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CONTENTS

ELIT
Economic Laboratory Transition
Research Podgorica

Montenegrin Journal of Economics

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Exploring the Nonlinear Impact of Credit Supply on Economic Security in the United Arab Emirates

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ABSTRACT

This study examines the asymmetric effect of credit supply on economic security in the UAE from 1990 to 2023 using the nonlinear autoregressive distributed lag method. The results confirm a significant cointegrating relationship between economic security and credit supply. Additionally, the results reveal that the effect of credit supply on economic security in the UAE is nonlinear. Particularly, though positive adjustments in credit supply impair long-run economic security, positive and negative adjustments in credit supply have short-run positive impacts on economic security. Essentially, while short-term increases in credit supply enhance economic security, prolonged expansions have a negative long-term impact. Also, lending interest rates, public expenditure, weak institutions, and nonperforming loans negatively affect economic security, whereas oil prices provide support. These findings highlight the need for stronger credit risk management, controlled credit growth, institutional reforms, and economic diversification.

INTRODUCTION

Credit supply plays a fundamental role in economic stability and security by facilitating investment, consumption, and overall economic growth (Ehigiamusoe et al., 2019). A well-functioning credit market ensures efficient capital allocation, enabling households, businesses, and governments to access essential goods and services, finance productive activities, and mitigate the effects of economic shocks (Sakanko et al., 2020). By smoothing consumption and investment cycles, credit enhances long-term economic resilience, particularly during downturns, by providing liquidity to businesses and individuals facing temporary financial constraints (Abu et al., 2022a; Sakanko et al., 2024). This, in turn, fosters entrepreneurship, employment growth, and infrastructure development. However, inefficiencies in the credit market—often characterized by excessive or mismanaged credit expansion and weak credit risk management—can have adverse consequences, including unsustainable debt accumulation, financial instability, and broader economic vulnerabilities. Rapid credit expansion without adequate regulatory oversight can fuel asset bubbles, inflationary pressures, and systemic financial crises. Historical evidence from the 2008/2009 global financial crisis and the Asian financial crisis underscores how unchecked credit growth and rising loan defaults can destabilize financial markets, erode consumer and business confidence, and trigger widespread economic insecurity (Khan et al., 2020).

Although some studies suggest that credit supply may not always contribute positively to economic growth and stability (Rousseau & Wachtel, 2011), this weakness is often attributed to factors such as excessive financial deepening, financial crises, widespread financial liberalization, and inadequate legal or regulatory infrastructure (Ehigiamusoe et al., 2019). Nonetheless, credit contractions—whether due to tighter lending regulations, declining investor confidence, or broader economic shocks—can be equally detrimental. They can restrict access to capital, exacerbate unemployment, and heighten financial distress among households and businesses. Therefore, while credit supply is a key driver of economic growth and stability, its impact on economic security is complex and may depends on the broader economic context and how credit dynamics evolve over time.

The existing literature on the relationship between credit supply and economic performance has predominantly focused on a linear perspective (e.g., Garcia-Escribano & Han, 2015; Korkmaz, 2015; Vieira & Silva, 2023; Ozili et al., 2022; Sassi, 2014). However, credit supply does not necessarily exert uniform effects on economic security. Increases and decreases in credit supply can have varying impacts depending on existing credit levels, institutional frameworks, and macroeconomic conditions (Ho & Saadaoui, 2022). This suggests that the relationship between credit supply and economic security is nonlinear, with positive and negative adjustments producing asymmetric effects. For instance, while short-term increases in credit availability may enhance economic security by stimulating investment and consumption, prolonged or excessive credit expansion can lead to financial fragility, higher default rates, and systemic risks. Conversely, credit contractions may initially reduce financial vulnerabilities by curbing excessive lending but could ultimately suppress economic activity if households and businesses face liquidity constraints. These dynamics highlights the potential of that nonlinear nature of the relationship between credit supply and economic security and stability in an economy.

Despite significant credit expansion, rising default rates, and financial disruptions in the UAE, little research has explored whether the relationship between credit supply and economic security is asymmetric. Most existing studies on the UAE have examined only the linear relationship between credit supply and economic performance (see Al-Malkawi et al., 2012; Shadab, 2021). Given the rapid credit expansion alongside increasing nonperforming loans, it is essential to investigate whether the effect of credit supply on economic security is asymmetric. Understanding this relationship is crucial for maintaining sustainable financial and economic stability. Like many emerging economies, the UAE has witnessed not only an expansion in credit growth and nonperforming loans in recent decades but also significant macroeconomic disruptions, including rising unemployment, increasing out-of-pocket health expenditures, and fluctuations in per capita income and aggregate economic activity (World Bank, 2024). External shocks, such as fluctuations in oil prices and global capital flows, further complicate the credit-economic security nexus, making it imperative to assess how credit supply influences economic security under different economic conditions.

Therefore, this study contributes to the literature by examining whether the relationship between credit supply and economic security in the UAE is asymmetric over the 1990–2023 period. It makes several significant contributions. First, this is the first known study to explicitly investigate the asymmetric effect of credit supply on economic security in the UAE. To the best of our knowledge, empirical research on this topic remains scarce despite mounting evidence suggesting such asymmetries. Second, the study develops a multidimensional economic security index (ESI) for the UAE following on Hacker et al. (2014), providing a more comprehensive measure of economic security than traditional macroeconomic indicators. Third, to ensure robust results, the study employs the nonlinear autoregressive distributed lag (NARDL) estimation technique, which is well-suited for capturing asymmetries in the short- and long-run effects of credit supply. Finally, by exploring the nonlinear effects of credit supply on economic security in the UAE, the study aims to provide valuable insights for policymakers, researchers, and relevant stakeholders both within the UAE and in other countries with similar economic structures.

The rest of this paper is arranged as follows. The research method and data are discussed in the second section. Section three presents and discusses the results. The conclusion and policy recommendations are taken up in section four.

1. Methodology and Data

1.1 Model specification

Gleaning from empirical studies which focuses on the linear relationship between credit supply and economic performance in the UAE (e.g., Al-Malkawi et al., 2012; Shadab, 2021), an econometric model illustrating a nonlinear relationship between economic security and the positive and negative adjustments and credit supply is specified as follows:

$$es_t = a + \pi_1 cs_t^+ + \pi_2 cs_t^- + \vartheta' Z_t + \mu_t \quad (1)$$

where es, the dependent variable, represent economic security. cs^+ and cs^- are the positive and negative adjustment in credit domestic supply, respectively. The process of decomposing the credit supply variable to positive and negative components is presented in the next subsection. Z is a set of control variables (nonperforming loans, lending interest rate, institutional quality, oil price, and public spending). t denotes time. a is the intercept. and π and ϑ are slope coefficients. μ_t is the error term, with zero mean and constant variance.

1.2 Estimation Technique

To examine the asymmetric relationship between credit supply and economic security in the UAE, this study employs the nonlinear autoregressive distributed lag (NARDL) model by Shin et al. (2014), an extension of the ARDL bounds-testing approach of Pesaran et al. (2001). The NARDL model is particularly advantageous as it captures short- and long-run asymmetries while retaining the ARDL method's ability to handle cointegration in finite samples, regardless of the series' order of integration (Abu et al., 2022b; Gamal et al., 2024, 2025; Ryoji et al., 2025). Additionally, it effectively models potential nonlinearity in economic relationships (Abu et al., 2022c; David et al., 2020).

The NARDL estimation begins with a simple regression incorporating the partial sums of the asymmetric variable, which can be expressed as a bivariate NARDL(p, q) model expressed as:

$$y_t = c + \beta^+ x_t^+ + \beta^- x_t^- + \chi' Z + \upsilon_t \quad (2)$$

where β^+ and β^- are the coefficients of the partial sums of x_t, the asymmetric variable. Z is the vector of variables entering the model symmetrically. υ_t is the residual. The asymmetric variable, x_t, is a $k \times 1$ vector of regressors. It is decomposed as:

$$x = x_0 + x_t^+ + x_t^- \quad (3)$$

where x_t^+ and x_t^- are the partial sum process of positive and negative adjustments in x_t. The partial sums of the asymmetric variable, x_t, are generated by computing:

$$x_t^+ = \sum_{i=1}^{t} \Delta x_i^+ = \sum_{i=1}^{t} \max(\Delta x_i, 0) \tag{4}$$

$$x_t^- = \sum_{i=1}^{t} \Delta x_i^- = \sum_{i=1}^{t} \min(\Delta x_i, 0) \tag{5}$$

Following Shin et al. (2014), the generalised NARDL(p, q) model in Equation (2) can be rewritten in an unrestricted form to illustrate an asymmetric relationship between series x_t and y_t. This can be expressed as follows:

$$\begin{aligned} y_t = \alpha + \rho y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \gamma' Z + \sum_{i=1}^{p-1} \sigma_i \Delta y_{t-i} + \sum_{i=0}^{q} (\omega_i^+ \Delta x_{t-i}^+ + \omega_i^- \Delta x_{t-i}^- \\ + \varphi' \Delta Z_{t-1}) + \sum_{j=1}^{r} \eta_j' D_{t,j} + \upsilon_t \end{aligned} \tag{6}$$

where Δ is the first difference operator. ρ is the coefficient of the lagged level dependent variable. $\theta^+ = -\rho\beta^+$, and $\theta^- = -\rho\beta^-$. ω_i^+ and ω_i^- are the short-run parameters of the decomposed partial sums. γ is the vector coefficient of the lagged level of covariates entering the model symmetrically. and φ is the vector coefficient of differenced symmetric variables. $D_{t,j}$ denote the structural break dummy variable. The optimal lag-length (p, q) are determined automatically by AIC.

Following Pesaran et al. (2001), the asymmetric relationship between the series is established by testing the null hypothesis of no cointegration in Equation (6). Specifically, the presence of cointegration between y_t and x_t is assessed by testing $H_0: \rho = \theta^+ = \theta^- = \gamma = 0$ against the alternative of cointegration $H_1: \rho \neq \theta^+ \neq \theta^- \neq \gamma \neq 0$. The null must be rejected for cointegration to hold. The Wald test-based F-statistic is compared with the critical bounds from Pesaran et al. (2001), confirming cointegration only if it exceeds the upper bound; results are inconclusive if it falls between bounds. Once cointegration is established, both long-run and short-run models are estimated. Additionally, symmetry relationships are tested using the Wald test. Long-run symmetry is assessed by testing the null of additive symmetry $H_0: -\theta^+/\rho = -\theta^-/\rho$ against its alternative. Similarly, short-run symmetry is examined by testing $H_0: \sum_{i=0}^{q} \pi_i^+ = \sum_{i=0}^{q} \pi_i^-$ against the corresponding alternative.

1.3 Data

This study utilises annual time-series data spanning from 1990 to 2023. The variables are measured as follows. Economic security is defined following Hacker et al.'s (2014) multidimentionals economic security index approach. cs is measured as the ratio of credit extended by banks and other financial institutions to the private sector and state-owned enterprises relative to GDP. npl represents bank nonperforming loans as a percentage of total gross loans, while lir is measured by the interest rate charged by banks or other financial institutions on loans. The variable iq is measured using a political corruption index that ranges from 0 to 1, with 0 indicating low corruption and 1 indicating high corruption. $oilp$ is defined as the annual average price of Murban crude oil per barrel in US dollars, and pex represents the aggregate public spending of the federal government in billions of dollars. The data used are obtained from various sources, including the UAE's Federal Competitiveness and Statistics Authority, the Central Bank of the UAE, the UAE Ministry of Economy, OPEC's annual statistics bulletin, Varieties of Democracy (V-Dem) Institute, and WDI database.

2. RESULTS AND DISCUSSION

2.1 Preliminary data analysis

Before estimating the NARDL model to examine the asymmetric relationship between credit supply and economic security in the UAE, we computed descriptive statistics and tested the stationarity of the variables. Table 1 presents the summary statistics. The UAE's economic security index averaged 0.0057 from 1990 to 2023. Domestic credit supply averaged US$301.56 billion, ranging from US$25.56 billion to US$690.55 billion. Nonperforming loans, as a percentage of gross loans, averaged 9.25%. Lending interest rates averaged 6.87%, fluctuating between 2.3% and 10.6%. The institutional quality index, measured by the political corruption perception index, had a mean of 0.1314 and ranged from 0.108 to 0.219. Murban crude oil prices averaged US$52.09 per barrel, exhibiting high volatility between US$12.67 and US$111.76. Lastly, public expenditure averaged US$61.39 billion, with values ranging from US$14.20 billion to US$121.02 billion.

Table 1 Descriptive statistics

	es	cs	npl	lir	iq	$oilp$	pex
Mean	0.005682	301.56	9.252717	6.868235	0.131353	52.09471	61387.5
SD	0.011328	250.11	4.337387	1.869611	0.031097	32.49169	43530.9
Min.	0	25.56	2.3	2.3	0.108	12.67	14201.28
Max.	0.027931	690.55	15.7	10.6	0.219	111.76	121022

Source: Author's computation using EViews 13

Furthermore, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, along with the Zivot-Andrews (ZA) test, are employed to assess the stationarity properties of the series. As summarised in Table 2, the ADF test finds the economic security index, lending interest rate, and institutional quality index stationary at levels (5 percent significance level), while the PP test confirms stationarity at levels only for the economic security index and institutional quality index. Both tests indicate that domestic credit supply, nonperforming loans, oil prices, and public expenditure become stationary after first differencing. Since ADF and PP tests do not account for structural breaks, the ZA test is applied for robustness. The ZA results show that only the economic security index and nonperforming loans are stationary at levels (1 percent significance level), while the remaining variables achieve stationarity after first differencing (5 percent significance level). This suggests that except for the economic security index and nonperforming loans, which are integrated at I(0), all other series are integrated at I(1). Despite variations in integration order across tests, the presence of both I(0) and I(1) variables supports the use of the NARDL bounds-testing approach for cointegration analysis.

Table 2. Results of Unit Root Tests

		esi	dcs	npl	lir	iq	$oilp$	pex
ADF	Level	-3.6061**	-1.3206	-1.4459	-3.2479**	-3.2703**	-1.4600	-0.694
	1st Diff.	-5.6471***	-1.6514*	-3.3071***	-3.3355***	-4.8968***	-5.2687***	-3.9240***
PP	Level	-3.7380***	-1.1922	-1.0662	-2.1751	-7.9469***	-1.3900	-0.694
	1st Diff.	-12.6316***	-1.6532*	-3.4028***	-4.5459***	-4.8906***	-5.2775***	-3.9428***
ZA	Level	-5.4066***	-3.532	-5.5279***	-3.6984	-2.4521	-4.5979*	-4.5632
	T_b	2011	2004	2005	2011	2018	2015	2008
	1st Diff.	-6.4458***	-5.4486***	-5.2717**	-5.0888**	-7.9413***	-6.3096***	-6.0491***
	T_b	2014	2009	2012	2000	1996	2014	2010

Notes: T_b is the structural break-date. ADF represents the Augmented Dickey-Fuller test, PP denotes Philips-Peron test, and ZA is the Zivot and Andrews (1992) test with one break. The ADF and PP unit root test tests the null hypothesis of unit root against the alternative hypothesis of a stationary process. ZA tests the null of unit root against the alternative hypothesis of a trend-stationary process with one-time structural break occurring at an unknown point in

time. The ZA unit root test is conducted based on Model A which represent structural change in the level shift or intercept. The optimal lag length selection in ADF, and ZA tests are based on the Schwarz Information Criteria (SIC), while the maximum lag-length is set to 8. For PP test, the bandwidth is automatically determined based on the Newey-West method using the Bartlett kernel spectra estimation method. MacKinnon's (1996) critical values (CV) for ADF and PP tests (no intercept and trend) are given as: -2.6471 (1%), -1.9529 (5%), -1.6100 (10%), at 1%, 5% and 10% levels, respectively. ZA's CV for structural change in the level shift are: -5.34 (1%), -4.93 (5%) and -4.58 (10%). Asterisks (***), (**) and (*) indicate significance at 1%, 5% and 10% level, respectively.
Source: Authors' computation using EViews 13

2.2 NARDL bounds-testing cointegration test

We apply the NARDL bounds-testing method to assess the nonlinear cointegrating relationship between economic security and adjustments in credit supply in the UAE. The bounds-testing results, based on the estimated NARDL(1,2,2,2,0,2,2) model selected by the Akaike Information Criterion (AIC), are summarised in Table 3. The computed F-statistic of 9.302 exceeds the upper critical bound value of 5.694 at the 1 percent significance level. This result indicates that there is sufficient evidence to reject the null hypothesis of no cointegration between the series. Therefore, we conclude that a significant nonlinear cointegrating relationship exists between the variables.

Table 3. NARDL bounds-testing result

Model	*Lag Length*		*F-statistic*
$esi = f(dcs^+, dcs^-, npl, lir, corr, oilp, pex, D_{2008})$	1,2,2,2,0,2,2		9.302**
	$K = 7$		$N = 31$
Critical values for Case II: restricted constant and no trend	10%	5%	1%
I(0)	2.277	2.730	3.864
I(1)	3.498	4.163	5.694

Notes: K is the number of explanatory variables, and N represents the sample size. Asterisk (**) denotes significance at 1% level based on critical values provided by Pesaran et al. (2001). The optimal lag-length is suggested by AIC.
Source: Authors' computation using EViews 13.

2.3 Estimation results of the NARDL model

Since the bounds test confirms cointegration between economic security and credit supply, both long-run and short-run NARDL models are estimated using the AIC-suggested lag length (1,2,2,2,0,2,2). Table 4 summarizes the results: Panel A and B present the long-run and short-run models, Panel C reports symmetry tests (performed using Wald restriction test), and Panel D provides post-estimation diagnostics. The long-run symmetry test (W_{LR}) rejects the null of additive symmetry at the 1% level, while the short-run test (W_{SR}) is insignificant. This suggests asymmetric long-term effects of credit supply adjustments on economic security, but no significant short-term asymmetry.

The long-run estimation results in Panel A of Table 4 show that both positive and negative adjustments in domestic credit supply negatively impact economic security. However, while the effect of positive credit shocks is statistically insignificant, negative shocks are significant at the 5 percent level, with a one percent decline in domestic credit supply reducing economic security by 0.00069 percentage points. These findings align with prior research indicating that rapid credit expansion can undermine economic security in developing and emerging economies (Balgova et al., 2016; Zhang et al., 2022). Thus, both credit supply increases and decreases exert long-term negative effects, though their magnitude and significance vary. In contrast, the short-run results in Panel B indicate that positive credit shocks initially enhance economic security but have a delayed negative effect. A one percent increase in credit supply leads to an immediate 0.00058 percentage point rise in economic security (significant at the 1 percent level), but a one-period lag results in a 0.00038 percentage point decline (significant at the 10 percent level). Meanwhile, the immediate effect of negative credit shocks is statistically insignificant, but when lagged by one period, a one percent decline in credit supply improves economic security by 0.00137 percentage points (significant at the 1 percent level).

Overall, these asymmetric effects suggest that while short-term credit expansions provide immediate liquidity and economic support, prolonged adjustments—whether positive or negative—can destabilize economic security. In the UAE, where financial stability and economic diversification are key priorities, these findings highlight the risks of over-reliance on credit expansion and emphasize the need for a balanced approach that maximizes short-term gains while mitigating long-term vulnerabilities.

Table 4 Results of NARDL Model

Panel A: NARDL(1,2,2,2,0,2,2) Long-run coefficient estimates–Dependent variable: es							
$Cons$	cs^+	cs^-	npl	lir	iq	$oilp$	pex
0.6219	-0.00011	-0.00069	-0.0034	-0.0037	-0.3162	0.0783	-0.1401
(3.2547)***	(-0.6921)	(-3.3353)**	(-2.4115)**	(-1.6349)*	(-1.874)*	(5.0057)***	(3.7571)***

Panel B: NARDL(1,2,2,2,0,2,2) Short-run coefficient estimates – Dependent variable: Δes		
Regressors	Lag order	
	0	1
Δcs^+	0.00058 (4.0774)***	-0.00038 (-1.9098)*
Δcs^-	0.000094 (0.6076)	0.00137 (6.4471)***
Δnpl	0.00875 (8.4171)***	0.01287 (9.7542)***
Δlir	0.00056 (0.5913)	0.0057 (5.2959)***
Δiq	0.0214 (0.2141)	0.6495 (5.9429)***
Δpex	-0.1308 (-4.8348)***	-0.1521 (-7.3905)***
D_{2008}	0.0115 (1.6533)*	

Panel C: Long- and short-run asymmetric tests	
W_{LR}	18.5914 [0.0020]***
W_{SR}	0.2532 [0. 2696]

Panel D: Diagnostic statistics tests					
ECT_{t-1}	$\chi^2_{SC}(3)$	$\chi^2_{FF}(1)$	χ^2_{HET}	χ^2_{NORM}	$Adj.R^2$
-1.617***(-12.575)	1.623 [0.121]	1.358 [0.277]	19.832 [0.301]	6.022 [0.049]	0.7609

Notes: Δ represent first difference operator. Asterisk (***), (**) and (*) denotes significance at 1%, 5% and 10% level, respectively. The superscripts "+" and "−" represents positive and negative partial sums, respectively. Values in parenthesis (.) in panel A and B are the t-ratio, and values in square parenthesis [.] in panel C and D are the probability values of test statistics. W_{LR} refers to the Wald test of long-run symmetry, defined by $-\hat{\theta}^+/\hat{\rho} = -\hat{\theta}^-/\hat{\rho}$, and W_{SR} is the short-run symmetry, defined by $\sum_{i=0}^{q}\pi_i^+ = \sum_{i=0}^{q}\pi_i^-$. ECT_{t-1} represent the error correction term. χ^2_{SC}, χ^2_{HET}, χ^2_N, and χ^2_{FF} denotes BG LM tests for serial correlation, BPG LM test heteroscedasticity, JB normality test and Ramsey RESET f-statistic, respectively. The model is estimated by setting the maximum lag to 4, while the optimal lag-length is suggested by AIC

Regarding the control variables, the long-run estimates show that nonperforming loans, lending interest rates, and weak institutional quality significantly reduce economic security at the 10 percent level, with a 1 percent increase lowering economic security by 0.0034, 0.0037, and 0.3162 percentage points, respectively. In contrast, short-run results indicate a positive effect at the 1 percent level, with a 1 percent rise in nonperforming loans (current and lagged) improving economic security by 0.00875 and 0.01287 percentage points, respectively. Similarly, a 1 percent increase in lending interest rates and weak institutional quality (lagged) raises economic security by 0.0057 and 0.6495 percentage points. Public expenditure, often seen as a stabilizer, significantly reduces economic security at the 1 percent level in both periods, with a 1 percent rise lowering economic security by 0.1401 percentage points in the long run and by 0.1308 and 0.1521 percentage points in the short run. Conversely, oil prices enhance long-run economic security at the 1 percent level, with a unit increase improving economic security by 0.0783 percentage points.

Essentially, the short-term positive effect of nonperforming loans, despite their long-run risks, suggests temporary liquidity measures mitigating credit risks, likely reflecting proactive financial institution interventions. Similarly, while higher lending interest rates weaken economic security over time, their short-run benefits may stem from improved resource allocation or financial stabilization. The temporary positive effect of weak institutional quality may arise from informal governance structures expediting transactions, though long-term inefficiencies distort resource allocation and weaken resilience (Aljassmi et al., 2024; David et al., 2024; Sakanko et al., 2024). The positive effect of oil prices underscores their role in UAE's

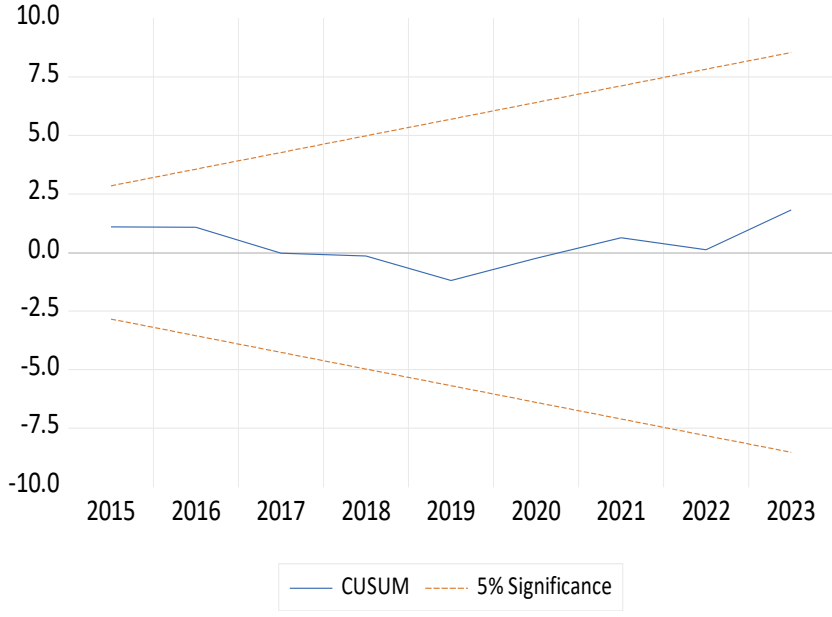
stability, as oil and gas revenues fund essential programs, enhancing economic security. However, reliance on oil exposes the economy to fiscal instability from price fluctuations. Lastly, the negative impact of public expenditure in both periods suggests inefficiencies or overreliance on fiscal stimulus, leading to economic distortions, inflation, and fiscal imbalances that undermine economic security.

The convergence coefficient, representing the error correction term lagged by one period, falls between -1 and -2 and is statistically significant at the 1 percent level. Though uncommon, this magnitude suggests an exceptionally rapid adjustment of economic security toward its long-run equilibrium, with a risk of overshooting (Abu et al., 2024; Narayan & Smyth, 2005). Specifically, a one-unit deviation from equilibrium triggers a 1.617-unit correction in the following period. Such rapid adjustment may cause oscillations as the system over-corrects before stabilizing. Instead of a smooth, direct return to equilibrium, the process involves dampened fluctuations around the long-run path. However, once these fluctuations subside, convergence accelerates, reinforcing long-term stability.

2.3 Results of diagnostics and model stability tests

To ensure the NARDL model's reliability for policymaking, several diagnostic tests were conducted: the Breusch-Godfrey test for serial correlation, the Breusch-Pagan-Godfrey test for heteroscedasticity, the Jarque-Bera test for normality, and the Ramsey RESET test for specification errors. These tests confirm compliance with key regression assumptions—no serial correlation, homoscedasticity, normal residuals, and correct specification. Results in Panel D of Table 4 show no issues of serial correlation, heteroscedasticity, or misspecification, with normally distributed errors. Additionally, the CUSUM and CUSUMSQ plots (Figures 1a & 1b) confirm the model's parameter stability over time.

(a)



(b)

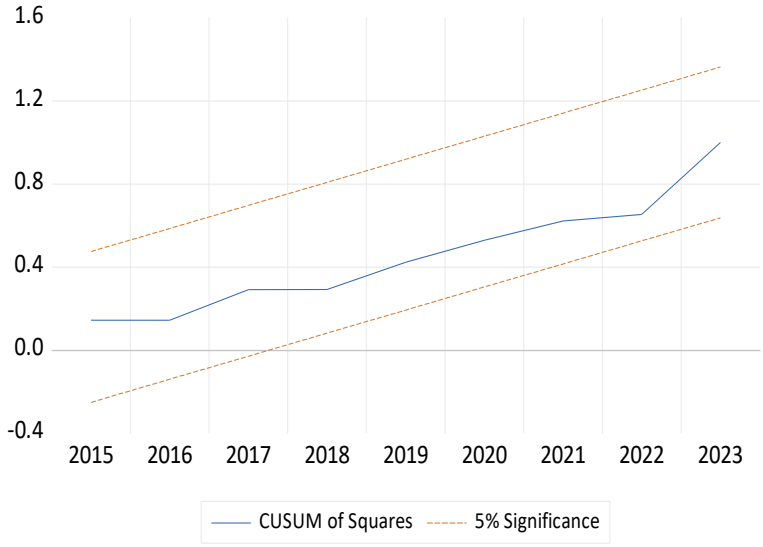


Figure 1. Plots of CUSUM (a) and CUSUMSQ (b)
Source: Authors' computation

CONCLUSION AND RECOMMENDATIONS

This study examines the nonlinear impact of credit supply on economic security in the UAE over the period 1990 to 2023 using the NARDL bounds-testing method. The bounds-testing procedure provides evidence of a cointegrating relationship between economic security and both the positive and negative components of credit supply, alongside control variables. The estimation results demonstrate that the effect of credit supply on economic security is asymmetric. Specifically, while positive adjustments in credit supply have a significant negative long-run effect on economic security, the short-run impacts of both positive and negative adjustments are positive and significant. Overall, the findings suggest that short-term increases in domestic credit supply may enhance economic security by providing immediate liquidity and supporting economic activities. However, prolonged adjustments, regardless of direction, could undermine long-term economic stability. Additionally, the results indicate that lending interest rates, public expenditure, weak institutional quality, and nonperforming loans exert a negative long-run effect on economic security, whereas their short-run effects are positive and significant. In contrast, oil prices contribute positively to economic security. Based on these outcomes, policy recommendations include stricter credit risk management to curb unchecked credit expansion and mitigate rising nonperforming loans. Additionally, reducing reliance on the oil and gas sector is crucial for long-term economic security.

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Probabilistic Risk Analysis for Energy Storage Systems: Application of Gamma Distribution and Event Modeling

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ABSTRACT

The article presents a study of the probabilistic risk assessment for energy storage systems based on the analysis of data on power outages to consumers in St. Petersburg for 2022. The object of the study is power outages resulting in undersupply of electrical energy. The subject of the study is the probabilistic characteristics of risks and methods for their minimization. The aim of the work is to develop approaches to risk management through the use of energy storage systems. The research methodology includes event modeling, approximation of probability distributions using normal and gamma distributions, as well as an assessment of the quantiles of probability prices. The analysis showed a significant impact of scheduled and unscheduled outages on losses from undersupply of electricity. Based on mathematical modeling, probabilistic damage profiles were constructed, average values and quantile indicators for each type of outages were calculated. An economic assessment showed that the integration of energy storage systems can reduce losses by compensating for undersupply of electricity. The paper also substantiates the parameters of the optimal distribution of costs for the implementation of these systems, taking into account the payback period. The obtained results form a theoretical and applied basis for improving the efficiency of energy infrastructure management in large cities.

INTRODUCTION

The relevance of the study is justified by the growing need to improve the sustainability of energy supply in countries with rapidly developing economies, such as Russia, India and China, members of the BRICS group. These countries are experiencing rapid growth in urbanization, increasing energy loads and significant depreciation of energy infrastructure, giving rise to challenges in the field of energy supply management. In megacities, including St. Petersburg in Russia, Mumbai in India and Shanghai in China, power outages lead to economic and social costs, requiring the implementation of technologically sound solutions, such as energy storage systems.

The purpose of the study is to study the probabilistic characteristics of power outages, analyze their risks and assess the applicability of energy storage systems to improve the efficiency of energy supply in megacities.

Research objectives:

- Conducting an analysis of statistical data on power outages using St. Petersburg as a representative metropolis as an example.
- Studying the parameters of using energy storage systems to minimize damage from undersupply of electricity.
- Building probabilistic models for assessing the risks of outages that take into account the specifics of megacities in Russia, India and China.
- Forming approaches to improving the energy infrastructure of the BRICS countries with an emphasis on urbanized areas.
- Developing practical recommendations for the implementation of energy-saving technologies and managing energy supply risks.

The object of the study is power outages in large cities of the BRICS countries. The subject of the study is the probabilistic characteristics of the risks of outages and their impact on the implementation of energy storage systems.

Research methods include event modeling, analysis of probability distributions, economic assessment and building analytical models for quantitative assessment of damage from outages and assessment of the effectiveness of energy storage systems.

The study focuses on St. Petersburg as an example of a megacity where power outages have economic and social consequences. Analysis of statistical data showed that current energy supply management is often limited to the use of diesel generators, which have disadvantages such as noise, harmful emissions and dependence on fuel. The focus of the study is on the integration of innovative solutions into the energy sector of the BRICS countries, which requires the development of a regulatory framework, stimulation of investment in high-tech projects and the construction of analytical tools to assess their effectiveness. The proposed methods contribute to the formation of a sustainable energy infrastructure capable of minimizing the risks of outages and losses from undersupply of electricity in urbanized areas.

2. RESEARCH METHODOLOGY

Energy storage system (ESS) integration and probabilistic energy supply risk analysis are becoming the focus of research, especially in rapidly urbanizing economies such as the BRICS countries. Using probabilistic models to assess energy supply risks allows for multiple factors related to infrastructure instability and forecast uncertainty to be taken into account. Research provides evidence on the application of ESS as tools to improve energy resilience in the face of increased grid loads. These developments demonstrate the potential to minimize losses from outages and improve energy supply efficiency.

Shi et al. proposed a probabilistic planning method for power and energy balance risks based on distributed robust optimization (Shi et al., 2024). This approach addresses the instability and uncertainty issues that arise in power systems with a high share of renewable energy sources (RES). The use of probabilistic indices in this method allows for the quantitative assessment of power and energy balance risks. In the study by Pudela, Dubey, and Bose probabilistic metrics are proposed that are used to assess the

operational resilience of electricity distribution systems to high-severity and low-probability events. Their model-based framework analyzes the resilience performance under different weather scenarios and provides recommendations for planning measures aimed at risk mitigation (Poudel et al., 2019).

Qi et al. proposed a unified model for universal energy storage systems (ESS) that takes into account exogenous and endogenous uncertainties. The probabilistic approach used in this study serves to assess the efficiency of ESS integration into urban power grids, ensuring energy consumption optimization (Qi et al., 2022). This approach takes into account uncertainties in forecasts and proposes solutions that contribute to improving the resilience of power systems.

The work of Zhogova et al. offers a toolkit for assessing the socio-economic situation of municipalities taking into account the impact of power outages on urban areas (Zhogova et al., 2022). In addition, the BRICS Energy Report highlights the relationship between energy infrastructure and socio-economic processes in cities (BRICS Energy Report, 2022). It also highlights the need for synergies between the energy systems of the participating countries, which play a significant role in the global energy system. The report proposes measures to stimulate direct investment, increase the transparency of licensing for exploration and development of energy resources, and enhance technology transfer between countries.

The development of positive energy balance areas, as well as connected urban areas and energy-efficient buildings, is becoming increasingly important in light of modern approaches to energy system management, as shown in the work of Anastasovski et al. (2024). Energy storage plays a special role in ensuring the balance between centralized and distributed energy generation, contributing to increased energy security and stability. Energy storage technologies provide flexible generation and transmission of energy, contributing to the development of a sustainable energy supply network. In addition, their use in modern energy networks allows avoiding peak costs and increases the efficiency of energy supply. Given the growing transition to inexhaustible energy sources, storage technologies are becoming an integral part of the energy system of the future.

For example, forecasting and classifying oil and gas production in the oil and gas industry are complex tasks that require significant computational resources. The reservoir modeling software used is used to predict future production and develop optimal field development plans, but the forecasting process requires tens or hundreds of model runs, making it labor-intensive. To overcome these limitations, machine learning and deep learning methods are used to significantly speed up the forecasting process. As shown in the source by Ibrahim et al., such algorithms adapted for the energy industry can be used not only to manage the performance of oil wells, but also to predict and optimize the operation of energy storage systems, increasing their efficiency and adaptability to changing energy consumption conditions (Ibrahim et al., 2022).

The scientific work by Zaytsev et al. is devoted to the analysis of the economic aspects of green energy development with an emphasis on strategic sustainability and environmental protection (Zaytsev et al., 2022). The study emphasizes the importance of integrating RES into the transition to RES. This approach contributes to the reliability of energy supply in the context of urbanization and the creation of sustainable infrastructure for megacities. The economic aspects under consideration demonstrate the need to develop strategies aimed at optimizing the use of RES and reducing dependence on traditional energy sources. The study by Zhao and analyzes the relationship between the introduction of green energy, economic growth and innovation in OECD countries (Zhao et al., 2024). The work emphasizes the importance of green energy, supported by economic growth and technological innovation, for achieving sustainable development. For the analysis, a random forest regression model was used, which processes nonlinear dependencies and assesses the importance of factors influencing the studied indicators. Statistics for the period 2013–2022 show that green energy adoption, enhanced by economic growth and innovation, has a significant impact on the human development index. This finding supports the need for a systemic approach to integrating green technologies into economic growth and sustainable development strategies.

Wei et al. investigated the impact of renewable energy transition, green growth, technology, and trade on environmental quality in sustainable development countries (Wei et al., 2023). The methodological basis of the study was the Cross-sectional-Augmented Auto Regressive Distributed Lag (CS-ARDL), Augmented Mean Group (AMG), and Common Correlated Effect Mean Group (CCEMG), which allow identifying long-term relationships between variables. The results show that renewable energy consumption and

green technology adoption have a positive effect on environmental performance, while trade liberalization improves environmental quality in the short and long term. The findings support the pollution halo hypothesis and highlight the role of foreign investment in the development of green policies. Ullah et al. analyzed the impact of green investment, energy intensity, and economic complexity on the trade-off between economic growth and environmental degradation (Ullah et al., 2024). Using a panel autoregressive distributed lag model, augmented mean group, and common correlated effects group means, the authors investigated the impact of green investment, energy intensity, and trade liberalization on environmental quality in sustainable development countries. complex dynamics of interactions between economic factors and carbon emissions. The results show that in the early stages of economic growth, increases in GDP and energy intensity lead to an increase in carbon emissions, but in more advanced stages, green investments contribute to their reduction, which confirms the hypothesis of the environmental Kuznets curve. The unidirectional and bidirectional causal relationships revealed by the Dumitrescu-Hurlin method demonstrate systemic interactions between economic growth, energy intensity, and environmental complexity.

The study by Zaytsev et al. assesses the innovative potential of alternative energy in the context of the transition to a circular economy (Zaytsev et al., 2021). ASEs are considered as an element for integrating alternative energy sources and increasing the resilience of energy systems. ASEs provide a balance between the growing demand for energy and the need to reduce the negative impact of traditional energy sources on the environment, contributing to the sustainable development of megacities. Emerging economies characterized by high energy intensity face energy price volatility, which can increase macroeconomic instability and complicate sovereign debt management. The study, which implements a quantile vector autoregressive model based on 2011–2024 data, analyzes the interactions between economic uncertainty, energy risks, and sovereign risk in BRICS countries (Gnagne et al., 2024). The empirical results show that energy risks act as shock transmitters in all countries except Russia and India, where sovereign risks play a more significant role. Risk dynamics reflect the heterogeneity of country profiles, their economic structure, market conditions and energy trade status. Policy decisions should take into account energy, economic and debt factors to ensure macroeconomic stability. For BRICS countries, developing a balanced energy policy focused on the integration of renewable energy sources and financial risk management is the basis for sustainable economic growth, as confirmed in the work M. Draz (Draz et al., 2024). The combination of these approaches strengthens adaptability to crises and reduces the impact of global volatility.

The fundamentals of power system analysis and operation presented in Chapter focus on steady-state, transient and dynamic modes of operation of the power infrastructure (Nucci et al., 2021). Technical aspects related to power system analysis include load flow calculations, short-circuit analysis, frequency control, electromagnetic transient modeling, and transmission system stability. Particular importance is given to distributed generation and smart grids. In the context of a high share of renewable energy sources, which are characterized by variability and intermittency, energy storage systems (ESS) become an important element for stabilizing power systems. Overgeneration problems arising from the mismatch between renewable energy sources and loads highlight the need for standardized approaches to the economic evaluation of ESS, including the levelized cost of storage. A probabilistic approach applied to power system modeling offers an alternative to deterministic methods, which are often insufficient to manage operational uncertainty. The use of data-driven algorithms, as shown in the work of Haugen et al.,in forecasting and optimal power flow (OPF) problems improves risk management (Haugen et al., 2023). The forecasted data serve as a basis for assessing operational instability, power losses, financial costs and waste of renewable energy sources. Neural networks, surpassing traditional machine learning algorithms in accuracy, in combination with linear-quadratic controllers provide a balance between complexity and performance. Probabilistic OPF methods minimize power losses, identify load irregularities and optimize the use of energy resources.

The widespread use of conventional fossil fuels in power and electricity generation poses global environmental and climate challenges. In the context of integrated energy systems operation, taking into account the randomness of distributed generation and load, significant operational risks arise, which was developed in the paper by Y. Li and his colleagues (Y. Li et al., 2022). Probabilistic approaches such as multi-energy flow models are becoming critical to assessing the safety and cost-effectiveness of operation. Such models are based on stochastic methods including cumulant analysis, Cholesky decomposition, and Nataf transform, which allow correlations to be established between random variables. Risk indicators are

developed based on these methods. The study by Mirdanies et al. (2022) analyzed the impact of MNE on reducing the risks of power outages in urban power grids with a high share of renewable generation. The use of the Monte Carlo method allowed analyzing probabilistic scenarios of power supply failures and demonstrated the ability of MNE to ensure continuity of power supply even under extreme conditions. In the work of L. Li et al., an explicit model for battery and hydrogen storage systems (HSS) is constructed, proposing optimal load shedding strategies using a sequential Monte Carlo method (Li et al., 2021). The study confirms that the implementation of HSS reduces the load on the power systems and increases their resilience, which is especially relevant for the BRICS countries, where the implementation of such technologies can minimize the impact of power outages on socio-economic stability.

The study on the relationship between energy consumption and economic growth in the BRICS countries covers the period from 1990 to 2018 (Khobai et al., 2021). The panel data analysis revealed long-term cointegration relationships between the variables under consideration, as well as causal relationships, which were studied using the Granger causality method. The analysis shows a unidirectional relationship from economic growth to energy consumption, which confirms the possibility of implementing energy conservation policies in the BRICS countries without a significant negative impact on economic growth. The results emphasize the need to develop sustainable energy strategies aimed at reducing unnecessary energy losses, especially in the context of ongoing urbanization. The risk assessment of water supply and energy supply in urban areas was carried out in the study using the copula function to analyze the relationship between monthly water and energy consumption for the period from 2011 to 2022 (Goodarzi et al., 2024). The forecast of future needs from 2023 to 2032 is based on the seasonal autoregressive integrated moving average (SARIMA) method and cumulative distribution functions (CDF). Pearson correlation analysis showed a strong relationship between water and energy supply, indicating the importance of an integrated approach to infrastructure management. Data distributions were described by a lognormal function for water supply systems and a gamma distribution for energy supply using the Gumbel Copula function, which minimized the Akaike Information Criterion (AIC). The projected risks of water supply, energy supply and their joint dependence (WEN) show an increasing trend, which creates the need for careful assessment and planning to prevent critical situations in cities.

The issues of import substitution of processors and software in Russia are related to restrictions on external technology supplies, which significantly affects technological independence, which was considered in the study by Kurochkina et al. (2024). The development of digital solutions to overcome dependence on imported technologies is becoming a key area for ensuring the sustainability of energy systems and the implementation of energy storage systems (ESS). The use of domestic processors and specialized software allows maintaining the stability of the energy infrastructure, minimizing dependence on global supplies. This solution strengthens national energy security and creates a basis for the independent development of energy technologies.

3. METHODOLOGY

The study implemented statistical data on power outages to consumers (using the city of St. Petersburg as an example for 2022).

During 2022, 3932 consumers out of 8098 registered power outages. Outages are classified into three main categories:

- Planned outages (P) - necessary for preventive maintenance and equipment upgrades. Their schedule is agreed upon in advance, which minimizes their impact on consumers.
- Emergency outages (E) - occur as a result of equipment failures or network disruptions. These outages are difficult to predict due to many influencing factors, including the technical condition of the infrastructure and external conditions.
- Unscheduled outages (U) - carried out by operational teams or remotely, often as a result of relay protection and automation. They occur when the condition of the equipment creates a high risk of an emergency outage.

An example of reporting documentation on outages in the company Lenenergo (supplying the city of St. Petersburg) is presented in Table 1, which illustrates the main parameters: type of facility, duration of outage, consumer reliability categories and voltage levels.

Table 1. Example of a report on outages in the Lenenergo company in 2022

Data on the fact of termination of transmission of electric energy															
Electricity Transmission Termination Number / Total Line Number	Name of the structural unit of the network organization	Object type: cable power line, overhead power line, overhead cable power lines, substation, transformer substation, distribution substation	Highest voltage class of disconnected equipment of the grid organization, kV	Type of termination of electricity transmission (P, E, U)	Duration of interruption of electric power transmission, hours	Number of points of supply of consumers of the grid organization's services for which there was a power supply interruption, pcs., including:									Total volume of actual load (power) at consumer connections, kW
						TOTAL	in the division of reliability categories of consumers of electric energy			in the division of voltage levels of the consumer electronic control unit of electrical energy				Related grid organizations and producers of electric energy	
							1st category of reliability	2nd category of reliability	3rd category of reliability	HV (110 kV and above)	MV1 (35 kV)	MV2 (6-20 kV)	LV (0.22-1 kV)		
1	2	3	5	8	9	13	14	15	16	17	18	19	20	21	22
1	"Rosseti Lenenergo" Kolpinsky district of electric networks	CPL	6 (6.3)	U	0.7500	0	0	0	2	0	0	2	0	0	200.00000
2	"Rosseti Lenenergo" Resort district of electric networks	CPL	10 (10.5)	U	0.2833	0	0	1	1	0	0	0	2	0	20.00000

Source: own

An analysis of power outage data for 2022 at Lenenergo revealed that out of 8,098 consumers, 3,932 experienced power outages. The classification of outages showed that 1,374 cases were scheduled outages, and 2,558 were unscheduled. No emergency outages were recorded during the year, indicating a relatively high level of technical control. To assess the economic losses from outages, the undersupply of electricity was calculated for each type. The analysis of the data presented in Tables 2 and 3 showed that the number of technological violations (4,107 cases) significantly exceeds the number of recorded outages. This aspect is due to the fact that technological violations cover a wider range of events, including local faults and preventive maintenance.

