the workplace in Punjab whereas, it happens to be statistically insignificant in the case of Haryana, likely due to its industrial composition, and massive accidents at the workplace in the automobile sector. Additionally, an error correction model examines short-term dynamics and finds the existence of robust adjustment mechanisms in both states. The study is vital as it comparatively analyzes the association among occupational safety and economic growth in two Indian States and it points towards the execution of more inclusive and effective policies to promote occupational safety along with economic growth.

Keywords: Occupational Safety, Economic Growth, Comparative Analysis, Punjab, Haryana, Autoregressive Distributed Lag Model.

INTRODUCTION

The 2030 agenda adopted in 2015 concerning sustainable development emphasized 17 Sustainable Development Goals (SDGs). It has been widely accepted throughout the world by more than 150 world leaders (1). SDG - 8 is one of the global goals, it promotes productive, full employment, along with decent work for everyone accompanied by inclusive, sustainable, and sustained economic growth (2). The Sustainable Development Goal (SDG)-8 encompasses two key components: decent work and economic growth (2-4). One of the critical aspects of decent work is occupational safety, which reflects

the conditions of work (5). Fatal accidents at the workplace serve as a proxy for occupational safety (6-10). Amidst the pursuit of rapid economic growth, ensuring occupational safety is pivotal for fostering decent work and economic growth (11-13). Occupational safety reflects the workers' rights (5) and the employers' responsibility. The present study explores the coherence between occupational safety and economic growth, aiming to highlight the comparative analysis of the interaction between these two variables. The research seeks to include decent work, specifically occupational safety, into economic growth strategies, as the promotion of SDG-8 requires effective implementation of both. This study focuses on two Indian states namely Punjab and Haryana in an intriguing case for comparative examination of the coherence in relation to occupational safety and economic growth. Historically both states are agricultural states but over time, the role of manufacturing and service sectors towards Gross State Domestic Product (GSDP) per capita has significantly increased (14,15) owing to this, the period from 1999 to 2022 has been chosen as a considerable timeframe for the study. A significant rise in GSDP Per Capita has been witnessed over the years, indicating ample economic growth (14,15). The study is bifurcated into several subparts. The initial section emphasizes the rationale and context of the concerned study. The second subpart stresses reviewing the literature. The third subpart highlights a comprehensive explanation of the adopted methodology, whereas the fourth subpart delineates the results and discussion and finally the fifth portion sheds light upon its conclusion.

REVIEW OF LITERATURE

The study emphasizes the importance of occupational safety in economic growth. This argument is also supported in a study by Jilcha and Kitaw (2017) (12), which stresses that effectively managing occupational safety and health (OSH) is pivotal for fostering economic growth and development. It also emphasizes the need for appropriate strategies that emphasize occupational safety along with technological advancement and productivity enhancement to ensure long-run socio-economic progress. Gümüş and Gülsün (2020) (13) complement this perspective through their study by emphasizing the association between occupational safety and economic growth. This study relates to Turkey for a period from 1998 to 2014. The study finds the presence of a positive association between GSDP per capita and fatal accidents at the workplace. It stresses educational and preventive measures inclusion to ensure occupational safety along with economic growth. Dijk et al. (2015) (16) in their study have highlighted the major importance of education and training especially in developing economies for the promotion of occupational safety and health (OSH). To improve existing plight, the study identifies the need for comprehensive training programs emphasizing the promotion of workers' safety. The research also suggests the adoption of OSH training through innovative educational methods such as participatory workshops, and interactive e-learning. Blended education modes have also been stressed to reach underserved worker populations. The study finds that through the reduction in the economic burden of occupational injuries and illness, OSH education can positively contribute to economic growth. Tan et al. (2012) (17) further supports this view in their study. It has been found that improvements in production safety and economic growth are positively associated. The study has found a long-term contribution share of 7.7%. These findings highlight the need for safety investments to boost economic progress. In addition to these perspectives, the study by Krishnamurthy et al. (2017) (18) stressed occupational safety to mitigate productivity losses and health risks through necessary interventions. The study emphasized a case of the steel industry in southern India where, thermal stress severely impacted workers' health and productivity. Furthermore, the study by Samanta and Gochhayat (2021) (19), reviewed challenges concerning occupational safety in the Indian construction sector. The study finds major issues revolving around psychological stress, insufficient training, the dearth of personal protective instruments, poor communication, and improper work postures acting as determinants that negatively impact occupational safety. These findings suggest the urgent need for adopting adequate safety practices and policies in the form of improved workplace ergonomics, sufficient training and awareness programs, a safety-oriented culture, and improved information flow to address these challenges. Additionally, the study by Thakur et al. (2018) (20), highlighted occupational injuries suffered by Himachal Pradesh's municipal solid waste (MSW) workers and found insufficient protective equipment as a reason behind it and emphasizes that overcoming it promotes economic growth as well. Another similar study by

Mitropoulos, Abdelhamid and Howell (2005) (21) delves into the causes of accidents at construction sites. The research stressed that fatal accidents at the workplace mark the need for the adoption of enhanced safety measures and better regulation. The study finds that the effectiveness of safety frameworks can be assessed through the number of fatal accidents at the workplace. Al-Thani et al. (2015) (22) also examined the epidemiology of occupational accidents, specifically concerning migrant workers in Qatar, and found that the adoption of tailored preventive measures and safety measures is vital to mitigate worker safety and overcome occupational hazards. It also enunciates the role of these necessary occupational safety-related interventions for the promotion of economic growth.

However, significant research has highlighted the coherence between occupational safety and economic growth. However, there persists a notable gap owing to the dearth of comparative studies examining Indian states, particularly Punjab and Haryana in the context of the association with respect to occupational safety and economic growth. The study also makes a vital contribution owing to the inclusion of the ARDL (Autoregressive Distributed Lag) model to show the short-run and long-run impact of economic growth on occupational safety. This research aims to fill the existing gap and offer understandings that serve as a crucial tool that boosts informed policy strategies to promote workplace safety as well as economic growth. The research aims to comparatively examine the extent of occupational safety despite economic growth in respective states and examines the coherence between occupational safety and economic growth in Punjab and Haryana.

METHODOLOGY

The annual data commencing from 1999 to 2022 has been employed to comparatively analyze the association in relation to economic growth and occupational safety in the north Indian states of Punjab and Haryana. This timeframe has been specifically chosen because during this period an increase in the contributory share of service as well as manufacturing sector in GSDP despite being historically agrarian economies has been witnessed (14,15) and the availability of data constraints concerning occupational safety also serves to be another reason. The study uses gross state domestic product (GSDP) per capita at constant prices (2011-12) as an indicator of economic growth (3, 23-27). On the other hand, Occupational Safety has been reflected in fatal accidents in the workplace (5-10). The author has computed the gross state domestic product per capita based on data collected from RBI reports. Data related to fatal accidents at the workplace has been retrieved from the Statistical Abstract of Punjab and Haryana (14,15). Natural logarithms of all variables have been undertaken for analysis and the data spanning 24 years has been reflected through descriptive statistics (table 1).

The association concerning occupational safety and economic growth has been analyzed through the application of the ARDL model. Moreover, this is appropriate in the case of small sample sizes (28). Initially, the unit root test was performed using the Dickey-Fuller generalized least squares (DF-GLS) test to analyze integration order as well as stationarity concerning variables (29). The DF-GLS has been chosen owing to its appropriateness in the case of small sample size and power (30). This test confirms that variables are not I (2). So, as to ensure the validity of F-statistics (28). To minimize the variability concerning data and effectively normalize the exponential trend if any, natural logarithm form of all variables is taken under consideration (31). The transformation of concerned variables in logarithmic form majorly enhances parameter estimation (32). Further short-run as well as long-run coefficients have been estimated and finally, the results concerning the ARDL model have been validated for reliability through several diagnostic and stability tests.

The study employs the following long-run (cointegrating) form of model:

$$\ln FA = a_o + a_1 \ln GSDP_t + E_t \quad (1)$$

Where FA represents fatal accidents at the workplace, GSDP shows gross state domestic product per capita, ln represents transformation in natural logarithmic form and E shows the error term.