Table 2. Power outages at Lenenergo in 2022

Type of accident	*Number of accidents per year*	*Number of enterprises*
Planned outages (P)	1 374.00	8098
Emergency outages (E)	0.00	8098
Unscheduled outages (U)	2 558.00	8098

Source: own

Table 3. Cost of outages in Lenenergo in 2022

Summary of emergency shutdowns	*Q1 2022*	*Q2 2022*	*Q3 2022*	*Q4 2022*	*Total*
Number of technological violations, pcs.	993	1042	916	1156	4107
Undersupply of electricity, thousand kWh	145.3	79.9	87.9	144.4	457.5

Source: own

To assess the undersupply of electricity for each type of outage, a calculation method was developed based on the ratio of the total volume of undersupply of electricity to the number of technological disruptions. The calculated indicator is multiplied by the number of outages by types presented in Table 2. The cost of electricity, set at 1 ruble per kWh, made it possible to estimate the economic losses from the undersupply of electricity. For unscheduled outages, an increased tariff is applied (+0.4 rubles), which is associated with a greater load on operational resources and high costs of restoration work.

The data presented in Table 4 indicate that scheduled shutdowns resulted in a shortfall of 151.14 thousand kWh and financial losses of 151,140 rubles. Unscheduled shutdowns were more costly – 281.38 thousand kWh and 383,700 rubles, respectively. This difference emphasizes the need to develop management strategies to minimize economic damage.

Table 4. Summary table of outage and cost data

Number of technological violations, pcs.	*4107*
Undersupply of electricity, thousand kWh	457.5
Undersupply of electricity per one scheduled outage, thousand kWh	0.110
Undersupply of electricity per one unscheduled outage, thousand kWh	0.150
Number of scheduled outages	1374
Number of unscheduled outages	2558
Undersupply of electricity due to scheduled outages, thousand kWh	151.14
Undersupply of electricity due to unscheduled outages, thousand kWh	281.38
Amount of lost profit due to scheduled outages, rubles	151140
Amount of lost profit due to unscheduled outages, rubles	383700

Source:own

The risk profile analysis presented in Table 5 shows that unscheduled outages require more attention, as they are the most costly. The introduction of energy storage systems (ESS) can significantly reduce the likelihood and consequences of unscheduled events. ESSs allow reducing the load on the network by providing backup power in the event of unforeseen outages. Considering that the number of emergency outages is zero, it was decided to exclude these types of outages as not affecting the analysis. Based on the above statistical data, the risk profile presented in Table 5 was compiled.

Table 5. Risk profile obtained for 2022 for outages in Lenenergo

Type of shutdown	*Number of shutdowns per year, pcs.*	*Number of substations, pcs.*	*Total amount of damage, rubles*
P-Planned shutdown	1 374.00	8098	151 140.00
U-Unscheduled shutdown	2 558.00	8098	383 700.00

Source: own

Strategic planning in the BRICS countries should include:

- Integrating outage forecasting methods using probabilistic models and machine learning technologies.
- Developing grid modernization programs taking into account local characteristics and risks.
- Optimizing tariff policies to stimulate investment in grid reliability.

The energy infrastructure of the BRICS countries faces increasing challenges associated with the intensive growth of energy consumption, urbanization, and the need to integrate renewable energy sources. Analysis of power outage data, as in the case of St. Petersburg, provides tools for assessing the vulnerability of energy systems, as well as developing strategies to improve their resilience.

For Russia, the results of the analysis allow identifying the most vulnerable links in the energy infrastructure, providing a basis for grid modernization programs and the introduction of backup energy systems. India, with its rapid growth of renewable energy, can adapt the proposed methods to reduce the impact of unscheduled outages on megacities such as Delhi and Mumbai. China, as the largest electricity producer, can use these approaches to manage loads in megacities and reduce economic losses caused by grid overloads. South Africa and Brazil can use these tools to adapt infrastructure to growing challenges, including eliminating the economic consequences of outages. The use of SES in the BRICS countries is becoming a strategic direction that can minimize losses from undersupply, increase grid stability and strengthen energy security. Risk profile analysis and development of management decisions based on statistical data ensure resource allocation and investment planning.

4. RESULTS & DISCUSSION

4.1 Probabilistic structure of the risk portfolio

To perform event modeling in Python, it is necessary to first define the probabilistic structure of the risk portfolio. Analysis of power outage events requires the use of a probabilistic approach based on modeling the frequency and severity of each event. These indicators, when multiplied by each other, form a probabilistic estimate of the cost of an outage. For the analysis, a simulation of one million events was carried out using a normal probability distribution. A variance equal to 50% of the mathematical expectation characterizes the acceptable level of price deviation.

The results of the modeling are presented in Table 6. They show probabilistic prices for scheduled and unscheduled outages, as well as the corresponding quantile values for 99% and 95% of cases.

Table 6. Probability structure of the risk portfolio

Type of shutdown	*The likely cost of shutdown*	*99 quantile probability*	*95 quantile probability*	*Probability of exceeding average severity*	*Probability of exceeding half of average damage*
P-Planned shutdown	18,67	196,19	139,87	8 %	17 %
U-Unscheduled shutdown	47,34	288,66	225,10	16 %	31 %

Source: own

The data visualization is presented in Figure 1 in the form of histograms of probable outage prices for different types of events.

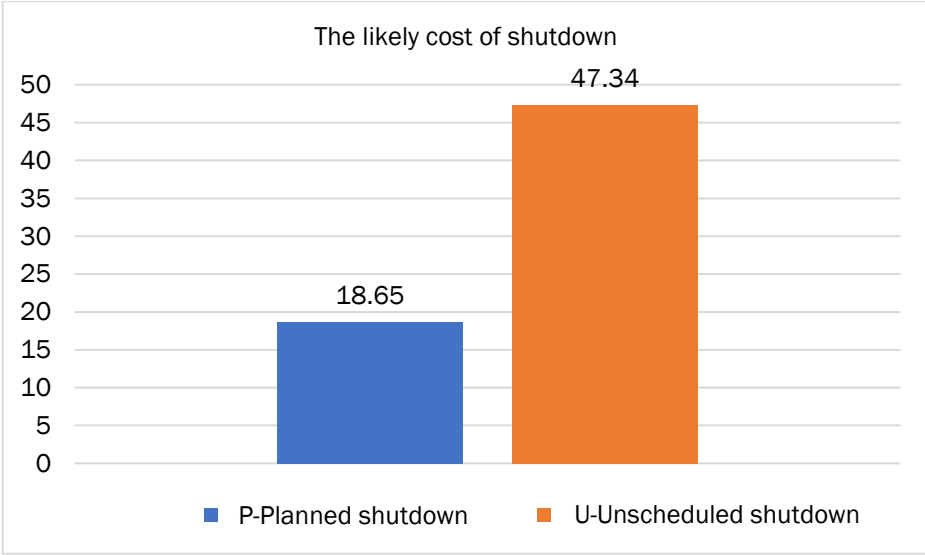

Figure 1. Probable cost of shutdown
Source: own

The graph shows that unscheduled outages are more expensive than scheduled ones, which is confirmed by the probability quantile parameters. Figure 2 shows the 99th quantile, which reflects the maximum possible price in 99% of cases.

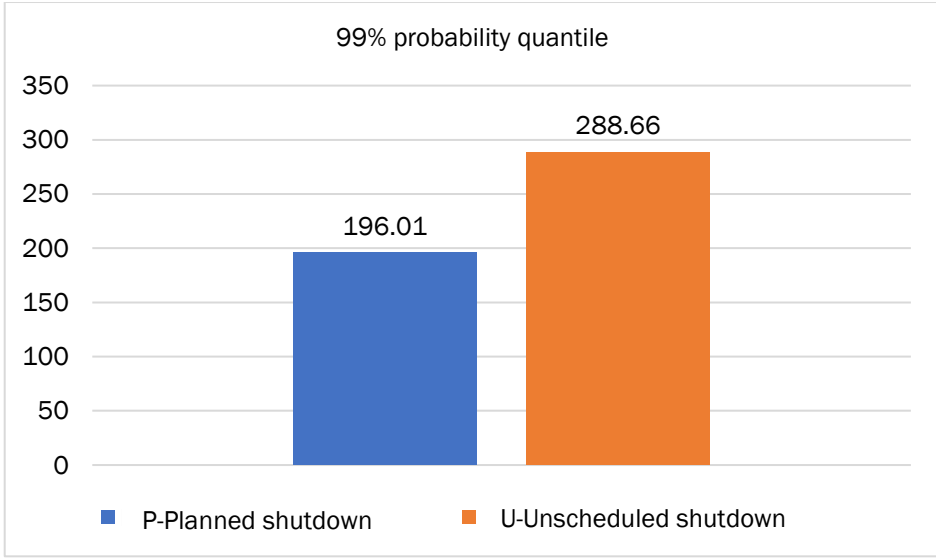

Figure 2. 99th probability quantile
Source. own

The analysis showed that the cost of unscheduled outages is significantly higher than the cost of planned outages, which is confirmed by the data presented in the probability price graphs. The analysis of the 95th probability quantile, visualized in Figure 3, shows that the maximum probable cost of unscheduled outages exceeds the cost of planned outages, reflecting the same pattern as when considering the 99th probability quantile. Such a stable trend indicates the need for special attention to the management of unscheduled events, since their financial consequences are the most significant.

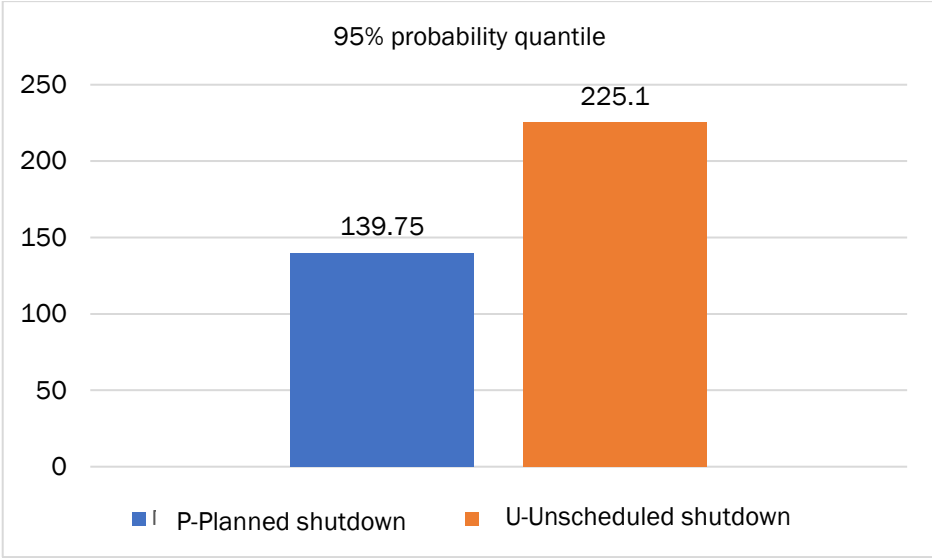

Figure 3. 95th probability quantile
Source: own

The correlation of probable costs of outages and their probability quantiles allows us to formulate several conclusions:

- All types of outages require management, since neglecting any of them can lead to significant financial and operational losses.
- Unscheduled outages are characterized by the highest probable cost and a high value of the 99th probability quantile, which requires the development and implementation of compensatory measures aimed at minimizing the consequences of such events.
- Despite the fact that the cost of planned outages is lower, their probability is also quite high, which dictates the need to plan and minimize their impact.

Figure 4 presents data on the probability of exceeding the average damage and half the average damage for different types of outages.

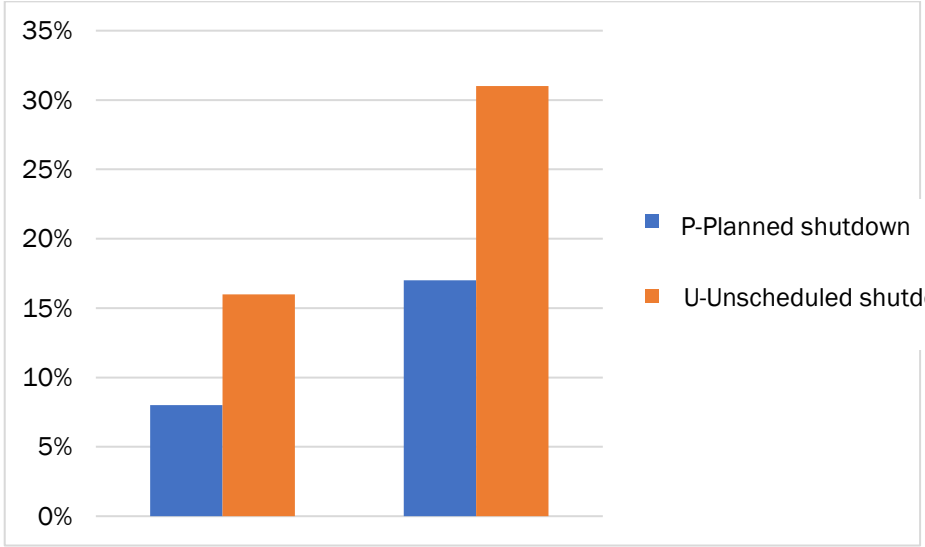

Figure 4. Probability of exceeding the average damage and half of the average damage
Source: own

The analysis of the probability of exceeding the average damage confirms that unscheduled outages demonstrate a high level of uncertainty: the probability of exceeding the average damage is 31%. This indicates a significant spread of possible prices and the need to suppress this type of event.

Event classification and strategic recommendations. Based on the analysis, two types of events were identified:

- Suppressed events: unscheduled outages that require minimization through the introduction of compensating mechanisms and increased control over operational processes.
- Controlled events: planned outages for which effective planning can significantly reduce their negative impact.

To reduce risks and minimize damage, it is recommended to:

- Develop risk management strategies based on probabilistic analysis of events and cost assessment.
- Invest in outage forecasting and prevention technologies, including energy storage systems.
- Develop adaptive network management mechanisms aimed at reducing the impact of both unscheduled and planned outages.

The proposed measures are particularly relevant for the BRICS countries, where complex energy systems and a high degree of urbanization require the implementation of innovative solutions to ensure stable energy supply.

4.2 Approximation by normal distribution

To estimate the probability distribution of the cost of events, the obtained data was approximated by a normal distribution function described by the formula:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

μ is the mathematical expectation, which coincides with the median and mode of the distribution; σ is the standard deviation, which determines the width of the distribution.

This approach allows systematizing the array of probable prices of events (severities), adjusted for the frequency of their occurrence. Approximation is an attempt to reflect the patterns of data distribution and identify the degree of their compliance with the theoretical model. Figure 5 shows a visualization of the approximation of the array of probable prices by a normal distribution.

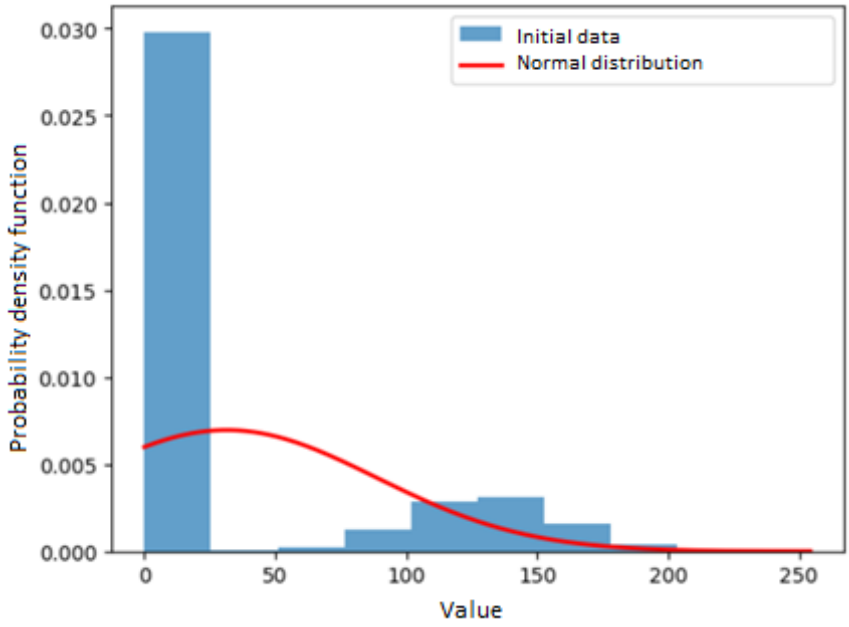

Figure 5. Approximation of the probable price by a normal distribution
Source: own

The approximation analysis is performed using the determination coefficient (R^2), which evaluates the degree of compliance of the model with the empirical data. In the case under consideration, the determination coefficient is $R^2 \approx 0{,}52$. This aspect indicates an average level of accuracy of the model and suggests that the events have a high degree of individuality. Thus, the approximated function only partially reflects the general patterns and trends in the data array.

Interpretation of results:

- The determination coefficient value within R2 ≈0,52 indicates a moderate compliance of the data with the theoretical model (explained by the significant variability of events, which makes them difficult to predict).
- Low approximation accuracy demonstrates the need to consider individual events at the individual level, especially for high-severity events, such as unscheduled outages.
- Normal distribution approximation can be used to obtain preliminary estimates, but for more accurate modeling, it is recommended to involve additional parameters that take into account asymmetry and outliers. The normal distribution is a useful tool for analyzing the structure of probable prices of events and identifying underlying patterns in the distribution of data. However, in conditions of increased uniqueness of events, such as power outages, this approximation method has limitations. The results of the analysis confirm the need to develop adaptive probability models that include stochastic and nonlinear dependencies to improve the accuracy of the forecast.

4.3 Gamma distribution approximation

To analyze the probability structure of the outage cost, an approximation using the gamma distribution was used. The probability density function of the gamma distribution is defined as follows:

$$f(x,a) = \frac{x^{a-1}e^{-x}}{G(a)}$$

for $x \geq 0, a > 0$. Here $G(a)$ refers to the gamma function. Gamma takes a as a shape parameter.

In order to effectively select the shift coefficient of the function, an iterative algorithm in Python is used. This algorithm determines at what shift value the function becomes most predictable. That is, it selects the value of a at which the gamma function describes the generated array in the best way.

As a result of the algorithm implementation, it turned out that the determination coefficient behaves non-uniformly. Moreover, at certain values of a, the dispersion increases significantly, while at others, calm sets in, i.e., there are convergence periods. Moving averages are used to correctly identify these periods. The idea of the moving average is to take the average value for a certain number of previous periods to get a "moving average" for this period. A window of 15 values was chosen to calculate the moving averages.

Figure 6 shows an approximation of the probable price of events using the gamma distribution.

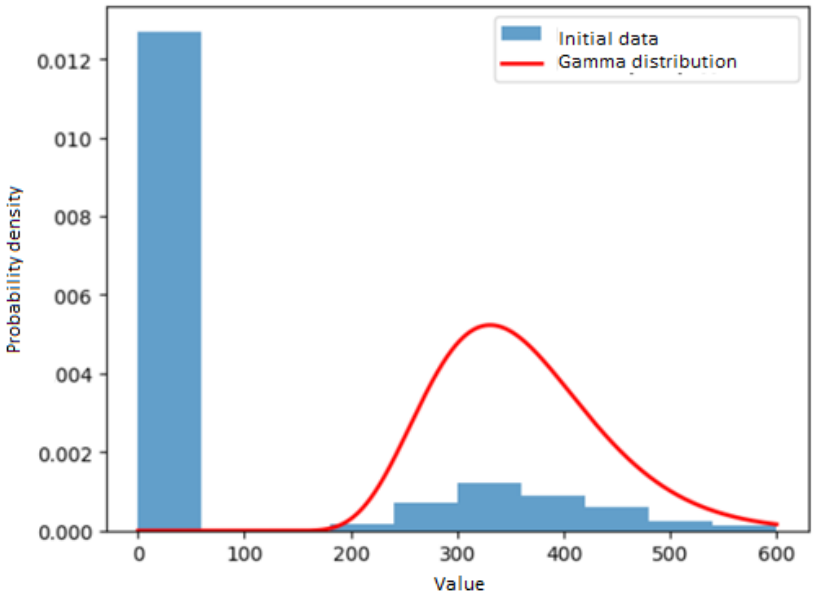

Figure 6. Approximation of the probable price by the gamma distribution
Source: own

Features of the model:

- Localization of marginal values. The gamma distribution effectively describes data areas corresponding to high-cost outages and is less suitable for analyzing periods characterized by a low event frequency, which is due to the features of the function focused on values with non-zero damage severity.
- Low event frequency. It was found that periods when there are no outages occupy a significant part of the time. However, when they occur, there is a high cost, which confirms the need to focus on compensating for marginal losses.
- Analysis of outliers. The model demonstrates that the cost of the most significant outages is subject to high variability, which is determined by the parameter a. In such conditions, the gamma approximation method shows high accuracy in describing the severity distribution of the events that occurred.

The gamma distribution is an effective tool for analyzing the cost of outages, especially in the case of high-cost events. The main focus should be on managing marginal losses and minimizing their consequences. At the same time, for events with zero damage severity, which are not taken into account in the model, it is advisable to develop additional approaches. The use of the gamma function confirms the possibility of accurately assessing risks in the energy infrastructure and allows adapting management methods to improve the reliability of energy supply.

4.4 Applying the gamma distribution to each group of violations

For an in-depth analysis of the characteristics of various types of outages, including scheduled and unscheduled ones, we calculated data arrays generated based on the gamma distribution. The approximation process included selecting the parameter a (shape parameter) so that the gamma function best described the distribution of probable event prices. Based on the calculations, we obtained the alpha parameter values and constructed the corresponding approximation graphs for each group of violations.

Figure 7 illustrates changes in the alpha parameter, where a pattern is observed: as the parameter a increases, the distribution shifts to the right, indicating an increase in the average cost of events.

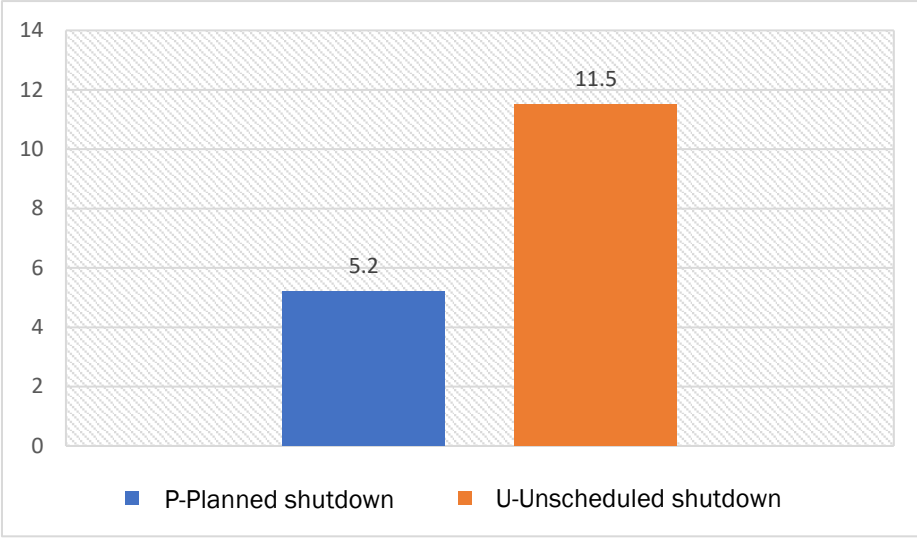

Figure 7. Alpha parameter

Figure 8 presents a gamma distribution fit for planned outages. The data demonstrates relatively low variance and high predictability, indicating a systematic nature of these events. The low variance confirms the presence of careful planning and risk minimization associated with this type of outage.

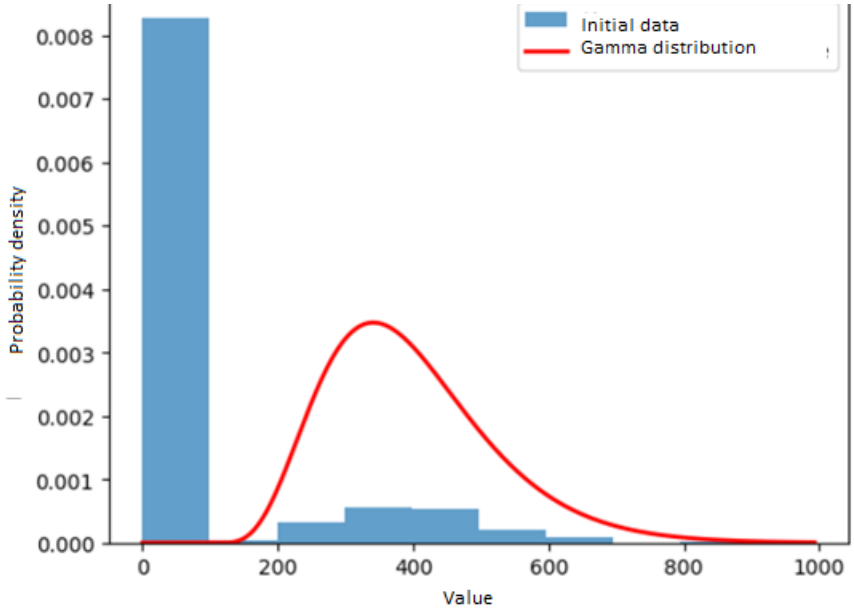

Figure 8. Gamma distribution fit for planned outages

Figure 9 shows the approximation for unscheduled outages, where a significant shift in the distribution is observed. The high values of dispersion confirm the instability of this type of outages and the need for additional control measures. The analysis shows that the average price and the maximum damage values for unscheduled outages are significantly higher than for planned ones.

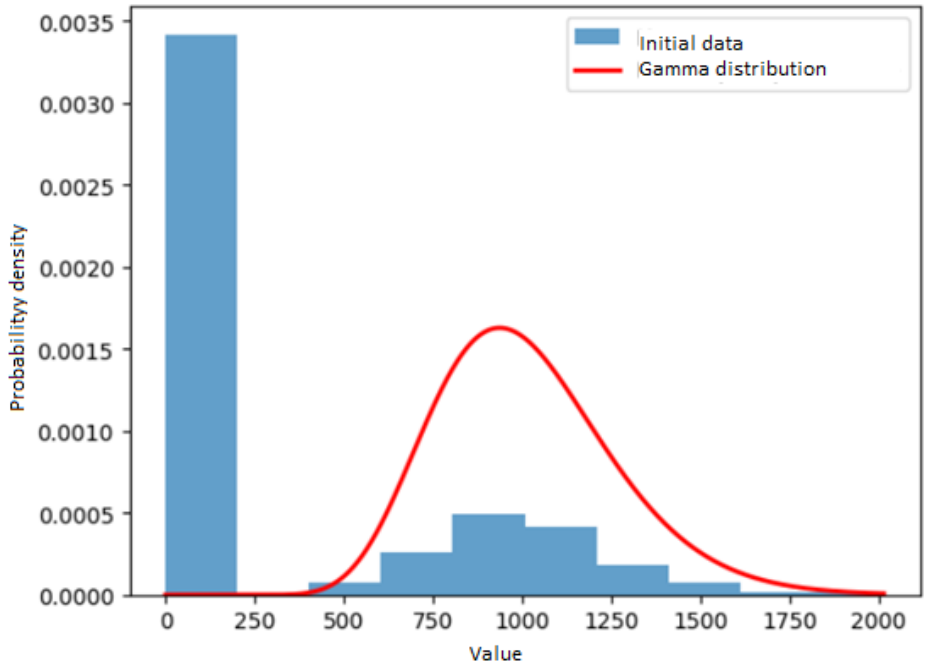

Figure 9. Gamma distribution approximation for unscheduled outages

Comparative analysis:

- Shape parameter (a). Scheduled outages have a higher a value, indicating their stability and predictability. For unscheduled outages, a low a value reflects a high degree of uncertainty and randomness.
- Probability quantiles. The values of the probable price, the 99th and 95th probability quantiles calculated for both types of outages coincide with the simulated values, confirming the reliability of the selected model.
- The shift in distributions for unscheduled outages is significantly greater, indicating higher risks associated with these events. In turn, the distribution of scheduled outages is characterized by smaller fluctuations.

Applying the gamma distribution to the cost analysis of different types of outages confirms that scheduled outages are systemic in nature, while unscheduled outages require close attention due to their high cost and uncertainty. Taking into account the parameter a and building accurate approximation models is an important step in developing effective power system management strategies, especially in the context of complex infrastructure and limited resources. The results presented in the graphs indicate the need for differentiated approaches to managing outage risks.

CONCLUSION

Conclusions from the Python Analysis

The analysis performed using Python methods demonstrated that both types of outages under study - scheduled and unscheduled - are high cost and require a strategic approach to management. Consideration of the probabilistic structure of the outage costs, as well as analysis of the 99th and 95th probability quantiles, allowed us to identify key patterns in the risks associated with these events.

Key findings:

- Analysis of the probable cost of events. The graph of the probable cost of events (Figure 1) showed that both types of outages are costly. Scheduled outages have a more predictable cost, while unscheduled ones are characterized by a higher price spread.

- The ratio of the probable cost to the 99th quantile (Figure 2). Unscheduled outages have the highest values of both the probable cost and the 99th quantile, which indicates the need to develop compensation and management measures aimed at reducing the frequency and consequences of such outages. Planned outages, despite their lower cost compared to unscheduled ones, still require systematic management. Their high 99th quantile indicates that they can only be eliminated with careful planning and modernization of the network infrastructure.
- Event typification. Containable events - unscheduled outages are included in this category, since their high cost and uncertainty require special attention. Controllable events – planned outages can be classified in this category, as they are characterized by high predictability and can be systematically minimized by improving the efficiency of planning and preventive maintenance processes.
- Necessity of control and compensation measures. Unscheduled outages require the implementation of measures aimed at reducing their frequency, which may include the installation of monitoring systems, the introduction of energy storage systems and the use of predictive models to minimize the likelihood of these events. For planned outages, it is necessary to strengthen the processes of optimizing the schedules of preventive maintenance and equipment modernization.

The conducted analysis emphasizes the need for a differentiated approach to managing different types of outages. Unscheduled outages, due to their high cost and uncertainty, require special attention. At the same time, planned outages, although less expensive, should be included in strategic plans for the modernization of energy infrastructure. The presented results form the basis for the development of management decisions aimed at reducing economic losses and increasing the reliability of energy systems.

Interpretation of Results for Energy Storage Systems

An analysis of the probabilistic characteristics of outages showed that it is impossible to completely eliminate the probability of power outages, as this requires significant investments in upgrading the infrastructure and increasing the reliability of equipment. This approach is not economically feasible due to the high cost of implementing modern solutions with minimal payback. Instead, it is advisable to focus on the ESS as an alternative for managing the consequences of outages and reducing damage from undersupplied electricity.

A. The problem of equipment reliability:

- In the process of designing electrical equipment, a certain level of reliability is established, which assumes the possibility of failures in a limited percentage of cases. For example, overhead power lines are designed to withstand the effects of medium-intensity lightning, but can be disconnected when directly hit by high-intensity lightning.
- The economic logic of this approach is that the losses from undersupplied electricity are less than the costs of building more reliable systems.

B. The role of energy storage systems:

- The SES provide an alternative solution to the problem, ensuring the possibility of temporary backup power supply during a main grid outage, which helps minimize losses without requiring capital investments in global modernization of power systems.
- For unscheduled outages, the SES can be used to completely eliminate their consequences. In this case, investments in such systems should be justified by calculations demonstrating that the costs of their installation and operation will be lower than the economic damage from outages during the payback period.

C. Approach to planned outages:

- For planned outages that are known in advance, the SES allow for temporary power supply, minimizing economic damage.
- Since the outage schedule is known, the company can optimize the logistics and use of the SES, determining their capacity and placement depending on the needs of specific consumers.
- Planning the installation of the SES for such outages helps achieve a balance between the costs of purchasing and installing equipment and losses from lost electricity supply.

D. Economic feasibility of implementing SES:

- Investment costs for the purchase and operation of SES should be calculated in such a way that their payback is achievable within a reasonable time frame.
- Particular attention should be paid to optimizing the capacity of storage devices and their number. For unscheduled outages, it is advisable to implement backup systems in the most vulnerable areas, and for planned outages, to use mobile energy storage devices that can be distributed according to a schedule.

SES are an effective tool for managing the consequences of outages, minimizing losses and increasing the flexibility of energy systems. Their integration is especially relevant for countries with a high load on energy networks, such as the BRICS countries, where urbanization and economic growth increase the risks of infrastructure overload. The use of SES helps to reduce damage from outages and create a sustainable energy system adapted to local characteristics and needs.

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Analyzing the Impact of FDI, Government Debt, and Economic Indicators on Renewable Energy Development

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Nordic European countries

ABSTRACT

The current research examines the effect of FDI, government debt (GD), and economic indices (GDP, INF, and GNI) on the consumption of renewable energy in Nordic European nations between 1993 and 2022. Data was collected from reputable databases, such as World Bank Open Data (WBOD), and Our World in Data (OWD). Using the ARDL method, the findings demonstrate that FDI has a short-term but positive influence on renewable energy consumption. In contrast, GD has a favorable and significant influence on green energy in the long term, suggesting that increasing GD is associated with greater consumption of renewable energy. There is also a large and continuous positive effect of economic development measures (GDP, INF, and GNI) on renewable energy consumption. GNI stands out as the most significant of these. To promote sustainable growth, policy implications emphasize the necessity of efforts that enhance economic development and maximize energy tax laws. Furthermore, it is crucial to increase investors' and individuals' ability to embrace renewable energy technologies. These results expand the existing literature on sustainable energy transitions and could be useful in other developed economies with comparable circumstances. It is recommended that future studies examine the connections between macroeconomic variables and renewable energy in various economies, paying special attention to exchange rate effects and income levels.

INTRODUCTION

In response to changes in the climate, the entire globe is experiencing environmental problems. This becomes a central issue for governments, economists, activists for the environment, and policymakers globally (Przychodzen and Przychodzen, 2020). The growth of economies throughout the world characterized by fast modernization and population expansion, has fueled an increase in energy demand. Over the years, humanity has relied heavily on fossil fuels to satisfy its needs, which is the primary factor contributing to rising carbon dioxide (CO2) levels (Samour et al., 2023). This brings global warming and, consequently, accelerating changes in the environment. To reduce the detrimental effects of conventional energy

sources that use fossil fuels on the environment, moving to greener and more sustainable energy sources is vital. The use of renewable power, which includes wind, hydropower, and solar, provides a replacement for fossil fuels to significantly lower greenhouse gas emissions and adapts to a more ecologically and sound economy (Ali and Seraj, 2022; García-Álvarez et al., 2016). However, by 2050, green sources of energy might provide up to half of the global energy requirements, and therefore searching for sustainable energy is an important goal (Krewitt et al., 2007).

Moreover, a potential future transition to a sustainable economy requires the switch from traditional sources of energy to renewable power sources (Jiang et al., 2018; Karim et al., 2023). Environmental protection, exploiting resources, welfare in society, and sustainability all depend heavily on energy production and consumption, which guarantees that these processes of change appear at both political and social levels (Aguirre and Ibikunle, 2014). Yu et al. (2023) also argue that utilizing renewable energy sources that avoid to use of natural resources benefits both the environment and the economy. According to Rahman et al. (2017) greenhouse gases have dropped due to using biofuels and clean energy. Recent investigations have demonstrated the strong and detrimental connection between alternative energy sources and environmental risks, and they have also identified the most effective ways to adopt sustainability practices (Islam et al., 2022; Samour et al., 2023). Hence, Governments, policymakers, and regulators need to swiftly convert from the current power system to a more practical one. By transforming their energy infrastructure, developed countries are leading the way in a more sustainable economic path.

There are some elements that significantly influence the adoption of environmentally friendly sources. These factors include FDI, government debt, and some economic parameters. FDI serves as critical for transferring knowledge, technology, creativity, and financing renewable energy plans, particularly in nations with low levels of national capital investment (Samour et al., 2023). In addition, debt from the government may have a significant effect on a nation's ability to make investments in long-term initiatives including infrastructure for making green energy and its affordability (Qamruzzaman, 2022). From this perspective, Auteri et al. (2024) government participation in outside funding, particularly through debt financing, may be a viable alternative for implementing sustainability or renewable energy goals. On the contrary, if the debt levels are high, national economies may suffer because of the related expenses. Investment also could decline due to high debt levels that cause higher spending (Karim et al., 2023; Böcskei and Hágen, 2017). Economic factors such as GDP, inflation, and Gross National Income (GNI) provide valuable information about how economic development and stability affect countries' capacity and desire to seek renewable energy sources (Deka et al., 2022; Tudor and Sova, 2021; Wei et al., 2022).

Prior research examined the connection between FDI and renewable sources (Karim et al., 2023; Wei et al., 2022), and few between governmental debt and renewable energy (Auteri et al., 2024; Karim et al., 2023), and also between economic development and adoption of clean energy (Tudor and Sova, 2021). However, no study has been found to investigate the impact of these factors together on adopting renewable energy sources. Additionally, studies to explore the above connection among the Nordic European countries are exceedingly rare. Therefore, an empirical investigation needs to be conducted in Nordic countries to determine how FDI, government debt, and economic indicators affect clean energy sources. Moreover, the Nordic nations have been historically innovators in alternative energy sources and sustainable growth. It is critical for these countries to comprehend the complicated relationships of governmental funds, FDI, and economic parameters on the adoption of green energy. In order to maximize utilization of resources, drive sustainable investment, and facilitate the shift to green energy, such studies can help and guide decisions about a low-carbon economy. Hence, this research can be used as a framework by other countries interested in finding a balance between sustainable development or sustainable environment and economic expansion.

1. LITERATURE REVIEW

1.1 FDI and renewable energy

Foreign direct investment (FDI) is a stream that has historically been connected to the movement of technology, managerial methods, and expertise from home nations to their destination nations and become a multinational corporation. According to Abdouli and Hammami (2017) FDI is considered to be

crucial for boosting financial stability because of its positive impact on economic expansion and the preservation of the environment. Although FDI offers investors savings, accessibility to markets, and diversity, it also carries hazards, such as regulatory difficulties and political unpredictability. Moreover, when host nations benefit from increased capital, employment, and technology, they may also experience economic reliance, profit outflows, and foreign companies' dominance of the market (Lu et al., 2020; Fazekas and Becsky-Nagy, 2015).

There have been conflicting results from studies on the link between FDI and utilization of energy. For instance, Doytch and Narayan (2016) collected data from 74 countries around the world for a prolonged period from 1985-2012 and found that FDI serves to reduce non-renewable energy consumption. Likewise, Fan and Hao (2020); Rezagholizadeh et al. (2020) explored the effect of FDI on energy consumption and they demonstrated that FDI has a considerable influence on sustainable development and energy from renewable sources. However, some other investigations have reported an opposite relationship between FDI and the installation of sustainable energy. From this point of view, Sbia et al. (2014) investigated the relationship between the use of energy, economic progress, FDI, and greenhouse gases using data from the United Arab Emirates between 1975-2011. Their results display that energy consumption is reduced by both FDI and carbon emissions. Tariq et al. (2023) illustrated that FDI hindered the use of clean energy in the short run. However, Sadorsky (2010) used a GMM technique to examine how FDI and equity market growth influence the consumption of energy in a group of 22 developing nations. The author finds no evidence of the connection between FDI and energy demand while demonstrating a strong and favorable correlation between energy use and the growth of the stock market.

1.2 Government debt and renewable energy

The effect of public debt on the low-carbon economy or green energy is a complicated and often contentious topic. There have been conflicting findings in the scientific community about the effect of government debt on the adoption of green energy. Research by Auteri et al. (2024) argues that the efforts at the national level to implement and advance green power can be financed in part by government loan. Nonetheless, since government debt is linked to rising payment commitments, Sun and Liu (2020) believe that it serves as an obstacle to green energy. Moreover, focusing on 20 developing economies and collecting data from 1990-2016, Hashemizadeh et al. (2021) found that government debt positively influences the adoption of renewable energy. Similarly, Qamruzzaman (2022) applied data from 1990-2020 and showed that there is an asymmetric link between government debt and renewable energy power. More recent studies by Auteri et al. (2024) examined data from 1990-2021 for G7 countries and illustrated that increasing debt levels can make it more difficult to make investments in infrastructure for green power, while more renewable energy can improve the dynamics of public debt.

Another quest is made by Florea et al. (2021) to explore how state budgets affect renewable energy consumption. They utilize two financial metrics (budget deficit and government borrowing) to analyze 11 nations in the European Union. Based on their findings, renewable energy consumption is positively altered by both public financing strategies. However, Katırcıoğlu and Çelebi (2018) assert that using foreign debt to finance economic expansion and consumption of energy can worsen the environmental harm.

1.3 Economic indicators and renewable energy

Sustainable development is affected by economic patterns through an increase in GDP, inflation control, human development, and stock market improvement. Sustainable development is impacted by economic intermediation through the business cycle, demand curve, buyer influence, and stock exchange effect. Several investigations examined the connection between economic progress and renewable energy demand by employing multiple types of econometric techniques, but the findings remain inconsistent. Çoban and Topcu (2013) reached the conclusion that economic expansion significantly benefits energy consumption. In a further investigation, Islam et al. (2013) examined the effect of financial development. Their findings demonstrated that sustainable energy demand is favorably influenced by economic development in Malaysia. In a similar context, Inglesi-Lotz (2016) used a sample of 34 countries that were members of the OECD from 1990 to 2010, and the findings indicated that renewable sources of energy are positively impacted by economic expansion.

Furthermore, Ullah et al. (2024) discovered how the utilization of hydroelectric power affects economic growth. The findings showed that hydropower significantly affects financial development and economic expansion. In contrast to the above argument, Tiwari et al. (2022) studied how economic growth affected Asian nations' use of renewable energy. Their findings concluded that the quantity of economic development is negatively related to the utilization of clean energy. However, Ozturk et al. (2010) claimed that there is no meaningful relationship between energy demand and economic prosperity.

2. METHODOLOGY

2.1 Data

The data in this investigation is gathered primarily from reputable databases, such as World Bank Open Data (WBOD), and Our World in Data (OWD). Five Nordic nations (Denmark, Finland, Iceland, Norway, and Sweden) constitute the study sample. The study period, which runs from 1993 to 2022, includes a time when these countries experienced substantial changes in their energy and economic policies. Since this study examines the effect of FDI, government debt, and economic indicators on renewable energy, the dependent (explained) variable is renewable energy. Moreover, FDI, government debt, and economic indicators work as independent (explanatory) variables. Table 1 shows the definition of the study variables.

Table 1. Data summary

Variable	*Status*	*Notation*	*Unit*	*Source*
Renewable energy consumption	Dependent	RenCo	kWh, per capita	OWD
Foreign direct consumption	Independent	FDI	Net inflows (% of GDP)	WBOD
Government debt	Independent	GD	Central government debt, total (% of GDP)	WBOD
Economic indicator: Gross domestic product	Independent	GDP	GDP growth (annual %)	WBOD
Inflation	Independent	INF	Inflation, consumer prices (annual %)	WBOD
Gross national income	Independent	GNI	GNI per capita	OWD

Source: Own elaboration

2.2 Method and model

In this investigation, secondary data at the country level released by reputable databases, such as WBOD and OWD is analyzed quantitatively. Exploring the suggested link is performed using an explanatory research design. The study focuses on both short-term and long-term relationships after illustrating the cointegration test between the variables. To achieve this objective, Autoregressive distributed lagged (ARDL) is applied in this study. The method was initially proposed by (Pesaran et al., 1999) and they determined both short and long-run values in empirical evaluation. According to Tariq et al. (2023) ARDL approach has the benefit of producing an accurate figure despite the size of the sample, which sets it apart from normal cointegration testing. Banerjee et al. (1993) also noted that a dynamic error correction model can be obtained from the ARDL by performing an ordinary linear conversion. These attributes make the ARDL method frequently utilized by previous investigations (Qamruzzaman, 2022; Samour et al., 2023; Tariq et al., 2023; Wei et al., 2022). Based on the above arguments, this study will apply the ARDL method and the equation was formulated as follows:

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i Y_{t-i} + \sum_{j=0}^{q} \gamma_j X_{t-j} + \epsilon_t$$

Where, Y_t represent the dependent (explained) variable; Y_{t-i} denotes lagged values of the dependent variable (considered as independent variables); X_{t-j} is the independent (explanatory) variables, both present and lagged value; α is constant; β_i, γ_j represents coefficients of lagged dependent and independent

variables; ϵ_t is the standard error. Considering the variable definitions provided in table 1, the dynamic model appears as follows.

$$RenCo_t = \alpha + \sum_{i=1}^{p} \beta_i RenCo_{t-i} + \sum_{j=0}^{q_1} \gamma_j FDI_{t-j} + \sum_{j=0}^{q_2} \gamma_j GD_{t-j} + \sum_{j=0}^{q_3} \gamma_j GDP_{t-j} + \sum_{j=0}^{q_4} \gamma_j INFL_{t-j} + \sum_{j=0}^{q_5} \gamma_j GNI_{t-j} + \epsilon_t$$

3. RESULTS AND DISCUSSION

3.1 Statistical overview

Table 2 shows the overall information on the parameters we employ in this investigation, including mean, range, and standard deviation. The mean value of RenCo is considerably high at 10.19, with a deviation of 1.18 for the sample of Nordic countries. This illustrates how strongly the region is committed to energy from renewable sources. The lowest and highest values of RenCo are 6.92, and 11.92, respectively. The mean values of FDI and GD are 3.19, and 55.47 with a standard deviation of 5.59, and 27.43, respectively. The minimum and maximum values of FDI are -28.30 and 31.73 respectively, while the lowest and highest values of GD are 18.53, and 156.09, respectively. The range and standard deviation show that over the sample period, there were both incredibly high and low investment activities. The mean value of FDI indicates large inflows during times. The arithmetic values of the GDP and INF are relatively low, which are 2.34 and 2.30 respectively with a deviation of 2.72 and 2.02. Additionally, the mean value of GNI is 10.77 with a low standard deviation of 0.20. The minimum and highest values of GNI are 10.23 and 11,14, respectively. Overall, the statistical results show that, despite their common dedication to financial stability and consumption of renewable energy, the Nordic nations exhibit notable variation in key economic metrics, which reflects various fiscal strategies and regional growth trends.

Table 2. Summary Statistics

	RenCo	*FDI*	*GD*	*GDP*	*INF*	*GNI*
Mean	10.193	3.191	55.471	2.346	2.303	10.774
Std. Dev.	1.188	5.594	27.431	2.726	2.023	0.203
Minimum	6.922	-28.307	18.532	-8.074	-0.494	10.233
Maximum	11.929	31.738	156.092	8.881	12.694	11.144
Obs.	150	150	150	150	150	150

Source: Author's computation using EViews

Moreover, according to Hágen and Ahmed (2024) the residuals are typically assumed to be normal in regression analysis. Table 3 shows the normality test based on the Jarque-Bera test and the result displays that the p-value is significantly above the 5% level, implying that the data in this study exhibit normal distribution.

Table 3. Test of normality

Groups	*Type of test*	*Chi-Square*	*Probability*
All countries	Jarque-Bera	0.838	0.657

Source: Author's computation using EViews

3.2 Pearson correlation

The correlation matrix presented in table 4, gives an in-depth comprehension of the connections between the variables examined in this research. The results show some noteworthy trends. The correlation

between FDI and RenCo is negative but statistically insignificant. However, GDP has a favorable influence on RenCo, again the result is statistically not significant. In addition, a moderate positive association is noticed between GD and INF with RenCo. The relationship between GD, GDP, and GNI with FDI is weak and positive. However, in the case of GD, and GNI, the results are statistically not significant. GDP and GNI have a negative effect on GD, but a positive in the case of INF. Both INF and GNI have weak and adverse correlations with GDP.

Moreover, a correlation matrix can be used to test multicollinearity issues. According to Ahmed et al. (2023) in a regression model, multicollinearity occurs when explanatory variables show significant relationships with one another. Because the findings in Table 4 show that there is not a strong relationship among the independent variables (all of them are much lower than 0.70), this study does not have a problem with multicollinearity. The above conclusion is secured by the test of Variance Inflation Factor (VIF) as demonstrated in Table 4. A study released by Newbold et al., (2013) argues that the acceptable value for VIF should be less than 10. The findings of table 4 illustrate that the highest VIF value is 1.412. Hence, multicollinearity is absent from our investigation.

Table 4. Correlation matrix

	RenCo	FDI	GD	GDP	INF	GNI	VIF
RenCo	1	-0.029	0.194**	0.092	0.334***	0.201**	1.143
FDI	-0.029	1	0.103	0.297***	0.176**	-0.101	1.412
GD	0.194**	0.103	1	-0.001	0.327***	-0.428***	1.109
GDP	0.092	0.297***	-0.001	1	-0.005	-0.096	1.183
INF	0.334***	0.176**	0.327***	-0.005	1	-0.003	1.276
GNI	0.201**	-0.101	-0.428***	-0.096	-0.003	1	1.143
Mean							1.225

Note(s): ***p < 1%; **p < 5%

Source: Author's computation using EViews

3.3 Ramsey RESET test

Ramsey RESET Test was conducted to verify that a regression model is appropriately defined. As indicated in table 5, the p-value is larger than 5% significant level, thus, it can be concluded that no important variables are omitted from the model. In other words, the fitted panel ARDL method is suitable and does not violate any assumptions. Hence, the model and method are accurately described.

Table 5. Ramsey RESET Test

	Value	*Prob.*
t-statistic	0.886	0.376
F-statistic	0.785	0.376

Specification: RenCo RenCo(-1) FDI GD GDP INF GNI C

Source: Author's computation using EViews

3.4 Unit root test

Panel data stationarity test indicates robustness to heterogeneity, as illustrated in Table 6. To exploit any potential hidden characteristics, this study considers an estimation of individual intercepts and trends. When the variables are analyzed at their level form, there is not enough data to rule out the null hypothesis that there is non-stationarity. This suggests that the variables may not be stationary in their original form, which would suggest the existence of unit roots. As shown in table 6, all variables were integrated of order one, I(1) (first difference). As a result, the study is able to capture the short- and long-run relationship between FDI, GD, GDP, INF, and GNI with RenCo.

Table 6. Panel data stationarity test

Variables	ADF I(0)	ADF I(1)
RenCo	17.689	53.790***
FDI	13.387	50.787***
GD	11.840	18.052***
GDP	35.933**	72.685***
INF	8.722	31.704***
GNI	9.911	24.770***

Note(s): ***p < 1%
I(0) represent the level; I(1) represent the first difference
Source: Author's computation using EViews

3.5 Cointegration test

After verifying that the factors were stationary at their first difference, the long-term relationship between the variables was evaluated using a panel cointegration test. The outcomes of the panel cointegration test are summarized in Table 7.

Table 7. Cointegration test

Panel	*Panel v*	*Panel rho*	*Panel PP*	*Panel ADF*
Stat.	-1.013	1.424	-1.505*	-0.548
Stat.	-1.796	0.707	-5.951***	-2.609***
Group				
Stat.		1.579	-6.690***	-2.863***

Series: RenCo FDI GD GDP INF GNI
Note(s): ***p < 1%; *p < 10%
Source: Author's computation using EViews

The outcomes show that the series for different panel groupings are cointegrated with RenCo serving as an explained variable and statistical evidence refusing the null hypothesis of no cointegration. In other words, the p-value at the 5% significance level indicates that the null hypothesis is invalidated. This finding strongly supports the co-integration of the variables under investigation. Thus, a long-term link between the components under research might be inferred.

3.6 Regression analysis

Table 8 displays the ARDL estimation results for the panel of all countries based on the elasticity of RenCo regarding the input factors under investigation for both the short and long term. In the long run, FDI does not exhibit statistical significance, however, it does have a minor positive coefficient of 0.001. This means that if other factors remain constant, FDI in the long run does not have any influence on green energy. With a coefficient of 0.007 at the 1% confidence level, government debt (GD) significantly and positively affects RenCo, suggesting that increasing GD is linked to greater use of renewable power. Additionally, at the 5% level, GDP exhibits a significant connection with a value of 0.022, indicating that economic growth promotes the utilization of green energy. INF also has a considerable positive impact with a beta coefficient of 0.017. This implies that a unit rise in GDP and INF causes a 0.022 and 0.017 unit rise in the long-term adoption of renewable energy, respectively. GNI is essential for encouraging the consumption of green energy, as evidenced by its highest positive long-term impact and a significant coefficient of 0.893 at the 1% level. This shows that a one percent rise in GNI causes an increase in using renewable energy by 0.89 percent.

Moreover, the extent and importance of the interactions vary in the short term. FDI has an instant but little influence on using green power, as documented by the small and strong positive effect with a coefficient of 0.002 at the 5% confidence level. This suggests that a unit increase in FDI brings about a rise in

the adoption of sustainable energy by 0.002 units in the short term. There is no significant influence for other factors in the short run, such as (GD, GDP, INF, and GNI).

The above findings demonstrate the complex interplay between important economic variables and the short- and long-term use of green energy. According to the findings, governmental debt (GD), and economic development metrics including GDP, INF, and GNI are crucial in encouraging long-term utilization of renewable energy, with GNI having the most influence. This emphasizes how crucial GD and economic growth are to accelerate the switch to sustainable energy. In contrast, FDI does not appear to have a substantial impact over the long run, suggesting that it may not be able to entirely encourage the growth of renewable energy in the absence of additional supportive variables. Curiously, the analysis also shows that other determinants do not show meaningful short-term impacts, whereas FDI has a beneficial influence on short-term consumption of energy. These results imply that while long-term policy initiatives should concentrate on stimulating economic expansion and leveraging revenues to promote the utilization of clean energy, short-term benefits can need focused tactics to improve FDI's efficacy in renewable energy domains.

Table 8. Dynamic regression analysis

Explained Variable: D(RenCo)				
Variables	*Long run*		*Short run*	
	Coef.	Std. Error	Coef.	Std. Error
FDI	0.001	0.003	0.002**	0.001
GD	0.007***	0.001	0.001	0.002
GDP	0.022**	0.011	-0.002	0.004
INF	0.017**	0.008	0.003	0.005
GNI	0.893***	0.108	-0.547	0.797

Note(s): ***p < 1%; **p < 5%
Source: Author's computation using EViews

These outcomes are in line with the arguments of (Auteri et al., 2024; Florea et al., 2021; Hashemizadeh et al., 2021) who highlight a positive and significant correlation with government debt. Similarly, the results align with the investigation managed by (Rezagholizadeh et al., 2020), which identifies a long-term beneficial connection between FDI and green energy. Furthermore, the findings correspond to the studies by (Inglesi-Lotz, 2016; Islam et al., 2013; Ullah et al., 2024), which demonstrate the beneficial link between national economic improvement and the expansion of sustainable energy sources.

Moreover, according to the automated lag selection, the maximum dependent lag is 1 as presented in table 9. The criteria technique used in choosing a model are AIC. All variables employed in the model proved to have a significant impact on RenCo. These factors are especially crucial for comprehending dynamic behavior as their long-term elasticity coefficients outperform their short-term equivalents.

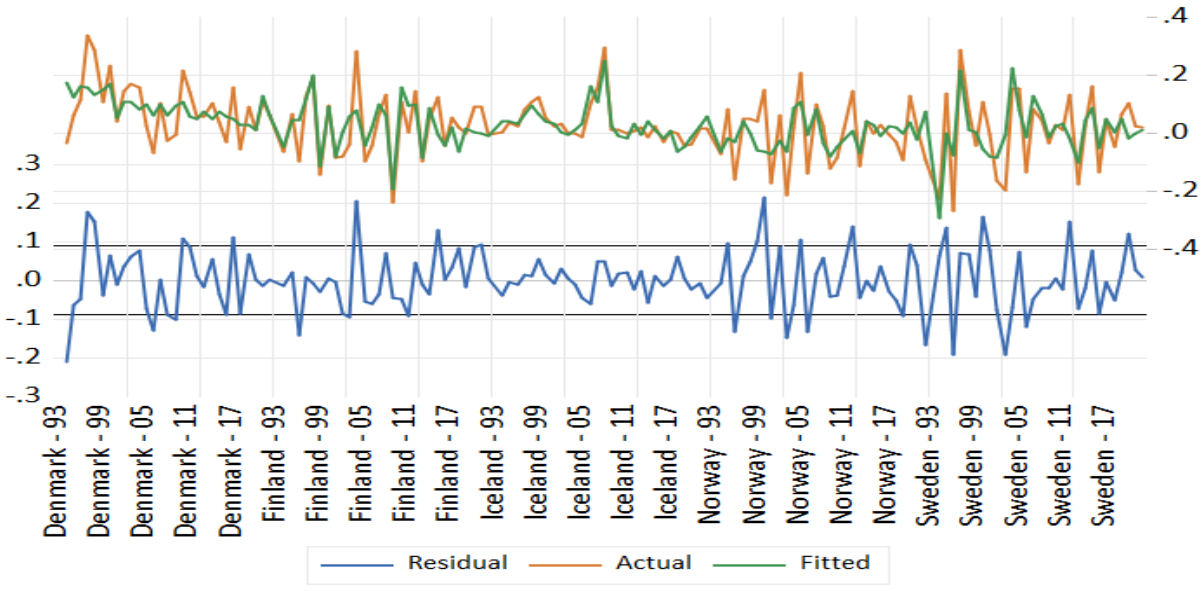
Table 9. Model selection

Model	LogL	AIC*	BIC	HQ	Specification
RenCo	181.514	-1.951	-1.130	-1.618	ARDL (1, 1, 1, 1, 1, 1)

Sample: 1993 – 2022
Source: Author's computation using EViews

The graphic illustration of residuals, fitted values, and actual values following regression is also shown in Figure 1. By lowering residuals, the apparent trend line and the near correspondence among the actual and fitted values improve homoscedasticity. Hence, the concept of homoscedasticity is supported by this pattern, which suggests no discernible heteroscedasticity.

Figure 1. Panel ARDL Model (RenCo)



Source: Author's computation using EViews

CONCLUSION

The main objective of the article is to provide an updated attestation by utilizing the bootstrap ARDL technique to evaluate the impact of FDI, government debt, and economic indicators on the use of renewable energy in Nordic European countries. Since the Nordic nations have been historically innovators in the use of alternative energy sources and sustainable growth, this investigation enriches the current literature to determine how FDI, government debt, and economic indicators affect green energy. Data were collected primarily from reputable databases, such as World Bank Open Data (WBOD), and Our World in Data (OWD) over 1993-2022. Five Nordic nations constitute the study sample. The results are checked for robustness using a variety of models and estimations.

The outcomes of the investigation illustrate that FDI has a weak and favorable influence on the utilization of green energy. However, this result is statistically significant in the short run only. There is also a strong and positive effect of GD on using green power, suggesting that increasing GD is associated with greater consumption of sustainable energy use in the long run. Metrics of economic development such as GDP, INF, and GNI are essential for promoting the long-term usage of renewable energy, with GNI having a major effect. This highlights how important growth in the economy is to hasten the transition to renewable energy. The results are attributable to the European Nordic nation's significant economic expansion and modern infrastructure, resulting in an increase in the use of green energy.

Policymakers in this nation are advised to focus on utilizing economic and energy resources to enhance sustainable growth. The study's outcomes show the need for policies and practices that assist in the sharing of energy consumption from renewable sources to support sustainable development. Improving the application of energy tax regulations and expanding the capacity of investors and individuals to utilize clean and sustainable energy options in their homes and companies.

These findings may be transferable to other developed economies with comparable circumstances to Nordic European countries, and further research should be performed on looking at how currency exchange rates are impacted by the installation of green power in both industrialized and less developed nations. In addition, future research is also encouraged to expand empirical studies to other economies around the world or to include global data from various nations while maintaining a focus on their income levels.

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The Determinants of Regional Taxpayers' Compliance through the Moderation of Religiosity

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ABSTRACT

This study investigates the determinants of regional taxpayer compliance through religiosity as a moderator, particularly given the prominence of religiosity in current literature. Data in this study was garnered through a questionnaire distributed to 220 restaurant business actors, who served as regional taxpayers. Data analysis powered by SmartPLS has found that tax sanctions, tax rates, tax fairness, tax socialization, and religiosity generate a positive effect on tax compliance. Meanwhile, religiosity was not proven influential to the relationship between tax sanctions, tax rates, tax fairness, and tax socialization on tax compliance. This study contributes to the literature concerning tax compliance by using the slippery slope framework and religious commitment theory. It also affords contribution to local governments to improve regional taxpayer compliance, by considering the relationship between research variables and respondent characteristics.

INTRODUCTION

Taxes are collected by almost every single country globally, leading to over-dependence on taxes (Le et al., 2020; Shafaruddin et al., 2022). However, one issue seems to remain prevalent across countries, which is encouraging tax compliance (Cummings et al., 2009) as a result of tax avoidance. For the Indonesian government, tax is critical to maintain sustainable development. One of the initiatives by the government to optimize tax revenue is through Law Number 1 of 2022 concerning Financial Relations between the Central Government and Regional Governments, which helps to map regional tax potential. Regional taxpayers, including Micro, Small, and Medium Enterprises (MSMEs), are definitely affected by this regulation. MSMEs play a pivotal role in driving economic development, especially in developing countries (Fajriana et al., 2023; Le et al., 2020; Timothy & Abbas, 2021). MSMEs aid in improving economic growth and raising employment opportunities (Amah et al., 2021). Taxes from MSMEs also increase state revenues (Fajriana et al., 2023). Many developed and developing countries provide special tax treatment for MSMEs to help them satisfy their responsibility (Nigatu & Belete, 2022).

Banyuwangi is one of the regions in East Java Province, Indonesia. The increasing number of incoming tourists is expected to contribute to regional revenue, especially regional taxes (Puspita & Wicaksono, 2020). This study attempts to link tax sanctions, tax rates, tax fairness, and tax socialization because the results of previous works are still inconclusive. To better understand the complex relationship, this study engages religiosity as a moderating variable. This relates to the fact that the majority of Nahdliyin communities in Indonesia reside in East Java. Another fact is that the winning party of the 2024 legislative election in East Java is a party with a strong religious nationalist ideology, which also contributes to the urgency to investigate the role of religiosity. Sanctions are one of the most important ways to stop bad taxpayer behavior. Tax audits and fines for non-compliance strongly determine taxpayer compliance decisions (Alm et al., 2023). However, several research results are contradictive to that, such as Cummings et al (2009) noting that severe penalties can backfire because they create a situation where bribery and corruption will prevail, resulting in low tax compliance and loss of trust in public institutions.

Tax rates can affect tax compliance. A study in the Afar Region, Northeast Ethiopia, has revealed that tax rates have a negative effect on tax compliance. Meanwhile, tax knowledge, the power of tax authorities, tax system fairness, and the simplicity of the tax system have a positive effect on tax compliance (Nigatu & Belete, 2022). Tax compliance behavior of the middle-income group in Malaysia is significantly influenced by tax rates and self-interest, while general fairness and special provisions do not significantly affect their tax compliance behavior (Shafaruddin *et al*., 2022). Another study in Nigeria reports the opposite, showing that the MSME tax rate does not significantly affect tax non-compliance behavior (Vincent, 2021).

Fairness is a determinant of tax morale (Wan, 2024). Taxpayers demonstrate higher tax compliance when they believe that the government has acted fairly in taxation and wealth distribution (Timothy & Abbas, 2021). Research in Poland documents the main issue regarding the social discourse on taxes, which is tax fairness. Two types of tax fairness widely studied are distributive justice and procedural justice (Niesiobedzka, 2014). Most citizens are willing to bear their tax obligations if they acknowledge fair tax system and fair distribution of tax rates among community members (Bejakovic & Bezeredi, 2019). Contrary findings indicate that the tax compliance behavior of the middle-income group in Malaysia is significantly influenced by tax rates and self-interest. However, perceptions of fairness do not exert a significant impact on tax compliance behavior (Shafaruddin et al., 2022).

Another study confirms that socialization of tax information, the complexity of the tax system, tax morale, trust in the government, and perception of the value of COVID-19-related expenditures influence an individual's willingness to pay taxes (Khozen & Setyowati, 2023). In Bulgaria, initiatives to improve tax morale of entrepreneurs are exercised through tax education and awareness-raising campaigns, by informing the benefits of compliance and showing the public the goods and services received for the taxes they paid (Williams, 2020). However, on the contrary, tax socialization does not affect the compliance level of MSME taxpayers in Bandung Regency. This is partly because the information is deemed unclear, leading to a poor understanding of tax (Meiryani et al., 2023). Another important factor to ponder for escalating tax compliance is religiosity. The culture of society and individual values have to be taken into consideration when designing policies aimed at improving tax compliance (Andriani, 2016). Religious societies tend to be less tolerant of tax evasion than non-religious societies. This resonates with the general assumption that all religions have the same goal of encouraging good behavior and preventing bad behavior (Rysavá & Zídková, 2021). The most important aspects of religiosity, such as religious denomination, belief in God, and the importance of God, as well as the level of belief in other religions and churches, have a noteworthy positive impact on tax morale (Davidescu et a*l*., 2022).

The present study is projected to make theoretical and practical contributions to the field of tax accounting and behavioral science. This study aims to contribute to the understanding of tax compliance by examining the role of tax incentives and cultural factors, particularly religiosity. In terms of practical implications, the research provides valuable insights for regional governments in developing a taxpayer compliance model following the enactment of Law Number 1 of 2022.

1. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

1.1 Slippery Slope Framework

The slippery slope theory states that tax compliance will rise due to authority and trust in authority (Kirchler et al., 2008). Power and authority are taxpayers' perceptions of the tax authorities' ability to detect and sanction taxpayers who violate tax regulations. This trust represents the extent to which individuals or groups believe in tax authorities to deliver decent service for the sake of the community (Schoeman *et al*., 2022).

1.2 Religious Commitment Theory

Religious Commitment Theory was first developed by Glock & Stark (1965). It includes five dimensions of religious commitment: belief, practice, experience, knowledge, and consequences. They explain that a person's religious commitment affects various aspects of his life, including social and moral behavior. As such, religiosity accounts for taxpayer compliance as seen from the five dimensions of religiosity.

1.3 Tax Sanctions and Tax Compliance

The government needs to maintain accountability and transparency in the distribution of tax revenues, as well as provide social services to the community (Nigatu & Belete, 2022). The more people trust, the less they are willing to commit fraud (Rysavá & Zídková, 2021). Notwithstanding, different results are reported by Strielkowski & Cábelková (2015), noting that trust in government institutions is not related to tax compliance.

Community culture and individuals are critical considerations when designing policies to improve tax compliance (Andriani, 2016), such as religiosity. Aspects of religiosity such as belief in God and belief in religion positively impact tax morale (Davidescu et al., 2022). It has been widely endorsed that clear and firm tax sanctions result in tax compliance. Firm sanctions stimulate taxpayers to comply with tax regulations. These aspects of religiosity are also believed to reinforce the relationship between tax sanctions and tax compliance.

Hypothesis 1a. Tax sanctions have a positive effect on tax compliance

Hypothesis 1b. Religiosity moderates the relationship between tax sanctions and tax compliance

1.4 Tax Rates and Tax Compliance

Tax evasion is observed to diminish when the tax rate within a progressive framework is reduced. The reduction of elevated tax rates may contribute to a long-term decrease in tax evasion. Furthermore, this phenomenon may elucidate the rationale behind systemic reforms that incorporate flat rates, which can yield a beneficial effect on enhancing taxpayer integrity honesty (Lamantia & Pezzino, 2021). Research conducted in the Afar Region has indicated that factors such as tax literacy, likelihood of detection, perceptions regarding governmental expenditure, organizational capacity of the tax authority, equity of the tax regime, and the simplicity of the tax structure positively influence tax compliance; conversely, tax rates exert a detrimental effect on tax compliance (Nigatu & Belete, 2022).

Those arguments, however, are not in resonance with a study in Nigeria. SME tax rates in Nigeria do not significantly affect tax non-compliance behavior (Vincent, 2021). Instead, a well-managed tax system affords incentives for investment and growth (Bejakovic & Bezeredi, 2019). Its relationship with religion accords moral behavioral control (Rysavá & Zídková, 2021).

Researchers argue that excessively high tax rates will reduce tax compliance since this will hamper business growth. Religiosity is predicted to weaken the relationship between tax rates and tax compliance.

Hypothesis 2a. Tax rates have a positive effect on tax compliance

Hypothesis 2b. Religiosity moderates the relationship between tax rates and tax compliance

1.5 Tax Fairness and Tax Compliance

Empirical evidence suggests that tax justice—both procedural and distributive—along with cognitive trust in the tax system, significantly influences the voluntary compliance of MSME taxpayers in Malang Raya, Indonesia (Fajriana *et al*., 2023). Research in Poland highlights tax justice as a central issue in social discourse on taxation, with distributive and procedural justice being the most extensively studied dimensions (Niesiobedzka, 2014).

Empirical studies have yielded contradictory findings Khozen & Setyowati (2023) found that tax morality and trust in the government exhibit a positive and statistically significant relationship with tax compliance, while the perceived fairness of the tax system, though positively correlated, is not statistically significant. Additionally, religiosity plays a crucial role in shaping tax compliance, as beliefs in God and religious principles have been shown to significantly enhance tax morale (Davidescu et al., 2022). Scholars argue that perceptions of tax justice contribute to taxpayer satisfaction, thereby fostering greater compliance. Furthermore, religiosity is expected to strengthen the relationship between tax justice and tax compliance, reinforcing ethical and moral motivations for fulfilling tax obligations.

Hypothesis 3a. Tax justice has a positive effect on tax compliance

Hypothesis 3b. Religiosity moderates the relationship between tax justice and tax compliance

1.6 Tax Socialization and Tax Compliance

The complexity of tax system, socialization of tax information, tax morale, and trust in the government influence tax compliance (Khozen & Setyowati, 2023). To foster tax compliance, the government needs to socialize tax laws, maintain close supervision, implement e-tax, and improve tax information for taxpayers and the public (Do et al., 2022). However, tax socialization does not affect the level of taxpayer compliance when clear socialization is absent (Meiryani et al., 2023). A well-managed tax system will incentivize investment and growth (Bejakovic & Bezeredi, 2019). Its relationship with religion is expected to provide moral behavioral control (Rysavá & Zídková, 2021).

Effective socialization will increase tax compliance because taxpayers will know the tax regulations and thus understand how to navigate their roles as taxpayers. Furthermore, religiosity is predicted to strengthen the relationship between socialization and tax compliance.

Hypothesis 4a. Tax socialization has a positive effect on tax compliance

Hypothesis 4b. Religiosity moderates the relationship between tax socialization and tax compliance

1.7 Religiosity and Tax Compliance

Religiosity reflects the extent to which a person practices the values, teachings, and beliefs of his religion in his daily life. It influences individual behavior, including compliance with tax obligations. According to Andriani (2016), community culture and individual values are critical points when pursuing tax compliance. With regard to religiosity, empirical evidence suggests that individuals with strong religious beliefs exhibit lower tolerance for tax evasion compared to their non-religious counterparts (Rysavá & Zídková, 2021).

Empirical studies present mixed findings on the role of religiosity in tax compliance. Research in the Czech Republic suggests that religion influences tax compliance primarily through church attendance (Strielkowski & Cábelková, 2015), while in Spain, individualistic factors such as national pride and education exert a stronger impact, with religiosity being only marginally significant (Bilgin, 2014). Nonetheless, prior studies generally indicate a positive relationship between religiosity and tax compliance, suggesting that stronger religious values among taxpayers contribute to higher compliance levels.

Hypothesis 5: Religiosity has a positive effect on tax compliance.

2. RESEARCH METHOD

This study focuses on restaurant taxpayers registered as regional taxpayers in Banyuwangi Regency, East Java, Indonesia. Banyuwangi was selected due to its unique regional tax characteristics, religious

demographics, and rapid restaurant growth driven by tourism. The sample includes taxpayers registered for at least one year to assess economic and non-economic perceptions of tax compliance. Data were collected through questionnaires distributed and analyzed using SmartPLS to ensure validity and reliability before proceeding with statistical and hypothesis testing. The study examines six variables: tax compliance (dependent), tax sanctions, tax rates, tax fairness, and tax socialization (independent), with religiosity as a moderating variable. Responses were measured using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

a. Tax Compliance
   Tax compliance represents taxpayers' awareness of tax obligations which include calculating, reporting, and paying tax obligations on time (Surugiu et al., 2024), despite sanctions and tax debts (Timothy & Abbas, 2021).
b. Tax Sanctions
   Tax sanctions refer to the authority of tax officers in enforcing tax laws and regulations (Khozen & Setyowati, 2023).
c. Tax Rates
   This deals with the taxpayer's perception of tax rate (Surugiu et al., 2024), which includes the amount of tax and the impact on the taxpayer's business.
d. Tax Fairness
   Tax fairness is the taxpayer's perception of the fairness of the tax system, encompassing procedural, distributive, and retributive justice.
e. Tax Socialization
   Tax socialization aids in delivering tax information from the tax authority to taxpayers through information media (Meiryani et al., 2023).
f. Religiosity
   Religiosity is how much a person performs religious services, membership in a religious organization, perceptions of religion and its importance, and belief in God. This concept helps to analyze the extent to which a particular religious denomination is associated with tax compliance (Davidescu et al., 2022).

3. RESULT AND DISCUSSION

3.1 Respondent Characteristics

The characteristics of respondents in this study are shown in Table 1.

Table 1. Respondent Profile

Number	*Description*	*Category*	*Frequency*	*Percentage*
1	Gender	Male	108	49,09
		Female	112	50,91
2	Position	Business Owner	105	47,73
		Management	115	52,27
3	Education	No Formal Education	0	0
		Elementary School	2	0,91
		Junior High School	11	5,00
		Senior High School	157	71,36
		Diploma	21	9,55
		Bachelor's Degree	29	13,18
		Master's Degree	0	0
		Doctorate	0	0
4	Owner's and Management Age	Below 18 years	0	0
		18-30 years	50	22,73

		31-40 years	39	17,73
		41-50 years	81	36,82
		51-60 years	47	21,36
		Above 60 years	3	1,36
5	Business Duration	1-2 years	11	5,00
		3-5 years	42	19,09
		6-9 years	64	29,09
		10-15 years	59	26,82
		16-20 years	19	8,64
		21-30 years	8	3,64
		More than 30 years	17	7,73

Source: Data processed using Excel (2025)

Table 1. shows that the majority of business owners and managers are women, totaling 112 people (50.91%) compared to 108 men (49.09%). Based on the job profiles of restaurant business owners and managers, the questionnaire was primarily completed by business managers, accounting for 115 respondents (52.27%). The majority of respondents, 157 persons (71.36%), have completed high school education. In addition, the second and third position ranks concerning educational background are characterized by bachelor's degrees totaling 29 persons (13.18%) and diplomas involving 21 persons (9.55%). The majority of business owners, 81 individuals (36.82%), are in the productive age range of 41-50 years, followed by 50 respondents (22.73%) in the relatively young age group of 18-30 years. Most restaurants are in the mid-development stage, with 64 businesses (29.09%) operating for 6-9 years, and 59 businesses (26.82%) in the 10-15 year range. This indicates that most businesses are in the development phase.

3.2 Descriptive Statistics

Descriptive statistics compare the minimum, maximum, mean, and standard deviation values of each research variable.

Table 2. Descriptive Statistics

Statistic	*N*	*Range*	*Minimum*	*Maximum*	*Mean*	*Std. Error*	*Std. Deviation*
TCO	220	20	15	35	28,63	0,219	3,249
TSC	220	19	16	35	27,33	0,28	4,159
TRT	220	22	10	32	21,06	0,306	4,533
TFR	220	19	16	35	27,15	0,239	3,543
TSO	220	22	13	35	26,81	0,303	4,498
REL	220	10	25	35	30,57	0,178	2,64

Source: Data processed using SPSS (2025)

Table 2 delineates the descriptive statistics for the six variables: TCO (Tax Compliance), TSC (Tax Sanctions), TRT (Tax Rates), TFR (Tax Fairness), TSO (Tax Socialization), and REL (Religiosity), encompassing a total of 220 samples. The TCO variable exhibits a range of 20 values, encompassing a minimum score of 15 and a maximum score of 35, with an average of 28.63 and a standard deviation of 3.249, thereby indicating a relatively uniform distribution surrounding the mean. The TSC variable demonstrates a range of 19, an average of 27.33, and a standard deviation of 4.159, which signifies a heightened level of variability in comparison to TCO. TRT manifests an average of 21.06 and a standard deviation of 4.533, thereby reflecting a greater degree of variation within the dataset. TFR, with an average of 27.15 and a standard deviation of 3.543, illustrates a lesser degree of dispersion than either TSC or TRT. TSO is characterized by an average of 26.81 and a standard deviation of 4.498, indicating a distribution akin to that of TRT. REL presents the highest average of 30.57, alongside the lowest standard deviation of 2.640, suggesting that the data is most densely concentrated around the mean.

3.3 Model Validation

The research model below displays the relationship between the research variables.

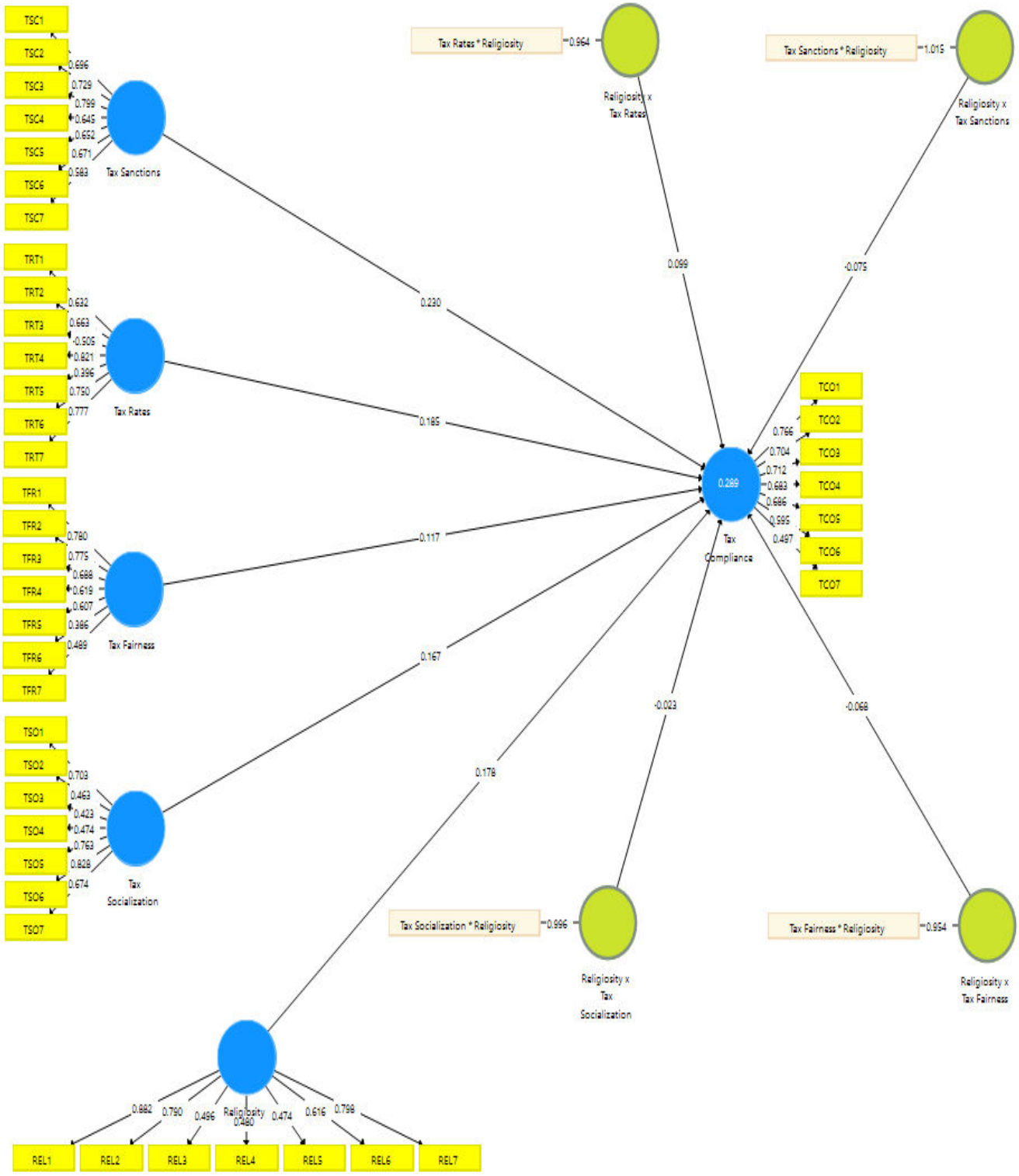

Figure 1. First Research Model
Source: Data processed using SmartPLS (2025)

Figure 1 documents several invalid indicators which accounts for why the model still does not pass the validity test. This is indicated by variables having a loading factor below 0.6, which needs to be removed from the model. The removal leads to the following modified model which contains indicators possessing loading factor above 0.6. This confirms the model validity.

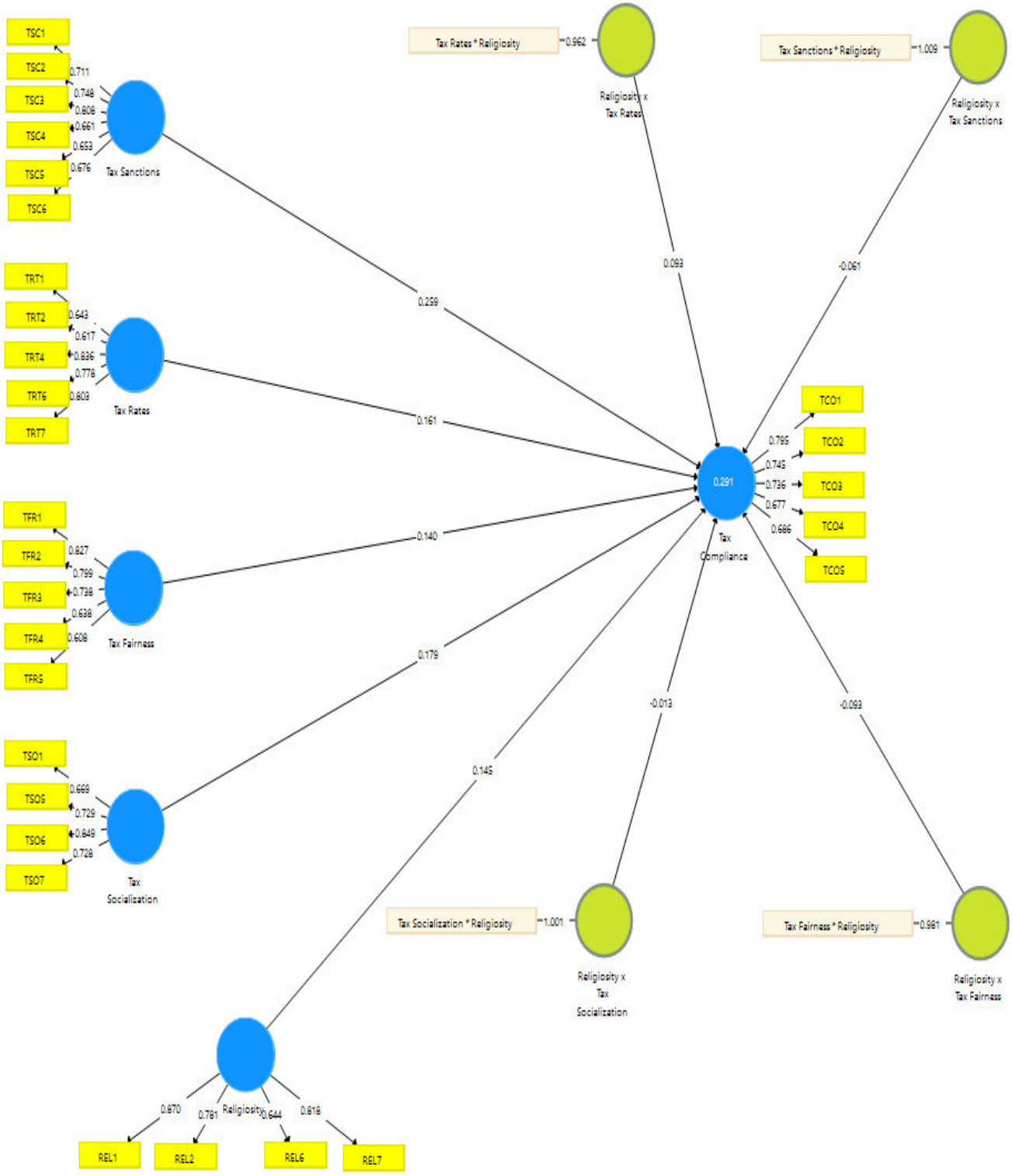

Figure 2. Second Research Model
Source: Data processed using SmartPLS (2025)

3.4 Reliability Test

Validity and reliability tests ensure that the questionnaire measures what is intended in a consistent fashion.

Table 3. Reliability Test

Description	*Cronbach's Alpha*	*rho_A*	*Composite Reliability*
Tax Fairness	0,781	0,823	0,847
Tax Compliance	0,779	0,790	0,850
Religiosity	0,800	0,866	0,862
Religiosity x Tax Fairness	1,000	1,000	1,000
Religiosity x Tax Sanctions	1,000	1,000	1,000
Religiosity x Tax Socialization	1,000	1,000	1,000
Religiosity x Tax Rates	1,000	1,000	1,000
Tax Sanctions	0,809	0,831	0,859
Tax Socialization	0,748	0,801	0,834
Tax Rates	0,791	0,815	0,857

Source: Data processed using SmartPLS (2025)

As seen from Table 3, the Cronbach alpha across variables is above 0.7, demonstrating highly reliable items. This also affirms the internal consistency of indicators in the latent variables.

3.5 Model Fit Test

Model fit testing is conducted to assess whether the research model is in the Fit category. If the model fits, then data analysis can be carried out on hypothesis testing.

Table 4. Model Fit

Description	*Saturated Model*	*Estimated Model*
SRMR	0,080	0,080
d_ULS	2,806	2,805
d_G	0,872	0,872
Chi-Square	1101,688	1101,695
NFI	0,600	0,600

Source: Data processed using SmartPLS (2025)

From Table 4., The SRMR is 0.080 found in the range of <0.10, so the model is considered fit. Furthermore, the NFI value is 0.750, ranging between 0 and 1, so it is included in the model fit category.

3.6 Determinant Coefficient

The coefficient of determination is used to assess how much the exogenous construct can explain the endogenous construct.

Table 5. Determinant Coefficient

Description	R Square	R Square Adjusted
Tax Compliance	0,291	0,260

Source: Data processed using SmartPLS (2025)

Table 5 exhibits an R square of 0.291 and an adjusted R square of 0.260. This means that the independent variable can explain tax compliance by 26%, while the remaining 74% is driven by extraneous factors.

3.7 Hypothesis Testing

Hypothesis test results are reported in the table below.

Table 6. Hypothesis Test

Description	*Original Sample (O)*	*Sample Mean (M)*	*Standard Deviation (STDEV)*	*T Statistics (|O/STDEV|)*	*P Values*
Tax Sanctions -> Tax Compliance	0,259	0,267	0,059	4,411	0,000
Tax Rates -> Tax Compliance	0,161	0,163	0,057	2,804	0,005
Tax Fairness -> Tax Compliance	0,140	0,153	0,069	2,018	0,044
Tax Socialization -> Tax Compliance	0,179	0,179	0,071	2,511	0,012
Religiosity -> Tax Compliance	0,145	0,158	0,062	2,337	0,020
Religiosity x Tax Sanctions -> Tax Compliance	-0,061	-0,059	0,062	0,972	0,332
Religiosity x Tax Rates -> Tax Compliance	0,093	0,073	0,062	1,513	0,131
Religiosity x Tax Fairness -> Tax Compliance	-0,093	-0,087	0,078	1,186	0,236
Religiosity x Tax Socialization -> Tax Compliance	-0,013	-0,015	0,076	0,174	0,862

Source: Data processed using SmartPLS (2025)

Table 6 shows that independent variables (tax sanctions, tax rates, tax fairness, tax socialization, and religiosity) yield a positive effect on tax compliance. However, religiosity cannot affect the relationship between tax sanctions, tax rates, tax fairness, and tax socialization.

4. DISCUSSION

Hypothesis 1a: Tax sanctions have a positive effect on tax compliance.

Hypothesis 1a has been validated, suggesting that tax sanctions exert a considerable positive influence on tax compliance. Consequently, stringent sanctions are identified as a factor that enhances tax compliance. Conversely, permissive tax sanctions are likely to result in diminished tax compliance. Tax sanctions demonstrate efficacy in deterring tax infractions. Within the theoretical framework of the slippery slope, tax sanctions augment the authority's power. In this context, the tax authority is perceived as possessing the capability to enforce tax legislation through oversight and punitive measures. When taxpayers believe that sanctions will be applied strictly, they tend to comply to avoid punishment. Kirchler et al (2008) mention that lenient sanctions indicate that the tax authority is weak.

The results are in line with several researchers such as Oladele et al (2019) and Nguyen et al (2020). Tax sanctions must be strict enough to yield a deterrent effect for people who do not pay taxes while encouraging the ability to pay (Oladele et al., 2019). Furthermore, tax authorities need to consistently examine tax returns, tax payments, and corporate tax restitution (Nguyen et al., 2020).

The research results show that the average score for tax sanctions ranges from 3.68 to 4.00, indicating that respondents recognize the importance of enforcing strict sanctions to enhance compliance. In contrast, the average score for the tax compliance variable is higher, ranging from 3.87 to 4.14, suggesting a generally high level of compliance. This indicates a positive relationship between the enforcement of strict sanctions and increased tax compliance. Strict sanctions create a deterrent effect for violators. According to the slippery slope theory, strong sanctions enhance the authority of tax agencies, which in turn strengthens taxpayers' commitment to adhere to regulations. Therefore, effectively applying sanctions can be a key to boosting taxpayer compliance.

Hypothesis 1b: Religiosity strengthens the relationship between tax sanctions and tax compliance.

Hypothesis 1b is rejected. Religiosity cannot affect the relationship between tax sanctions and tax compliance. Based on religious commitment theory, religiosity focuses on the internalization of moral and spiritual values that foster compliance as a form of responsibility to God and society. Therefore, religiosity tends to work independently of such external factors as tax sanctions, which are coercive and rely on fear of punishment. Individuals with strong religiosity are intrinsically motivated to comply, without being too influenced by external sanctions. This explains why religiosity cannot strengthen or weaken the relationship between tax sanctions and tax compliance because the compliance driven by sanctions is more based on external regulations than internal religious values. The results are also in line with Sritharan et al (2023) who report that religiosity cannot moderate the relationship between determinant factors and tax compliance. Sunarsih et al (2024) also found that religiosity does not moderate the relationship between independent variables and tax evasion.

This study revealed that both tax sanctions and religiosity directly have a significant positive effect on tax compliance, without the moderating role of religiosity. Religiosity moderation does not influence the relationship between tax sanctions and tax compliance because the sanction mechanism primarily relies on coercive compliance, enforced by external authorities through punishments and threats. In the context of the slippery slope framework, coercive compliance is driven by the authority's power. On the other hand, religiosity, according to religious commitment theory, typically influences compliance through intrinsic values like morality and integrity. When compliance is driven by fear of sanctions, the influence of religiosity as an internal value is diminished because external mechanisms have already ensured compliance. Therefore, religiosity does not provide a significant additional contribution to compliance behavior driven by external authority.