The ARDL representation of the equation:

$$\Delta \ln FA_t = a_0 + \sum_{i=1}^{p} a_{1i} \Delta \ln FA_{t-i} + \sum_{i=0}^{p} a_{2i} \Delta \ln GSDP_{t-i} + a_3 \ln FA_{t-1} + a_4 \ln GSDP_{t-1} + E_t \quad (2)$$

Where the maximum lag order is represented by p, Δ serves to be the difference operator, and t reflects the period (t=1,..T). The short-term relationship has been represented by the coefficients with summation signs i.e. a_1 and a_2. The null hypothesis concerning equation 2 is as follows:

$a_3=a_4=0$

Afterward, the F-Bounds test is performed, in case the F-Statistic value is higher in comparison to the value of the upper critical bound, consequently, H_0 reflecting the absence of co-integration stands rejected. It marks the existence of long-term co-integration amid variables. Whereas there will be no co-integration if the lower critical bound value is more than the F-Statistic. However, the test seems to be inconclusive if its value lies between values of lower and upper bounds. The error correction model concerning ARDL should be constructed in case of the establishment of a long-term association. The following equation represents the error correction model:

$$\Delta \ln FA_t = b_0 + \sum_{i=1}^{p} b_{1i} \Delta \ln FA_{t-i} + \sum_{i=0}^{p} b_{2i} \Delta \ln GSDP_{t-i} + \lambda EC_{t-1} + \mu_t \quad (3)$$

Where λ is the feedback effect or the adjustment parameter. The residuals from the assessed model (Equation 1) are represented by EC. The study also employs diagnostic and stability tests for analysis of reliability concerning ARDL results.

RESULTS AND DISCUSSION

Summary statistics concerning GSDP per capita and fatal accidents at the workplace from 1999 to 2022 in both Punjab and Haryana has been depicted in table 1. These include mean, standard deviation, maximum, minimum, and observations. The GSDP per capita indicates economic growth and fatal accidents at the workplace reflect occupational safety.

Table 1: Descriptive Statistics related to fatal accidents and GSDP in Punjab and Haryana

	Punjab		Haryana	
	Fatal Accidents	**GSDP Per Capita**	**Fatal Accidents**	**GSDP Per Capita**
Mean	35.63	91946.50	499.17	119630.3
Std. Dev.	12.31	27193.44	73.89	49725.16
Maximum	56	136405.00	642	196782
Minimum	16	56624.00	341	53424
Observations	24	24.00	24	24

Note: Here, fatal accidents relate to fatal accidents at the workplace; GSDP Per Capita is gross state domestic product per capita, specifically taken at 2011-12 constant prices.

Comparison reveals that Punjab has lower economic growth as well as fatal accidents at the workplace in comparison to Haryana. It shows that Haryana accompanies greater economic growth with more decent work violations in the form of the dearth of occupational safety. Before proceeding further, the stationarity property of the dataset was examined through the Dickey-Fuller Generalized Least Square (DF-GLS), unit root test. Moreover, to proceed with ARDL, none of the variables must be I (2) or beyond. The study has further bifurcated empirical analysis into two sections: the first relates to Punjab and the other to Haryana. Table 2 indicates the DF-GLS (Dicky Fuller- Generalized Least Square) unit root test results, applied to the log of GSDP per capita (lnGSDP) and the log of fatal accidents at the workplace (lnFA) concerning both Punjab and Haryana. Initiating with Punjab,

lnGSDP is stationary at first difference under individual intercept and individual intercept and trend models at 1% and 5% significance levels respectively. However, lnFA achieves stationarity at the first difference at a 1% significance level for both states.

Moving towards Haryana, the study finds that lnGSDP becomes stationary at the first difference at a 1% level of significance for individual intercept and individual intercept and trend. On the other hand, lnFA becomes stationary at a level for both models at a 1% level of significance.

Table 2: Results of Unit Root Tests for GSDP and FA Variables in Punjab and Haryana

	Deterministic	**Punjab**		**Haryana**	
lnGSDP	Intercept	-0.04	-3.29***	-0.23	-4.49***
	Intercept and Trend	-2.61	-3.33**	-1.08	-4.99***
lnFA	Intercept	-2.69***	-6.37	-3.67***	-7.42
	Intercept and Trend	-4.11***	-5.39	-3.90***	-7.54

Note: Lag length based on Schwarz information criterion (SBC).

Here, log of GSDP per capita ; lnGSDP, and the log of fatal accidents at the workplace :lnFA

Significance level: *** p< 0.01, ** p<0.05, *p< 0.10 t statistics reported.