Hypothesis 2a: Tax rates have a negative effect on tax compliance.

Hypothesis 2a is rejected. Tax rates have a significant positive effect on tax compliance, suggesting that competitive tax rates encourage higher compliance. Conversely, low tax rates can result in decreased compliance. According to the slippery slope framework, moderate tax rates that do not impose excessive financial burdens can enhance compliance, as taxpayers are more willing to meet their obligations. Kirchler et al (2008) argue that tax rates reflect the power of tax authorities, and excessively high rates may be perceived by taxpayers as an infringement on their rights. The results are in harmony with several previous researchers such as Lamantia & Pezzino (2021) and Shafaruddin *et al* (2022). According to Lamantia & Pezzino (2021), tax avoidance tends to sink when the tax rate is lowered. Lowering tax rates can help mitigate tax avoidance. In other words, implementing a flat rate can have a positive impact on increasing taxpayer honesty. Furthermore, Shafaruddin *et al* (2022) stated that tax compliance behavior is significantly influenced by the government, tax rates, and personal interests.

In summary, the average score on the relatively low tax rate variable (2.4 to 3.22) indicates that most respondents feel that the tax rate is a fair obstacle for their business. However, tax compliance has a higher score (3.87 to 4.14), indicating that compliance remains high even though the tax rate is seen as burdensome. The slippery slope theory emphasizes the power of tax authority and underlines tax rate as an instrument that strengthens this authority when applied consistently. When the rate is perceived as an obligation, the tax authority can use regulatory and law enforcement powers to stimulate taxpayer compliance, in spite of the high rate. Taxpayers will be more motivated to comply with the rules because of the potential for sanctions and strict supervision.

Hypothesis 2b: Religiosity weakens the relationship between tax rates and tax compliance.

Hypothesis 2b is rejected. Religiosity does not influence the relationship between tax rates and tax compliance. According to religious commitment theory, religiosity is driven by the internalization of moral and spiritual values that motivate individuals to comply with an ethical responsibility to God, irrespective of external factors like tax rates. Individuals with strong religiosity view tax compliance as a moral duty. Therefore, religiosity does not modify the effect of tax rates on compliance, as it is based on intrinsic values rather than economic considerations. This study supports Sritharan et al (2023) who stated that religiosity cannot moderate the relationship between determinant factors and tax compliance. Sunarsih et al (2024) also found that religiosity does not moderate the relationship between independent variables and tax evasion.

This study found that tax rates and religiosity yield a significant positive effect on tax compliance directly, without the moderating effect of religiosity. Religiosity does not affect the relationship between tax rates and tax compliance because tax rates are perceived more as external factors that are technocratic and objective in nature. In the slippery slope framework, tax compliance is influenced by the power of authority and trust in the government which foster the perception that tax is a general responsibility. Meanwhile, religious commitment theory explains that religiosity encourages behavior based on intrinsic values, such as integrity and morality, which are not always relevant to tax rate changes.

Hypothesis 3a: Tax fairness has a positive effect on tax compliance.

Hypothesis 3a is accepted. Tax fairness has a significant positive effect on tax compliance. This suggests that when tax fairness is perceived as appropriate, tax compliance will increase. Conversely,

perceived unfairness in tax policies can lead to lower compliance. The role of fairness, particularly procedural and distributive fairness, is crucial in enhancing taxpayer trust in tax authorities. A fair distribution of the tax burden fosters increased compliance, as taxpayers are more likely to trust a tax system perceived as just. Kirchler et al (2008) argue that justice is related to trust in authority, which is achieved through procedural and distributive justice.

This finding aligns with previous studies by Niesiobedzka (2014), Bejakovic & Bezeredi (2019), Timothy & Abbas (2021), Shafaruddin et al., (2022), and Fajriana *et al* (2023), which emphasize that tax fairness and taxpayer trust are key drivers of voluntary compliance. Policymakers aiming to boost government revenue and improve socioeconomic outcomes must prioritize tax system fairness to enhance compliance. As noted by Shafaruddin et al., (2022), a more equitable tax structure can increase tax compliance and improve living standards for taxpayers, while Fajriana et al., (2023) highlighted the significance of procedural and distributive fairness in fostering compliance among SMEs. The central theme of tax-related social discourse is tax fairness, with distributive and procedural fairness being key areas of focus (Niesiobedzka, 2014). Taxpayers tend to show higher compliance when they perceive the government as fair in both taxation and wealth distribution (Timothy & Abbas, 2021). Furthermore, most citizens are willing to fulfill their tax obligations when they believe the tax system is fair and the tax burden is equitably distributed (Bejakovic & Bezeredi, 2019).

Tax fairness has a fairly high average score, ranging from 3.69 to 3.90, indicating that respondents generally feel that tax policies have been implemented fairly. On the other hand, tax compliance is also found high, between 3.87 to 4.14, implying the perception that tax fairness contributes positively to compliance. When taxpayers perceive that the tax burden is fairly distributed and that tax policies offer corresponding benefits, they are more likely to comply, as they feel valued and treated equitably. Based on the slippery slope theory, tax fairness increases taxpayer trust in the tax authority perceived to operate with integrity and concern for the welfare of taxpayers.

Hypothesis 3b. Religiosity strengthens the relationship between tax fairness and tax compliance

Hypothesis 3b is turned down. Religiosity cannot strengthen or weaken the relationship between tax fairness and tax compliance. Based on religious commitment theory, religiosity encourages individuals to comply with legal and moral obligations, including paying taxes, despite the perception of tax fairness. Religious individuals tend to see tax obligation as a moral act, regardless of whether or not the tax is considered fair. Because religious motivation is intrinsic and rooted in spiritual values, the relationship between tax fairness and tax compliance is not significantly influenced by religiosity. In other words, tax fairness is more related to rational perceptions of the distribution of the tax burden, while religiosity operates on a deeper moral dimension and ignores perceived fairness. This study's findings align with Sritharan et al (2023), who concluded that religiosity does not moderate the relationship between determinant factors and tax compliance. Similarly, Sunarsih et al (2024) found that religiosity does not moderate the link between independent variables and tax evasion.

This study found that both tax fairness and religiosity have a significant positive effect on tax compliance directly, without the moderating role of religiosity. Religious moderation does not influence the relationship between tax fairness and tax compliance, as tax fairness is primarily associated with rational evaluations of government policies and tax systems. In the slippery slope framework, tax fairness affects compliance through trust in authority, based on transparency and fairness. While religious commitment theory suggests that religiosity motivates behavior through moral and spiritual values, its influence is insufficient to moderate the technocratic perceptions of tax fairness. Therefore, religiosity does not yield additional influence in this context, as it primarily focuses on intrinsic values, while tax fairness is evaluated through normative analyses of tax policy.

Hypothesis 4a: Tax socialization positively influences tax compliance.

Hypothesis 4a is approved. Tax socialization poses a significant positive effect on tax compliance. This indicates that strict socialization will elevate tax compliance. However, if tax socialization are not enforced, low tax compliance will emerge. Within the slippery slope framework, effective tax socialization can increase compliance by developing taxpayers' understanding of their obligations. When clear and comprehensive information is delivered, the public becomes more aware of the benefits of taxes and their role in

supporting development. Kirchler et al (2008) voice that tax socialization aids in increasing taxpayer understanding.

The findings of this study cohere with several researchers such as Williams (2020) and Do et al (2022). Williams (2020) points out that tax education and awareness-raising campaigns help to improve tax morale since these measures can make explicit the benefits of compliance as well as the advantage of taxes for the public (Williams, 2020). Furthermore, and Do et al (2022) state that to improve tax compliance, tax laws, and support services to companies need to be maintained at all times. They further argue that disseminating information on tax compliance for taxpayers and the community is pivotal for tax compliance (Do et al., 2022).

The research findings indicate that tax socialization has a positive effect on tax compliance, as evidenced by the high average scores of both tax socialization (3.71–4.40) and tax compliance (3.87–4.14). Respondents perceive tax socialization by the tax authority as effective, which enhances their understanding of tax rules and the importance of tax payment. According to the slippery slope theory, clear and relevant tax socialization fosters trust in the tax authority, as taxpayers feel educated and supported. This trust strengthens voluntary compliance, as taxpayers are motivated by a transparent relationship with the authority.

Hypothesis 4b: Religiosity strengthens the relationship between tax socialization and tax compliance.

Hypothesis 4b is turned down. Religiosity cannot strengthen or weaken the relationship between tax socialization and tax compliance. Religious commitment theory points out that religiosity encourages tax compliance through internalization of moral and spiritual values, without relying on external influences such as tax socialization. Individuals with substantial levels of religiosity tend to be intrinsically motivated to comply because they consider taxes as part of their moral obligations and responsibilities to God. Therefore, tax socialization, aiming to increase taxpayer understanding and awareness through an educational approach, poses no additional effect on religious individuals who have internalized these values of obedience. Another reason for this insignificant influence is that the two factors operate on different motivational pathways: religiosity is grounded in internal values, while tax socialization focuses on behavioral change through external information. The findings in this study are in harmony with Sritharan et al (2023) who stated that religiosity cannot moderate the relationship between determinant factors and tax compliance. Sunarsih et al (2024) also found that religiosity does not moderate the link between independent variables and tax evasion.

In this study, tax socialization and religiosity are found to yield a significant positive effect on tax compliance directly, without any moderating role of religiosity. Religious moderation does not affect the relationship because tax socialization focuses on increasing taxpayers' technical knowledge and understanding of tax obligations. Following the slippery slope framework, this study presumes that tax socialization cements tax compliance by increasing trust in authorities by disseminating clear and transparent information. In the same vein, religious commitment theory explains that religiosity encourages behavior based on moral and spiritual values, such as integrity and honesty, but this influence may not be relevant in a more technical context such as tax socialization. As a corollary, religiosity yields no significant moderating effect because compliance resulting from socialization is driven by a logical and rational understanding of tax regulations.

Hypothesis 5. Religiosity Influences Tax Compliance

Hypothesis 5 is approved. Religiosity generates a significant positive effect on tax compliance, implying that high religiosity increases tax compliance, and *vice versa.* Based on religious commitment theory, religiosity is positively related to tax compliance because commitment to religious values encourages honesty, obedience, and responsibility, including in paying taxes. This relationship can be strengthened through exercising social norms that associate taxes with religious and moral responsibilities.

The research results cohere with several researchers such as Andriani (2016), Rysavá & Zídková (2021), and Davidescu et al (2022). Andriani (2016) argues that community culture and individual values need to be in consideration when designing policies aimed at fostering tax compliance. The most pivotal components of religiosity, such as religious denomination, belief in God, the importance of God, and the

level of belief in other religions and churches, positively impact tax morale Davidescu et al (2022). In relation to religiosity, religious individuals are less tolerant of tax evasion than non-religious people. This follows the general assumption that all religions encourage good behavior (Rysavá & Zídková, 2021).

To sum up, the high average score of religiosities, between 4.30 to 4.45, indicates that the respondents have a strong belief in the importance of religious values for running a business. This is in line with the substantial score of the tax compliance, found between 3.87 to 4.14, demonstrating a positive relationship between religiosity and tax compliance. Religious values encourage taxpayers to comply with tax obligations, as part of their moral and religious responsibilities. Based on religious commitment theory, individuals who have a high religious commitment tend to demonstrate behavior in resonance with moral and ethical values, including in fulfilling tax obligations. Religiosity strengthens the awareness of a contribution to the common good through paying taxes.

5. ADDITIONAL ANALYSIS

Table 7. Respondents' Characteristics and Tax Compliance

Description	*Category*	*TSC*	*TRT*	*TFR*	*TSO*	*REL*
Gender	Male	Sig +	Sig +	N.s	N.s	N.s
	Female	Sig +	N.s	N.s	Sig +	Sig +
Position	Business Owner	Sig +	N.s	N.s	N.s	Sig +
	Management	N.s	N.s	N.s	Sig +	N.s
Education	Primary and Secondary	Sig +	Sig +	N.s	N.s	N.s
	Higher Education	Sig +	N.s	N.s	N.s	N.s
Owner's and Management Age (years)	Young (18-30)	Sig +	Sig +	N.s	N.s	N.s
	Early Adulthood (31-40)	N.s	N.s	N.s	N.s	N.s
	Middle Adulthood (41-50)	Sig +	N.s	Sig +	Sig +	N.s
	Pre-Elderly (>50)	Sig +	N.s	N.s	N.s	N.s
Business Duration (years)	New (1-5)	N.s	N.s	N.s	N.s	N.s
	Growing (6-9)	Sig +	N.s	N.s	Sig +	N.s
	Stable (10-15)	N.s	Sig +	N.s	N.s	N.s
	Established (>15)	Sig +	N.s	N.s	N.s	N.s

Source: Data processed using SmartPLS (2025)

Table 7 summarizes the relationship between respondent characteristics and research variables under investigation. Attending to the gender category, men show a significant relationship between tax penalty and tax rate. Meanwhile, women show a significant positive relationship with tax sanctions, tax socialization, and religiosity. This strongly evinces that women are more responsive to government efforts in enforcing tax regulations and socialization, presumably related to a higher level of sensitivity to information and fairness concerning taxation.

Business owners exhibit a significant positive relationship with tax sanctions and religiosity, while business managers are only significantly related to tax socialization. This suggests that owners, as primary decision-makers, are more influenced by regulations and religious values, whereas managers, primarily implementers, engage more with tax socialization. Batrancea et al (2022) highlight that for entrepreneurs, trust in authorities has a greater impact on tax compliance than law enforcement.

Respondents with primary and secondary education show a significant positive relationship with tax penalties and tax rates, while those with higher education are only significantly related to tax sanctions. This suggests that less-educated taxpayers are more responsive to policy changes, particularly regarding sanctions and rates, due to their greater vulnerability. In contrast, highly educated respondents emphasize sanction enforcement as a key driver of compliance. Cyan et al., (2016) found that tax morale is higher among educated individuals, with a U-shaped effect, where both the least and most educated exhibit greater tax morale than those with intermediate education levels.

Young respondents are associated with a significant positive relationship between tax sanctions and tax rates, while middle-aged respondents display a significant relationship with tax sanctions, tax fairness, and tax socialization. In essence, middle-aged respondents are more sensitive to various tax policies, perhaps due to greater experience and responsibility. On the contrary, pre-elderly respondents were only significant on the tax sanction variable. Furthermore, early adult respondents show no noteworthy

relationship on all variables, indicating that the early adult age group may be less concerned about tax issues. Kumi & Kwasi Bannor (2023) state that age has a positive effect on tax morale.

Growing businesses exhibit a significant positive relationship with tax sanctions and tax socialization, while established businesses are only significantly related to tax sanctions. In contrast, new businesses show no significant relationship with any variables. This suggests that more developed businesses are more tax-aware due to their scale and interaction with tax authorities, whereas new businesses may lack familiarity with the tax system. MSME owners prioritize business survival over tax obligations, making tax compliance a secondary concern (Amah et al., 2021).

CONCLUSION

This study has identified determinants of local taxpayer compliance, which encompass tax sanctions, tax rates, tax fairness, tax socialization, and religiosity. Religiosity is not proven to affect the relationship between tax sanctions, tax rates, tax fairness, and tax socialization on tax compliance.

Despite the findings, some limitations need to be taken into account. This study only captures the dynamics of tax compliance along with associated variables among local taxpayers in Banyuwangi, East Java, Indonesia. For further researchers, future researchers may cover more diverse sites, such as the entire East Java, allowing for more accurate results. Furthermore, the variables of tax socialization and religiosity have yet to pass the validity test, which is believed to result from the involvement of only four indicators. Future research is advised to perform a pilot test for a more reliable questionnaire.

Theoretically, this research has enriched the literature concerning tax compliance through the slippery slope framework and religious commitment theory. It investigates non-economic aspects of tax compliance related to religious values. The results offer practical insights for local governments to raise tax compliance by considering taxpayers' characteristics in relation to tax sanctions, setting effective tax rates, creating fair tax policies, and informing tax regulations.

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Market Structure, Credit Risk, and Sustainable Banking Stability in Tanzania's Post-Pandemic Era

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Banking Stability,
GMM Estimation,
Post-Pandemic,
Tanzania

ABSTRACT

The COVID-19 pandemic has reshaped global banking dynamics, intensifying credit risk and altering market structures. This paper investigates the relationship between market structure, credit risk, and sustainable banking stability in Tanzania's post-pandemic era. Grounded in the Competition-Stability Hypothesis, the paper employed a dynamic panel data method using the System Generalized Method of Moments to address endogeneity and persistence effects. Analyzing a panel of ten large commercial banks from 2010 to 2024. The study found a significant negative relationship between credit risk and market competition, supporting the notion that increased competition enhances banking stability. The results also reveal a strong persistence of credit risk over time, underscoring the need for robust risk management strategies. Furthermore, the COVID-19 crisis exacerbated credit risk, yet competitive market structures mitigated these adverse effects, highlighting competition's moderating role in financial stability. This study extends the banking competition and risk management literature by integrating crisis dynamics into empirical analysis. The findings provide valuable insights for banking regulators and policymakers to design competition-enhancing policies while strengthening risk mitigation frameworks, fostering a more resilient and sustainable banking sector in developing economies.

INTRODUCTION

The banking sector plays a crucial role in economic development by facilitating financial intermediation, capital allocation, and systemic stability (Bawuah, 2024)). In emerging economies such as Tanzania, commercial banks are essential for liquidity provision and credit allocation due to the limited diversification of financial markets (Ngweshem & Isiksal, 2021). However, the stability of the banking sector is shaped by market structure, competition dynamics, and credit risk management strategies, particularly in response to economic disruptions like the COVID-19 pandemic (Mateev et al., 2024). The relationship between market competition and banking stability remains widely debated in financial literature. The competition-fragility hypothesis argues that excessive competition erodes profit margins, prompting banks to engage in riskier lending practices, and ultimately increasing financial instability (Berger et al., 2017). Conversely, the competition-stability hypothesis suggests that greater competition enhances efficiency,

diversifies credit risk, and strengthens financial resilience (Mateev et al., 2024). While extensive research has explored these competing theories, there remains no consensus on the optimal balance between competition and stability, especially in emerging markets with evolving regulatory frameworks (Nguyen, et al., 2024).

The COVID-19 pandemic exposed vulnerabilities in the global banking system, heightening credit risks, liquidity shortages, and loan defaults. Governments and central banks worldwide implemented policy interventions to sustain financial stability, yet the long-term effectiveness of these measures remains uncertain (Shabir et al 2023). In Tanzania, regulatory actions helped mitigate systemic risks, but the surge in non-performing loans (NPLs) raised concerns about the sector's post-pandemic stability (Bank of Tanzania, 2024). This underscores the importance of examining how market competition influenced banking resilience in the wake of economic shocks. Tanzania's banking sector exhibits moderate competition, with a mix of dominant large banks and smaller financial institutions operating under varying regulatory constraints. The sector's exposure to economic volatility has reignited debates on whether market concentration enhances financial stability by allowing banks to build capital buffers or encourages riskier lending behaviour due to the "too-big-to-fail" phenomenon (Simpasa, 2011).

This paper aims to examine the interplay between market structure, credit risk, and sustainable banking stability in Tanzania, with a specific focus on the post-pandemic period. Building on the framework of Mateev et al. (2024), this research examines whether competition mitigated or exacerbated credit risk during and after the COVID-19 crisis. Employing a *panel data approach*, known as the *Generalized Method of Moments (GMM) estimator*, this study addresses endogeneity and persistence effects in the banking industry. The findings will provide critical insights for policymakers, regulators, and banking institutions, providing evidence empirical findings based on recommendations for fostering a stable and competitive financial environment in Tanzania.

The structure of the paper is as follows: Section 2 reviews the literature, focusing on theoretical perspectives on market competition and banking stability. Section 3 outlines the research methodology of the study including data sources, sample selection, and econometric modeling. Section 4 discusses the empirical findings, including descriptive statistics, regression results, and robustness tests. Finally, Section 5 discusses key conclusions and policy implications,

1. REVIEW OF LITERATURE

1.1 Theoretical Framework

The relationship between market structure, credit risk, and banking stability remains widely debated, particularly in the post-pandemic financial landscape (Feleaga et al., 2024; Voznakova et al., 2024). This study draws from market power theory and financial intermediation theory to examine these dynamics in Tanzania's banking sector (Mateev et al. (2024), The competition-fragility hypothesis posits increased competition erodes profit margins, compelling banks to engage in riskier lending (Keeley, 1990). Studies in emerging markets link heightened competition to rising non-performing loans (NPLs) and systemic vulnerabilities (González et al., 2017). Given Tanzania's evolving market structure, the extent to which competition influences credit risk remains a critical concern.

Conversely, the competition-stability hypothesis suggests that greater competition enhances stability by lowering lending rates and reducing default risks (Boyd & De Nicolò, 2005; Espinosa et al., 2023). Empirical studies in Sub-Saharan Africa highlight that concentrated banking sectors may foster inefficiencies and limit credit access, increasing systemic risks (Sarpong-Kumankoma et al., 2018). This perspective underscores the need for a balanced competitive environment in Tanzania. A *non-linear relationship hypothesis* presents a U-shaped effect, where moderate competition reduces credit risk, but excessive competition weakens financial buffers (Martinez-Miera & Repullo, 2010). Post-pandemic economic shocks have reshaped this dynamic, requiring further investigation into Tanzania's banking sector (Tabak et al., 2011). While theoretical perspectives remain contested, their application to Tanzania's post-pandemic banking stability is underexplored. This paper aims to bridge the empirical gaps by examining how market structure influences credit risk and banking stability in the post-pandemic era.

1.2 Empirical Literature Review

The relationship between market structure, credit risk, and banking stability remains a critical concern in financial economics, particularly in emerging economies where banking sector vulnerabilities are more pronounced (Brei et al., 2020; Beck et al., 2015). The COVID-19 pandemic has further reshaped competitive dynamics, regulatory oversight, and risk management frameworks within banking systems worldwide. In Tanzania, where financial inclusion initiatives and regulatory interventions have evolved post-pandemic, understanding these structural shifts is essential for fostering a resilient and sustainable banking sector (Bank of Tanzania, 2024). Empirical studies on the *market structure-credit risk nexus* present three dominant perspectives. The *Competition-Fragility Hypothesis* argues that heightened competition erodes profit margins, compelling banks to engage in riskier lending practices, and ultimately increasing financial fragility (Marcus, 1984; Keeley, 1990; Oliinyk et al., 2021). Empirical evidence from both developed and emerging markets supports this view, suggesting that excessive competition weakens banks' capitalization buffers, leading to a rise in *non-performing loans (NPLs)* (Alam et al., 2019). Recent findings in *sub-Saharan Africa* (Brei et al., 2020) and the *GCC region* (Ahmed et al., 2022) confirm that banking systems with low market concentration experience increased credit risk due to aggressive lending strategies.

In contrast, the *Competition-Stability Hypothesis* suggests that increased competition fosters banking stability by enhancing efficiency, loan quality, and risk diversification (Boyd & De Nicolo, 2005; Szüle, 2023). Studies from African economies (Kimani et al., 2021) indicate that competitive banking markets lead to better credit allocation and financial inclusion, ultimately mitigating systemic risks. Empirical research in Kenya (Kimani et al., 2021) demonstrates that well-regulated competitive environments can enhance financial resilience by reducing credit concentration risks. Meanwhile, the *Non-Linear Competition-Risk Nexus* posits a U-shaped relationship, where moderate competition minimizes excessive risk-taking, while excessive competition induces instability (González et al., 2017; Martinez-Miera & Repullo, 2010). Empirical studies using quantile regressions and dynamic panel models (Tabak et al., 2012) confirm this hypothesis in emerging economies, particularly where banking markets exhibit mixed regulatory frameworks. In Tanzania's context, where the banking sector comprises both large dominant players and smaller microfinance institutions, understanding the non-linear dynamics of competition and risk-taking is essential (Bank of Tanzania, 2024).

Despite extensive empirical research, critical gaps remain. Most prior studies have either focused on developed economies or broad regional assessments (Kasman & Kasman, 2015), overlooking Tanzania's unique banking structure, regulatory reforms, and post-pandemic financial policies. Additionally, there is limited research on how recent financial inclusion measures and macroprudential regulations impact the market structure-credit risk nexus in Tanzania. This paper aims to bridge these gaps by conducting a comprehensive empirical analysis of Tanzanian banks, leveraging post-pandemic financial data (2020–2024) and incorporating regulatory interventions, macroeconomic stability indicators, and financial inclusion policies to provide a holistic understanding of sustainable banking stability in Tanzania.

2.3 Hypotheses Development. Based on the empirical literature and theoretical perspectives, the following hypotheses are formulated:

- *H1:* Increased competition in the Tanzanian banking sector is positively associated with higher credit risk, leading to greater financial fragility.
- *H2:* Greater banking sector competition enhances banking stability by improving credit allocation and financial resilience in the post-pandemic Tanzanian context.
- *H3:* The COVID-19 pandemic (2019–2020) moderated the relationship between market competition and credit risk in Tanzanian banks by reshaping lending regulations, risk management frameworks, and financial inclusion policies.

2. METHODOLOGY

2.1 Methodological Choice

This paper employed a quantitative research design to investigate the interplay between market structure, credit risk, and banking stability post-COVID-19. Quantitative research is appropriate because it facilitates empirical testing of hypotheses using numerical data and statistical tools (Creswell, 2014). Specifically, a panel data approach is adopted due to its advantages in controlling for heterogeneity, capturing dynamic effects, and improving the efficiency of econometric estimations (Baltagi, 2021). Panel data models facilitate the examination of both cross-sectional and time-series variations, making them crucial for evaluating banking stability over time

Furthermore, the study applies an explanatory research approach, which aims to establish causal relationships between independent and dependent variables (Saunders et al., 2023). This approach is justified as it enables rigorous hypothesis testing and enhances the robustness of empirical findings.

2.2 Sample Selection and Data Source

The Tanzanian banking sector is composed of domestic and foreign banks, classified into large, medium, and small banks. As of 2024, the Bank of Tanzania (BoT) reports a total of 36 commercial banks operating in the country (Bank of Tanzania, 2024). The sample for this study comprises ten large commercial banks in Tanzania. The selection of these banks is based on three critical factors: (i) representativeness of the Tanzanian banking sector, (ii) data availability and consistency, and (iii) homogeneity in operational characteristics (Saunders et al, 2023). Collectively, these large banks account for approximately 80% of the sector's total assets, loans, and deposits, making them a representative sample of the industry (Bank of Tanzania, 2024). The inclusion criteria require that banks must have operated continuously from 2010 to 2024, ensuring comparability over time and reducing distortions due to mergers, acquisitions, or bank closures (Bryman, 2016). The study period, 2010–2024, is chosen to capture the impact of significant regulatory reforms, technological advancements, and economic events that have shaped Tanzania's banking industry. Data sources include audited financial statements from individual banks, reports from the BoT, and relevant publications from the IMF and World Bank to ensure reliability and accuracy.

2.3 Model Specification

This paper employed a dynamic panel data regression model to investigate the relationship between market structure, credit risk, and post-pandemic banking stability in Tanzanian banks. The dynamic nature of credit risk and financial stability necessitates an estimation approach that accounts for endogeneity and persistence effects. Given the potential simultaneity between market competition and risk-taking behaviour, the study employs the Generalized Method of Moments (GMM) estimator, as proposed by Arellano and Bond (1991). The different GMM approach is chosen due to its ability to eliminate unobserved heterogeneity and mitigate endogeneity concerns by using lagged variables as instruments (Roodman, 2009). This estimation technique is particularly relevant in banking studies, where past risk behaviour influences current stability (Beck & Levine, 2004).

The model specification incorporates key control variables, including bank size, capital adequacy, liquidity ratio, and GDP growth. Additionally, the interaction between banking competition and the COVID-19 pandemic is analyzed to assess the moderating effects of financial disruptions on risk-taking behaviour. To ensure robustness, the validity of instrumental variables is tested using the Hansen J-statistic and Arellano-Bond test for autocorrelation.

The basic first-difference GMM model is specified as follows

$$Y_{i,t} = \alpha Y_{i,t-1} + \beta X_{i,t} + \delta_i + \varepsilon_{i,t} \qquad (1)$$

Where; $Y_{i,t}$= Dependent variable; $\alpha Y_{i,t-1}$=Lagged dependent variable capturing persistence; $\beta X_{i,t}$=Vector of explanatory variables; δ_i =Unobserved bank-specific effects; $\varepsilon_{i,t}$=Idiosyncratic error term

Transformation to First-Difference to Remove Fixed Effects is given the following equation (2)

$$\left(Y_{i,t} - Y_{i,t-1}\right) = \alpha\left(Y_{i,,t-1} - Y_{i,t-2}\right) + \beta\left(Y_{i,t} - Y_{i,,t-1}\right) + \left(\varepsilon_{i,t} - \varepsilon_{i,t-1}\right) \quad (2)$$

Since; $Y_{i,,t-1}$ is correlated with $\varepsilon_{i,t-1}$ the *instrumental variables* are required.

The Lagged levels as instruments for differenced equations:

$$\left[Y_{i,,t-s}\left(\varepsilon_{i,t} - \varepsilon_{i,t-1}\right)\right] = 0 \; for \; s \geq 2 \quad (3)$$

Moment conditions:

$$\left[Y_{i,,t-s} \,.\, \Delta\varepsilon_{i,t}\right] = 0 \;\; for \; s \geq 2 \quad (4)$$

The Arellano-Bond estimator uses these conditions to construct a GMM objective function:

$$\hat{\theta} = \arg\underbrace{min}_{\theta} \; (Z'\Delta Y)'W(Z'\Delta Y) \quad (5)$$

where = Instrument matrix (lagged values of Y and X); W = Optimal weighting matrix and θ= Parameter vector to be estimated

The final GMM Model specification for this paper is given in the following equation

$$\mathrm{CreditRisk}_{it} = \beta_0 + \beta_1 \mathrm{CreditRisk}_{\boldsymbol{i,t-1}} + \beta_2 \mathrm{Competition}_{it} + \beta_3 COVID_t + \beta_4(\mathrm{Competition}_{it} \; x \; COVID_t) + \beta_5 SIZE_{it} + \beta_6 CAR_{it} + \beta_7 LQD_{it} + \beta_8 GDP_{it} + \delta_i + \varepsilon_{it} \quad (6)$$

where: $\mathrm{CreditRisk}_{\boldsymbol{it}}$= Credit risk; $\mathrm{CreditRisk}_{\boldsymbol{i,t-1}}$= Lagged credit risk to capture persistence; $\mathrm{Competition}_{it}$ = Measure of banking competition; $COVID_t$= Dummy variable for COVID-19 ; $\mathrm{Competition}_{it} \; x \; COVID_t$=Interaction term to assess moderation effects; Control variables (bank size, capital adequacy, liquidity ratio and GDP growth); δ_i = Bank-specific fixed effects to control for unobserved heterogeneity across banks

2.4 Description of variables

Table 1 presents a detailed description of the variables employed in this paper, based on theoretical and empirical foundations.

Table 1. Operationalization of study variables

	Name of variable	*Acronym*	*Measurement*	*Empirical evidence*
Dependent variable	Credit Risk	Credit Risk	NPL/TL	Ozili, (2022)
Explanatory variables	lagged Credit Risk	$\mathrm{Credit\ Risk}_{\boldsymbol{i,t-1}}$	$NPL_{i,t-1}/TL_{i,t-1}$	Ozili, (2022)
	Competition	Competition	Lerner Index	Berger et al. (2017)
	Covid-19 dummy	COVID	1 for 2020–2024, 0 otherwise	Elnahass et al. (2021)
Control variables	Bank size	SIZE	Natural log of total assets	Khattak & Ali (2021)
	Capital Adequacy	CAR	Total capital/risk-weighted assets.	Swandewi & Purnawati, (2021)
	liquidity ratio	LQD	$total\ liquid\ assets/total\ \ assets$	Risfandy et al. (2022)
	GDP growth	GDP	Real GDP growth rate	(Msomi, 2022; Ahmed et al., 2021),

Source: Authors.

3. EMPIRICAL RESULTS AND DISCUSSIONS

3.1 Descriptive Statistics

The descriptive statistics provide key insights into Tanzanian banks' financial conditions in the post-pandemic era, highlighting variations in credit risk, liquidity, capital adequacy, and market competition. Table 2 summarizes these statistics, offering a foundational understanding of the banking sector's stability

The mean credit risk of 6.24 suggests moderate risk exposure, consistent with heightened post-pandemic loan default probabilities. The standard deviation of 1.87 indicates significant variability, likely due to differences in risk management strategies and sectoral exposures. The observed range (2.90–5.58) confirms that while some banks mitigate credit risk effectively, others remain vulnerable. The lagged credit risk variable closely mirrors current values, reflecting the persistence of risk trends over time. The competition index, with a mean of 0.424, indicates a moderately competitive market. A low standard deviation (0.012) suggests minimal variation across banks, though the range (0.344–0.548) highlights disparities in market dominance, influencing risk-taking behaviours. As competition intensifies, profit margins may narrow, potentially increasing financial risk exposure. The mean bank size of 12.28 suggests large banks dominate the sector. A low standard deviation (0.354) indicates relative uniformity. Larger banks are generally more resilient to economic shocks due to superior resources and diversification. The liquidity ratio (LQD), averaging 42.72, reflects strong short-term liquidity positions. However, the high standard deviation (16.26) suggests substantial variation in liquidity management practices. While most banks maintain stability (range: 37.70–47.80), some exhibit significantly higher liquidity, enhancing resilience during financial distress. The capital adequacy ratio (CAR) of 13.24 suggests that most banks exceed regulatory requirements, crucial for financial stability. However, the relatively high standard deviation (2.84) highlights significant disparities, with some banks at risk of capital shortfalls (range: 14.90–18.46). This underscores the need for robust regulatory oversight. The GDP growth rate, averaging 5.764, indicates moderate post-pandemic recovery. The standard deviation (1.486) suggests economic fluctuations, with the range (5.43–11.90) reflecting periods of both expansion and contraction, influenced by global economic challenges.

Table 2. Descriptive statistics

Variables	*Obs*	*Mean*	*Std. dev.*	*Min*	*Max*
Credit Risk (CR)	150	6.24	1.87	2.90	5.58
lagged Credit Risk	150	6.24	1.87	2.90	5.58
Competition	150	0.424	0.012	0.344	0.548
SIZE	150	12.28	0.354	4.682	16.18
LQD	150	42.72	16.26	37.70	47.80
CAR	150	13.242	2.842	14.90	18.46
GDP	150	5.764	1.486	5.43	11.90

Source: Author 2025

3.2 Results of Correlation Analysis and Variation Inflation Factor (VIF)

Table 3 presents the pairwise correlation coefficients and VIF results among key variables, providing insights into market structure, credit risk, and sustainable banking stability in Tanzania's post-pandemic era. The correlation matrix reveals a weak but significant negative relationship between credit risk and lagged credit risk (-0.024, $p < 0.05$), indicating banks' gradual adoption of risk-mitigation strategies. The inverse relationship between credit risk and competition (-0.035, $p < 0.05$) suggests that heightened competition slightly reduces credit risk, likely due to improved screening and risk assessment. Conversely, the positive correlation between credit risk and COVID-19 (0.076, $p < 0.05$) highlights the pandemic's adverse effects on banking stability, possibly due to increased loan defaults.

The negative correlation between bank size and credit risk (-0.109, $p < 0.05$) suggests that larger banks manage risk more effectively, potentially due to diversified loan portfolios. Similarly, competition's

positive association with capital adequacy (0.140, $p < 0.05$) implies that competitive pressures may drive stronger capital buffers. The negative correlation between GDP and credit risk (-0.057, $p < 0.05$) confirms economic growth's role in reducing credit risk, whereas GDP's positive link with COVID-19 (0.099, $p < 0.05$) reflects pandemic-induced volatility. The VIF results indicate that all values are below 5, with a mean VIF of 1.033, confirming the absence of serious multicollinearity concerns. This ensures the robustness of regression estimates in analyzing market structure, credit risk, and banking stability in Tanzania's post-pandemic landscape.

Table 2. Pairwise Correlation matrix

Variable	*CR*	*Lagged CR*	*Competition*	*COVID*	*SIZE*	*LQD*	*CAR*	*GDP*
CR	1.000							
Lagged CR	-0.024**	1.000						
Competition	-0.035**	0.038**	1.000					
COVID	0.076**	0.083**	-0.106**	1.000				
SIZE	-0.109**	-0.034**	-0.036**	-0.082*	1.000			
LQD	-0.016**	0.102**	0.052**	0.034*	-0.015*	1.000		
CAR	0.055**	-0.079**	0.140**	-0.034*	-0.101*	0.092*	1.000	
GDP	-0.057**	-0.088*	-0.017*	0.099*	0.172*	0.022*	-0.029*	1.000
VIF		1.026	1.018	1.025	1.031	1.050	1.056	1.028
1/VIF		0.975	0.983	0.976	0.970	0.952	0.947	0.972
Mean VIF	1.033							

Source: Author 2025: Note: Standard errors are in parentheses; *p<0.01 and **p<0.05,

3.3 GMM Estimation Findings and Discussion

The empirical results presented in Table 4 provide critical insights into the relationship between market structure, credit risk, and sustainable banking stability in Tanzania's post-pandemic era. The model demonstrates strong explanatory power, with an R-squared of 0.684 and an adjusted R-squared of 0.659, indicating that approximately 66% of the variation in credit risk is explained by the selected variables. The validity of the instruments used in the system GMM estimation is confirmed by the Hansen test result ($p = 0.341$), which suggests no overidentification problems. Additionally, the Arellano-Bond AR (1) test ($p = 0.017$) reveals the expected presence of first-order autocorrelation in dynamic panel models, while the AR (2) test ($p = 0.269$) confirms the absence of second-order autocorrelation, reinforcing the model's robustness.

The coefficient of lagged credit risk (0.672, $p < 0.05$) indicates a high degree of persistence in credit risk, suggesting that past credit risk significantly influences current risk levels. This finding aligns with theoretical expectations, reinforcing the notion that banking sector fragility is a long-term phenomenon shaped by historical risk-taking behaviours. The persistence of credit risk underscores the necessity for proactive risk management strategies to enhance banking sector resilience in the post-pandemic landscape. The coefficient of banking sector competition (-0.214, $p = 0.027$) is statistically significant and negative, implying that increased competition reduces credit risk. This result challenges the competition-fragility hypothesis (Marcus, 1984; Keeley, 1990) and instead supports the competition-stability perspective, where intensified market rivalry fosters improved credit allocation and risk assessment mechanisms (Boyd & De Nicoló, 2005). Consequently, Hypothesis H1 is rejected, while H2 is supported, confirming that greater competition contributes to enhanced banking stability in the Tanzanian context. The finding aligns with Kasman & Kasman (2015) on Turkey and Beck et al. (2006) for developed and developing countries which support the competition-stability view. The coefficient of the COVID-19 variable (0.189, $p = 0.038$) is positive and statistically significant, suggesting that the pandemic exacerbated credit risk. This finding is consistent with existing literature, which highlights that economic disruptions during the COVID-19 crisis heightened non-performing loans and financial vulnerabilities (Shabir et al., 2023). Moreover, the interaction term (Competition × COVID-19) exhibits a significant positive coefficient (0.267, $p = 0.001$), indicating that the pandemic intensified the competition-credit risk relationship. This supports Hypothesis H3,

suggesting that COVID-19 introduced non-linear dynamics in banking sector stability by amplifying the impact of competition on credit risk.

Regarding control variables, bank size (-0.109, p = 0.06) demonstrates a marginally significant negative relationship with credit risk, implying that larger banks benefit from economies of scale in risk management. The capital adequacy ratio (-0.087, p = 0.044) exhibits a negative coefficient, aligning with regulatory theories that suggest well-capitalized banks are better equipped to absorb financial shocks and mitigate risk exposure. Similarly, the liquidity ratio (-0.076, p = 0.041) is negatively associated with credit risk, reinforcing the view that higher liquidity enhances financial stability. Additionally, GDP growth (-0.054, p = 0.038) is negatively related to credit risk, suggesting that macroeconomic stability plays a crucial role in reducing banking sector vulnerabilities, consistent with findings in emerging economies (Beck et al., 2015). These findings contribute to the ongoing debate between the competition-fragility and competition-stability perspectives in banking. The negative relationship between competition and credit risk challenges the traditional competition-fragility hypothesis, instead supporting a nuanced competition-stability framework in the post-pandemic Tanzanian banking sector. Empirical evidence from emerging markets corroborates this view, demonstrating that increased competition enhances banking stability through improved risk assessment mechanisms (Brei et al., 2020). Furthermore, the significant moderating effect of COVID-19 underscores the transformative role of external shocks in reshaping competitive dynamics, emphasizing the need for adaptive regulatory policies. In light of these findings, policymakers and regulators should consider measures to promote healthy banking competition while implementing safeguards against external shocks. Strengthening risk management frameworks, enhancing capital buffers, and fostering financial innovation can help mitigate credit risk and ensure sustainable banking stability in Tanzania's evolving financial landscape.

Table 4. System GMM Estimation Results for Credit Risk

Variables	*Coefficients*	*Std. Errors*	*z-Statistic*	*p-Values*
Lagged Credit Risk	0.672**	0.045	14.93	0.000
Competition	-0.214**	0.097	-2.21	0.027
COVID-19	0.189**	0.091	2.08	0.038
Competition × COVID-19	0.267**	0.08	3.34	0.001
Bank Size	-0.109*	0.058	-1.88	0.06
Capital Adequacy Ratio	-0.087**	0.043	-2.02	0.044
Liquidity Ratio	-0.076**	0.037	-2.05	0.041
GDP Growth	-0.054**	0.026	-2.08	0.038
Constant	1.542*	0.487	3.17	0.002
R-Squared	0.684			
Adjusted R-Squared	0.659			
Hansen Test	0.341			
AR (1)	0.017			
AR (2)	0.269			
Number of Instruments	38			
Number of Observations	150			

Source: Author 2025: Note: *p<0.01 and **p<0.05

3.4 Robustness Check

To ensure the reliability of our findings, we conducted robustness checks using alternative model specifications (Models 1–4) to assess the stability of our results regarding the impact of credit risk in Tanzanian commercial banks. The robustness results, presented in Table 5, confirm the persistence of credit risk, as indicated by the positive and highly significant coefficients of the lagged credit risk variable across all models (0.690–0.712, $p < 0.01$). This suggests that past credit risk levels significantly influence current

credit risk, aligning with prior empirical evidence that credit risk remains a structural challenge in banking systems.

The relationship between market competition and credit risk exhibits variation across model specifications. In Model 1, competition positively and significantly influences credit risk (0.126, $p < 0.05$), supporting H1. However, when additional controls are introduced (Models 2–4), the effect turns negative and significant (-0.139 to -0.148, $p < 0.05$), supporting H2. This indicates that heightened competition reduces credit risk, possibly due to improved risk assessment strategies, enhanced borrower screening, and regulatory compliance in a competitive banking landscape. The shift in results suggests that failing to account for key control variables may initially overstate the risk-enhancing role of competition.

The interaction term (Competition × COVID-19) remains consistently positive and significant across all models (0.214–0.230, $p < 0.05$), supporting H3. This finding suggests that during the pandemic, competition intensified credit risk, potentially due to heightened uncertainty, increased default rates, and weakened borrower creditworthiness. The pandemic variable itself is positive and significant (0.184–0.205, $p < 0.05$), reinforcing the global trend of elevated credit risk stemming from economic disruptions, declining borrower capacity, and liquidity constraints. The results are consistent with theoretical predictions from the competition-stability views in banking, highlighting the nuanced effects of market structure on financial stability.

Table 5. Robustness Check

Variables	*Model 1*	*Model 2*	*Model 3*	*Model 4*
Lagged Credit Risk	0.712** (0.042)	0.698** (0.045)	0.705** (0.039)	0.690** (0.041)
Competition (H1, H2)	0.126** (0.058)	-0.139** (0.061)	-0.142** (0.057)	-0.148** (0.059)
COVID-19 (2019–2020)	0.184** (0.076)	0.192** (0.078)	0.198** (0.081)	0.205** (0.083)
Competition × COVID-19 (H3)	0.230** (0.095)	0.214** (0.091)	0.221** (0.089)	0.218** (0.087)
Bank Size (SIZE)	-0.078** (0.035)	-0.085** (0.038)	-0.081** (0.034)	-0.079** (0.032)
Liquidity (LQD)	-0.014* (0.006)	-0.013* (0.007)	-0.015* (0.006)	-0.014* (0.006)
Capital Adequacy Ratio (CAR)	-0.092** (0.044)	-0.089** (0.042)	-0.095** (0.041)	-0.091** (0.040)
GDP Growth Rate (GDP)	-0.067* (0.028)	-0.071* (0.030)	-0.069* (0.027)	-0.065* (0.026)
Constant	2.114** (0.358)	2.098** (0.362)	2.102** (0.355)	2.086** (0.349)
AR (1) p-value	0.014	0.016	0.013	0.017
AR (2) p-value	0.372	0.354	0.368	0.359
Hansen Test	0.512	0.498	0.521	0.510
Number of Observations	150	150	150	150
Number of instruments	35	35	35	35

Source: Source: Author 2025: Note: ; *p<0.01 and **p<0.05

CONCLUSIONS AND POLICY IMPLICATIONS

This study provides empirical insights into the interrelationship between market structure, credit risk, and sustainable banking stability in Tanzania's post-pandemic era. Using a dynamic panel data regression model estimated via the Generalized Method of Moments (GMM), the findings reveal that increased banking competition significantly reduces credit risk, supporting the competition-stability hypothesis. The

persistence of credit risk, as evidenced by the significant coefficient of lagged credit risk, underscores the necessity for proactive and sustained risk management practices. Furthermore, the COVID-19 pandemic has had an adverse effect on credit risk, highlighting the vulnerabilities of the banking sector during economic disruptions. The moderating effect of competition on the COVID-19-induced credit risk further demonstrates that well-functioning competitive banking environments can mitigate financial instability. These findings offer crucial implications for regulators, policymakers, and financial institutions in shaping strategies to foster sustainable banking stability in Tanzania.

Theoretical Implications. This study contributes to the existing body of literature on banking stability by reinforcing the competition-stability perspective within the Tanzanian banking context. Contrary to the competition-fragility hypothesis, the findings indicate that increased competition enhances financial stability by improving credit allocation efficiency and risk assessment mechanisms. Additionally, the results underscore the significance of external economic shocks, such as COVID-19, in influencing credit risk, thereby providing new theoretical insights into the role of macroeconomic disruptions in banking stability. These findings call for a reassessment of traditional risk management frameworks to incorporate competition dynamics and external shocks in financial stability models.

Practical Implications. The findings have several practical implications for banking institutions, regulators, and policymakers in Tanzania. First, the negative relationship between banking competition and credit risk suggests that policymakers should encourage a competitive banking environment through regulatory frameworks that promote market efficiency. Second, given the persistence of credit risk, banks should enhance their credit risk management practices by implementing robust early warning systems and stress-testing mechanisms to anticipate and mitigate future risks. Third, the observed impact of the COVID-19 pandemic on credit risk highlights the need for contingency planning and adaptive financial resilience strategies. Regulators should incorporate macroeconomic shock scenarios into risk assessment frameworks to strengthen the sector's ability to withstand future crises. Lastly, policymakers should consider developing financial stability policies that integrate market competition as a critical element in enhancing overall banking resilience.

Limitations and Areas for Future Research. While this study provides valuable insights into the dynamics of market structure, credit risk, and banking stability in Tanzania, it has certain limitations. First, the study focuses solely on large commercial banks, which may limit the generalizability of the findings to smaller banks and microfinance institutions. Future research should incorporate a broader spectrum of financial institutions to capture a more comprehensive picture of the banking sector. Second, the study period, spanning from 2010 to 2024, may not fully capture the long-term structural transformations in Tanzania's banking sector. Extending the study period further could provide deeper insights into the evolving nature of market structure and risk dynamics. Finally, future research could explore the role of technological advancements, such as digital banking and fintech innovations, in shaping credit risk and banking stability post-pandemic

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Entrepreneurial Intentions and Gender Inequality in MENA (GEM 2019)

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ABSTRACT

This study examines the interplay between gender inequality and entrepreneurial intentions in the Middle East and North Africa (MENA) region using 2019 Global Entrepreneurship Monitor (GEM) data and the Gender Inequality Index (GII). The research investigates how networks, perceived opportunities, knowledge/skills, fear of failure, and community perceptions influence entrepreneurial intentions, with gender inequality as a moderator. Employing binary logistic regression on 19,119 respondents across nine MENA countries, the study tests six hypotheses to assess direct and gendered moderating effects. Results reveal that networks, knowledge/skills, courage, and favorable community perceptions significantly drive entrepreneurial intentions for both genders, whereas perceived opportunities lack direct influence. Notably, gender inequality exhibits paradoxical effects: while it does not directly suppress women's intentions, it negatively moderates their network efficacy while amplifying their perceived opportunities. The study challenges simplistic narratives of gender inequality as uniformly detrimental, illustrating its dual role as both a structural barrier and an inadvertent motivator for women. Methodological limitations, including reliance on cross-sectional data, highlight opportunities for future longitudinal and qualitative research. This work advances understanding of gendered entrepreneurship in MENA, offering pathways to promote inclusive economic participation.

INTRODUCTION

The creation of new businesses has a significant influence on economic growth. It is pivotal for developing regions and nations as it creates employment opportunities, increases productivity, diversifies markets, improves social welfare, and promotes economic development. Therefore, policymakers worldwide encourage it to aid economic growth (Abdinnour & Adeniji, 2023; Gu et al., 2021). In the context of the MENA region, Alkasmi et al. (2018) stated in their report that the region is booming as a hub of commercial innovation and entrepreneurial activities. However, the region had one of the highest youth populations. Meanwhile, youth unemployment is also among the highest rates, according to the World Bank (2022). This unemployment rate, in addition to other factors such as the youth population, digital economy, and technology, eases the way for youth to start their businesses (Alkasmi et al., 2018; Xiong et al., 2024)

However, according to GEM-Global Entrepreneurship Monitor (2023), women are still behind in the MENA region's entrepreneurial activities compared to men; for instance, the male percentage of established startups is 8% compared to the female percentage of 4.9%. The report also shows that women have

one of the highest percentages among other regions in terms of “startup or entrepreneurial intention," which is 31.4%, compared to men, which is around 37.9%. As the above percentages show, activity rates generally decline as one moves from startup intentions to established business. This highlights the urgency of understanding early-stage potential entrepreneurs' intentions, which is paramount for practitioners (Touissate & Azdimousa, 2021). Esfandiar et al. (2019, p.173) state, “To ensure a continuous supply of entrepreneurs, academics and practitioners need to know how early-stage potential entrepreneurs' intentions originate as well as what factors stimulate entrepreneurship. Therefore, according to Krueger et al. (2009), entrepreneurial intention is one of the best indicators that could predict the establishment of new businesses, where it is defined as individual inclination and perceived capability and ability to be engaged in startup activities (Oosterbeek et al., 2010). The next content of the paper is structured as follows: Section 2 provides the related literature and the hypothesis development; Section 3 is the research methodology; Section 4 presents the empirical analysis; Section 5 discusses the findings and concludes our study with suggestions for future research

1. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Global female entrepreneurship reflects persistent gender inequalities, with environments structurally favoring men and limiting women’s access to resources and opportunities (Marlow & Patton, 2005). While some scholars argue gender inequality inadequately explains entrepreneurial gender disparities (Baughn et al., 2006; Bastian et al., 2019), others contend advancing equality could bridge this gap (Sarfaraz & Faghih, 2011). This study investigates how gender inequality shapes entrepreneurial intentions in the MENA region, contributing to this unresolved debate.

The Women’s Entrepreneurship Report (2023) highlights a paradox: women in low-income countries exhibit high entrepreneurial intentions but lower business start-up rates, often due to economic barriers. Scholars attribute this gap to gender discrimination and hostile work environments (Salamzadeh et al., 2013), non-economic drivers like autonomy and work-life balance (Godany & Mura, 2021), and systemic inequalities in resource access, education, and societal norms (Sullivan & Meek, 2012). Thus, we hypothesize:

H1: *Gender inequality negatively correlates with men’s and women’s entrepreneurial intentions in the MENA region.*

Authors such as Alam et al. (2011), Dawson & Henley (2013), Johansen (2013), and Mishra (2015) indicate that such contextual factors as the level of women entrepreneurs’ involvement are associated with the degree of interaction of social networks, social media and professional networks; the difficulty of receiving support is institutional, familiar, and financial. Consequently, the following two hypotheses, a and b, are formulated:

H2a: *The network positively affects the entrepreneurial intentions of men and women in the MENA region.*
H2b: *Gender inequality will negatively moderate the relationship between the network and the entrepreneurial intentions of men and women in the MENA region.*

Emerging economies face distinct barriers to women’s entrepreneurial participation compared to developed nations, including unequal access to capital for both genders (Cardella, 2020; Gautam & Mishra, 2016; Raghuvanshi et al., 2017; Touissate & Azdimousa, 2021). Challenges such as limited institutional, familial, and financial support hinder business creation (Johansen, 2013), while institutional backing, credit access, and social networks motivate female entrepreneurs (Mishra, 2015). This informs the hypotheses:

H3a: *Perceived opportunity positively affects the entrepreneurial intention of men and women in the MENA region.*
H3b: *Gender inequality will moderate the relationship between women's perceived opportunity and entrepreneurial intention compared to men in the MENA region.*

Moreover, knowledge, skills, and risk tolerance are critical for entrepreneurial intentions, yet women face barriers such as fear of failure, low self-confidence, and weak social networks (Dawson & Henley, 2013). Personality traits (e.g., self-efficacy) and contextual factors (e.g., networks) are intertwined in

shaping sustainable ventures (Alam et al., 2011), with fear of failure and self-efficacy identified as key deterrents (Wieland et al., 2019). Thus, we hypothesize:

H4a: *Knowledge and skills are positively correlated with the entrepreneurial intentions of men and women in the MENA region.*
H4b: *Gender inequality will negatively moderate the relationship between knowledge and skills and women's entrepreneurial intention compared with men in the MENA region.*
H5a: *Courage (not fear of failure) is positively correlated with the entrepreneurial intention of men and women in the MENA region.*
H5b: *Gender inequality will negatively moderate the relationship between courage (not fear of failure) and the entrepreneurial intention of women compared with men in the MENA region.*

Social perceptions associating entrepreneurship with masculine traits (e.g., risk-taking, economic ambition) hinder women's entrepreneurial motivation, as women are often stereotyped as caregivers prioritizing social value (Hechavarría et al., 2019; Pereiro, 2019). These stereotypes, coupled with perceived male dominance in business (Langowitz & Minniti, 2007), discourage women from pursuing ventures, exacerbated by lower risk tolerance (Dawson & Henley, 2013) and systemic barriers like limited support and societal stigma (Johansen, 2013; Touissate & Azdimousa, 2021). This informs the hypotheses:

H6a: *Community perception of startups positively correlates with men's and women's entrepreneurial intentions in the MENA region.*

H6b: *Gender inequality will negatively moderate the relationship between women's and men's perceptions of startups in the business community and their entrepreneurial intentions in the MENA region.*

This study primarily aims to explore how individual factors—such as networks, perceived opportunities, knowledge and skills, fear of failure, and community perceptions of startups—influence entrepreneurial intentions among both men and women while also examining the moderating role of gender inequality, as shown in Figure 1.

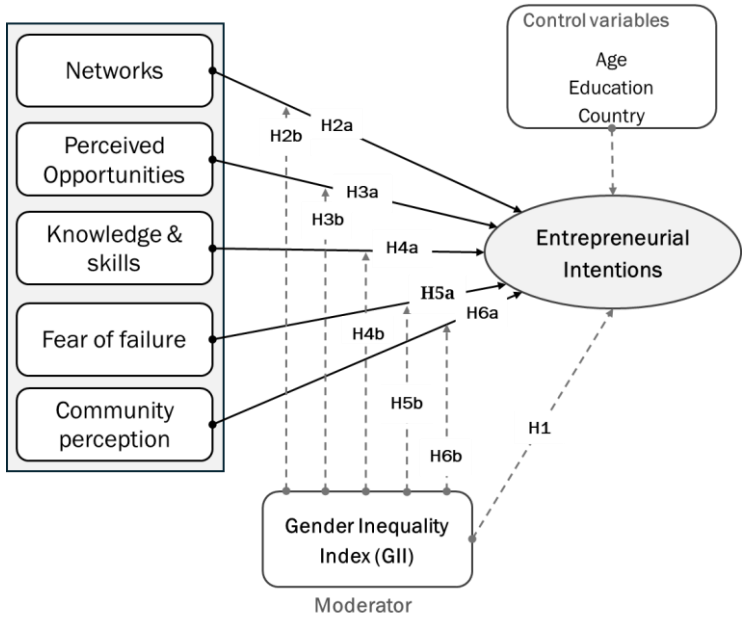

Figure 1. Research conceptual framework
Source: Own illustration

2. METHODOLOGY

The dataset to test the hypotheses is collected from the Global Entrepreneurship Monitor (GEM) Adult Population Survey (APS) 2019 and the Gender Inequality Index (GII) for the year 2022[1]. The dataset includes 19,119 observations. Table 1 provides variable descriptions and sources. The Global Entrepreneurship Monitor (GEM) is a globally recognized research initiative established in 1999 to assess entrepreneurial activity, attitudes, and ecosystems across over 100 countries. It employs standardized surveys, including the Adult Population Survey (APS), which collects individual-level data on perceptions, intentions, and barriers related to entrepreneurship, ensuring cross-country comparability. For this study, the 2019 GEM dataset was utilized to analyze nine MENA countries, focusing on binary variables such as network (knowing an entrepreneur), perceived opportunity, knowledge/skills, fear of failure, and community perception of startups, alongside the dependent variable entrepreneurial intentions (expecting to start a business within three years), as shown in table (1). GEM's rigorous methodology and emphasis on early-stage entrepreneurial dynamics make it ideal for exploring gender disparities, as its harmonized data allows for nuanced comparisons of how social, cultural, and institutional factors shape intentions in the MENA region.

Table 1. Variable descriptions and sources

Variable	*Description*	*Scale*	*Source*
Dependent variable			
Entrepreneurial intention	Expecting to start a new business in the next three years	1: Yes, 0: No	GEM
Independent variable			
Network	Knowing someone personally who started a business in the past two years.	1: Yes, 0: No	GEM
Perceived opportunity	Perceiving good opportunities for starting a business in the next six months	1: Yes, 0: Else	GEM
Knowledge and Skills	Has the knowledge, skill and experience required to start a new business	1: Yes, 0: No	GEM
Fear to Fail	Having a fear of failure to start up a business	1: Yes, 0: No	GEM
Community Perception	Perceived perception of startups by the community in their country, where most people consider starting a new business a desirable career choice	1: Yes, 0: Else	GEM
Moderator			
Gender Inequality Index	The Gender Inequality Index (GII) reflects gender-based disadvantages in three dimensions: reproductive health, empowerment, and the labor market.	It ranges between 0, where women and men fare equally, and 1, where one gender fares as poorly as possible in all measured dimensions	GII[2] - 2022
Control variable			
Age	Aged 18–64		GEM
Gender	Male or Female	1: Male, 2: Female	GEM
Education	The level of education	1: Above Secondary Education, 0: Secondary Education or below	GEM
Country	Egypt, Iran, Israel, Jordan, Morocco, Oman, Qatar, Saudi Arabia, and the United Arab Emirates		GEM

Source: own processing

3. RESULTS AND DISCUSSION

[1] United Nations Development Programme (UNDP) 2022, Human Development Report, Undp.org.

[2] United Nations Development Programme (UNDP) 2022, Human Development Report, Undp.org.

3.1 Descriptive statistics

The number of female and male respondents for each country is not much different, except in the case of Oman, Qatar and United Arab Emirates where the number of male respondents is nearly 2 times higher than the number of female counterparts. On average, male respondents have higher entrepreneurial intention, except for Egypt and Oman. Moreover, while the United Arab Emirates has the lowest GII at 0.035, and Iran has the highest at 0.484. Table 2 provides descriptive statistics for participants' gender, age, education, and Gender Inequality Index (GII) for each country.

Table 2. Cross tabulation of country, participants' gender, age, education, Gender Inequality Index (GII)

Country	*Participants*		*% Yes: Entrepreneurial Intention*	*Age Average*	*% Education (more than a secondary degree)*	*Gender Inequality Index*
	Gender	*Count (%)*				
Egypt	Female	846 (46.2%)	79.7	33	65.5	0.389
	Male	985 (53.8%)	50	36	64.1	
Iran	Female	1,255 (49.5%)	41.8	36	59.9	0.484
	Male	1,282 (50.5%)	49.6	37	67.6	
Israel	Female	586 (49.2%)	25.1	39	74.1	0.092
	Male	605 (50.8%)	32.1	39	67.8	
Jordan	Female	925 (51.3%)	25.7	39	16.6	0.449
	Male	877 (48.7%)	33.2	40	19.3	
Morocco	Female	1,556 (49.4%)	40.2	35	33.0	0.404
	Male	1,593 (50.6%)	48.5	35	31.0	
Oman	Female	549 (34.3%)	69.2	34	69.2	0.267
	Male	1,053 (65.7%)	68.3	34	68.3	
Qatar	Female	652 (26.2%)	58.3	32	77.3	0.212
	Male	1,839 (73.8%)	52.6	34	75.7	
Saudi Arabia	Female	1,237 (41.7%)	30.4	38	52.0	0.229
	Male	1,730 (58.3%)	34.7	37	57.6	
United Arab Emirates	Female	475 (30.7%)	41.9	33	73.5	0.035
	Male	1,074 (69.3%)	51.7	35	79.3	
Total	*Female*	*8081 (42.3%)*	*40.7*	*36*	*50.8*	*Ave = 0.284*
19,119	*Male*	*11038 (57.7%)*	*49.0*	*36*	*55.1*	

Source: own processing

Table 3 reports descriptive statistics for the independent variables. It shows that females in Saudi Arabia exhibit the highest confidence in their "entrepreneurial networks," with 83.8% network perception. Conversely, Jordanian females report the lowest network perceptions at 38.4%. Among males, Saudi Arabia maintains the highest network perception (85.8%), while Jordanian males show the lowest (52.5%). As for the "perceived opportunities," Egyptian female respondents perceive ample entrepreneurial opportunities (73.4%), while Israeli female respondents express the lowest perception at 27.1%. On the male respondents' side, Egyptians perceive ample entrepreneurial opportunities with 71.7%, contrasting with Iran's lowest perception (30.2%). Moreover, regarding "knowledge and skills", female respondents from Saudi Arabia feel the most equipped with knowledge and skills (81.5%), whereas Israeli females exhibit the lowest confidence at 34.1%. Saudi Arabia again stands out for male respondents with the highest percentage (83.9%), while Israeli male respondents demonstrate the lowest confidence (50.7%). For "fair to fail," Jordanian female respondents expressed the highest fear of failure (63.8%), contrasting with Omani females, who displayed the lowest fear at 39.7%. Among males, Iranian respondents show the lowest fear (35.3%), while Jordanian males express the highest (64.0%). Egyptian females exhibit the highest community perception at 78.1%, while Iranian female respondents demonstrate the lowest at 38.3%. For males, Omani male respondents have the highest perception (76.9%), while Iranian male respondents exhibit the lowest (38.8%).

Table 3. Cross tabulation of country, participants' gender, and independent variables of study

Country	*Gender*	*Network (%)*		*Perceived Opportunity (%)*		*Knowledge & Skills (%)*		*Fear to Fail (%)*		*Community Perception (%)*	
		No	Yes	Else	Yes	No	Yes	No	Yes	Else	Yes
Egypt	Female	59.6	40.4	26.6	73.4	34.2	65.8	46.2	53.8	21.9	78.1
	Male	38.4	61.6	28.3	71.7	26.0	74.0	48.3	51.7	24.9	75.1
Iran	Female	54.0	46.0	60.9	39.1	38.4	61.6	56.8	43.2	61.7	38.3
	Male	34.4	65.6	55.1	44.9	23.0	77.0	64.7	35.3	61.2	38.8
Israel	Female	31.2	68.8	72.9	27.1	65.9	34.1	41.0	59.0	54.1	45.9
	Male	29.4	70.6	69.8	30.2	49.3	50.7	45.8	54.2	54.7	45.3
Jordan	Female	61.6	38.4	56.8	43.2	49.2	50.8	36.2	63.8	25.5	74.5
	Male	47.5	52.5	69.6	30.4	31.9	68.1	36.0	64.0	31.6	68.4
Morocco	Female	54.1	45.9	53.6	46.4	46.3	53.7	48.5	51.5	23.7	76.3
	Male	41.9	58.1	47.7	52.3	28.7	71.3	58.4	41.6	23.6	76.4
Oman	Female	32.2	67.8	31.1	68.9	42.8	57.2	60.3	39.7	23.0	77.0
	Male	20.9	79.1	37.9	62.1	36.9	63.1	59.0	41.0	23.1	76.9
Qatar	Female	49.2	50.8	32.8	67.2	34.4	65.6	60.1	39.9	23.9	76.1
	Male	33.4	66.6	30.7	69.3	21.2	78.8	55.5	44.5	29.7	70.3
Saudi Arabia	Female	16.2	83.8	29.4	70.6	18.5	81.5	56.8	43.2	32.7	67.3
	Male	14.2	85.8	32.8	67.2	16.1	83.9	55.1	44.9	38.0	62.0
United Arab Emirates	Female	41.5	58.5	44.4	55.6	42.3	57.7	51.4	48.6	37.1	62.9
	Male	34.9	65.1	45.7	54.3	34.4	65.6	58.9	41.1	41.4	58.6
Total	Female	45.4	54.6	46.2	53.8	39.9	60.1	50.8	49.2	34.0	66.0
	Male	32.0	68.0	43.5	56.5	27.3	72.7	54.9	45.1	35.4	64.6

Source: own processing

3.2 Regression Results and discussion

3.2.1 Direct Effects

The data analysis in Table 4 revealed some interesting gender-based differences in entrepreneurial intentions with the effect of the country's model. Contrary to our initial hypothesis (H1) predicting a negative impact for both genders, the gender inequality variable showed no significant effect on women. Interestingly, it had a positive and significant association for men with a coefficient of 1.681, therefore, the results do not support hypothesis H1. Supporting our hypothesis (H2a), the networking variable emerged as significant for both men and women, with a stronger influence on the women's variable (coefficient of 0.667) compared to the men's variable (coefficient of 0.304). The model's results did not support our hypothesis (H3a) that perceived opportunity has a positive influence, as it showed no significant effect on either gender's perceived opportunity variable. In contrast, the knowledge and skills variable played a significant role (confirming H4a) with a more substantial positive effect on women (coefficient of 1.132) compared to men (coefficient of 0.765). For instance, for each unit increase in knowledge and skills, the odds of having entrepreneurial intention among women increase by approximately 3 while men by 2.2, holding all other variables constant. Wald's statistics for knowledge and skills are the highest among other variables for both genders. Moreover, it can be interpreted that the coefficient for knowledge and skills is significantly different from zero. Hence, knowledge and skills significantly affect entrepreneurial intention among females. Similar to H4a, our hypothesis (H5a) that courage (not fearing failure) is positively linked to entrepreneurial intention was confirmed for both genders, with a more robust coefficient for the men's courage variable (0.506) than the women's (0.304). Finally, supporting H6a, the community perception of startups variable emerged as a significant factor for both genders. Interestingly, the effect was more substantial for the women's variable (coefficient of 0.590) than the men's (coefficient of 0.289).

3.2.2 Moderating Effects

Table 4 shows that the impact of gender inequality differs between genders. It did not affect the relationship between networking and entrepreneurial intentions for men. However, it acted as a negative moderator for women, with a coefficient of -0.859. The odds ratio of 0.423 indicates that for a one-unit increase in gender inequality, the odds of having entrepreneurial intention among females decrease by approximately 0.42, holding all other variables constant. Consequently, H2b is not fully supported. Similarly, perceived opportunity played a different role for each gender. It significantly impacted entrepreneurial intentions for women (coefficient of 1.243) but not for men. The odds ratio of 3.466 indicates that for a one-unit increase in gender inequality, the odds of having entrepreneurial intention among females increase by approximately 3.466, holding all other variables constant. This finding suggests that H3b is also not fully supported. The moderating effect of gender inequality on knowledge and skills (H4b), courage (H5b), and community perception (H6b) was not significant for either men or women. Therefore, hypotheses H4b, H5b, and H6b are all rejected. Table 5, provides a summary of the Hypotheses and Results Summary

3.2.3 Country Effects

Table 4 reveals the influence of the national context on entrepreneurial intentions. The independent variables have a significant positive effect in most countries except Iran. Egypt, Oman, Qatar, and the United Arab Emirates all exhibit a positive correlation between the variables and entrepreneurial intentions. However, the strength of this correlation differs. Oman boasts the highest coefficients (1.072 for men, 1.546 for women), while Qatar displays a weaker positive correlation (0.271 for men), and the United Arab Emirates shows the weakest positive correlation for women (0.549). This highlights the role of country-specific factors in shaping entrepreneurial aspirations. Interestingly, Jordan and Saudi Arabia present a contrasting picture. Here, the coefficients for both genders hold negative values (e.g., Jordan: -0.348 for women, -0.540 for men; Saudi Arabia: -0.525 for women, and -0.501 for women). This suggests that cultural or traditional aspects in these countries might discourage entrepreneurship. These results showcase the multifaceted nature of entrepreneurial intention. While individual characteristics are essential, national context, including culture and traditions, plays a significant role.

Table 4. Binary logistic regression

Variable	*Female*			*Male*		
	B	*Wald*	*Exp(B)*	*B*	*Wald*	*Exp(B)*
Control Variables						
Age	-0.018***	64.23	0.982	-0.016***	86.21	0.984
Education	-0.297***	29.56	0.743	-0.223***	24.62	0.800
Independent Variables						
Gender Inequality	1.089	3.46	2.972	1.681***	11.85	5.372
Network	0.667***	21.43	1.948	0.304**	8.308	1.355
Perceived Opportunity	-0.085	0.35	0.919	-0.084	0.687	0.920
Knowledge & Skills	1.132***	59.69	3.101	0.765***	48.73	2.150
Courage (not fear of failure)	0.304*	5.47	1.355	0.506***	28.47	1.659
Community Perception	0.289*	4.19	1.335	0.590***	35.13	1.805
Moderating effects						
Gender Inequality X Network	-0.859*	4.74	0.423	-0.295	0.87	0.745
Gender Inequality X Perceived Opportunity	1.243**	9.99	3.466	1.004	10.6	2.730
Gender Inequality X Knowledge & Skills	-0.100	0.06	0.905	-0.006	0.00	0.994

Variable	*Female*			*Male*		
	B	*Wald*	*Exp(B)*	*B*	*Wald*	*Exp(B)*
Gender Inequality X Fear to Fail	0.645	3.07	1.906	1.161	15.32	3.194
Gender Inequality X Community Perception	-0.422	1.12	0.656	-1.381	19.88	0.251
Dummy variables: Countries (reference country is Morocco)						
D-Egypt	0.745***	63.55	2.106	0.769***	76.80	2.157
D-Iran	0.145	1.84	1.156	-0.176	3.31	0.838
D-United Arab Emirates	0.549***	11.39	1.731	0.671***	27.83	1.957
D-Jordan	-0.348***	11.08	0.706	-0.540***	30.78	0.583
D-Oman	1.546***	181.12	4.691	1.072***	155.26	2.920
D-Qatar	0.923***	66.59	2.518	0.271***	11.63	1.311
D-Saudi Arabia	-0.525***	29.76	0.592	-0.501***	40.59	0.606
Constant	-1.616***	55.18	0.199	-1.350***	59.71	0.259
Cox & Snell R Square	0.167			0.108		
Nagelkerke R Square	0.226			0.144		
R Square changes	0.073			0.063		
Percentage Correct (%)	69.1			64.1		
Omnibus Tests of Model Coefficient	1478.2***			1257.9***		
Note: *** p < 0.001, ** p < 0.01, * p < 0.05.						

Source: own processing

3.2.4 Goodness of fit

Cox and Snell R^2 (conservative) and Nagelkerke R^2 (adjusted to 0–1 range) were used to assess model fit. For females, Nagelkerke R^2 improved from 0.153 (prior model) to 0.226, and males increased from 0.081 to 0.144 in Table 5, indicating stronger explanatory power. Classification accuracy also improved: females rose from 64.4% to 69.1%, and males from 59.1% to 64.1%, reflecting better predictive performance. The Omnibus tests confirmed both models significantly outperformed the null model (females: χ^2=1478.2, p<.001; males: χ^2=1257.9, p<.001), with all predictors collectively enhancing fit. These results, alongside higher R^2 and accuracy, validate the robustness of the final models.

Table 5. Hypotheses and Results Summary

Hypothesis	*Description*	*Result*
H1	Gender inequality negatively correlates with men's and women's entrepreneurial intentions in the MENA region	Not Supported
H2a	The network positively affects the entrepreneurial intentions of men and women in the MENA region	Supported
H2b	Gender inequality will negatively moderate the relationship between the network and the entrepreneurial intentions of men and women in the MENA region	Not fully supported
H3a	Perceived opportunity positively affects the entrepreneurial intention of men and women in the MENA region	Not Supported
H3b	Gender inequality will moderate the relationship between women's perceived opportunity and entrepreneurial intention compared to men in the MENA region	Not fully supported
H4a	Knowledge and skills are positively correlated with the entrepreneurial intentions of men and women in the MENA region	Supported
H4b	Gender inequality will negatively moderate the relationship between knowledge and skills and women's entrepreneurial intention compared with men in the MENA region	Not Supported
H5a	Courage (not fear of failure) is positively correlated with the entrepreneurial intention of men and women in the MENA region	Supported
H5b	Gender inequality will negatively moderate the relationship between courage (not fear of failure) and the entrepreneurial intention of women compared with men in the MENA region	Not Supported
H6a	Community perception of startups positively correlates with men's and women's entrepreneurial intentions in the MENA region	Supported
H6b	Gender inequality will negatively moderate the relationship between women's and men's perceptions of startups in the business community and their entrepreneurial intentions in the MENA region	Not Supported

Source: Own

4. LIMITATIONS AND FUTURE RESEARCH AREAS

While this study provides comprehensive insights into the interplay of gender inequality and entrepreneurial intentions in the MENA region, it is important to acknowledge certain limitations. The reliance on secondary data from the Global Entrepreneurship Monitor (GEM) may introduce constraints related to the depth of personal and cultural insights that primary data could offer. Additionally, the study's scope is limited by the cross-sectional nature of the data, which restricts our ability to infer causality between gender inequality and entrepreneurial intentions. Future research could benefit from longitudinal data to better understand the dynamics over time and incorporate qualitative approaches to capture more nuanced aspects of the entrepreneurial experience across different genders in the MENA region

CONCLUSION

Based on the model above and the analysis of the MENA region, women's and men's intentions to establish a business are influenced by all factors, namely network, skills and knowledge, courage, and community perception. However, the perceived opportunity predictor does not affect the entrepreneurial intention of both genders. The national context is essential regarding the entrepreneurial intentions of both women and men, and this is in line with several studies that have shown that gender disparity in entrepreneurship differs thoroughly across countries (Hechavarría & Ingram, 2019; Hechavarria et al., 2019).

However, this study shows that gender inequality does not directly affect women's entrepreneurial intentions but surprisingly affects men's entrepreneurial intentions positively and significantly. This could be because men have better access to resources than men in the developing countries in the MENA region (Mishra, 2015; Johansen, 2013), which possibly encourages men to be engaged in entrepreneurial intentions; the more gender inequality exists with women, the more opportunities men will have. Alternatively, it is possible, as Baughn et al. (2006) argued, based on their studies on GEM data, that gender inequality

is not a predictor for the low rate of female entrepreneurship activities. Instead, it is due to the lack of support from the general normative society, which affects women more than men.

On the other hand, gender inequality as a moderator does not moderate any independent variables for men, but it does for women in two predictors: network and perceived opportunity. The network was affected significantly and negatively, which suggests that the more gender inequality exists, the less supportive network women would have. In our study, network means knowing at least one person involved in entrepreneurship activities. In the MENA region, women who have established businesses are between 4% and 5%, according to the GEM women report (2023). Women in the MENA region had fewer choices of having men in their network as entrepreneurs due to the strict social norms that do not allow women in most of the communities to create a network or connection with men; the more negative social norms increase, the more discrimination occurs, which possibly leads to less women's ability to make a network of entrepreneurs.

This study shows that the gender inequality index moderates the relationship between perceived opportunities and entrepreneurial intentions. Women are positively affected. In contrast, gender inequality does not interfere with the ability of men to perceive opportunities, which is in line with other scholars. Kelly et al. (2013) state that gender inequality may positively affect more women. Verheul et al. (2006) state that dissatisfaction with organizational structures, glass ceiling issues, or discriminatory labor laws may push women to leave and start businesses. Also, Bastian et al. (2019; p.19), in their study about the effect of gender inequality on entrepreneurial intentions, stated, we think that the gendered context presents many push factors that motivate women to become entrepreneurs. This dissatisfaction might make women more inclined to select self-employment once the opportunity presents itself. These conditions make women more prone to choose entrepreneurship as a professional "survival strategy" because they experienced discrimination in their previous workplace, the labor market, and the wider environment.

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Organizational and Economic Measures to Improve the Efficiency of Using the Resource Potential of Agricultural Production

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ABSTRACT

Agriculture in Kazakhstan still faces a number of serious systemic problems that hinder the efficient use of the resource potential of the industry. These problems include: the predominance of small-scale production in certain subsectors, low rates of renewal of agricultural machinery, low energy intensity, high capital intensity, limited access to modern production resources, an ineffective system of product marketing and insufficient promotion of agricultural products to domestic and foreign markets. In addition, there remains a high dependence on imported resources, which reduces the industry's resilience to external economic shocks. The purpose of this study is to develop organizational and economic measures aimed at increasing the efficiency of using the resource potential of agricultural production in the Republic of Kazakhstan. To achieve this goal, the following tasks have been defined: to analyze the current state of the production potential of personal subsidiary farms (PSF) and assess the efficiency of agricultural cooperation; develop recommendations for strengthening the material and technical base of agricultural formations; assess the resource and production potential of the country's agricultural sector; identify factors hindering the development of private household plots and agricultural cooperation; formulate strategic directions for increasing the sustainability of agricultural production. Research hypothesis. It is assumed that the implementation of the developed

institutional development and placement of the deep processing system

organizational and economic recommendations will allow for a comprehensive solution to the problems of increasing the competitiveness of the domestic agricultural sector, increasing labor productivity, rationalizing the use of production resources and ensuring the formation of an effective infrastructure of the agro-industrial complex. Main results. The study included a comprehensive analysis of the state of the resource potential of agricultural production in Kazakhstan, assessed the rate of equipment renewal, provision of equipment and material and technical resources. Statistical and dynamic data on the development of agriculture are presented, key problems in the current system of state support for the industry are identified. An economic assessment of the production potential of private household plots is given, barriers limiting their development are identified, and possible ways of more efficient use of available resources are proposed. In addition, the market environment and competitive positions of the Kazakh agricultural sector are analyzed. A set of recommendations for eliminating the identified problems is formulated and a strategy for sustainable development of agricultural production is presented.

INTRODUCTION

The agricultural sector of Kazakhstan has significant resource potential and national competitive advantages compared to other countries, which, with an effective agricultural policy, can ensure its sustainable development and make a significant contribution to the country's economy and improve the well-being of the population. At the same time, there are still features and circumstances that hinder the efficient use of resource potential and accelerated development of the industry. These include, first of all, high risks associated with specific natural and climatic conditions;

- lack of effective methods of control over the processes of land use, distribution and redistribution of land resources;
- limited water resources and dependence on neighboring countries in water supply of the industry in the southern regions;
- high degree of degradation and desertification of pastures;
- significant remoteness from world transport corridors;
- low share of processing industries in the products of the agro-industrial complex;
- underdevelopment of trade and logistics infrastructure and wholesale link;
- low rates of renewal of agricultural machinery; - increasing shortage of qualified personnel at any level in the industry;
- high share of imported resources for production;
- insufficient level of social infrastructure of rural areas and much more.

The relevance of this study is that it examines ways to ensure the efficient use of limited resources in agriculture, their balance and optimality. In this regard, the main tasks are:

- assessment of the use of the production potential of personal subsidiary farms through agricultural cooperation and the effectiveness of their role in the development of the agro-industrial complex;
- organizational and economic measures to strengthen the material and technical means and equipment of agricultural formations;
- assessment of the resource and production potential of the food and processing industry of Kazakhstan.

The solution of these problems requires the implementation of measures in a system that includes economic, market, social, agrotechnical and biophysical components. In general, this study will provide recommendations that will facilitate a comprehensive solution to the problem of increasing the competitiveness of domestic products, labor productivity, rational use of resource potential, and the formation of the necessary infrastructure.

1. LITERATURE REVIEW

Currently, there is no single scientific approach to the study of such a multifaceted concept as "potential". In modern economic literature, the term is interpreted in different ways, and various levels of its analysis are distinguished. The most common classification is that the agro-resource potential is considered at four levels:

- the level of an individual enterprise;
- the level of an industry;
- the level of a region or state;
- at the global (world) level.

At the enterprise level, economic potential is most often associated with production capabilities, resource security, market position or production capacity. In the sectoral context, potential is understood as either the availability of resources or the ability to function within a certain historical and economic situation. In our opinion, it is advisable to consider the analysis of the potential of a territory and a state as a single whole. Scientific literature also offers three key paradigms for interpreting the concept of "potential":

- as a set of resources concentrated in a specific territory;
- as a result of the functioning of economic relations in a given territory;
- as the ability of productive forces to achieve a certain economic effect.

In global analysis, the emphasis is usually placed on the availability of resources in the world economy or on potential production volumes achievable with their efficient use. In addition to these interpretations, there are also a number of concepts based on sustainable development approaches and process analysis.

Summarizing the existing approaches, two dominant ones can be distinguished:

- resource approach, where potential is interpreted as a set of available resources;
- performance approach, where it is defined as the ability to achieve certain economic results based on available resources and interaction mechanisms.

We are inclined to the performance interpretation of agro-resource potential, since it includes such important aspects as the level of technology and the management system. Even with significant labor, natural and material resources, the lack of modern technologies or effective management can significantly reduce the real potential of a territory. An important indicator of the efficiency of agro-resource potential is not only the volume, but also the structure of the manufactured products. These parameters allow us to judge the technological level, the efficiency of resource use and the quality of the management system.

Despite the preference for the results-based approach, the importance of the resource approach cannot be denied. Without a minimum set of resources, economic activity itself is impossible, which means that the potential itself is absent. It is through the use of natural and climatic and material and technical resources that the surplus product is formed and the development of the economy is ensured. Also, there is no consensus in scientific circles regarding the composition of the elements of agro-resource potential. There are various options - from three (natural and climatic, material and technical, labor) to ten or more components. Some researchers further differentiate these elements: for example, labor potential can include psychophysical, qualification and personal characteristics. We propose a comprehensive approach to the analysis of the resource potential of agricultural production, within the framework of which the following main elements are distinguished:

- natural and climatic potential, including natural and climatic resources of the territory;
- material and technical potential, covering not only equipment and technology, but also financial resources;
- labor potential, reflecting the availability and characteristics of labor resources.

These three components are basic and equal in the structure of the agro-resource potential. Their combined influence determines the level of production potential, that is, the possible volumes of output

with current resources and conditions. Thus, based on the scientific research of the authors in this area, it can be determined that the resource potential of agricultural production can be divided into several main categories (Table 1).

Table 1. Resource potential of agricultural production

Resources	*Components*
Land resources	Arable land Hayfields and pastures Irrigated and dry lands Soil fertility (natural and improved)
Labor resources	Permanent workers (agronomists, machine operators, etc.) Seasonal workers Staff qualifications Employment level and labor productivity
Material and technical resources	Agricultural machinery (tractors, combines, etc.) Equipment (irrigation, storage facilities, sorting and packaging lines) Fuels and lubricants (F&L) Spare parts, tools
Biological resources	Seeds, planting material Breeding cattle, young animals Fertilizers (organic and mineral) Plant protection products (pesticides, insecticides)
Financial resources	Own working capital Loans and subsidies Investments Insurance
Information and innovation resources	Agrotechnologies (AgTech, Smart Farming) Climate, weather, soil data Software (accounting, planning, monitoring) Education, access to scientific research

Source: compiled by the authors

Assessing the impact of individual indicators or factors of agricultural policy on the development of agriculture allows us to obtain clear results, but they are partial and do not reflect the simultaneous impact of all internal and external indicators and activities. Risk factors and their consideration in the analysis and development of effective solutions for state support of the agricultural sector in Kazakhstan represent a huge layer of unsolved problems. There are very few publications by domestic researchers on this topic. As for recent studies, such as the work of Ochilov Ilhom Sayitkulovich, et al (2024), Elena Krasnoperova (2020), a comprehensive methodology for assessing the organizational and economic efficiency of agro-clusters is proposed, taking into account various aspects of management, resource use and financial sustainability.

In their studies, Zhumakhan Mustafayev, Akhmetkal Medeu (2024) focus on the methodology for assessing the agro-resource potential of agricultural landscapes, based on the integration of knowledge from various fields of science. The issues of improving the organizational and economic management mechanisms in industrial enterprises based on the experience of agricultural production, with an emphasis on optimization and sustainable development strategies are the subject of the studies by G. Boykuzieva (2024) and Janker, J. & Mann, S. (2020). The team of authors A. Akhmetova, et al. (2025) in their works consider the methodological aspects of assessing the effectiveness of integrated production in agriculture in Kazakhstan, where a balanced system of indicators is proposed for assessing the productivity of agricultural enterprises. At the same time, an important aspect is providing farmers with training and autonomy in decision-making, which helps to increase technical efficiency in the face of economic shocks (Takeshima, et al. 2024).

In light of the digital transformation, the development of an economic management model in the agricultural sector of Kazakhstan is the subject of works (Durmanov, et al. 2024; Beketova, et al. 2024), in which the integration of production with digital technologies contributes to increased productivity, reduced costs and improved technical efficiency, provides economic opportunities for the use of renewable energy sources using artificial intelligence technologies (Durmanov et al. 2024; Beketova K. et al, 2024). Y. Kenzheali & A. Makhmetova (2024) analyze the key economic and climatic indicators of sustainable development of agriculture in Kazakhstan, offering recommendations for improving the use of resource potential. O. Abraliyev et al. (2024). consider some popular definitions of sustainable agriculture and believe that they primarily focus on resource conservation at the farm level and profitability as the main components of sustainability.

2. RESEARCH METHODS

The study will be based on the principles of systems analysis, which will allow studying the relevant agrotechnical, biophysical, social and market processes in their unity and interrelation. Abstract-logical, calculation-constructive, economic-mathematical, economic-statistical and digital modeling methods will be used.

The work will use the Solow model - a macroeconomic model that explains long-term economic growth taking into account capital accumulation, population growth (or labor force), technological progress and productivity. The use of economic-mathematical models to assess the impact of agricultural policy on the development of agriculture allows us to avoid these shortcomings. In the models, a change in one variable affects the value of other variables, and the supply of not only this but also all other products, the limited general resources, current prices in world markets, and the values of exogenous variables are taken into account. The economic literature provides a description of many models that, with varying degrees of detail, describe the impact of agricultural policy on the development of agriculture. Official open sources of government agencies are used as sources of primary statistical information.

3. ANALYSIS AND RESULTS

A significant share (70% of fruit and vegetable, 50% of meat and dairy products) is produced in private subsidiary farms (PSF) of the country, which indicates the key role of household plots in ensuring food security of the country. However, there are a number of circumstances that do not allow to fully realize the potential of PSF: the regulatory framework for their functioning, the principles and mechanisms of state regulation and support for their activities have not been defined - despite the attempts to adopt the draft law of the Republic of Kazakhstan "On Personal Subsidiary Farming" in 2003, 2017, 2021. There is a need to legislatively consolidate the concept of PSF, determine the criteria for classifying farms into this category, develop recommendations for the formation of a new regulatory framework for their activities, change the legal status of PSF, the mechanism for the creation and effective functioning of promising models of PSF cooperatives.

Data of the Ministry of Agriculture of the Republic of Kazakhstan as of 01.01. 2025 show that of the total number of available agricultural machinery, only 30% of tractors, 39% of grain harvesters and about 25% of mounted and trailed machines have a service life within the standard of up to 10 years. With the required technological renewal level of 10 ÷ 12.5% per year, today the renewal occurs only within 1 ÷ 3%. The volumes of domestic production of agricultural machinery in quantitative terms over the past 5 years amounted to 18-38% of the total supply volumes, depending on the type of equipment. In fact, the country is faced with the task of rebuilding issues of technical support. At present, the use of new environmental, practically proven resource-saving mechanized and other effective technologies puts forward the need to assess the real need for technical means and equipment, forms the prerequisites for economic justification of the quantitative and qualitative characteristics of the modernized technical base for the production of agricultural crops. In addition, it should be taken into account that a multi-level system of technical equipment formation has developed in agricultural production (production unit, farm, organizational and economic structure for the provision of mechanized services).

Government measures taken to regulate economic processes in agriculture do not always and do not necessarily lead to positive effects. This is explained mainly by two groups of reasons. Firstly, economic,

social, environmental and political goals often contradict each other. Secondly, attempts at state regulation of economic relations inevitably lead to distortion of market signals about the actual efficiency of agricultural production in different natural and economic conditions (Table 2).

Table 2. Main problems of agricultural production development in the Republic of Kazakhstan

Factors	*Problems*
Small-scale nature of agricultural production	- high share of households in the total volume of gross agricultural output, especially livestock products (75%); - a trend towards a decrease in land allotments of agricultural producers: 65% of farms have land up to 50 hectares, the average size of land use of agricultural enterprises (JSC, LLC, PC) has decreased, especially in the eastern region by 2.8 times, in the central region - 2.3 and in the south - 6 times.
Underdevelopment of infrastructure in the system of purchasing, storing, processing and marketing of agricultural products:	- many intermediaries in the process of moving products from the producer to the consumer; - low purchase prices that do not cover the invested costs of agricultural producers and do not stimulate an increase in the volume of agricultural production and their quality; - low share of processing of agricultural products (milk - 21.8%, meat - 21.4%, fruits and vegetables 7.8%), the consequence is the underutilization of production capacities of processing enterprises, low competitiveness of domestic products compared to imported ones.
Financial insolvency of small businesses	- weak material and technical base (lack of own agricultural machinery, financial resources for purchasing seeds, fertilizers, feed, fuel and lubricants, etc.); - inaccessibility for most small farms of state support measures in the form of subsidies, preferential loans due to the lack of collateral, etc.

Source: compiled by the authors

The main target indicators for the development of the agro-industrial complex, outlined in state programs, are the following criteria: the share of gross output in GDP, the volume of gross agricultural output, investments in fixed capital of agriculture, export of processed agricultural products, import and labor productivity per person employed in agriculture (Table 3).