Thus, long-run coefficients can be estimated and compared for both the states because series are not integrated of order two, I(2) (33). Table 3 shows results concerning equation 2, which represents long-run coefficients. The F-bound test checks for the long-term association among variables. Equation 2 is estimated in which lnFA (log of fatal accidents at the workplace) is the endogenous variable and lnGSDP (log of gross state domestic product per capita) serves to be the exogenous variable. Table 3 reflects the F-test results for both Punjab and Haryana.

Table 3: Results of ARDL F-Bounds test

	Punjab		**Haryana**	
Test Statistics	Value	K	Value	K
F-statistics	5.56	1	4.74	1
critical value bounds				
Significance	I (0)	I (1)	I (0)	I (1)
10%	3.02	3.51	3.02	3.51
5%	3.62	4.16	3.62	4.16
1%	4.94	5.58	4.94	5.58

Initiating with Punjab, the F- statistic value stands at 5.56, which is higher in comparison to the upper bound value standing at 3.5 at a 10% level of significance and 4.16 at a 5 % significance level. It points towards the long-run association between occupational safety and economic growth. This implies that these variables move together in the long run even after a short period of deviation from each other (34).

Moving towards Haryana, the F-Statistic value stands at 4.74. It is higher than the upper bound value at 10% (3.51) and 5% (4.16) level of significance. It marks the long-run association between these variables (34). Thus, both Punjab and Haryana witness a long-term equilibrium association in relation to GSDP per capita and fatal accidents at the workplace. Thus, the study finds long-term cointegration in the series concerning both states. The estimates concerning the long-run coefficients of the variables are presented in Table 4. It highlights the extent of the long-run association concerning occupational safety and economic growth in both states. The result indicates that economic growth poses a negative and significant influence on occupational safety in Punjab. Specifically, the value indicates that in the long run, a 1% rise in GSDP is related to a 0.79% fall in fatal accidents at the workplace.

Table 4: The Long-run Coefficient of ARDL

States	Variable	Coefficient	Standard Error	t-statistic	Probability
Punjab	lnGSDP	-0.79	0.24	-3.31	0.00
	C	12.55	2.73	4.59	0.00
Haryana	lnGSDP	0.10	0.09	1.1	0.28
	C	5	0.09	4.61	0.00

It suggests that other factors not included in the model also influence the dependent variable (13,35). In contrast, Haryana has encountered a statistically insignificant probability value for lnGSDP standing at 0.10, which indicates a lack of long-term association between fatal accidents at the workplace and GSDP per capita in its case.

Therefore, the study finds differing trends in both states, Punjab exhibits a long-term association between two variables, unlike Haryana which shows no long-term association between occupational safety and GSDP per capita over the period considered. One reason accountable for this major decent work deficit in Haryana in comparison to Punjab is the existence of a giant automobile sector in Haryana as it is the largest manufacturer of cars and tractors owing to the presence of Hero, Escorts, Honda, and Maruti Suzuki. The government of India has recognized the Gurugram-Manesar-Bawal region located in Haryana as an auto-hub (36). The employees working in this sector are more prone to work-related accidents, of which several sufferers are injured or face fatal accidents during training (37). Another probable cause is the dearth of adequate inspection of the safety measures adopted by industries (38). Other reasons revolve around increased mechanization and complex layouts owing to limited space accompanied by multiple product lines (39). The study also examines short-run dynamics between the variables by applying an error correction model (ECM). The error correction term depicts the speed concerning the adjustment of variables' convergence towards equilibrium. Variations in lag structure implied upon first differenced variables influence F-test results. The lagged error correction term (ECT) also marks the determination of long-term relations among the variables (28). Table 5 depicts the coefficients of error correction terms for both Punjab and Haryana. These are highly significant and also non-positive for both states. It indicates a stronger tendency for the variables to return to their long-term equilibrium after a shock (40).

Table 5: Short Term Estimation

States	Variable	Coefficient	Standard Error	t-statistic	Probability
Punjab	CointEq(-1)*	-0.89	0.21	-4.28	0.00
Haryana	CointEq(-1)*	-0.83	0.21	-3.96	0.00

Initiating with Punjab, the coefficient value standing at -0.89 implies that 89% of the disequilibrium correction in the next period indicates a rapid adjustment. This smaller standard error value points towards reliable estimates and the t-statistic value of 4.28 depicts the significantly different value of the coefficient from zero.

Moving towards Haryana, it has -0.83 as its coefficient value which indicates that 83% of the disagreement correction in the next period. Like Punjab, its lower standard error value signifies reliable estimates, and the t-statistic value highlights the coefficient being significantly different from zero. This study through a comparative analysis of both states finds that Punjab has a slightly faster adjustment process in comparison to Haryana as exhibited by its larger coefficient value. However, the study finds the existence of efficient adjustment mechanisms in both states.

The estimated ARDL model can be validated based on significance concerning variables and several diagnostic tests. These tests comprise the Jarque-Bera test for normality of errors, the Ramsey Reset test to check for specification errors, the Glejser test for heteroscedasticity, and the Breusch- Godfrey Serial Correlation LM test for checking autocorrelation (41- 44). The diagnostic test results are specified in Table 6 for Punjab and Haryana. It shows no autocorrelation. The study finds that the residuals are distributed normally. Moreover, there is the absence of heteroskedasticity, and there is the correct specification of the model concerning both Punjab and Haryana.

Table 6: Diagnostic and Stability Test Results Concerning Punjab and Haryana

Diagnostic Test	Punjab	Haryana
	χ2 statistic (Probability)	χ2 statistic (Probability)
Breusch-Godfrey Serial Correlation LM Test	0.64 (0.42)	0.19 (0.66)
Heteroskedasticity Test: Glejser	2 (0.36)	4.79 (0.09)
Jarque-Bera Test: Normality	5.13 (0.08)	0.23 (0.89)
Ramsey Reset Test: Functional Form	0.94 (0.33)	0.76 (0.38)

Further to examine the structural stability of regression coefficients cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) tests have been employed (7). Figures 1 and 2 indicate the CUSUM and CUSUM Square test for Punjab; figures 3 and 4 show that for Haryana.