Table 3. Key indicators of the development of the agro-industrial complex of Kazakhstan for 2019-2024

Indicators	2019	2020	2021	2022	2023	2024
Share of gross output in GDP,%	7,5	9,0	9,0	8,1	6,4	7,0
Volume of gross agricultural output, billion tenge	5177,9	6 334,7	7 549,8	8 407,5	7 625,2	8233,0
Volume of investments in fixed capital of agriculture, billion tenge	494,9	565,4	772,5	850,3	904,3	829,8
Volume of exports of processed agricultural products and food industry, million dollars	2479,1	2700,0	3126,0	3000,0	1960,0	2500,0
Volume of imports of agricultural products and food industry, million dollars	4107,7	4200,0	5000,0	5100,0	4350,0	4670,0
Labor productivity per person employed in agriculture, million tenge	2,4	2,6	2,8	2,8	2,9	2,8

Source: compiled by the authors according to https://www.stat.gov.k

The data in Table 3 show that the gross agricultural output increased (compared to the 2019 level) by almost 2.3 times;

- the volume of investments in fixed capital of agriculture (compared to the 2019 level) increased by almost 1.7 times;
- the volume of exports of processed agricultural products (compared to the 2019 level) increased by 1.0 times;
- the volume of imports of processed agricultural products (compared to the 2019 level) increased by 1.1 times;
- labor productivity per person employed in agriculture (compared to the 2019 level) remained almost at the same level.

However, despite the growth of the main indicators of the development of the agro-industrial complex, the share of gross output in GDP decreased from 7.5 to 7.0%. For these purposes, in order to ensure agro-food security of our republic, it is necessary to implement a state policy that shows the priority of the agricultural sector. Based on the objectives of stabilization and further sustainable development of agricultural production, it is necessary to take measures of state support for agricultural production taking into account compliance with the rules of the World Trade Organization. Not the least important place should be occupied by the solution of issues of improving financial levers for supporting and developing agricultural production.

Measures to promote investment in the regional economy should include assisting investors in obtaining investment preferences, creating infrastructure facilities (industrial zones, business incubators, technology parks, engineering centers) in order to attract potential investors. Creation and development of rural cooperation and large farms. In this direction, the following measures should be implemented: promoting the unification of small producers into cooperatives by providing the state with preferential loans for the purchase of special technological equipment, vehicles, mini-shops for primary processing of livestock products and raw materials, participation in subsidizing the cost of compound feed, involving the livestock industry in a leasing program for technical and technological re-equipment.

Difficulties in introducing innovative technologies into agricultural production are caused by the fragmentation and small-scale nature of agricultural formations. More than 250.9 thousand agricultural formations and 1.6 million households are engaged in agricultural production in the country. Of the total number of agricultural formations, 94% (285.3 thousand units) are peasant (farm) households, of which 40% have no more than 10 hectares of agricultural land (Table 4, Fig. 1). Grouping of peasant, farm households, by the availability of land shows that 63% of them have up to 50 hectares of agricultural land and 81% have no more than 50 hectares of arable land.

Table 4. Number of agricultural formations for 2019-2024, units.

Year	*Peasant (farm) households*	*Individual entrepreneurs*	*Legal entities*	*Total number of agro-formations*
2019	265000	20000	17000	302000
2020	260000	19800	17500	297300
2021	255000	19500	18000	292500
2022	250000	19000	18300	287300
2023	265300	19900	18400	303600
2024	250900	15700	18700	285300

Source: compiled by the authors according to https://www.stat.gov.k

Despite such a large share in the number of agricultural formations, peasant (farm) households produce more than 31% of gross output. It is the small-scale structure of agricultural production that has led to a decrease in competition between agricultural producers.

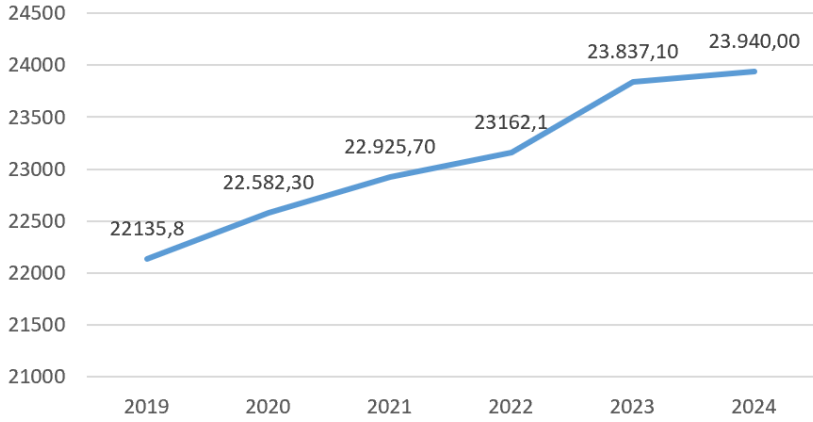

Figure 1. Adjusted sown area of agricultural crops, thousand hectares
Source: compiled by the authors

Today, large-scale farming is not being properly developed in Kazakhstan's agriculture, which should guarantee the provision of planned food volumes. The lack of a long-term development strategy also affects the development of cooperation and integration between the spheres of agricultural production. Today, a strategic plan is drawn up for five to seven years, although a rational period would be ten years. Defining a ten-year period serves as a forecast for the development of certain sectors of agricultural production, allows for the regulation and redistribution of financial resources in problem areas.

The measures taken in the republic to unite peasant and farm households, personal subsidiary farms in reality do not fully reflect the principles of cooperation that should stimulate rural producers to increase agricultural output, and not receive only subsidies under the guise of cooperative forms of farms. At the same time, such work should take into account the specific features of certain sectors of the agro-industrial complex. The concept of development of the agro-industrial complex of the Republic of Kazakhstan for 2021-2030 (December 30, 2021) reflects that:

- it is necessary to start with the formation of private household farm cooperatives, which should be created in each rural district, the creation of pilot cooperatives in 30-60 rural districts of 3-6 districts of 2-3 regions;
- at the second stage, cooperatives of small peasant (farmer) farms will be created at the level of rural districts, district associations of rural private household farm cooperatives will be created;
- at the third stage - the creation of cooperatives of medium and large agricultural producers at the regional level and the creation of regional associations of district cooperatives.

However, to stimulate cooperation, state support measures are necessary: investment subsidies for the cost of equipment, subsidies for the cost of services provided by cooperatives to their members; budget financing of knowledge dissemination activities. When implementing strategic goals, it is necessary to develop an effective mechanism for public-private partnership, which will ensure the implementation of all adopted state programs and increase the competitiveness of agricultural enterprises. As the President of the country noted in his message, the solution to this problem is seen in the creation of large, commodity farms based on vertical and horizontal cooperation. The vertical form of cooperation of peasant farms in the form of integration processes will expand the capabilities of the marketing service, study the capacity of the domestic and foreign market in certain regions of the republic, introduce innovative technologies into production, as well as rationally use the main means of production, including land, labor and material resources, reduce the costs of building effective channels of goods distribution.

Horizontal cooperation is a form of integration of agricultural enterprises, in which enterprises specialize in the production of a certain product or type of activity in order to make the most complete use of resources and, as a rule, do not affect the status of a legal entity and economic independence. Competitive struggle, the need for accelerated economic development force us to look for ways to effectively organize production, apply innovative technologies. It is not possible to implement them in small farms. As of 2024, the number of operating agricultural cooperatives was 3911 units (Figure 2).

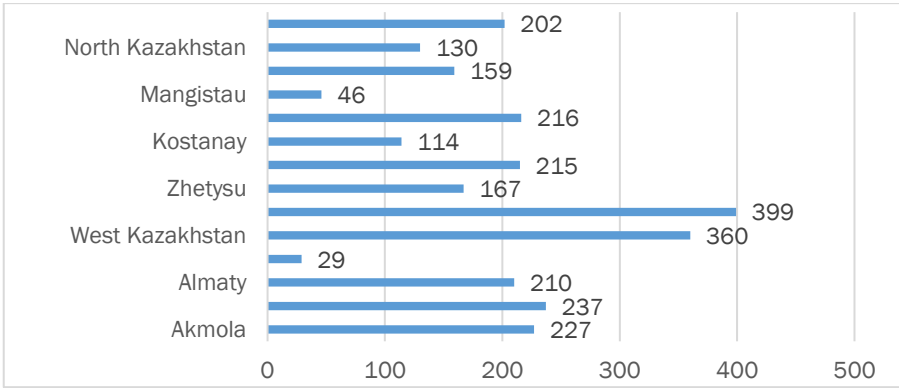

Figure 2. Number of operating agricultural cooperatives in 2024
Source: compiled by the authors

Production cooperatives are aimed at the production, processing of agricultural products, as well as joint cultivation of land, use of agricultural machinery. Marketing cooperatives are engaged in the procurement, storage and sale of products manufactured by cooperative members. Marketing activities also include the collection, storage, sorting, drying and sale of raw materials in fresh or processed form wholesale or retail and transportation of products of cooperative members. Processing cooperatives are engaged in the processing of agricultural products and their sale through the wholesale and retail trade system, including the organization of their own trade network.

Supply cooperatives provide agricultural producers with the resources and materials necessary in the production process: equipment, fuel and lubricants, seeds, fertilizers, pesticides, feed, spare parts, construction and other materials associated with agricultural production; Service cooperatives provide their members with services related to the process of production and sale of agricultural products (agrochemical services, water supply, electricity supply, repair and maintenance of equipment, telephones, breeding and selection activities, etc.). At the present stage, with the vector of development of Kazakhstan to enter the number of the most developed countries of the world, in the prism of which the main and responsible task of the state is to achieve high-quality new indicators of development of the industry in agriculture, is to increase the competitiveness of the industry. The transition of agriculture to the industrial-innovative path of development based on strengthening its material and technical base, improving the quality of agricultural products requires the effectiveness of financing and the efficiency of agricultural production.

Efficiency indicators can be determined both for the entire agricultural industry as a whole, and for crop production and livestock farming, by categories of farms, as well as by sources and types of financing of the industry. The following indicators can be taken as the result of production:

- at the state level GDP - gross output;
- at the regional level GRP - gross regional product;
- at the level of industries and enterprises GVA - gross added value.

The following are considered as production resources (hereinafter referred to as PR) or factors of production: fixed production assets (hereinafter referred to as FA), working capital (hereinafter referred to as WC) in the form of inventory items (I&M) and stocks, labor, land and natural resources. To study the impact of such main factors of production as capital, labor and technological progress on economic growth, the Solow model is most often used, in which output is described by the production function according to formula (1):

$$Y=F(K,L,E); \quad (1)$$

where

Y – volume of output or gross domestic product GDP,
K – capital or production assets,
L– real living labor,
E – labor efficiency of one worker.

The variable E reflects the level of "knowledge" accumulated in society, or the labor-saving type of scientific and technological progress (hereinafter referred to as STP), under the influence of which the labor efficiency of one worker or the quality of human capital increases. Output Y can change over time only when the factors of production change over time. Changes in the number of workers and labor efficiency E are always considered together, since at each moment in time the economy has L workers with increased labor efficiency or an increased number of workers with constant initial labor efficiency (*L·E*). Thus, the output is described by the production function *Y=F(K,L·E)*. With respect to the production function, it is assumed that:

A) it is not significantly influenced by other factors;
B) there is a constant return to scale, which allows for a transition to a production function in an intensive form per unit of labor with constant efficiency; $F'_K > 0, F'_L > 0$, i.e. as resources grow, output grows;

C. $F''_K < 0, F''_L < 0$, i.e., with an increase in resources, the rate of growth of output slows down.

D. The most frequently used is the multiplicative production function with the listed properties according to formula (2):

$$Y = A \cdot K^{\alpha} \cdot L^{\beta}; \quad (2)$$

where *A* - coefficient of neutral scientific and technological progress;

α, β – coefficients of elasticity of output by fixed assets and labor, respectively.

A special case is the Cobb-Douglas production function, first proposed by the Swedish economist Knut Wicksell. It has the form shown in formula (3):

$$Y = A \cdot K^{\alpha} \cdot L^{1-\alpha}; \quad 0 < \alpha < 1 \quad (3)$$

The multiplicative production function is determined by a time series of outputs and resource inputs (Y_t, K_t, L_t), t =1,...,T, where T – length of the time series. Since this function is linear in logarithms, we obtain a linear multiple regression model using formula (4):

$$\ln Y = \ln A + \alpha \cdot \ln K + \beta \cdot \ln L + \varepsilon; \quad (4)$$

where ε – an adjustment random component that matches actual and estimated output and reflects fluctuations in output due to other factors. The parameters of this function can be determined using the least squares method using standard Statictica application packages.

To obtain function (4), we use the data of the Statistics Committee of the Ministry of National Economy of the Republic of Kazakhstan on the gross output of goods (services), on investments in fixed capital and the number of people employed in the economy by type of economic activity Agriculture, forestry and fisheries for the period 2015-2024 (Table 5).

Table 5. Data for constructing the Solow Model

Indicator	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Gross agricultural output, billion tenge (Y)	3307,0	3684,4	4070,9	4474,1	5177,9	6 334,7	7 549,8	8 407,5	7 625,2	8233,0
Fixed capital, billion tenge K(t)	2604,5	3150,0	3572,9	4130,2	4785,8	5673,5	6500,8	7641,5	8100,2	8234,2
Labor productivity, billion tenge L/Y	1,2	1,5	1,7	2,0	2,4	3,0	3,3	4,6	4,3	4,5
Labor, million people (L)	2755,8	2456,3	2394,7	2237,1	2157,5	2111,6	2287,8	1827,7	1772,1	1829,6

Y/ L - output per 1 employee	1,20	1,50	1,70	2,0	2,40	3,0	3,30	4,60	4,30	4,50
K/ L – capital per 1 worker	0,95	1,28	1,49	1,85	2,22	2,69	2,84	4,18	4,57	4,50
log(k) Ln(K/ L) – logarithms used in regression to estimate the parameter α	-0,57	0,247	0,400	0,613	0,796	0,988	1,045	1,429	1,519	1,504
log(y)Ln (Y / L)	0,182	0,405	0,531	0,693	0,875	1,099	1,194	1,526	1,458	1,504

Source: calculated by the authors

$$y=A\cdot k\alpha \Rightarrow \log(y)=\log(A)+\alpha\cdot\log(k)$$
$$\log(y)=a+\alpha\cdot\log(k)$$

Indicator α reflects the elasticity of output with respect to capital — если $\alpha \approx 0.88$, as in the graph, this means that capital explains 88% of the growth in output. Thus, the Solow calculation model (Table 5) shows the relationship between output and the volume of fixed capital per worker using statistical data as an example. Based on the transformed Cobb-Douglas production function in logarithmic form, a regression was conducted between the logarithm of output per worker and the logarithm of capital per worker. The results of the regression analysis made it possible to estimate the parameter of elasticity of output by capital (α) at the level of 0.88, which significantly exceeds the classical value (about 0.3-0.4), typical for neoclassical growth models. This may indicate the importance of capital-intensive factors in the development of agricultural production and can serve as a basis for the formation of organizational and economic measures to improve the efficiency of using the resource potential of the industry.

Despite the average annual growth rate of agriculture at the level of 2-3%, there is no active mobilization of resources in the sector and there is no significant activation of qualitative factors of economic dynamics. The current state of the industry is characterized as backward and uneven, with an obvious deficit in the field of technological and innovative solutions. Thus, in 2024, the official inflow of funds into agriculture amounted to only 16 million US dollars, which indicates limited external investment.

An analysis of the current state showed that the current mechanism for managing economic growth in agriculture is focused primarily on the use of natural resources and labor, but does not fully correspond to the key determinants and drivers of industry growth. The decline in the contribution of agriculture to overall GDP growth, high volatility and low dynamic rates of production indicate a discrepancy between the current growth rates and the resource-intensive potential of the sector. In this regard, in order to ensure sustainable and effective development of national agriculture, it is necessary to implement the proposed tools for forming a mechanism for managing economic growth in the agricultural sector (Figure 3).

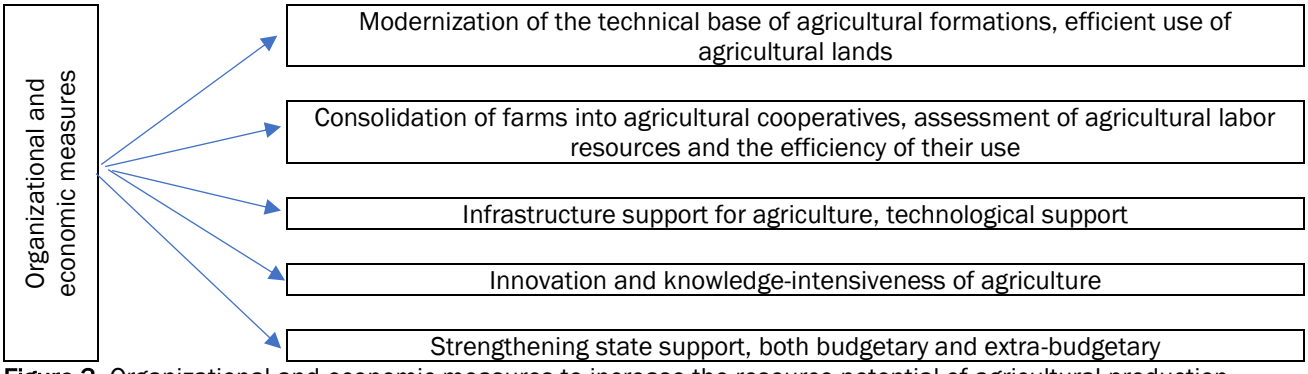

Figure 3. Organizational and economic measures to increase the resource potential of agricultural production
Source: Compiled by the authors

In order to stabilize and sustainably develop agricultural production, it is necessary to develop and implement measures of state support that will comply with the rules of the World Trade Organization. It is also important to focus on improving the financial support for the development of the agricultural sector. One of the key areas is attracting investment in agriculture. To do this, it is necessary to create incentives for investors, including assistance in obtaining investment preferences, as well as develop infrastructure such as industrial zones, business incubators, technology parks and engineering centers. These measures will help attract potential investors and create favorable conditions for the development of the agro-industrial complex. Particular attention should be paid to the creation and development of rural cooperation and large farms. In this direction, it is necessary to implement the following measures: support for the unification of small producers into cooperatives with the provision of preferential loans for the purchase of special technological equipment, vehicles, mini-shops for the primary processing of livestock products, as well as participation in subsidizing the cost of compound feed. An important component is the involvement of livestock farming in the leasing program for technical and technological re-equipment.

CONCLUSION

Agricultural production is a promising sector of the economy of Kazakhstan, demonstrating growth in production volumes. Tools for ensuring the quality of economic growth in agriculture have a number of specific industry features, such as seasonality and dependence on natural factors. One of the key areas of development is the need to increase public funding and investment in the agricultural sector.

In addition, an important factor is the importance of agriculture for the socio-economic development of the country, as well as the role of rural areas in overall economic progress. The efficiency of using the production potential of personal subsidiary farms through agricultural cooperation also contributes to the development of the agro-industrial complex.

To strengthen the material and technical base of agricultural formations, organizational and economic measures should be taken to improve the equipment and facilities.

An increase in gross added value in the agricultural sector will have the most significant impact on employment growth, improving the quality of life, increasing income and well-being of the population. To achieve sustainable development, it is necessary to introduce advanced technologies and innovations in the production and processing of agricultural products, as well as expand export opportunities through marketing development. Improving product quality, creating new and branded products will become important tools for increasing the competitiveness of the sector and improving the quality of life of the population.

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The Nexus Between Economic Growth, Foreign Direct Investments, and Exports: Empirical Evidence in Chinese Provinces

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China

ABSTRACT

This unique study examines the causal relationships between economic growth, foreign direct investments (FDI), and exports in Chinese provinces by analyzing an unbalanced panel with 31 provinces in China from 2005 to 2022. The empirical results indicate a positive relationship between FDI and exports regarding economic growth in Chinese provinces. Moreover, economic growth will attract more foreign direct investment and promote exports from Chinese provinces. The findings support China's municipal governments in developing the economy sustainably. Specifically, the findings suggest that local governments should create incentives and favorable conditions to draw in more foreign direct investment and enhance export-oriented sectors to develop the economy sustainably. The findings align with industrial organization, international commerce, and endogenous growth theories.

INTRODUCTION

Export activity is widely recognized as a key driver of economic growth through its capacity to stimulate employment, enhance productivity, and improve a country's global competitiveness (Rauf & Jalil, 2021). Export growth also contributes indirectly to economic expansion by generating income and employment opportunities within export-oriented sectors (Rauf & Jalil, 2021). In the context of global development priorities, sustainable economic growth remains a central objective, particularly for developing economies. However, while a considerable body of literature has examined the individual effects of foreign direct investment (FDI) and exports on economic growth, most studies focus on unidirectional relationships (Sunde, 2017). Existing empirical investigations often isolate either the impact of FDI on economic growth (Saleem & Cheema, 2022), the relationship between FDI and exports (Muhammad Tariq Majeed, 2022; Yang & Li, 2019; Hayakawa et al., 2020; Duong et al., 2023), or the linkage between exports and economic growth

(Shafiullah et al., 2017; Sojoodi & Baghbanpour, 2023). Despite this, the evidence remains inconclusive, and the triangular, potentially bidirectional causal relationships between economic growth, FDI, and exports remain underexplored.

This study aims to address this gap by providing an integrated empirical assessment of the causal nexus among FDI, exports, and economic growth within the context of Chinese provinces. China presents a particularly relevant case for such investigation due to its unique economic trajectory. Since joining the World Trade Organization in 2001, China has undertaken extensive trade liberalization, fundamentally transforming its economic structure and positioning itself as one of the leading global exporters and top destinations for FDI inflows (Hayakawa et al., 2020). The country's experience provides an opportunity to draw broader implications for developing economies seeking to leverage trade and investment for sustainable development (Yang & Li, 2019).

Using a panel dataset covering 31 Chinese provinces over the period from 2005 to 2022, the study follows Le et al. (2024) and Duong et al. (2023) in applying three econometric models such as Pooled Ordinary Least Squares (OLS), Fixed Effects Model (FEM), and Random Effects Model (REM) to evaluate the dynamic nexus among the variables. The selection of the most appropriate estimation technique is guided by the Breusch-Pagan Lagrange Multiplier test and the Hausman specification test (Le et al., 2023; Tran et al., 2023). The empirical findings demonstrate significant bidirectional causality between exports, FDI, and economic growth, suggesting that each variable influences and is influenced by the others.

This research makes two primary contributions. First, it is among the few studies that comprehensively assess the interdependent relationships between economic growth, FDI, and exports at the subnational level in China. Second, by drawing on China's experience, the study provides valuable policy implications for developing countries seeking to design integrated trade and investment strategies that support long-term, sustainable economic development (Hayakawa et al., 2020).

The study is organized as follows. The next section summarizes the theoretical aspects of the trilogy on economic growth, foreign direct investments, and exports in China. Section 3 provides a data overview and explains our empirical methodology. Section 4 reports empirical results, Section 5 discusses the results, and Section 6 concludes.

1. LITERATURE REVIEW

1.1 The relationship between FDI and economic growth

China's economic landscape has been significantly shaped by the large inflow and outflow of FDI in recent years. FDI acts as an external source of capital that bridges the host country's capital and technological gaps while enhancing economic growth in the domestic market (Jonah et al., 2018). While FDI is not a novel concept, its influence on economic development remains a subject of incomplete and contentious research. Duong et al. (2023) explored FDI's role in international trade, focusing on technology transfer and knowledge spillover. Previous studies demonstrated FDI's positive impact on economic growth (Duong et al., 2023; Oanh et al., 2021; Sultanuzzaman et al., 2018; Liu et al., 2002), while others argue that FDI hampers a country's economic development (Gunby et al., 2017).

China's unique and intricate economy, shaped by its geographic location, ethnic diversity, and religion, poses a challenge for studying FDI's impact on economic growth. China's remarkable growth in recent years has been closely linked to its ability to attract FDI and effectively leverage technology. Chuang and Hsu (2004) show that foreign trade and FDI support China's economic expansion in the long term (Liu et al., 2002). The trade openness policy has facilitated the interaction between FDI and domestic production capacity, shaping its economic trajectory (Duong et al., 2023).

In addition, Saleem et al. (2018) indicate that when developing market economies try to open up to external commerce, it can attract an increase in inward FDI. Furthermore, GDP growth is an important indicator of FDI inflows. Le et al. (2023) demonstrate that increased economic growth draws more FDI to Asia-Pacific nations.

Based on this literature review, we expect that FDI will positively impact economic growth in China (Sultanuzzaman et al., 2018). Furthermore, this economic growth, in turn, creates a more robust foundation for attracting increased FDI inflows. Therefore, we propose the following hypothesis:

H1: FDI has a significant positive impact on economic growth in Chinese provinces.

H2: Economic growth has a significant positive impact on FDI in Chinese provinces.

1.2 The relationship between exports and economic growth

Prior studies have explored the relationship between exports and economic growth (Kónya, 2006; Sunde, 2017; Shafiullah et al., 2017; Sojoodi & Baghbanpour, 2023; Saleem & Cheema, 2022). Kónya (2006) revealed a bidirectional causal relationship between exports and GDP in Canada, Finland, and the Netherlands. Sunde (2017) demonstrated that exports and FDI positively influence South Africa's economic growth. Shafiullah et al. (2017) explored the export-led growth theory at the sectoral level, identifying that exports of mining and fuels were critical drivers of Australia's economic expansion. Saleem and Cheema (2022) identified an asymmetric unidirectional causal relationship between exports and economic growth in Pakistan. Sultanuzzaman et al. (2018) found that while FDI inflows positively impacted economic growth in the short and long term, exports showed a strong negative correlation with economic growth. Muhammad Adnan Hye (2012) identified a bidirectional long-term relationship between China's economic growth, exports, and imports.

On the other hand, Sojoodi and Baghbanpour (2023) indicated no significant relationship between high-tech exports and GDP growth. According to the 2022 WTO report, China, the United States, and Germany were the top three exporters of goods in 2021, accounting for 15%, 8%, and 7% of global exports, respectively. China's accession to the WTO on December 11, 2001, has significantly bolstered international investor confidence, leading to a surge in FDI that has expanded production capacity and spurred the growth of export-oriented industries. Consequently, China's exports have risen sharply, positioning the country as a major player in global trade.

Drawing from the Chinese context and previous studies, we hypothesize that exports will significantly impact economic growth in China. Furthermore, this economic growth is expected to strengthen the foundation for attracting more exports. Therefore, we propose the following hypotheses:

H3: Exports significantly impact economic growth in Chinese provinces.

H4: Economic growth has a significant positive impact on exports in Chinese provinces.

2. DATA AND METHODOLOGY

2.1 Data

This research examines yearly statistics from 31 provinces in China from 2005 to 2022. Essential variables such as GDP, FDI, exports, labor, wages, transportation, investment, and capital are collected from reputable sources such as the China Statistical Yearbook. The exchange rates were obtained from the World Bank. We follow Le et al. (2023) and Tran et al. (2023) to exclude observations that do not have sufficient data to estimate the required variables. The final sample is an unbalanced panel with 588 annual observations from 31 provinces in China, covering the years 2005 to 2022

2.2 Model Construction

We follow Saleem and Cheema (2022) and Duong et al. (2023) to examine the link between exports and GDP. We construct the first model to estimate the impacts of FDI and exports on economic growth in provinces in China as follows:

$$GDP_{it} = \beta_0 + \beta_1*FDI_{it} + \beta_2*Exp_{it} + \beta_3*Tra_{it} + \beta_4*Hum_{it} + \beta_5*Exc_{it} + \beta_6*Lab_{it} + \beta_7*Cap_{it} + \beta_8*Wag_{it} + \varepsilon_{it} \quad (1)$$

Where GDP is the gross domestic product unique to each region, it includes all domestic output, a comprehensive measure of a nation's economic health. GDP is measured as the GDP growth rate from the prior year.

Foreign direct investment refers to the practice of FDI within an area. FDI initiatives can take many forms, including founding associates or subsidiaries abroad, taking a majority ownership in already-existing foreign businesses, and merging or forming joint ventures with foreign organizations. Increasing FDI inflows positively empower economic growth in the Chinese economy, especially in the high-tech manufacturing and services sectors. The entire value of products and services exported from a particular region is represented by its export value. Export earnings support international interactions and increase the GDP at the national level. This model (1) uses labor, capital stock, exchange, transportation, wages, and human capital as control variables.

In line with Yao (2006), GDP, wages, real exchange rate, and transportation are the key explanatory factors for foreign direct investment. Because of its relatively large economy, a province with a relatively high GDP may attract more foreign direct investment. GDP illustrates the size of the market. On the other hand, FDI can be absorbed by transportation and human capital. The actual exchange rate is a pricing component, and adequate salaries present the cost. Therefore, we develop the second model to test the impact of economic growth on luring FDI projects in Chinese provinces as follows:

$$FDI_{it} = \beta_0 + \beta_1 * GDP_{it} + \beta_2 * Wag_{it} + \beta_3 * Exc_{it} + \beta_4 * Tra_{it} + \varepsilon_{it} \quad (2)$$

Model (2) includes FDI, GDP, Wages, Exchange, and Transport.

GDP and the real exchange rate are predicted to influence exports. GDP shows the market size, whereas the exchange rate shows the cost of China's exports to other nations. Therefore, we construct the third model to examine the impacts of economic growth on exports in provinces in China as follows:

$$Exp_{it} = \beta_0 + \beta_1 * GDP_{it} + \beta_2 * Exc_{it} + \varepsilon_{it} \quad (3)$$

The GDP, export, and exchange rates are identical to those provided in (1). Table 1 lists the data sources and variable definitions for all variables.

Table 1. Definitions of variables

Variable	Variable meaning	Calculation formula	Citation
GDP	GDP	The GDP growth rate from the prior year. Data is collected from the China Statistical Yearbook.	Sojoodi & Baghbanpour (2023). Duong et al. (2023); Tran et al. (2023); Oanh et al. (2021)
FDI	Foreign Direct Investment	Net FDI inflow (% of GDP). Data is collected from the China Statistical Yearbook.	Duong et al., 2023; Le et al. (2024); Sultanuzzaman et al., 2018; Liu et al., 2002; Nguyen et al., 2024
Exp	Export	The export growth rate from the prior year. Data is collected from the China Statistical Yearbook.	Rauf and Jalil (2021); Sojoodi & Baghbanpour, 2023; Saleem & Cheema, 2022
Cap	Capital Stock	- Initial Capital Stock:	Yao (2006); Rauf and Jalil (2021)

		$K_0 = \frac{I_0}{(g+\delta)}$ $K_{it+1} = (1-\delta)K_{it} + \frac{I_{it+1}}{p_i^K}$ Where: + I: Fixed Asset Investment + g: Fixed Asset Growth Rate + δ: Capital stock depreciation rate + p: Investment Price Index Data is collected from the Statistical Yearbook.	
Exc	Exchange Rate	Actual Exchange Rate Effect. Data is collected from the World Bank.	Yao (2006); Muhammad Tariq Majeed (2022)
Hum	Human Capital	The growth rate of new students enrolling in secondary or higher education from the prior year. Data is collected from the China Statistical Yearbook.	Rauf and Jalil (2021); Yao (2006)
Lab	Labor	The growth rate from the previous year in the number of employed people. Data is collected from the China Statistical Yearbook.	Tran et al. (2023); Oanh et al. (2021); Yao (2006)
Tra	Transport	The combined length of roads, trains, and waterways. Total People in Employment. Data is collected from the China Statistical Yearbook.	Yao (2006)
Wag	Wages	Average wages as a percentage of GDP per capita. Data is collected from the China Statistical Yearbook.	Saleem et al. (2018); Yao (2006)

Source: Own

2.3 Estimation Methods

This study adopts a rigorous empirical approach to analyze panel data from 2005 to 2022. To ensure model reliability, it begins with multicollinearity diagnostics using Variance Inflation Factors (VIF) and correlation coefficients (Tran et al., 2023). Following Nghiem et al. (2024), a panel unit root test is conducted to examine the stationarity of variables. The empirical analysis proceeds with the estimation of Pooled Ordinary Least Squares (Pooled OLS), Fixed Effects Model (FEM), and Random Effects Model (REM). Model selection is guided by the Redundant Fixed Effects test and the Hausman specification test, as recommended by Le et al. (2023) and Tran et al. (2023). While Pooled OLS assumes homoscedasticity, FEM accounts for time-invariant individual heterogeneity, and REM captures random variations across provinces (Le et al., 2024). This combined modeling strategy provides a robust and comprehensive framework for assessing the determinants of foreign direct investment inflows across the Asia-Pacific region.

3. EMPIRICAL RESULTS

3.1 Descriptive statistics

Table 2. Descriptive statistics

Variable	Obs.	Mean	Min	Max	Std. Dev.
GDP	588	0.1118	-0.3128	0.2380	0.1180
FDI	588	0.1319	-0.6794	1.0147	0.3641
Exp	588	0.1377	-0.5409	0.6530	0.2821
Cap	588	-0.0081	-0.0372	0.0519	0.0284
Exc	588	0.0722	0.0614	0.0828	0.0083
Hum	588	0.0473	-0.6895	1.2559	0.3877
Lab	588	0.0036	-0.5506	0.2726	0.1527
Tra	588	0.0545	-0.0168	0.4212	0.0988
Wag	588	0.0127	0.0072	0.0224	0.0042

Note: Table 1 reports each definition of a variable. The final sample included 588 annual observations from 2005 to 2022.

Source: own

Table 2 indicates that the average value of the GDP growth is about 0.11, the maximum value of GDP growth is about 0.23, and the minimum value is about -0.31. In addition, Table 2 also describes the average values of FDI, Exp, Cap, Exc, Hum, Lab, Tra, and Wag, which are 0.1319, 0.1377, -0.0081, 0.072, 0.0473, 0.0036, 0.0545, and 0.0127, respectively

3.2 Pearson Correlation Matrix

Table 3. Pearson Correlation Matrix

Correlation	FDI	Exp	Lab	Exc	Tra	Wag	Hum	Cap
FDI	1							
Exp	-0.0189	1						
Lab	-0.0203	-0.1966***	1					
Exc	0.0654	0.327622	-0.3268***	1				
Tra	0.1371***	0.089794	0.028460	0.3315***	1			
Wag	0.1485***	0.0747*	-0.0915**	0.1455***	0.0773*	1		
Hum	-0.0014	0.1727***	-0.0440	0.0128	0.0121	0.0249	1	
Cap	-0.0325	-0.1991***	0.2516***	-0.7698***	-0.2092***	-0.0157	0.0213	11

Note: All the variables are defined in Table 1. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: own

The correlation coefficient explains how independent and dependent variables are correlated linearly. It suggests that variations in one variable influence variations in another. The correlation matrix may be used to investigate the correlation between independent and dependent variables. All the factors' correlations are shown in Table 3.

Table 4. Variance Inflation Factors

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
FDI	2.19E-06	1.055941	1.041848
Exp	0.000199	1.459104	1.178050
Lab	0.000670	1.162424	1.161778
Exc	0.600166	235.7749	3.103666
Tra	0.001620	1.533501	1.175532
Wag	0.800973	10.67924	1.069420
Hum	9.26E-05	1.050635	1.035211
Cap	0.042415	2.756286	2.548361
C	0.002812	209.4282	NA

Note: This table reports results from the VIF test. All variable definitions are reported in Table 1

Source: own

We also performed the VIF test to ensure that there is no multicollinearity. We infer that our study has no significant multicollinearity since Table 4 demonstrates that all VIF values are less than 5 (Duong et al., 2023; Le et al., 2023).

3.3 Unit Root Test

Table 5. Unit Root Test

LEVEL	LLC	IPS	ADF	PP
GDP	-1.205	-9.606***	209.032***	186.629***
	(0.114)	(0.000)	(0.000)	(0.000)
FDI	-12.036***	-15.533***	334.907***	1363.28***
	(0.000)	(<0.001)	(0.000)	(0.000)
Exp	-14.348***	-18.773***	396.387***	1235.08***
	(<0.001)	(<0.001)	(<0.001)	(0.000)
Cap	8.8	-9.21267***	202.48***	448.82***
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Lab	-8.3580***	-7.92225***	178.84***	204.19***
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Exc	-4.1302***	-4.34472	101.03***	100.36***
	(<0.001)	(<0.001)	(0.001)	(0.002)
Tra	-7.6172***	-2.0125**	85.263**	96.093***
	(<0.001)	(0.0221)	(0.027)	(0.004)
Hum	-3.31509***	-1.74053**	113.58***	116.62***
	(<0.001)	(0.0409)	(<0.001)	(<0.001)
Wag	-7.74521***	-7.54895**	183.27***	241.20***
	(<0.001)	(<0.001)	(<0.001)	(<0.001)

Note: The parenthesis surrounds the P-value. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: own

Models 1, 2, and 3 could yield biased findings if the variables are not stationary. One characteristic of a static variable is that it has no periodic oscillations, and its mean, variance, and autocorrelation structure do not vary with time. Developing theories and models becomes significantly more complicated if the variables are not stationary. Models must thus have static variables. We follow Tran et al. (2023) and Nghiem et al. (2024) to apply the panel unit root test to check whether the variables are stationary. Our findings

for all four approaches support the null hypothesis, which states that the variables are non-stationary. Therefore, the panel regression method is suitable for our study.

3.4 The impact of FDI and Exports on economic growth

Table 6. The Impacts of FDI and Exports on Economic Growth in China

Dependent variable: GDP	Pooled OLS	FEM	REM
FDI	0.1018***	0.0995***	0.1018***
	(<0.001)	(<0.001)	(<0.001)
Exp	0.1756***	0.1720***	0.1756***
	(<0.001)	(<0.001)	(<0.001)
Cap	-0.4730***	-0.6879***	-0.4730***
	(0.0138)	(0.0015)	(0.0123)
Exc	0.4630	0.9383	0.4630
	(0.5225)	(0.2119)	(0.5155)
Hum	0.0503***	0.0458***	0.0503***
	(<0.001)	(<0.001)	(<0.001)
Lab	-0.0300	-0.0501**	-0.0300
	(0.2145)	(0.0375)	(0.2069)
Tra	0.0378	0.0229	0.0378
	(0.3108)	(0.5358)	(0.3027)
Wag	-0.8736	-14.7753***	-0.8736
	(0.2934)	(<0.001)	(0.2854)
Constant	0.0436	0.1860***	0.0436
	(0.3784)	(0.0011)	(0.3705)
Observations	588	588	588
Adj. R-squared	50.68%	52.69%	50.68%
Redundant test (Prob.)		50.79	
		(0.0102)	
Hausman test (Prob.)			42.54
			(<0.001)

Note: All the variables are defined in Table 1. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: own

The regression results for Model 1 using three alternative methods, such as Pooled OLS, REM, and FEM, are presented in Table 6. First, across all models, the Adjusted R-squared shows that the explanatory factors account for over 50% of the fluctuations in the dependent variable. We implemented two further experiments to ascertain which approach was best for our dataset. In the fixed-effect method, we employ the Redundant Effects Tests. The Chi-square statistic is 50.79 at a 5% significance level, so the Redundant Fixed Effects Tests indicate that the OLS regression model is unsuitable. In addition, we use the Hausman test to select between the FEM and REM. The Hausman test results suggest that FEM is the best regression method.

3.5 The impact of economic growth on FDI

Table 7. The nexus between economic growth and FDI in China

	Pooled OLS	FEM	REM
GDP	1.4735***	1.5062***	1.4735***
	(<0.001)	(<0.001)	(<0.001)
Wag	8.1047**	18.2184*	8.1047***
	(0.0082)	(0.0691)	(0.0087)
Exc	3.1482*	2.2081	3.1482*
	(0.0711)	(0.2639)	(0.0732)

Tra	0.0854 (0.5342)	0.0901 (0.5202)	0.0854 (0.5374)
Constant	-0.3675*** (0.0027)	-0.4319*** (0.0017)	-0.3675*** (0.0029)
Observations	588	588	588
Adj R-squared	27.46%	26.33%	27.46%
Redundant test (Prob.)		<0.001	
Hausman test (Prob.)			<0.001

*Note: All the variables are defined in Table 1. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.*

Source: own

Table 7 presents the Model 2 regression findings using three distinct approaches: FEM, REM, and pooled OLS. Then, we employ Redundant Fixed Effects Tests to indicate that the OLS regression model is unsuitable. In addition, we use the Hausman specification test to select between the FEM and REM. The Hausman test results suggest that FEM is the best regression technique.

3.6 The nexus between economic growth and exports in China

Table 8. The nexus between economic growth and exports in China

	Pooled OLS	FEM	REM
GDP	0.2121*** (<0.001)	0.2083*** (<0.001)	0.2121*** (<0.001)
Exc	8.6101*** (<0.001)	8.6492*** (-2.48)	8.6101*** (<0.001)
Constant	-0.5115*** (<0.001)	-0.5138*** (0.000)	-0.5115*** (<0.001)
Observations	588	588	588
Adj R-squared	17.41%	14.6%	17.41%
Redundant test (Prob.)		<0.001	
Hausman test (Prob.)			<0.001

*Note: All the variables are defined in Table 1. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.*

Source: Own

The regression results for Model 3 using three alternative approaches are presented in Table 8. Table 8 indicates that GDP growth positively influences exports at a 1% significance.

4. DISCUSSION

Table 6 demonstrates a positive relationship between FDI and economic growth in Chinese provinces. The estimated coefficients for the FDI variable vary from 0.0995 to 0.1018, meaning that a 1% increase in FDI growth leads to provincial GDP growth in China from 0.0995% to 0.1018%. FDI can finance new infrastructure, expand existing businesses, and fund various development projects. The increased investment in the local economy can stimulate economic growth and create employment opportunities. In addition, foreign investors frequently deliver modern technology, experience, and best practices to the host country. Technology transfer and information exchange can help to strengthen local industries, raise productivity, and boost competitiveness. Local firms and individuals can benefit from their

overseas counterparts and obtain essential skills and know-how, thus contributing to long-term economic growth. Finally, FDI can provide local businesses access to international markets through collaboration with foreign companies. This access can help local businesses expand their customer base and export their products and services globally. By integrating into global supply chains and markets, local firms can experience increased revenue and growth, benefiting the overall economy. These findings also align with earlier research conducted by Duong et al. (2023), Oanh et al. (2021), Sultanuzzaman et al. (2018), and Yao (2006). The findings also support hypothesis 1. In contrast, the findings of this study are inconsistent with those of Gunby et al. (2017), who used a meta-analysis method to investigate the corresponding empirical literature. However, meta-analysis results may be compromised when there is incorrect or missing information in study publications.

In addition, Table 6 also reports a positive relationship between exports and economic growth in Chinese provinces. The results indicate that a 1% increase in exports empowers provincial GDP growth in China from 0.172% to 0.1756%. Exports bring significant revenue to provinces in China. When local companies sell their products or services to foreign markets, they earn foreign exchange, which adds to the provincial economy. This revenue can be reinvested in local businesses and infrastructure, driving economic growth and development. Moreover, Export-oriented industries often require a large workforce, creating numerous jobs within a province. The growth of export-driven sectors, such as manufacturing and agriculture, can increase residents' employment opportunities. As more people find work, household incomes rise, leading to higher consumer spending and contributing to GDP growth. Additionally, as China continues to engage in global trade, it has adopted policies and strategies that promote exports as a fundamental driver of economic development. Provinces with a strong export-oriented focus are more likely to experience GDP growth, provided they can adapt to changing market demands and remain competitive in the global marketplace. The findings are consistent with Muhammad Adnan Hye (2012) and support hypothesis 3.

Table 7 demonstrates that a percentage increase in GDP will result in an increase in FDI of around 0.946% to 1.409%. Provinces experiencing robust economic growth represent attractive markets for foreign investors. Rising incomes and increased consumer demand create opportunities for businesses to sell their products and services in these areas. Companies may invest in provinces with growing economies to tap into the local customer base and expand their market presence, which can lead to higher returns on investment. Moreover, provinces with strong economic growth often have a well-educated and skilled workforce. This can be especially appealing to foreign investors looking for a talent pool with the expertise and capabilities to support their operations. FDI projects benefit from access to a skilled labor force that can contribute to productivity and innovation. Furthermore, Economic growth often goes hand in hand with infrastructure development, including improved transportation networks, logistics facilities, and utilities. This infrastructure can reduce operational costs for foreign investors, making setting up and running their businesses more cost-effective. Additionally, well-developed infrastructure can facilitate the movement of goods and services, which is crucial for FDI projects involved in manufacturing and distribution. The findings also support hypothesis 2.

Table 8 shows that GDP positively influences Exports at the 1% significance level for all three approaches. A 1% rise in GDP growth will result in a corresponding increase in exports from 0.2083% to 0.2121%. The findings are consistent with those of Yao (2006) and Muhammad Adnan Hye (2012).

CONCLUSION

This study investigates the two-way causal relationship between FDI, exports, and economic growth. We employ the FEM method to analyze an unbalanced panel with 31 provinces in China between 2000 and 2018. The findings indicate a substantial positive relationship between China's GDP, exports, and FDI. Our findings suggest that economic performance in Chinese provinces primarily relied on local exports and foreign direct investment.

The study provides practical policy implications for promoting economic growth in Chinese provinces. Local governments should attract FDI by offering tax incentives, establishing free trade zones, and providing subsidies for strategic sectors. Additionally, trade promotion through international agreements and dedicated investment agencies is recommended to improve market access and export capacity. Export-oriented initiatives can further support local businesses in reaching global markets. Finally, the study

emphasizes sustainable growth by encouraging eco-friendly FDI through financial incentives and strict environmental regulations, enhancing product reputation and long-term development potential in China.

This study has the following limitations. Our research has yet to examine the relationship between exports, FDI, and economic growth at the sectoral level. Future studies can explore the impact of FDI and exports on specific sectors of the economy to offer nuanced insights.

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The Impact of Rural Women's Education on Household Income in China: Empirical Study Based on CFPS

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ABSTRACT

This study examines the impact of rural women's educational attainment on household income in China using data from the 2018 China Family Panel Studies (CFPS). Drawing on human capital, market efficiency, and social capital theories, we test four hypotheses to evaluate the direct effects of education and mediating pathways through off-farm employment, entrepreneurial capability, and social capital. Employing multiple regression, instrumental variable (IV), and propensity score matching (PSM) methods to address endogeneity and selection bias, we find that rural women's education significantly increases household income, with a 1-year increase in education associated with a 3.0% rise in per capita income. Mechanism analyses reveal that entrepreneurial capability (H3) and social capital (H4) serve as critical mediators, explaining 29.1% and 4.6% of the total effect, respectively, while off-farm employment (H2) shows no significant mediating role. Heterogeneity analyses highlight regional and income-based disparities: the effect is strongest in China's eastern regions (coefficient = 0.036 vs. 0.020 in central and 0.032 in western areas) and among high-income households, where education contributes 1.2% to income growth, compared to negligible effects in low- and middle-income families. Robustness checks, including alternative datasets (CHFS 2019) and PSM models, confirm the results' consistency. The findings underscore the dual role of education in enhancing human capital and fostering social networks, which collectively empower rural women to access economic opportunities. However, structural barriers—such as limited resources in low-income households and regional economic imbalances—constrain these benefits in central/western regions. Policy implications emphasize targeted educational subsidies, skill-building pro-grams, and social capital initiatives for disadvantaged households, particularly in under-developed areas, to amplify the income-enhancing potential of women's education and reduce rural inequality. This study contributes empirical evidence to the discourse on gender, education, and rural development, advocating for context-specific interventions to maximize educational returns.

INTRODUCTION

Income inequality, particularly the persistent urban-rural divide, remains a critical challenge for China's continued economic development. While rapid economic growth has lifted millions out of poverty, rural incomes continue to lag behind urban counterparts, posing a significant obstacle to achieving equitable prosperity. Understanding the factors that contribute to this disparity is crucial for designing effective policies aimed at promoting rural development and reducing income inequality.

Existing research has explored various determinants of rural household income, including household characteristics (Kim, 2019; Wei, 2004; Huo and Chen, 2023; Chen et al., 2024), social and environmental factors (Chang et al., 2012; Yang and Liu, 2012; Biagini et al., 2020; Zhou and Yu, 2011; Liu J. and Liu H., 2004; Wan and Zhou, 2005; Ren et al. 2019; Chen et al., 2023; Chi and Oksana, 2023; Zhao et al., 2024), and employment diversification (Cui and Chen, 2000). However, the specific role of rural women's education in influencing household income has received relatively limited attention. This is a significant oversight given the increasing recognition of women's empowerment as a key driver of economic development and poverty reduction.

This study addresses this gap by examining the impact of rural women's educational attainment on household income in China using data from the 2018 China Family Panel Studies (CFPS). We investigate the causal relationship between rural women's education and household income, employing both propensity score matching (PSM) and an instrumental variable (IV) approach to address potential endogeneity concerns. Furthermore, we explore the underlying mechanisms through which education affects income, focusing on the mediating roles of entrepreneurial activities and social capital. Finally, we examine the heterogeneity of this effect across different regions and income levels to provide a more nuanced understanding of the relationship.

This research contributes to the literature in several key ways. First, we provide robust causal evidence on the impact of women's education on rural household income using a large, nationally representative dataset. Second, our analysis of mediating factors sheds light on how education translates into higher incomes for rural families. Third, the use of an IV approach strengthens the causal identification of the education effect. Fourth, our heterogeneity analysis reveals important regional and income-based variations in the impact of women's education on household income, offering valuable insights for targeted policy interventions.

The structure of the paper is as follows: Section 1 covers the theoretical framework and research hypotheses. Section 2 provides an overview of the data, sources, and descriptive statistics. Section 3 presents the econometric models and key empirical results. The final section concludes with a discussion of the policy implications.

1. THEORETICAL FRAMEWORK AND HYPOTHESES

1.1 Primary Effect: The Impact of Education for Rural Women on Family Income

Despite recent advancements in the economy and culture that have narrowed the educational gap between men and women, significant disparities still exist. Women in rural households continue to experience higher levels of poverty, lower educational attainment, and reduced consumption compared to their male counterparts (Wu et al., 2013). Access to education remains a challenge for many women in rural areas, making state and community support essential. Enhancing women's education is crucial for reducing gender discrimination. Supportive policies aimed at women, particularly those in rural regions, can facilitate their pursuit of higher education, yielding substantial gender dividends that contribute to increased household income (Xiao and Wang, 2021). According to Saeed et al. (2018), gender inequality in education exacerbates local household poverty rates. By improving their educational qualifications, women acquire advanced farming techniques and agricultural knowledge, enabling them to diversify

crop production and engage in value-added industries such as farming and food processing. Consequently, increased productivity in agribusiness can significantly enhance household income. Based on this analysis, we propose the following hypothesis for testing:

H1: Higher education levels among rural women contribute to an increase in household income.

1.2 Mediating Mechanisms

1.2.1 Off-farm Labor Participation

Firstly, increasing women's educational attainment contributes to boosting household income by encouraging participation in off-farm employment. According to human capital theory, education is viewed as a strategic investment that enhances an individual's knowledge, skills, and capabilities, thereby improving their competitiveness and productivity in the labor market. This not only strengthens women's ability to manage complex tasks but also equips them with essential skills to enter technologically advanced or knowledge-intensive non-agricultural sectors. These sectors typically offer higher wages and more stable employment opportunities, significantly improving the economic conditions of families. Therefore, we propose the following hypothesis:

H2: The impact of rural women's education on household income is mediated by their participation in off-farm employment.

1.2.2 Entrepreneurial Capability

Secondly, enhancing the educational levels of rural women significantly improves their entrepreneurial capabilities, which in turn leads to an increase in family income. Market efficiency theory posits that information asymmetry and restrictions can impede the effective functioning of markets. Education can mitigate information asymmetry, enabling rural women to better understand market demands and price fluctuations, thus facilitating more informed business decisions. Furthermore, education helps them build broader social networks, which can provide crucial business information and assist in accessing necessary resources and support, such as loans and technical assistance, thereby enhancing their entrepreneurial capabilities. Based on this analysis, we propose the following hypothesis:

H3: Rural women's education positively affects household income by enhancing their entrepreneurial capabilities.

1.2.3 Social Capital

Moreover, improving the educational levels of rural women can enhance family income by influencing their social capital. Social capital theory emphasizes that an individual's networks, social relationships, and level of social participation can significantly impact economic performance. In rural areas, enhancing women's education can strengthen their social capital on multiple levels, thereby affecting household income. Education improves rural women's social skills and communication abilities, which are fundamental for establishing and maintaining social networks. Through education, they can interact and collaborate more effectively with others, gaining access to more information and resources while enhancing their influence and status within the community. Such strengthened social networks can provide greater economic opportunities, such as participation in larger economic activities through cooperatives or community groups. Based on the above discussion, we propose the following hypothesis:

H4: Rural women's education influences household income by enhancing their social capital.

2. DATA COLLECTION AND VARIABLE DESCRIPTION

2.1 Data collection

The data utilized in this paper originate from the 2018 China Family Panel Studies (CFPS). CFPS1 is a large-scale national survey project organized and conducted by the China Social Science Survey Center at Peking University, encompassing the eastern, central, and western regions of China. There are four categories in the database: community, family, adult, and children. In this work, adult and family data are used. This research uses only samples with rural household registration since it examines the educational attainment of married women in rural areas. After excluding individuals with missing values, duplicate entries, and outliers, we ultimately obtained 2,383 valid observations, spanning 25 provinces and 206 counties. The details are displayed in the second column of Table 2.

2.2 Variable description

To effectively address the research questions, we will specifically present the research variables using operational indicators to measure them.

2.2.1 Dependent variable: Household Income(income).

The dependent variable in this study is household income per capita. Specifically, the annual per capita net income of rural households is selected as the measure of household income, following the approach of Yang and Zeng (2021). To address potential heteroscedasticity and reduce data skewness, the income variable is transformed logarithmically.

2.2.2 Independent variables: Education(edu).

The independent variable, “edu,” represents the educational attainment of rural women. Based on survey data, the education levels are categorized into seven types:

Never attended school (0 years).
Primary school (6 years).
Junior high school (9 years).
Senior high school (12 years).
Junior college (15 years).
Undergraduate degree (16 years).
Postgraduate degree (19 years).

2.2.3 Control variables.

Based on prior research and data availability, the study incorporates the following control variables:

2.2.3.1 Individual-Level Factors

Health: A binary variable where 1 represents good, excellent, or very good health, and 0 represents poor health.

Political Status (Party): A binary variable where 1 indicates the individual is a member of the Communist Party, and 0 otherwise.

2.2.3.2 Household-Level Factors

Size: The total number of family members.
Finance: The total financial assets of the household.
Fix: The value of household fixed assets.
Fhouse: The total property value of the household.

[1] Please check the following website for additional details regarding the CFPS data: http://www.isss.pku.edu.cn/cfps/

2.2.4. Mediator variables

This study examines three mediating variables related to the effect of rural women's education on household income:

Non-agricultural Employment (nr): This variable is derived from responses to the CFPS survey question: "Is this job agricultural or non-agricultural?" A value of 1 represents non-agricultural work, while 0 represents agricultural work.

Entrepreneurial Capability (Ability): This variable is based on responses to the CFPS survey question: "In the past 12 months, did any family member engage in self-employed business (individually operated businesses or private enterprises)?" A value of 1 indicates engaging in entrepreneurial activities, while 0 indicates otherwise.

Social Capital: Social capital is measured by expenditures on gifts for social relationships, as referenced by Xue et al. (2022). The spending on gifts is used as a proxy for the development and maintenance of social relationships.

2.2.5. Instrumental variable: iv-edu.

To address potential endogeneity issues, this study employs the instrumental variable method. The instrumental variable (iv-edu) is defined as the average educational attainment of rural women in the same county, excluding the women in the sample.

This approach is grounded in two key assumptions:

Correlation: The education levels of rural women within the same county are strongly associated due to shared cultural and economic contexts.

Exogeneity: The household income of the sampled individuals is not directly affected by the average education level of other women outside the sample.

Therefore, the instrumental variable (IV-Edu) satisfies the conditions of both relevance and exogeneity.

The detailed valuables as shown in Table 1 and Table 2.

Table 1. Explanation of the variables utilized in the study

Variables	Label	Description of variables
Dependent variable:		
Famer's income(log)	income	Average disposable income in the household
Independent variable:		
Level of the women's education in rural areas	edu	Education years Never been to school (0) Primary school (6) Junior high school (9) Senior high school/secondary school/technical school/vocational senior school (12) 3-year college (15) 4-year college (16) Master's program (19)
Control variables:		
Status of health	health	Excellent/very good/good=1 poor=0
Member of the Communist Party	party	Whether be a party member (yes=1 no=0)
Family members	size	Number of family members
Finance assets(log)	finance	Total household financial assets
Fixed assets(log)	fix	Household fixed assets

House assets(log)	fhouse	Total household property value
Mediator:		
Job category	nr	Off-farm job =1 agricultural job=0
entrepreneurial capability	ability	Whether engaged in self-employed business (yes=1 no=0)
Social capital(log)	social capital	Expenditure on gifts for social relations
Instrumental variable:	iv-edu	the average education level of rural women in the county except for the sample.

Source: own

Table 2. Descriptive statistics employed in this article

variable	obs	mean	sd	min	max
income	2382	9.401	0.923	0	12.638
edu	2382	6.963	4.502	0	19
health	2382	0.735	0.442	0	1
pty	2382	0.010	0.102	0	1
size	2382	5.002	2.052	1	15
finance	2382	7.667	4.364	0	15.009
fix	2382	4.101	4.595	0	17.728
fhouse	2382	11.897	1.546	0	16.524
nr	1989	0.488	0.500	0	1
ability	2383	0.107	0.309	0	1
social capital	2366	7.508	2.089	0	11.290
iv-edu	2310	6.990	1.727	0	16

Source: own

3. EMPIRICAL ANALYSIS

3.1 Model

In this study, multiple regression analysis has been used to examine the relationship between rural women's education and household income. The following is the econometric model:

$$\mathrm{Income_i} = \alpha + \beta edu_i + \gamma CV_i + \varepsilon_i \qquad (1)$$

In model 1, $\mathrm{Income_i}$ represents each capita income of the i farmer household. The term edu_i describes the rural women's educational attainment in the i family. If β is notably positive, it suggests a strong positive relationship between rural women's education and household income—the higher the education level of rural women, the greater the income of farmers. Conversely, the household's income level decreases as the education level of rural women decreases. CV_i represent the control variables that affect household income. ε_i is random error term.

Furthermore, this study adopts the intermediary effect model (Wen and Ye, 2014) and employs the stepwise regression method to explore the influence of rural women's educational attainment on the income of Chinese farmers. The regression model developed for this analysis is detailed below:

$$\mathrm{MD_i} = \chi_0 + \chi_1 edu_i + \chi_2 CV_i + \varepsilon_i \qquad (2)$$

$$\mathrm{Income_i} = \delta_0 + \delta_1 edu_i + \delta_2 \mathrm{MD_i} + \delta_3 CV_i + \varepsilon_i \qquad (3)$$

Where, MD is the intermediary variable in the model (2), including mediator nr (non-agricultural employment), ability (entrepreneurial capability), and social capital.

The coefficient $\chi 1$ represents the effect of the independent variable (edu) on the intermediary variable (MD). The coefficient δ2 of the model (3) represents the effect of the intermediary variable (MD) on farmers' income (Income) while accounting for the impact of the independent variable (edu). The coefficient δ1 measures the direct effect of the independent variable (edu) on the dependent variable (Income), controlling for the effects of the intermediary variable (MD). Definitions for other variables remain consistent with those given in eq. (1). The mediation effect is deemed significant if $\chi 1$, δ1, and δ2 each demonstrate statistical significance.

3.2 Baseline regression

In this study, the issue of multicollinearity among variables was assessed using Stata 14.0 software. The variance inflation factor (VIF) for all independent variables was found to be less than 2, indicating no significant multicollinearity concerns. Subsequently, multiple linear regression analyses were conducted based on econometric model specifications.

The analysis uses household income as the dependent variable, with rural women's educational attainment serving as the primary independent variable. Additional variables, including individual and household characteristics, are incorporated as control variables. The detailed regression outcomes are presented in Table 3. Specifically, Column (1) reports the baseline model, which examines the impact of rural women's educational attainment on household income without additional controls. Columns (2) and (3) progressively incorporate individual and household control variables to verify the robustness of the results.

The empirical findings consistently demonstrate that rural women's educational attainment exerts a statistically significant and positive influence on household income at the 1% level in all models. This result aligns with Hypothesis 1, suggesting that improving women's education levels can lead to substantial increases in household income. A plausible explanation is that higher educational attainment enhances women's cognitive abilities, providing them with better access to resources, social capital, and non-agricultural employment opportunities, thereby boosting household income.

In addition to the primary independent variable, several control variables exhibit significant effects. First, the health status of rural women positively influences household income at the 1% significance level. Women in rural areas often engage in physically demanding work, and better health enhances productivity and earning potential. Conversely, poor health adversely affects productivity and increases the likelihood of household poverty.

Second, household size negatively correlates with household income at the 1% significance level, indicating that a larger family size reduces per capita resources and income. This finding highlights the economic burden associated with larger households in rural areas.

Lastly, financial assets, fixed assets, and housing assets all exhibit positive and statistically significant coefficients at the 1% level. These results indicate that asset accumulation plays a critical role in improving household income. Assets not only provide economic security but also serve as a source of capital for investment and income generation.

Table 3. Regression results for the impact of rural women's education level on household income (OLS)

	(1)	(2)	(3)
edu	0.042***	0.039***	0.030***
	(0.004)	(0.004)	(0.004)
health		0.142***	0.139***
		(0.045)	(0.043)
pty		0.034	0.178
		(0.168)	(0.156)
size			-0.075***

			(0.009)
finance			0.045***
			(0.004)
fix			0.012***
			(0.004)
fhouse			0.133***
			(0.025)
Constant	9.117***	9.035***	7.481***
	(0.033)	(0.046)	(0.295)
Province Fixed Effects	Yes	Yes	Yes
Observation	2522	2433	2382
R-squared	0.141	0.142	0.264

Notes: Significance levels for P-values are denoted as follows: ***≤ 0.01; **≤ 0.05; *≤ 0.10. Standard errors in parentheses.
Source: The authors' detailed analysis of China CFPS data. The following tables are the same.

3.3 Mechanism investigation

Based on intermediary effect models 2 and 3, we have formulated the following empirical study.

3.3.1 Mediator: Non-agricultural employment (nr)

The enhancement of rural women's educational attainment is posited to positively influence family income by facilitating their engagement in off-farm employment. To investigate this hypothesis, this study identifies individuals participating in off-farm work as a mediating proxy variable. The results of this analysis are presented in Table 4.

Table 4. Testing of the Mediating Effect

	(1)	(2)
Variables	nr	Income
edu	0.046***	0.020***
	(0.002)	(0.005)
nr		0.273***
		(0.042)
Sobel		0.013
		(0.002)

Notes: Significance levels for P-values are denoted as follows: ***≤ 0.01; **≤ 0.05; *≤ 0.10. Standard errors in parentheses.
Source: own

The results in Table 4 indicate that the coefficient for educational attainment (edu) on non-agricultural employment (nr) is significantly positive, suggesting that an increase in women's education levels enhances their participation in off-farm employment. Furthermore, the coefficient for nr on household income is also significantly positive, indicating that engagement in off-farm employment contributes to increased household income.

However, the Sobel test results do not demonstrate statistical significance, implying that non-agricultural employment does not serve as a mediating factor in the relationship between women's education levels and rural household income. This finding suggests that the influence of women's educational attainment on family income is not mediated by their participation in non-agricultural employment. This outcome contradicts Hypothesis H2.

One potential explanation for this result is that off-farm employment may directly affect income growth for farmers, rather than functioning as an intermediary variable that influences the relationship between women's education and household income. This indicates that while education may enhance women's opportunities for off-farm work, the direct impact of education on income may operate through other channels.

3.3.2 Mediator: Entrepreneurial capability (Ability).

To evaluate Hypothesis H3, which posits that the impact of rural women's educational level on household income is mediated through the enhancement of their business capabilities, we conducted empirical analyses using Models 2 and 3. Following the research methodology outlined by Wen et al. (2004), we employed the Sobel test to assess the validity of the mediation effect. The findings are presented in Table 5.

Table 5. Testing of the Mediating Effect

	(1)	(2)
Variables	Ability	Income
edu	0.004***	0.031***
	(0.001)	(0.004)
Ability		0.291***
		(0.064)
Sobel		0.001***
		(0.001)

Notes: Significance levels for P-values are denoted as follows: ***≤ 0.01; **≤ 0.05; *≤ 0.10.
Standard errors in parentheses.
Source: own

The results indicate that the Sobel statistic's P-value is less than 0.01, signifying a significant mediating effect. This finding suggests that the influence of rural women's educational attainment on household income is, to a certain extent, realized through the enhancement of their management and investment capabilities. Women with higher education levels may possess greater skills in resource management and allocation within their households. Consequently, as their asset management skills improve, household income is likely to increase. This outcome supports Hypothesis H3.

3.3.2 Mediator: Social capital.

The concept of social capital, first introduced by French scholar Pierre Bourdieu in the 1970s, refers to the resource individuals can access through their social networks. These connections can enhance cultural capital and provide various advantages. To analyze whether improvements in women's educational attainment can influence household income through social capital, "Expenditure on gifts for social relations" was selected as the proxy variable for social capital. To address heteroscedasticity and reduce data skewness, this variable was processed logarithmically. The mediation effect was assessed using the Sobel test, and the results are presented in Table 6.

Table 6. Testing of the Mediating Effect

	(1)	(2)
Variables	Social-capital	Income
edu	0.023**	0.033***
	(0.009)	(0.004)
Social_capital		0.046***

	(0.008)
Sobel	0.001**
	(0.001)

Notes: Significance levels for P-values are denoted as follows: ***≤ 0.01; **≤ 0.05; *≤ 0.10.
Standard errors in parentheses.
Source:own

The results indicate that the P-value of the Sobel statistic is less than 0.05, signifying a significant mediating effect. This finding demonstrates that increasing women's educational attainment can enhance family income by improving social capital. As women's education levels rise, rural households gain better access to external resources, which subsequently contributes to increased household income. In other words, one pathway through which women's educational attainment affects farmers' income is by enhancing the family's social capital. Therefore, Hypothesis H4 is confirmed.

3.4 Robustness analysis

The following robustness tests are carried out to confirm the reliability and consistency of the findings in this work.

3.4.1 Alternative the dependent variable

The dependent variable per capita household income is replaced with total household income. The results of the regression analysis are displayed in column (1) of Table 7.

3.4.2 Substitute the database

The database CFPS2018 is replaced with the China Household Financial Survey Project (CHFS)2019 which is organized and managed by the China Household Financial Survey and Research Center, Southwestern University of Finance and Economics. Column (2) of Table 7 presents the outcomes of the regression analysis.

Table 7. Robustness analysis

	(1) Income	(2) Income	(3) Income
edu	0.035***	0.126***	
	(0.004)	(0.026)	
edu1			0.295***
			(0.054)
CV	Yes	Yes	Yes
Observation	2379	3071	927
R-squared	0.298	0.219	0.197

Notes: Significance levels for P-values are denoted as follows: ***≤ 0.01; **≤ 0.05; *≤ 0.10.
Standard errors in parentheses.
Source: Own

3.4.3 Sample matching

To avoid endogeneity issues caused by sample selection bias, we use propensity score matching (PSM) to test robustness. Firstly, we define the independent variable, edu1. This variable is assigned a value of 1 if the years of women's education in rural areas exceed 0, and a value of 0 otherwise. Subsequently, this study employs the widely used nearest-neighbor matching method, utilizing a caliper of 0.02 and setting k=1. The results presented in Table 8 indicate substantial decreases in Pseudo-R2, Mean

Bias, and LR chi2 following matching. The Average Treatment Effect on the Treated (ATT) is significantly positive at the 1% level. Figure 1 illustrates a notable reduction in standardized bias across covariates after nearest-neighbor matching.

Furthermore, Fig. 2, which shows the results of the common support hypothesis test, indicates that the propensity scores of the treatment and control groups exhibit a wide overlap, suggesting high-quality sample matching with low loss of samples. All these results indicate that the PSM analysis is valid.

Column 3 in Table 7 presents the regression results after PSM, revealing a statistically significant positive coefficient for edu1 at the 1% level. This suggests that rural women's education contributes to the enhancement of farmers' income. The alignment of these results with the benchmark regression underscores their robustness after mitigating sample selection bias. The above results suggest that the study's result is robust and reliable.

Table 8. Balance diagnostics of explanatory variables and average treatment effect of PSM.

Sample	Pseudo-R^2	LR chi^2 (p-value)	Mean Bias	ATT (s.e.)
Unmatched	0.058	149.00(0.000)	22.9	
Matched	0.004	21.64(0.001)	4.8	
				0.226***
				(0.622)

Notes: Standard errors in parentheses; ***p < 0.01.
Source:own

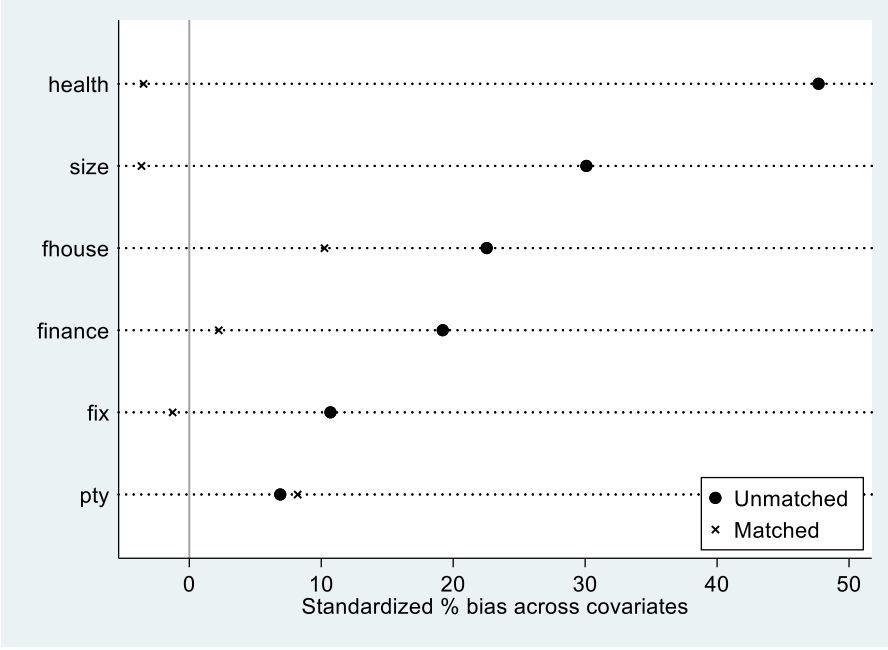

Figure 1. Standardized bias across covariates after nearest-neighbor matching

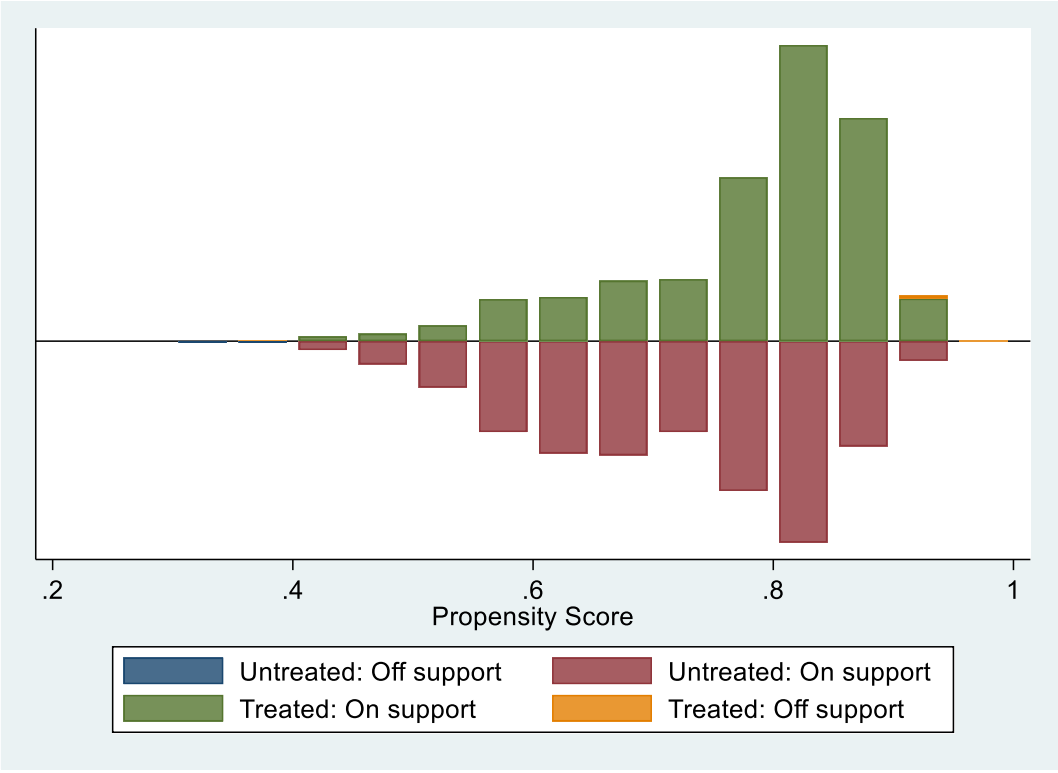

Figure 2. Common support of the propensity score.

3.5 Endogeneity analysis

The regression model may suffer from omitted variable bias due to the difficulty in collecting all relevant factors influencing farmers' income. Additionally, there exists the possibility that farmers' income could also affect the level of female education; for instance, wealthier farmers may be more likely to marry women with higher educational attainment. This potential mutual causality raises concerns about the endogeneity of female education level (edu) in relation to household income. To assess whether edu is an endogenous variable, we conducted the Durbin-Wu-Hausman test. The results, presented in Table 9, show a chi-square value of 10.727 with a probability of accepting the null hypothesis at 0.001. This indicates that the null hypothesis of exogeneity is rejected at the 1% significance level, thereby supporting the alternative hypothesis that edu is indeed an endogenous variable.

To address the endogeneity issue stemming from potentially omitted variables, this study incorporates as many control variables as possible to mitigate the impact of missing data on the model. Furthermore, to resolve the endogeneity problem arising from mutual causation, it is essential to identify instrumental variables that are correlated with the independent variable but not with the dependent variable. Following the approach of Xue (2022), we selected the average education level of rural women in the county, excluding the sample (iv-edu), as the instrumental variable. This variable is correlated with the family's female education level (the independent variable) but not with household income (the dependent variable), thus satisfying the criteria for a valid instrumental variable.

To confirm that the instrumental variable is not weak, we conducted additional tests. The findings in Table 9 indicate no issues with weak instruments, as Shea's partial R-squared is 0.0230 and the minimum eigenvalue statistic is 55.8903.

Table 9 compares the Ordinary Least Squares (OLS) and Instrumental Variable (IV) estimates of edu and household income. Column (1) presents the OLS regression results, while Column (2) displays the Two-Stage Least Squares (2SLS) regression results incorporating the instrumental variable (iv-edu).

Table 9. Comparison of the OLS and IV estimates

	(1) OLS	(2) 2SLS
edu	0.032***	
	(0.004)	
iv-edu		0.118***
		(0.024)
health	0.130***	-0.074
	(0.042)	(0.072)
pty	0.232	-0.055
	(0.153)	(0.167)
size	-0.086***	-0.099***
	(0.008)	(0.010)
finance	0.049***	0.044***
	(0.004)	(0.005)
fix	0.009**	0.008**
	(0.004)	(0.004)
fhouse	0.154***	0.117***
	(0.024)	(0.029)
Constant	7.260***	7.377***
	(0.286)	(0.311)
Observation	2383	2310
R-squared	0.222	0.079
Chi-square		10.727(p=0.001)
Shea's partial R-squared		0.0230
Minimum eigenvalue statistic		55.890

Notes: Significance levels for P-values are denoted as follows: ***≤ 0.01; **≤ 0.05; *≤ 0.10.
Standard errors in parentheses.
Source: Own

3.6 Heterogeneity analysis

3.6.1 Heterogeneity analysis based on East, Central, and Western grouping

Table 10 presents the results of the regional regression analysis, which considers locational variables from the eastern, central, and western districts. The findings indicate that rural women's educational attainment significantly affects rural household income across all three regions. The details are as follows: In the eastern region, the edu coefficient is 0.036 (significant at the 1% level), in the central region it is 0.020 (significant at the 5% level), and in the western region it is 0.032 (significant at the 1% level).

Notably, the coefficient for edu in the eastern region is larger than those in the central and western regions, suggesting that the eastern region has a higher marginal contribution rate of female education to household income. One possible explanation for this disparity is that the eastern region has a more developed economy compared to the central and western regions, along with superior resources and environmental conditions. In this context, highly educated women are better positioned to leverage these advantages and fully utilize their capabilities. Conversely, the lower contribution of female education in the central region may be attributed to economic constraints, cultural barriers, which limit job opportunities for educated women. Meanwhile, the western region, while showing a significant positive effect, reflects emerging opportunities that are beginning to recognize the value of women's education, albeit at a slower pace than in the eastern region.

Table 10. Estimation outcomes for the subsample models: East, Central, West

	(1) East	(2) Central	(3) West
edu	0.036***	0.020**	0.032***
	(0.007)	(0.008)	(0.008)
health	0.122*	0.119	0.138**
	(0.070)	(0.094)	(0.060)
pty	0.176	0.629	-0.002
	(0.218)	(0.425)	(0.156)
size	-0.107***	-0.053***	-0.081***
	(0.012)	(0.015)	(0.016)
finance	0.062***	0.036***	0.044***
	(0.008)	(0.007)	(0.006)
fix	0.005	0.014*	0.013**
	(0.006)	(0.007)	(0.006)
fhouse	0.129***	0.107***	0.228***
	(0.026)	(0.032)	(0.060)
Constant	7.592***	7.841***	6.332***
	(0.297)	(0.393)	(0.718)
Observation	875	698	799
R-squared	0.264	0.106	0.295

Notes: Significance levels for P-values are denoted as follows: ***≤ 0.01; **≤ 0.05; *≤ 0.10. Standard errors in parentheses.
Source: Own

3.6.2 Heterogeneity analysis based on household income classification (Low, Mid, and High)

To investigate the consistency of the relationship between women's education and household income across various family income situations, the samples are categorized into three groups: low-income families, middle-income families, and high-income families, based on per capita income. The results of the regression analysis for these three subsamples are displayed in Table 11.

Table 11. Estimation results of the subsample models: Low, Mid, High

	(1) Low	(2) Mid	(3) High
edu	-0.003	0.002	0.012***
	(0.009)	(0.002)	(0.004)
health	0.126**	0.018	-0.036
	(0.064)	(0.016)	(0.038)
pty	-0.097	0.176***	0.055
	(0.101)	(0.055)	(0.109)
size	0.014	-0.004	-0.048***
	(0.015)	(0.004)	(0.007)
finance	0.020***	0.001	0.018***
	(0.007)	(0.002)	(0.003)
fix	0.015**	0.001	0.003
	(0.006)	(0.002)	(0.003)
fhouse	0.117**	0.007	0.042***
	(0.053)	(0.004)	(0.014)
Constant	6.839***	9.339***	9.734***
	(0.622)	(0.055)	(0.170)
Observation	808	791	784
R-squared	0.073	0.014	0.108

Notes: Significance levels for P-values are denoted as follows: ***≤ 0.01; **≤ 0.05; *≤ 0.10. Standard errors in parentheses.
Source:Own

Table 11 shows the estimated outcomes for low-, middle-, and high-income households in columns (1), (2), and (3), respectively. The regression analysis reveals that while the effect of female education on household income is highly significant in high-income households (edu coefficient = 0.012, significant at the 1% level), it is not significant in low-income (edu coefficient = -0.003) and middle-income families (edu coefficient = 0.002). The disparity in the impact of women's education on household income across different income levels may be attributed to several interrelated factors. In low-income households, limited productive capital, social resources, and a supportive environment restrict the effective utilization of women's education, making it difficult for them to leverage their qualifications for economic gain. Additionally, the immediate need for income often forces women to prioritize short-term labor over opportunities that align with their education, leading to underemployment. Cultural norms and societal expectations further limit women's workforce participation in both low- and middle-income families, reducing the economic benefits of their education. In contrast, high-income households provide a more conducive environment where women's education can significantly contribute to household income, thanks to greater access to resources, networks, and opportunities that enable educated women to fully utilize their skills.

CONCLUSION

This study employs an econometric model to conduct an empirical analysis using the CFPS2018 data, demonstrating that rural women's educational attainment significantly influences household income. Notably, this effect varies across different geographical locations and income brackets. The Sobel test was utilized to investigate three mechanisms that may mediate the relationship between women's education and rural household income: off-farm employment, entrepreneurial capability, and business social capital. Additionally, robustness and endogeneity analyses were performed to ensure the validity of the empirical findings. The key findings of this research are as follows:

1.After controlling for individual and family characteristics, the results indicate a significantly positive relationship between the education level of rural women and household income. This suggests that higher educational attainment among women is associated with increased household income levels.

2.The impact of rural women's education on household income exhibits heterogeneity based on geographical and economic contexts. Specifically:

1)The influence is more pronounced in the eastern region compared to the central and western areas.

2)High-income families experience a greater positive effect from women's education than low-income families.

3.The relationship between rural women's education and household income is significantly mediated by factors such as entrepreneurial capability and social capital, while off-farm employment was found to be insignificant. This indicates that enhancing family management skills and fostering social support networks may be effective strategies for maximizing the economic benefits of women's education.

Based on the theoretical analysis and empirical findings, this paper offers several policy implications:

First, it is essential to encourage rural women to pursue higher education, as this can lead to increased family income and contribute to reducing income inequality.

Second, targeted interventions should be developed for low- and middle-income households, particularly in the western and central regions. Implementing supportive policies, such as educational subsidies and skill development programs, can enhance the effectiveness of leveraging women's education to improve family income.

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Determinants of Economic Inequality Reduction in the EU During the Fourth Industrial Revolution

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ABSTRACT

Economic inequality is one of the major global challenges in the 21st century causing the possibility of different social and economic disruptions. The Fourth Industrial Revolution caused by the rapid digital transformation affected different segments of the society and economy. Subject of this paper is the analysis of possibilities to reduce the economic inequality in the EU during the Fourth Industrial Revolution. The most important objective of this research is to identify the determinants of reducing the economic inequality in the EU countries during the period of the Fourth Industrial Revolution. The study is based on three central hypotheses: (1) Technological development has a negative and statistically significant effect on inequality in the EU, (2) Investment in health has a negative and statistically significant effect on inequality in the EU and (3) Trade liberalization has a negative and statistically significant effect on inequality in the EU. The study uses the two-stage dynamic panel Generalized Method of Moments (GMM) estimator applied to data from 27 EU countries. The results show that technological development, expressed in two indicators related to the Fourth Industrial Revolution, i.e., competitive industrial performance index and investments in research and development, healthcare spending and trade liberalization play an important role in reducing inequality during the Fourth Industrial Revolution. Based on these results, the paper recommends that the EU prioritize technological progress, increase investment in research and development — especially by the private sector — expand public and private health spending and reduce trade barriers to remain the global leader in facing inequality and reaching sustainable development goals.

INTRODUCTION

Economic inequality, also known as income or wealth inequality, has long been a problem. As the OECD (2015) and the European Parliament (2016) have noted, it leads to major social and economic injustices. Throughout history, inequality has contributed to the rise of radical movements and violent events, including uprisings, revolutions, terrorism and wars. It refers to the unequal distribution of wealth between individuals and countries. The Gini index is the most commonly used measure of this phenomenon, as reported by the World Bank (2024), Our World in Data (2023) and the United Nations (2024).

This study focuses on increasing inequality within the EU. According to the European Commission (2024) and the IMF (2022), inequality is increasing both in Europe and globally. It is one of the most pressing global challenges today. Inequality is not only a Sustainable Development Goal (SDG) in its own right, but also impacts other goals, including poverty reduction, access to education, food security, healthcare and general well-being. Maning (2017) emphasizes that inequality remains a global problem. It requires constant research in the social and natural sciences.

The Fourth Industrial Revolution (4IR) has had a decisive impact on the economy and society. Despite its impact, its social and economic consequences have not yet been sufficiently researched. Kipper et al. (2020) point out the lack of in-depth research on this topic. Philbeck and Davis (2018) describe the 4IR as a major change with political, social and economic consequences. It began in Germany in 2011 and, according to Garcia (2021), ended in 2020 due to the COVID-19 pandemic and the rapid digital transformation. The European Parliament (2019) considers the 4IR to be a central EU strategy. It aims to close the development gap with global competitors.

This paper attempts to answer three research questions:

1) What is the impact of technological development on inequality?
2) What impact does trade liberalization have on inequality?
3) What impact does investment in health have on inequality?

The paper begins with the introduction, followed by the literature review. Then the data and methodology are presented. Then the results and discussion are presented. The final section contains conclusions and policy implications.

1. LITERATURE REVIEW

This section examines the relationship between economic inequality and three key factors: technological and economic development, trade liberalization and investment in health.

The European Parliament (2016) defines economic inequality as the unequal distribution of income and wealth, usually measured by the Gini coefficient. This form of inequality is a persistent problem in the EU, where it has increased in recent decades, leading to social and economic consequences such as higher mortality rates, a decline in public health, weakened confidence and slower long-term growth. Smiesova et al. (2019) emphasize that reducing inequality is an important economic goal. Similarly, Thorbecke and Charumilind (2002) argue that inequality undermines social mobility, increases crime, impairs health and educational outcomes and weakens human capital. Halaskova and Bednar (2020) find that in the EU-27 countries, social spending, especially on healthcare, reduces inequality and poverty while improving human capital. Tahlova and Banociova (2020) add that economic growth and tax systems reduce inequality, while unemployment increases it.

The impact of the Fourth Industrial Revolution (4IR) on inequality is controversial and a subject of the scientific discussion. Although it brings opportunities for development, it can also exacerbate inequality. Kuzmenko and Roienko (2017) and Guoping, Yun and Aizhi (2017) point out that technological change can increase inequality if it is not mitigated by education and supportive public policies. Milanović (2024) and the World Inequality Report (2020) trace inequality over time, noting a sharp rise during the first industrial revolution and a persistently high level thereafter. Setyadi, Indriyani and Syaifudin (2023) argue that technological development tends to reduce inequality. Dafermos and Papatheodorou (2013) find that GDP per capita, social security and labor protection can reduce inequality in the EU, but labor force participation alone cannot. According to Our World in Data (2024), technological innovation and industrial transformation — often driven by research and development — have contributed to reducing inequality in the past.

Bogliacino (2014) emphasizes that the relationship between technology and inequality is one of the most controversial and discussed topics in current economic research. Knell (2016) puts forward the theory of the Kuznets curve, according to which inequality increases in early stages of development but decreases later due to broader access to opportunities. Trofymenko et al. (2023) argue that inequality itself

can limit access to new technologies, creating a feedback loop. They see Europe as a pioneer in reducing inequality through innovation. Stiglitz (2019) notes that the impact of 4IR technologies depends on the policy framework and adoption by the private sector. Nguyen (2023) finds that both technological development and trade liberalization reduce inequality. Kang, Kim and Seol (2019), together with Lee et al. (2018), identify R&D as an important driver of 4IR. Schäfer (2018) sees R&D not only key driver of the 4IR in the EU but also as central to the EU's global competitiveness in the digital age.

Roser, Ritchie and Mathieu (2024) show that past waves of innovation have improved access to vital resources such as clean water, sanitation, energy, education and healthcare, thereby reducing poverty and inequality. Aghion and Griffit (2024) emphasize that innovations, especially those resulting from private sector R&D, promote inclusive development by increasing productivity and mobility and consequently reduce inequality. Risso and Sánchez-Carrera (2018) find that R&D reduces inequality in 74 countries, including EU members, but emphasize the importance of political and institutional support. Gardiner and Hayek (2024) emphasize that R&D has been crucial not only for reducing inequality, but also for increasing growth and reducing poverty in the EU. Biurrun (2020) also finds that innovativeness, as measured by spending on R&D and skilled labor, plays a key role in reducing inequality in EU countries.

There are also mixed results on the relationship between trade liberalization and inequality. Jae-Hwa and Jong-Sung (2016) and Akyuz, Gueye and Karul (2022) find that there is a lack of targeted research in this area. While trade in goods tends to reduce inequality, the liberalization of services can have the opposite effect. Anser et al. (2020) report that trade liberalization lowers inequality, although they find that spending on healthcare increases inequality. Kandogan and Johnson (2024) argue that trade freedom, a measure of economic openness, helps to reduce inequality in different economies, although the effects vary across groups of countries. Pérez-Moreno and Angulo-Guerrero (2016) also associate economic freedom with lower inequality, but find that trade freedom has different effects in different EU countries. Asteriou, Dimelis and Moudatsou (2014) conclude that trade liberalization in the EU generally reduces inequality, while FDI tends to increase it. However, the impact of technology and innovation remains uncertain and context-dependent.

The role of investment in healthcare in reducing inequality has been less studied. Francis et al. (2023) argue that health spending improves equality in income, gender and access. Wang and Nguyen (2021) find a negative correlation between inequality and health spending in developed economies. Gamlath and Lahiri (2019) emphasize the role of public and private health investments and note that institutions influence outcomes. The European Commission (2014) emphasizes the importance of healthcare financing in reducing inequalities and achieving the goals of the Lisbon Strategy. Sánchez and Pérez-Corral (2018), like Cammerat (2020), note that social spending — especially on health — reduces inequality in the EU. Finally, Jianu (2018) points out that economic inequality remains an important research priority and that public policies in the areas of health and education are essential tools for reducing the Gini index.

2. METHODS AND CONCEPTION OF ANALYSIS

Income inequality represents one of the crucial societal issues as mentioned in the relevant literature such as OECD (2015) and EP (2016). The EU is oriented toward reduction of inequalities and it is set as one of the key strategic priorities, especially through cohesion policy that has the biggest share in the EU budget. Inequality is determined by variety of factors and it is the topic of huge research interest and scientific discussion, while its correlation with certain factors represents subject of extensive scientific discussion This is the reason why we decided to choose variables represented in the equation 1.

$$\mathrm{Gini} = \mathrm{f}\left(\mathrm{CIP}_{i,t};\ \mathrm{health}_{i,t};\ \mathrm{R\&D}_{i,t};\ \mathrm{trade}_{i,t}\right) \qquad (1)$$

We used the GMM as the primary estimation technique, which has been applied in previous studies such as Asteriou, Dimelis and Moudatsou (2014), Anser et al. (2020), Biurrun (2020) and Nguyen (2023). GMM is particularly well suited for dealing with endogeneity, a major problem in dynamic panel data models.