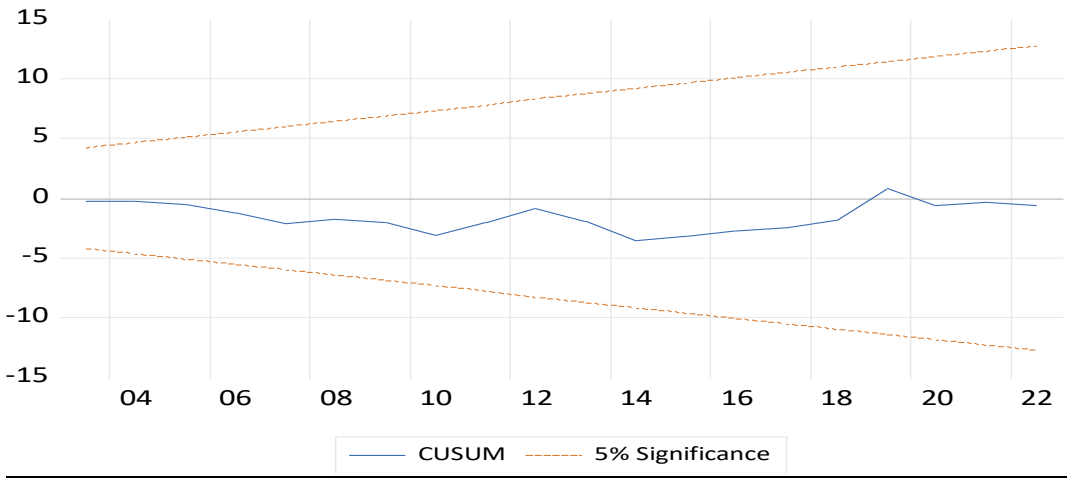

Figure 1: Plot of CUSUM Test concerning Punjab

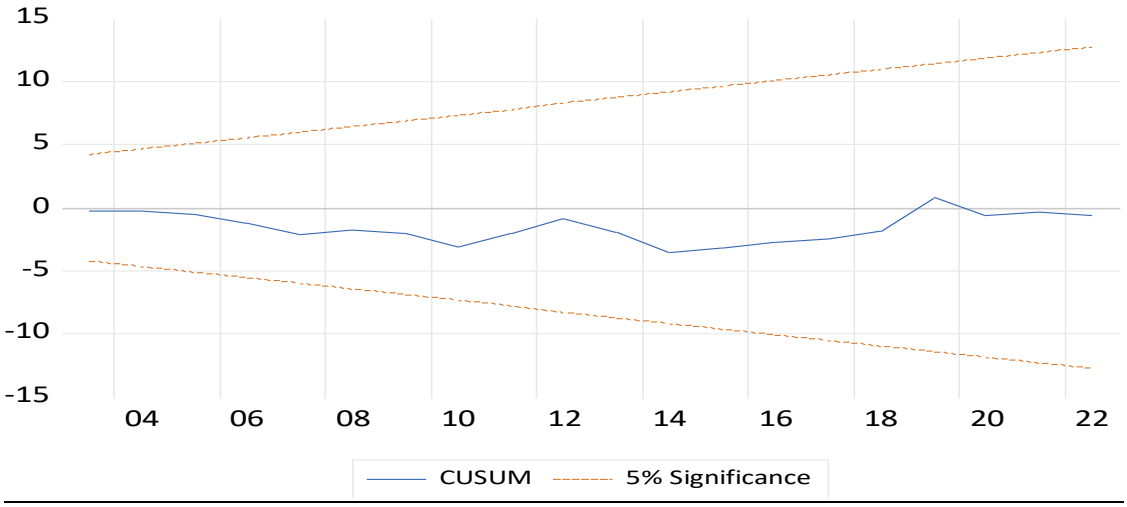

Figure 2: Plot of CUSUM Squares Test concerning Punjab

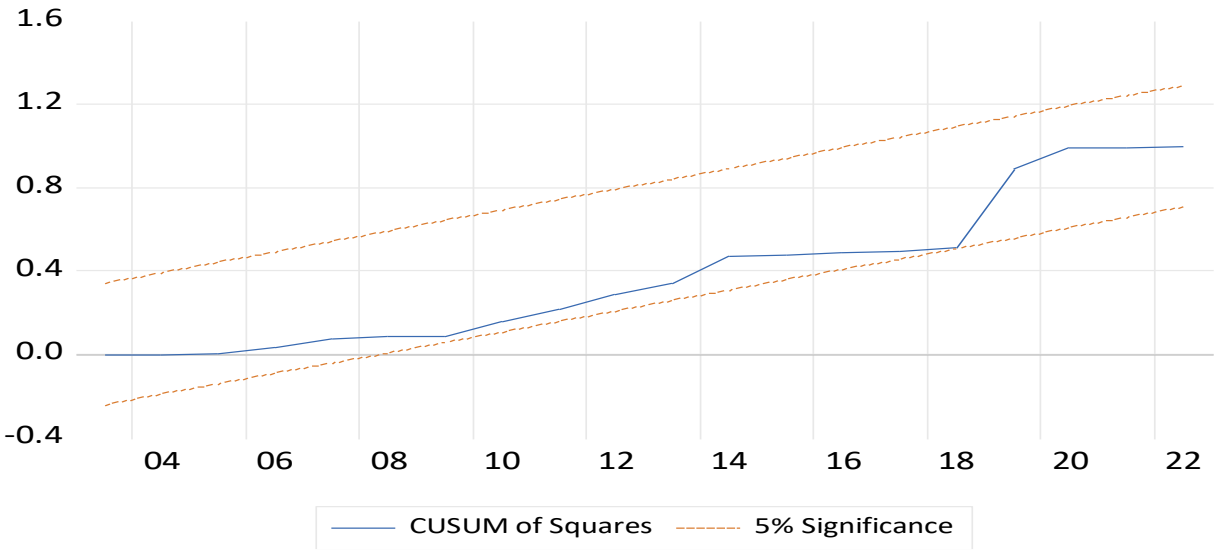

Figure 3: Plot of CUSUM Test concerning Haryana

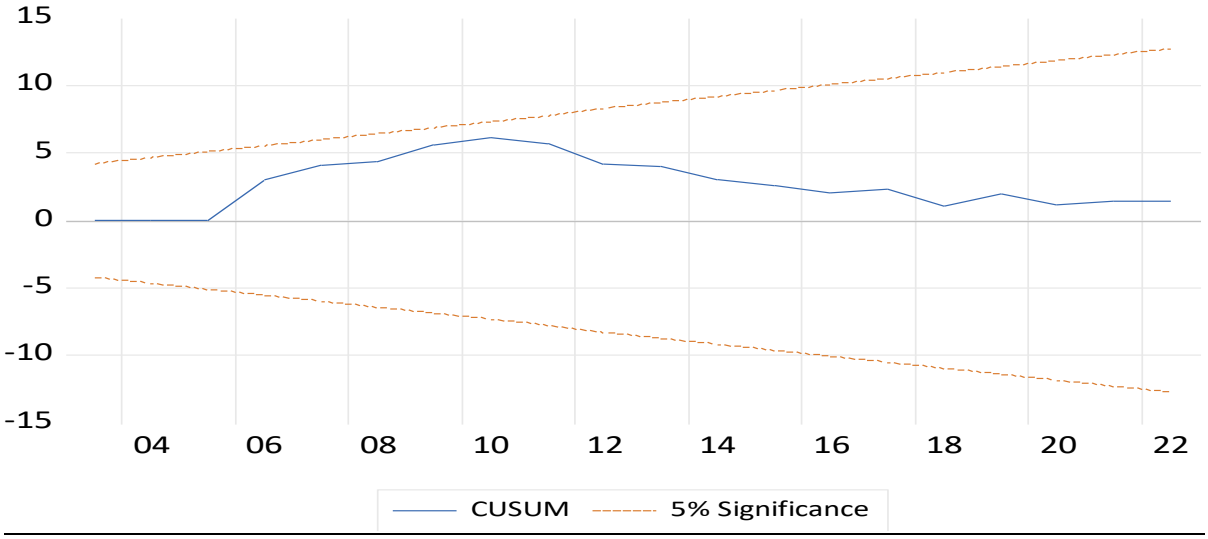

Figure 4: Plot of CUSUM Squares Test concerning Haryana

CONCLUSION

The study comparatively examines the association of economic growth and occupational Safety in the North Indian states of Punjab and Haryana over the period from 1999 to 2022. Fatal accidents at the workplace are utilized as an indicator of occupational safety, whereas GSDP per capita represents economic growth. Both short-run and long-run relationships have been analyzed by applying the ARDL model. The F-bounds test reveals a long-run equilibrium association among occupational safety and economic growth in both states. On the one hand, Punjab witnessed improved occupational safety as indicated by a substantial reduction in fatal accidents at the workplace along with the rise in economic growth. Thus, the state marks a negative long-term association between the concerned variables. Conversely, Haryana faces no long-term association between these variables that can be attributed to rising workplace accidents, particularly in the automobile sector in the Gurugram-Manesar-Bawal region located in Haryana, a prominent auto hub (36). To examine short-term dynamics, an error correction model has also been employed. It highlights the faster adjustment process in Punjab compared to Haryana. The study confirms the stability and reliability of the results through appropriate diagnostic tests and finds contrasting trends between both states with a major decent work deficit in Haryana in the form of rising fatal accidents at the workplace compared to Punjab. Therefore, it underscores the need for sufficient enforcement and safety regulations mainly in the automobile sector which is prone to more accidents in the workplace (37). Another probable cause is inadequate inspection of the safety measures adopted by industries (38), along with increased mechanization and complex layouts (39). Though there are other factors as well that also exert an influence on economic growth (13), occupational safety is also a critical issue that requires attention. Implementing appropriate measures by recognizing the targeted areas will ensure betterment in occupational safety like economic growth, especially in Haryana.

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CONFLICT OF INTEREST

The authors of this study clearly state that they have no conflicts of interest about its publication.

DATA AVAILABILITY

The datasets generated and analyzed during the current study are not publicly available due the fact that they constitute an excerpt of research in progress but are available from the corresponding author on reasonable request.

ABBREVIATION

ARDL - Autoregressive Distributed Lag, CUSUM: Cumulative Sum (CUSUM), CUSUMQ: Cumulative Sum of Squares DF-GLS - Dickey-Fuller Generalized Least Squares, C: Constant, ECM: Error Correction Model, ECT: Error Correction Term, FA: Fatal accidents at workplace, GSDP - Gross State Domestic Product, In: Natural Logarithm, MSW - Municipal Solid Waste, OSH - Occupational Safety and Health, SDG**s** - Sustainable Development Goals.

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