Roodman (2009) and Wooldridge (2012) emphasize that GMM eliminates unobserved fixed effects and reduces bias by differencing raw non-stationary data. By using lagged values of the dependent variable, GMM also efficiently captures dynamic relationships and helps account for possible reverse causality. It also minimizes data loss and is therefore ideal for panels having the cross-sections larger than the time-series. Ullah, Akhtar, and Zaefarian (2018) emphasize the value of diagnostic instruments such as the Sargan test and Arellano-Bond test, which GMM supports for checking the validity of instruments and detecting autocorrelation. Wintoki, Linck, and Netter (2012) also support the ability of GMM to produce consistent and unbiased estimates, especially when first differences are used to eliminate bias from omitted variables. Abrevaya and Donald (2017) describe GMM as one of the most effective methods for dealing with missing data and unobserved heterogeneity. Similarly, Brañas-Garza, Bucheli and García-Muñoz (2011) explain that GMM is widely used in economics because of these advantages. Hsiao (1985, 2020) also emphasizes the strength of the method in dealing with omitted variables, which increases the robustness and relevance of the empirical results.

In our study, the main goal was to identify the main determinants of inequality reduction during the Fourth Industrial Revolution. We focused on the years 2012 to 2019, reflecting the core phase of this period. According to Philbeck and Davis (2018), the Fourth Industrial Revolution began in 2011, while Garcia (2021) finds that 2020 is the beginning of the Fifth Industrial Revolution. Our balanced panel includes 129 observations across all EU Member States and allows for a reliable estimate of the relationships between inequality and its structural drivers.

$$y_{it} = \beta y_{it-1} + u_i + v_{it}, \quad |\beta| < 1 \qquad (2)$$

Equation 2 provides a dynamic model with one time-shifted lagged variable. In this model y_{it} is the dependent variable in period t, while y_{it-1} represents the dependent variable with one period lag from t and u_i is particular time-invariant effects and v_{it} represents the error term. Individual effects are treated as stochastic. Additional necessary assumptions related to the invariance of the model are errors v_{it} that are serially uncorrelated. Individual time-invariant impacts usually relate to past impacts of the dependent variable in used model, which points out endogeneity issue. In addition, in the Equation 3 we provide the test of our model.

$$\text{Gini}_{i,t} = \beta_0 + \beta_1 \text{CIP}_{i,t} + \beta_2 \text{health}_{i,t} + \beta_3 \text{R\&D}_{i,t} + \beta_4 \text{trade}_{i,t} + u_{i,t} + v_{i,t} \qquad (3)$$

3. EMPIRICAL DATA AND ANALYSIS

In this research we examine impact of technological development, investments in health and trade liberalization on inequality in the EU. Variable are shown in the Table 1.

Table 1: Variables

Symbol	Variable	Explanation	Database
Gini	Inequality	Gini index	World Bank (2024)
CIP	Technological development	Competitive industrial performance index	UNIDO (2024)
health	Investments in health	Current health expenditure per capita	World Bank (2024)
R&D	Technological development	R&D financed by business	World Intellectual Property Organization – Global innovation index (2024)
trade	Trade liberalization	Trade freedom	Heritage (2024)

Source: own

Figure 1 shows the variables used in the model. The dependent variable is the Gini index, which measures income inequality. This index indicates how income is distributed in a population and shows the degree of deviation from perfect equality. It ranges from 0 (perfect equality) to 100 (perfect inequality). As highlighted by Jianu (2018) and Smiesova et al. (2019), inequality remains a topic of great academic and

political interest. According to Tahlova and Banociova (2020) and major institutions such as the World Bank (2024), Our World in Data (2023) and the United Nations (2024), the Gini index is the most widely used metric to analyze inequality.

The main objective of this study is to identify the factors that contribute to reducing inequality in the European Union. This objective is based on the fact that both the European Commission (2024) and the IMF (2022) recognize inequality as a key societal challenge. Reducing inequality is seen as a strategic priority not only for the EU, but also globally. As Thorbecke and Charumilind (2002) explain, inequality remains a central topic of economic research due to its far-reaching social and developmental consequences. Jianu (2018) also emphasizes the relevance of this topic for scientific research.

To capture the impact of technological development, we use two indicators related to the Fourth Industrial revolution: d_CIP (Competitive Industrial Performance Index) and d_R&D (private sector investment in research and development). The CIP index, published by UNIDO (2024), reflects the degree of industrial transformation and technological development and export competitiveness of a country, especially in the manufacturing sector. This indicator is especially important in the context of the Fourth Industrial Revolution, which focuses on reindustrialization (Philbeck & Davis, 2019; McKinsey, 2022). The index ranges from 0 to 1, with higher values indicating greater industrial competitiveness and technological progress. It provides a broader picture than narrower industrial indicators as it includes production capacity, technological performance and export competitiveness.

The second indicator, private sector funded R&D, is also widely recognized in the literature. Scholars such as Aghion and Griffit (2024) and Biurrun (2020) note that R&D is closely linked to inequality outcomes, although the relationship is complex. Lee et al. (2018) and Schäfer (2018) identify private R&D as a fundamental driver of the Fourth Industrial Revolution and an essential element of the EU's economic strategy (EP, 2019). Given the EU's focus on innovation and the leading role of the private sector in R&D investment (EC, 2024; World Economic Forum, 2018), this variable is of great importance. The values range from minimum 0 to maximum 100, depending on the level of investment.

We have chosen both indicators because they reflect key dimensions of the Fourth Industrial Revolution. As Stiglitz (2019) argues, measuring inequality in this period is crucial to prevent the digital divide from deepening. The relationship between technology and inequality is an ongoing subject of academic debate (Bogliacino, 2014; Knell, 2016), to which this study aims to contribute. Another reason why we have chosen two indicators related to the Fourth Industrial Revolution is because according to Kipper et al. (2020), it is an understudied topic and requires more research, especially having in mind that relevant literature such as Garcia (2021) state that since 2020 world entered into the Fifth Industrial Revolution that is a continuation of the previous one.

For health investment, we use d_health, defined as current health expenditure per capita in USD, taken from the World Bank (2024). This indicator includes both public and private health expenditure. It is widely used and is considered a comprehensive measure of national investment in healthcare (EC, 2024; WHO, 2024). The choice of this variable is supported by the European Commission (2014), Gamlath and Lahiri (2019) and Francis et al. (2023), who all emphasize health expenditure as a key factor in reducing various forms of inequality. Despite its importance, the relationship between health spending and income inequality is still relatively under-researched.

To represent trade liberalization, we use d_trade as measured by the index of Trade Freedom from the Heritage Foundation's Index of Economic Freedom. This index captures both tariff and non-tariff barriers, government intervention and regulatory frameworks. It is more comprehensive than the standard indicators of trade openness. The values range from 0 to 100, with higher values indicating fewer trade barriers. Its use is supported by studies such as Anser et al. (2020) and Asteriou, Dimelis and Moudatsou (2014). Other scholars, including Jae-Hwa and Jong-Sung (2016) and Akyuz, Gueye and Karul (2022), have noted that there is relatively little focused research on the relationship between trade liberalization and inequality, making this variable particularly relevant.

Correlation matrix that tests multicollinearity can be found in the Table 2.

Table 2: Correlation matrix

d_Gini	d_CIP	d_trade	d_R&D	d_health	
1,0000	-0,1172	-0,1409	-0,0231	-0,0380	d_Gini
	1,0000	-0,0614	0,1040	0,2908	d_CIP
		1,0000	0,0519	-0,1885	d_trade
			1,0000	0,4033	d_R&D
				1,0000	d_health

Source: own

Results confirm that there is no multicollinearity among variables since all coefficients are below the critical value of 0.5. There are certain indicators with the negative sign but they are small in magnitude and close to zero. Negative signs are among Gini and all indicators, among trade and competitive industrial performance index and health.

To cope with the issue of non-stationarity we used first differences of chosen variables. To confirm stationarity of the variables we used KPSS test. According to Arltova and Fedorova (2016) and Lee and Schmidt (1996) this test provides more accurate and valid results than other tests and is the most suitable for shorter time periods such as the one we observe (2012-2019). Results of unit root test can be found in the Table 3.

Table 3: Results of unit root test

Variable	P-value
d_Gini	0,7931
d_CIP	0,5419
d_health	0,8620
d_R&D	0,8239
d_trade	0,1989

Source: own

Results confirm the hypothesis of KPSS test that data are stationary since for each variable p values is higher than the critical value of 0.05

4. RESULTS

Before providing results of the model, we aimed to test the robustness of the model. Results of robustness tests can be found in the table 4. The P-values marked *** indicate the significance level up to 1%. The P-values with the label ** indicate the significance level up to 5%. Results confirm that indicator CIP has the biggest impact on inequality, while investments in health mark the lowest impact. All results can be confirmed with the level of 1% significance.

Table 4: Building the model

d_Gini	d_CIP	d_trade	d_R&D	d_health
d_Gini	−12,3972***			
d_Gini	−9,86957***	−0,434966***		
d_Gini	−13,7109***	−0,396621***	−0,0145505***	
d_Gini	−11,6983***	−0,377161***	0,0116702***	−0,000278966**

Source: own

Table 4 shows the results of the sequential regressions in which the independent variables were included in the model one after the other. Across all model specifications, the ranking of the impact of the variables remains consistent. The Competitive Industrial Performance Index (CIP) shows the strongest negative effect on inequality. Trade freedom proves to be the second most important variable, followed by

R&D investment, while health expenditure continues to show the weakest impact. This consistency speaks for the robustness of the model. Diagnostic tests — including the Arellano-Bond test, the Sargan test and the chi-square test — confirm the validity of the instruments, the absence of autocorrelation and the overall robustness of the model in all specifications. The last column in Table 4 shows the full model, the coefficients of which are analyzed in more detail in the "Discussion" section. We test the following econometric model:

$$\text{d\_Gini}_{it} = \beta_0 + \beta_1 d_{Gini(-1)_{i(t-1)}} - \beta_2 d_{CIP\,it} - \beta_3 d_{trade\,it} + \beta_4 d_R\&D_{it} + \beta_5 d_{health_{it}} + \sum_{t=2014}^{2018} year_t + u_{it} + v_{it} \qquad (4)$$

Results of the model can be found in the table 5.

Table 5: Results of the model

	Coefficient	*Std. Error*	*z*	*p-value*	
d_Gini (-1)	−0,225319	0,0358110	−6,292	<0,0001	***
d_CIP	−11,6983	2,88097	−4,061	<0,0001	***
d_health~	−0,00027897	0,00011157	−2,500	0,0124	**
d_R&D	−0,0116702	0,00240766	−4,847	<0,0001	***
d_trade	−0,377161	0,0328376	−11,49	<0,0001	***
T3	0,227296	0,0694898	3,271	0,0011	***
T4	−0,339901	0,0993280	−3,422	0,0006	***
T5	−0,237308	0,0772262	−3,073	0,0021	***
T6	−0,724845	0,0685290	−10,58	<0,0001	***
T7	−0,142366	0,101209	−1,407	0,1595	
Sum squared resid	89,45180		S.E. of regr.	0,867004	
Observations			129		
Number of instruments			23		
Test for AR(1) errors (z)			-2,72988 [0,0063]		
Test for AR(2) errors (z)			0,341659 [0,7326]		
Sargan over-identification test: Chi-square(19)			11,1592 [0,5975]		
Wald (joint) test: Chi-square(6)			494,44 [0,0000]		
Wald (time dummies): Chi-square(5)			155,537 [0,0000]		

Source: own

5. DISCUSSION

The results show a negative and statistically significant effect of both the lagged dependent variable and all independent variables on the Gini coefficient. In particular, an increase in the Gini index in the previous year correlates with a decrease of 0.22 points in the current year, which is consistent with the Kuznets hypothesis that inequality decreases with increasing living standards — an effect that has been observed in the EU context (World Bank, 2024). This result is in line with Muszyńska, Oczki and Wędrowska (2018), who argue that higher levels of inequality in the past can lead to corrective policy changes and better socio-economic outcomes.

Among the independent variables, the strongest effect is observed for the Competitive Industrial Performance Index (d_CIP), which serves as a proxy for technological development and industrial change associated with the fourth industrial revolution. A 1% increase in this indicator leads to a significant decrease in the Gini index by 11.69 points. This result supports the findings of Trofymenko et al. (2023) and Nguyen (2023), although it contrasts somewhat with Milanović (2024) and the World Inequality Report (2020) and highlights the ongoing debates about the dual role of technology in mitigating or exacerbating inequality.

The second technological variable, private sector-funded R&D investment (d_R&D), also shows a negative and significant correlation with inequality. A 1% increase in this indicator corresponds to a 0.37% decrease in the Gini index, underpinning the arguments of Gardiner and Hayek (2024) and Biurrun (2020) about the inclusive impact of innovation when it is adequately supported.

Trade liberalization (d_trade) turns out to be the second most important factor after d_CIP, with a 1% increase in trade freedom being associated with a 0.37% reduction in inequality. This result supports earlier findings by Kandogan and Johnson (2024) and Asteriou et al. (2014), who note the redistributive effects of open trade regimes, particularly in the European context.

The weakest effect is found in per capita health expenditure (d_health), where a 1% increase leads to a 0.00027% reduction in the Gini index. The result is modest but statistically significant (at the 5% level) and is in line with Sánchez and Pérez-Corral (2018), Cammerat (2020) and Jianu (2018), who emphasize the long-term benefits of sustained investment in healthcare for the development of human capital and the reduction of inequality.

All variables, with the exception of d_health, are significant at the 1% level. The time dummies are also significant, with the exception of T7. These results are consistent with theoretical expectations, although the direction and strength of the relationships — particularly between technology and inequality — remain controversial in the literature. The results contribute to these ongoing debates by providing specific evidence for the EU in a crucial phase of industrial transformation.

Diagnostic checks confirm the reliability of the model. The AR(2) test confirms that there is no second-order autocorrelation, while the Sargan test validates the instrument. The Wald tests confirm the joint significance of the explanatory variables and the time dummies. Together with the tests for robustness and stationarity, these diagnostics support the validity of the model and the reliability of the estimated effects.

The main contribution of this study lies in the identification of the main determinants of inequality reduction in the EU during the Fourth Industrial Revolution — a period characterized by rapid technological change but relatively little empirical research (Kipper et al., 2020). By examining the interplay between technology, trade and investment in healthcare, this paper fills a gap in the literature and contributes to an ongoing debate on the socio-economic impact of the digital transformation (Bogliacino, 2014).

The findings have clear policy implications. To reduce inequality, EU policy makers should support the modernization of industry and encourage investment in research and development, especially in the private sector. Public support for innovation can improve productivity and socio-economic mobility. A continued commitment to trade openness is also essential, especially in light of emerging global protectionist trends. Finally, while investment in health has a comparatively smaller impact, its importance for the long-term development of human capital justifies prioritizing efficient health spending.

Despite its contributions, the study also has its limitations. The relatively short time frame (2012–2019) is a limitation, although it is acceptable for GMM estimation. The focus on this period reflects its categorization as the core phase of the fourth industrial revolution (Garcia, 2021). While the exclusion of the UK is methodologically intentional due to Brexit, it limits comparability with broader EU trends in the same years. Finally, while a variety of determinants influence inequality, the chosen GMM methodology helps to mitigate the bias from omitted variables, yet further research including institutional and labor market variables is warranted.

CONCLUSION

In this paper we aimed to identify determinants of inequality reduction because it is a topic that is never studied enough, crucial research interest and one of the key global societal issues. Our main motivation was to contribute to scientific discussion about understudied topics, such as the Fourth Industrial

Revolution and address real socio-economic issues and to provide new cognitions and knowledge about these topics.

Through introduction and literature review we provided theoretical framework related to the topic and explained why it is necessary to research it. Econometric model was used to test hypotheses that are confirmed and it provided the most important findings that technological development expresses with two variables related to the Fourth Industrial Revolution, investments in health and trade liberalization have statistically significant impact on lowering inequality.

It provided foundations to create theoretical and applicative contributions that are explained in the previous discussion section. The most important contributions are providing new knowledge about inequality that is key societal issue and research interest, such as the understudied topic of the Fourth Industrial Revolution and contribution to scientific discussion about correlation among technological development and trade with inequality. Applicative contribution is related to policy guidelines.

However, this research provides possibilities for the further research. Since inequality represents crucial societal issue, especially after Covid-19 pandemic, it will be very important to research it in the period of the Fifth Industrial Revolution that represents continuation of the previous one and is caused by rapid digital transformation. Areas for the further research are focusing on the direct impact of institutional variables, since as mentioned public policies are very important in reduction of inequality and mitigating possible negative impact of technological development on inequality. Another area for the further research is also role of overall globalization in reduction of inequality especially due to possible global trade war. The last are for the further research is examining consequences of inequality and its impacts on others socio-economic indicators, such as economic growth, living standard, human capital, educational and health outcomes, security aspects, democracy, human and economic freedom, focusing on the period of digital transformation in the 21st century.

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Financial Literacy Among Digital Lending Borrowers: Knowledge, Attitude and Behavior

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ABSTRACT

This study examines the interrelationship between financial literacy factors, including financial knowledge, choosing and using digital financial products and services, planning and managing finance, and financial attitude and behavior. This study used the OECD/INFE Toolkit for Measuring Financial Literacy and Financial Inclusion 2022 for digital borrowers. The sampling technique used is purposive sampling of Individuals who have used online loan applications and have a loan. The questionnaire was distributed via an online survey platform. It employed the survey method with data from 201 responses and was analyzed using partial least squares-based structural equation modeling (PLS-SEM). This study revealed that financial knowledge positively affected individuals' decisions on choosing and using digital financial products and services, then affected financial planning and management, which, in turn, affected attitude and behavior. This study can capture financial behaviors, attitudes, and knowledge, as well as a number of financial outcomes, to assess levels of financial literacy, financial inclusion, financial resilience, and financial well-being. This study contributes new insights by providing evidence from the empirical study of the financial literacy of digital lending borrowers on how to increase financial well-being. This study's findings offer valuable theoretical and practical insights into the development of financial literacy in a developing country.

INTRODUCTION

Across the globe, households are experiencing increasing financial pressure due to rising living costs, higher interest rates, and greater volatility in financial markets. This trend is evident in countries such as the United Kingdom (FPC, 2024) and Japan (Kihara, 2025). Additionally, the challenges many countries face globally are caused by economic downturns and rising inflation pressures, including in emerging market economies (OECD, 2022a). This indicates that the financial strain on households globally, particularly those with high levels of debt, is due to rising inflation and uncertain economic conditions. The rise of household debt and credit risk, coupled with the slowdown of the economy and tightening of

monetary conditions, may lead to increases in non-performing loans (NPLs) and credit risk for banks. This is particularly concerning for households with high debt-service ratios, as they may struggle with lending repayments amidst the weakening economic outlook and higher interest rates (OECD, 2022a). To respond to this situation, governments and institutions should prioritize financial education as a strategy to enhance individuals' capabilities in planning, saving, and managing money.

Simultaneously, innovations in the financial sector have led to the emergence of digital lending platforms, representing a transformative shift in financial technology (Asamani and Majumdar, 2024). Although Ali et al.(2023) reported a relatively low adoption of peer-to-peer (P2P) lending in Indonesia, recent developments paint a contrasting picture. With the widespread adoption of smartphones and mobility technology, P2P platforms have flourished (Yulisman, 2024). This trend aligns with findings by Suryono et al. (2021), citing data from the Financial Service Authority (OJK), a significant increase in fintech loan disbursements and the number of lender accounts in 2019 was noted. More recently, outstanding financing from P2P lending and Buy Now, Pay Later (BNPL) schemes in Indonesia increased by 31.06% and 59.1% year-on-year, respectively, as of February 2025 (Indonesia Financial Services Authority (OJK), 2025).

However, the rapid expansion of digital lending has also raised several concerns, particularly regarding the rise of illegal lenders and the limited financial literacy among borrowers. Many individuals in developing countries, such as Indonesia, remain unaware of the responsibilities associated with borrowing, such as timely repayment, which often leads to financial distress (Yulisman, 2024). The increasing use of online lending underscores the importance of sound financial planning. Defined as a strategic process to achieve life goals such as education, homeownership, and retirement, financial planning enables individuals to align their income, expenses, savings, and investments with their long-term objectives.

Financial literacy has thus become a vital life skill in navigating these modern financial challenges. It is not merely about knowledge but encompasses skills, attitudes, and behaviors that collectively promote financial well-being, economic resilience, and social inclusion. Scholars emphasize that financial literacy includes behavioral and attitudinal elements, such as financial planning, attitude toward money, and money management practices (Atkinson and Messy, 2012). Kumar et al. (2019) Further, it is asserted that financial literacy is a key determinant of financial planning. In this regard, the OECD's framework identifies three core dimensions of financial literacy: financial knowledge, financial attitude, and financial behavior (Goyal et al., 2021).

Most of the studies reviewed used the terms financial literacy and financial knowledge interchangeably. Financial knowledge influences how individuals perceive and make financial decisions, while attitudes toward money shape their orientation toward saving, spending, and investing (She et al., 2024). These attitudes, in turn, affect financial behavior, including budgeting, saving, and long-term planning. Moreover, money management has been identified as a crucial mediating factor that translates financial knowledge and attitudes into effective financial planning behavior (Mien and Thao, 2015). Alhenawi and Elkhal (2013) Investigate the relationship between financial knowledge and long-term financial planning behavior, and found that their relationship remains low.

Although recent studies highlight these interrelationships, there remains a lack of comprehensive empirical models integrating the financial literacy aspect into financial knowledge, financial attitude and behavior, and planning and managing, especially within the context of developing economies. This study addresses this gap by proposing a structural model of financial literacy. Specifically, it investigates how financial knowledge, digital finance adoption, planning, and managing finance interact to influence financial attitudes and behavior among digital lending borrowers and, ultimately, their financial well-being. The main research question guiding this study is how financial knowledge of digital financial borrowers affects the decision of digital finance adoption, and how planning and managing finance interact to influence financial attitude and behavior and ultimately enhance financial well-being in a developing country.stock markets.

1. LITERATURE REVIEW

1.1 Financial Literacy and Financial Well-being

Financial literacy is essential in individuals' capacity to make sound financial decisions (Rehman and Mia, 2024) and is increasingly recognized as a key determinant of personal financial well-being. Financial literacy refers to the aptitude and knowledge required to manage one's financial resources to enhance future well-being effectively (Wahyuni *et al.*, 2023). Potrich *et al.*(2016) financial literacy is the awareness, knowledge, skills, attitudes, and behaviors needed to make sound financial decisions and achieve personal financial well-being. It serves as a fundamental necessity to help individuals avoid financial problems and make informed financial decisions in both personal and business contexts (Rehman and Mia, 2024). Financial literacy is defined as a combination of financial knowledge, attitudes, behaviors, and confidence that enables individuals to manage their financial resources effectively (OECD, 2023). As financial markets become more complex and digital financial services continue to expand, individuals face increasingly sophisticated financial products and services. This growing complexity underscores the need for higher levels of financial literacy and proactive financial planning to achieve financial resilience, long-term financial security, and overall well-being.

Financial well-being is often conceptualized as the outcome of effective financial management and decision-making. It reflects a state where individuals can meet their current financial obligations, feel secure about their financial future, and be free to make financial choices that allow them to enjoy life. Brüggen *et al.* (2017) Defined financial well-being as the perception of having the ability to maintain current and future desired living standards and financial freedom. Moreover, Brüggen *et al.*(2017) Stated that many studies have used subjective and objective approaches to define and measure financial well-being. Objective indicators, such as income levels, debt levels, or debt-to-income ratios, while subjective measures focus on individual perceptions of their financial situation, their satisfaction with their financial status, and their perceived satisfaction with their standard of living, also include an individual or household's ability to manage and increase liquidity. Key contributors to financial well-being include financial knowledge, financial attitudes, money management, and financial planning, interlinked components that form the foundation of financial literacy. Financial behavior, alongside knowledge and attitudes, constitutes the core dimensions of financial literacy (OECD, 2023). Individuals who demonstrate positive financial behaviors, such as budgeting, saving regularly, and avoiding excessive debt, are more likely to experience higher levels of financial well-being. These behaviors are influenced by financial knowledge and underlying attitudes toward money and the ability to manage resources effectively.

1.2 Financial Knowledge

OECD (2023) emphasizes that financial knowledge is a key component of financial literacy. It involves understanding fundamental financial concepts and applying numeracy skills in financial situations (Drábeková *et al.*, 2022). Gusniarti and Pahlevi (2024) define "Financial knowledge is an understanding that a person possesses in relation to financial concepts that include financial planning, management, and decision-making". Financial knowledge enables individuals to manage their finances effectively, compare financial products and services to make informed choices, and respond to events that may impact their financial well-being. Some previous studies around the world have developed and measured the level of financial knowledge by using indicators of subjective and objective (Alhenawi and Elkhal, 2013);(Bien and Gębski, 2024);(Dewi *et al.*, 2020);(Lusardi, 2019);(OECD, 2022b);(Lee et al., 2025);(Tan et al., 2024). This study uses objective financial knowledge adopted from (OECD, 2022b) to measure basic financial knowledge and advanced financial knowledge.

1.3 Choosing and using financial products and services

Choosing and using financial products and services is part of financial literacy, which is crucial in shaping an individual's financial well-being (OECD, 2022b). Financial knowledge equips individuals to understand various financial products and services available, especially in the current context, along with the digitalization of financial services. With high individual knowledge, especially in numeracy as basic knowledge, individuals are better positioned to evaluate each product's features, benefits, and risks. The ability to make financial choices based on basic knowledge of financial concepts is, therefore, an important

life skill (Drábeková *et al.*, 2022). Financial knowledge influences an individual's ability to choose and use financial products and services effectively. It empowers individuals to make informed decisions, manage risks, avoid costly mistakes, and ultimately improve their financial well-being. Conversely, a lack of financial knowledge can lead to poor decisions, unnecessary financial strain, and missed opportunities for growth and security. Therefore, improving financial literacy is essential for successfully navigating the complex world of financial products and services. This study adopts the measurement of choosing and using financial products and services from (OECD, 2022b), Which has also been used in an empirical study conducted in China by Tan *et al.*(2024).

1.4 Planning and Managing Finance

Planning and managing finances are part of money management activities. Money management refers to an individual's ability to manage their personal financial activities, such as spending, saving, investing, and budgeting, to attain financial well-being (Atkinson and Messy, 2012). It also involves addressing issues of excessive spending, avoiding financial mistakes, and managing debt. Money management is the ability of individuals to manage financial activities to ensure financial well-being (Nawang and Shukor, 2023). Financial literacy and money management are closely tied; the better a person manages their finances, the better their level of financial literacy will be (Wahyuni *et al.*, 2023). The basics of financial management are reflected in how money is managed by individuals in daily transactions and payments, and how efforts are made to make ends meet. So, money management is an important task for an individual or household. Various aspects of money management, including credit and cash management, and saving money for future use (Mahdzan *et al.*, 2023). Referring to OECD (2022b), the measurement of planning and managing finance consists of several aspects, including budgeting, making ends meet, retirement planning, and active saving and financial shocks, which have also been used in an empirical study conducted in China by Tan *et al.* (2024).

1.5. Attitudes and Behavior

Attitudes are considered to be an important element of financial literacy, and behavior is an essential element and the most important of financial literacy (Atkinson and Messy, 2012). Individuals with a rather negative attitude toward saving for their future will probably be less inclined to engage in such behavior. The relationship between attitudes, behavior, and financial knowledge and decisions on choosing and using financial products and services is interconnected. Positive financial attitudes, fueled by financial knowledge and decisions, often lead to positive financial behaviors that support financial satisfaction and well-being. On the other hand, negative attitudes and low levels of financial knowledge can result in poor financial decisions and behaviors, contributing to financial distress. This study refers to the measurement of attitude and behavior from OECD (2022b), which has also been used in an empirical study conducted in China by Tan *et al.*(2024).

1.6 Hypothesis Development

Lyons and Kass-Hanna (2021); Hasan et al. (2021) found that financial knowledge will influence financial inclusion, as economically vulnerable populations are considerably less likely to be included in the financial systems. On the other hand, persons with higher levels of financial knowledge are more likely to be able to evaluate various financial products and services and choose the best ones that suit their financial goals. The higher financial knowledge is also believed will increase the motivation of the persons to do a better planning for their financial condition.

Individuals with greater monetary knowledge (e.g: understanding of fundamental financial concepts) are more inclined to do better at planning and managing especially in the term of personal finance. It relates to their ability to make well-informed choices about proficient financial planning habits, such as regular saving, cautious investing, and adequate retirement preparation. In the other term if the person will be able to manage both income and expenditure not only on a day-to-day basis but also planning for the future (European Union/OECD, 2022). Achieving financial well-being means that the individual should look beyond short-term considerations and take into account long-term financial needs. In particular, people with a better understanding of interest will be able to make more informed decisions regarding their investments and savings.

Previous studies suggested that financial information acquired at an early age may affect later financial behaviors as adults who exposed with personal financial education exhibit more responsible financial behaviors during their peak earnings period (35-49 years old) than adults who do not have education (Mutlu and Özer, 2022). In relation to that, there is also a notion that as the level of financial knowledge of students increases, their spending behaviors are balanced and their interest in financial matters increases (Mutlu and Özer, 2022). Financial experience and strong financial knowledge can lead to more complex financial perspectives, encouraging individuals to actively assess their financial condition and develop positive financial attitudes (Atmaningrum *et al.,* 2021). A good financial attitude is formed by a belief based on their financial knowledge. Productive age employees are individuals with learning related to very complex financial aspects, so that with this knowledge, employees are expected to be able to form a positive attitude towards finance. As this attitude is formed from the conceptualization of ideas related to the knowledge they have.

H1: Financial Knowledge affect the decision of choosing and using financial products and services

H2: The decision of choosing and using financial products and services affect the ability to plan and manage finance

H3: The decision of choosing and using financial products and services affect financial attitudes and behavior

H4: The ability to plan and manage finance affect the financial attitudes and behavior

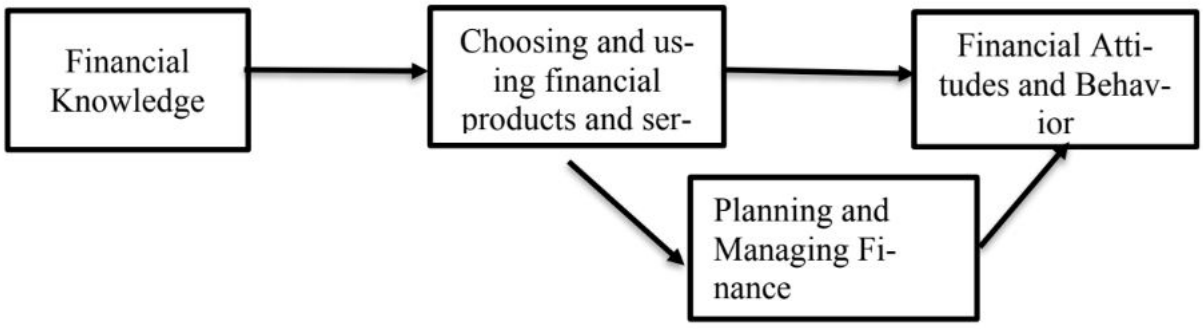

Figure 1. Conceptual Model

2. RESEARCH METHODOLOGY

This study uses a quantitative research approach to test the hypotheses of the conceptual framework of financial literacy and financial planning. The research design uses a cross-sectional study and survey method. The population for this study is digital lending borrowers who live in Java, Indonesia. Digital lending borrowers include P2P Lending, Buy Now, Pay Later (BNPL), and Online Cash Loans. The sample size was determined using (Lemeshow *et al.*, 1990)- The Lemeshow formula for sample size estimation:

$$n = \frac{(Z_{\frac{\alpha}{2}}^2 . p(1-p))}{d^2} = \frac{1.96\ X\ 0.5(1-0.5)}{0.05^2} = \frac{0.45}{0.0025} = 180 \qquad (1)$$

n= required sample size
$Z_{\alpha/2}$= critical value for a given significance level (typically 1.96 for a 95% confidence level)
P = estimated proportion of the outcome (if unknown, use 0.5 for maximum sample size estimation)
d= desired margin of error (often 0.05)

The sampling technique used is purposive sampling with screening questions: Individuals who have used online loan applications and have a loan. The questionnaire was distributed via an online survey platform called a t-survey, and 201 valid responses were collected, meeting the sample size minimum (formula 1). The questionnaire consists of several sets of questions/statements: individuals' socio-demographic characteristics, financial knowledge, Planning and managing finances, choosing and using financial products and services, Attitudes and behavior. Each set of questions includes a set of diverse questions. By answering these questions, respondents can assess the level of financial knowledge,

financial behavior, and financial attitude. Each question is evaluated on an appropriate scale. The indicators are adopted from the OECD/INFE Toolkit for Measuring Financial Literacy and Financial Inclusion 2022 (OECD, 2022b). The analytical tool used in this research is quantitative data analysis, which quantitatively estimates the direct and indirect influence of several independent variables on the dependent variable. All data were processed and tested using Partial Least Squares Structural Equation Modeling (PLS-SEM).

2.1 Results

The socio-demographic characteristics of the respondents show that the sample consists of a majority of males (66%) and the rest are female (34%). This gender distribution may influence financial behavior and literacy levels differently across genders, as various studies suggest gender-specific financial knowledge and decision-making patterns. Most respondents have completed high school (44.80%), followed by a bachelor's degree (36.80%). Education is a strong indicator of financial literacy, as higher levels of education are typically associated with better financial knowledge and behaviors. The relatively high proportion of high school graduates' background suggests that there could be a gap in financial literacy and a need for targeted financial education programs, especially for those with lower educational attainment.

The age group with the highest proportion of respondents is 25 - 34 (35.80%), followed by those aged 35-44 (29.40%). These age groups are typically at the stage of life where financial decisions, such as investments, savings, and loans, are highly influenced by career development and family responsibilities, which correlate with financial literacy levels and behavior. Most respondents are employed as staff or employees (45%) and self-employed (28.90%); the rest are retired, higher education students, professionals, and others. Employment status often correlates with financial stability and behavior, with self-employed individuals potentially facing more variability in income and a greater need for effective financial planning. On the other hand, staff and employees have more regular income streams, potentially influencing their financial literacy and decision-making. Respondents spend an average of $125 to $312 monthly.

Most respondents (73%) have used more than one type of online lending, including Buy Now, Pay Later (BNPL), Online Cash Loans, and P2P Lending. The prevalence of BNPL (60.1%) highlights a growing trend in digital finance, particularly among young and tech-savvy individuals. While this indicates a certain level of financial literacy in terms of understanding and utilizing new financial products, it also raises concerns about impulsive spending and debt accumulation, especially if users are not fully aware of the long-term financial implications of these lending options.

Tables 1, 2, and 3 show the measurement model (outer model) used to evaluate the validity and reliability. The evaluation of the outer model comprised the assessment of indicator reliability (loading factor value), composite reliability (CR), collinearity statistics (VIF), Cronbach's alpha, and average variance extracted (AVE) (see Table 1), as well as discriminant validity (Heterotrait–monotrait [HTMT] ratio and Fornell–Larcker criterion correlation (see Tables 2 And 3). On the other hand, Tables 4 to 7 show the results of the structural model (inner model), which explains the relationships between financial literacy aspects, including knowledge, decision on choosing and using digital financial products and services, planning & managing finance, and attitude & behavior.

Table 1. Validity and Reliability Test Results

Variable	Item indicator	Loading factor*	Loading factor**	VIF	Composite reliability (CR)	Average variance extracted (AVE)	*t-value*
Criteria		> 0.6	> 0.6	<0.7	> 0.7	> 0.5	> 1.960
Financial Knowledge	FK				0.739	0.588	
	AOF	0.823	0.842	1.034			8.080
	BOF	0.708	0.684	1.034			4.648
Chosing and Using Digital Financial Product and Services	DFA				0.835	0.505	
	DFA1	0.702	0.737	1.674			17.550
	DFA2	0.770	0.804	1.733			26.935
	DFA3	0.649	0.673	1.599			11.077
	DFA4	0.718	0.713	1.589			12.576
	DFA5	0.656	0.613	1.193			8.225
	DFA6	0.544*					
Financial Attitude and Behavior	FAB				0.904	0.824	
	FG	0.871	0.902	1.728			44.849
	FR	0.101*					
	MM	0.885	0.914	1.728			54.895
	PB	0.168*					
	PO	0.418*					
Planning and Managing Finance:	PMF				0.789	0.557	
	ME	0.565*					
	PK	0.671	0.690	1.224			10.571
	PP	0.705	0.707	1.203			10.128
	SB	0.751	0.834	1.220			23.218

AOF = Advanced Objective Knowledge; BOF = Basic Objective Knowledge.
Loading Factor*= First Iteration= * elimate at first iteration. Loading Factor**= Second Iteration
Source: own

Table 2 shows that each variable has a higher value than its correlation with other variables, meeting the Fornell-Larcker criterion. This means the variables in the model are distinct and do not overlap, fulfilling discriminant validity requirements. Table 3 shows that all HTMT ratio matrix values were less than 0.9 (Hair et al., 2022). Thus, all constructs in the model had good convergent consistency. This study uses the Heterotrait–Monotrait Ratio (HTMT) for a more robust discriminant validity assessment.

Table 2. Discriminant Validity: Fornell–Larcker Criterion

	Attitude and Behavior	Choosing and using digital financial products and services	Financial Knowledge	Planning and Managing Finances
Attitude and Behavior	0.908			
Choosing and using digital financial products and services	0.383	0.711		
Financial Knowledge	0.143	0.270	0.767	
Planning and Managing Finances	0.455	0.390	0.100	0.746

Source: own

Table 3. Discriminant Validity: Heterotrait–Monotrait Ratio (HTMT) Matrix

	Attitude and Behavior	Choosing and using digital financial products and services	Financial Knowledge	Planning and Managing Finances
Attitude and Behavior				
Choosing and using digital financial products and services	0.478			
Financial Knowledge	0.290	0.528		
Planning and Managing Finances	0.645	0.527	0.256	

Source: own

Table 4 presents the path coefficients of each independent variable that affected the dependent variable. This revealed that financial knowledge positively affected individuals' decisions on choosing and using digital financial products and services, then affected financial planning and management, which, in turn, affected attitude and behavior at the 5% confidence interval (CI) level.

Table 4. Significance of Path Coefficients (t-statistics)

Hypothesis	Path	Coefficient	Standard Deviation	*t-statistic*	*p-values*	Decision
1	Financial Knowledge -> Choosing and using digital financial products and services	0.270	0.064	4.231	0.000	Significant
2	Choosing and using digital financial products and services -> Attitude and Behavior	0.245	0.077	3.134	0.002	Significant
3	Choosing and using digital financial products and services -> Planning and Managing Finances	0.390	0.066	5.861	0.000	Significant
4	Planning and Managing Finances -> Attitude and Behavior	0.360	0.081	4.477	0.000	Significant

Source: own

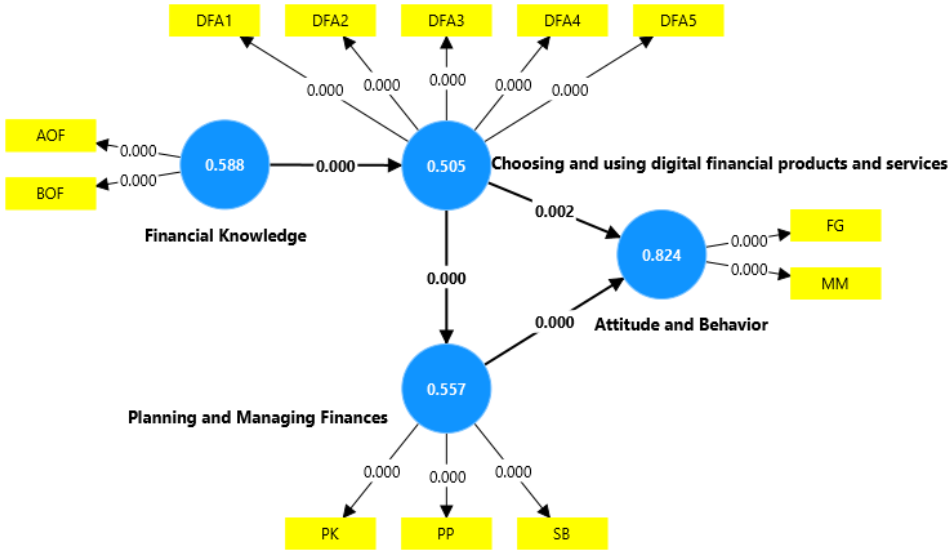

Figure 2. P-value, Average Variance Extracted (AVE)

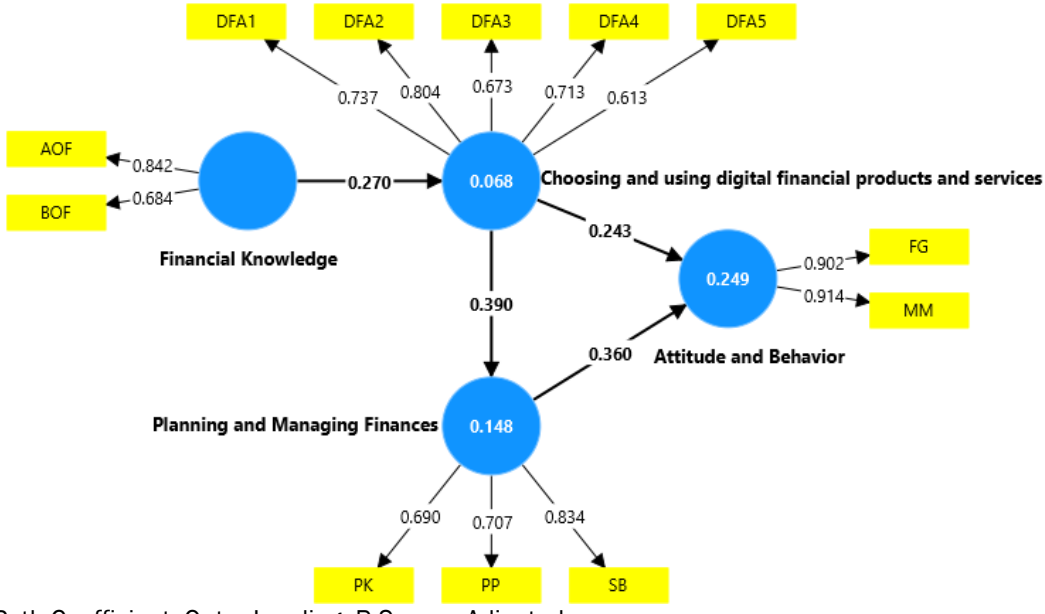

Figure 3. Path Coefficient, Outer Loading, R-Square Adjusted

Table 5 presents the coefficient of Attitude and Behavior of 0.249, which indicates that the direct contribution of Planning and Managing finance of respondents to Attitude and Behavior amounted to approximately 24.9%. The direct contribution of financial knowledge to choosing and using digital financial products and services is 6.8%, and the direct contribution of choosing and using digital financial products and services to Planning and Managing Finances is 14.8%. While the contribution in each aspect remains low, this study revealed that there is an interrelationship between financial literacy aspects: knowledge, attitude, and behavior.

Table 5. Coefficients of Determination (R2)

	R-square	R-square adjusted
Attitude and Behavior	0.257	0.249
Choosing and using digital financial products and services	0.073	0.068
Planning and Managing Finances	0.152	0.148

Source: own

Table 6 shows the model fit; the closer the Normed Fit Index (NFI) value is to 1, the better the fit (Schuberth & Rademaker, 2023). This model's NFI value of 0.487 represents an acceptable fit (Henseler et al., 2014). The standardized root means square residual (SRMR) was introduced as a goodness-of-fit measure for PLS-SEM to avoid model misspecification.

Table 6. Model fit

	Saturated model	Estimated model
SRMR	0.101	0.102
d_ULS	0.801	0.804
d_G	0.265	0.265
Chi-square	320,891	321,193
NFI	0.487	0.487

Source: own

Table 7 shows the prediction evaluation with Q2. The values for the four aspects of financial literacy are 0.015, 0.051, and 0.007. Thus, they are higher than zero, which is the cut-off value. This indicates that the model has predictive relevance.

Table 7. Prediction Model Evaluation

	Q^2predict	RMSE	MAE
Attitude and Behavior	0.015	1.004	0.789
Choosing and using digital financial products and services	0.051	0.982	0.805
Planning and Managing Finances	0.007	1.005	0.789

Note: Predictive relevance criteria: Q squared (Q^2) is more than zero (> 0); root mean square error (RMSE) is less than 1 (< 1); MAE = mean absolute error

Source: own

3. DISCUSSION

This study revealed that all hypotheses highlight a positive and significant relationship between financial literacy aspects. The results imply that borrowers with higher financial knowledge are more capable of making sound decisions on choosing and using digital financial products and services, are more motivated to have a planning and manage finance, and are motivated to have a good attitude and behavior on finance, which aligns with previous studies (Tan *et al.*, 2024).

Decision making is not a static case because it relates to stochastic behavioral factors. Someone who is rational and more confident in financial knowledge has an effect on more profitable financial behavior, such as in choosing better digital financial product and service (Wangi and Baskara, 2021). Higher financial knowledge leads to increased ability to evaluate information and to conduct more effective search, are likely to make better decisions about which service provider to choose, and are likely to form more realistic relationship expectations than less knowledgeable consumers. In addition, Hasan *et al*.(2021); Hasan *et al.*(2020) stated that the combination of financial literacy and internet usage increased the likelihood of using digital financial products and services to improve financial access.

Lyons and Kass-Hanna (2021) found that higher levels of financially literate people are more likely to be engaged in positive financial behavior and understand how to utilise money effectively and efficiently. As well as they are will be more motivated to plan and manage finance. The example of planning and managing finance such as, planning for expenditures, making a budget, using a budget to manage money

and avoiding unnecessary spending (Hasan *et al.*, 2021). Furthermore, people with higher financial knowledge or higher comprehension of monetary perceptions will be motivated to have better financial attitude and behaviour. For example, they will have better reaction and solution to their own financial troubles. As well as, having the ability to manage the cash in hand, doing a timely payment of bills, keeping the track of all payments and the planning of all future financial transactions (Banthia and Dey, 2022).

CONCLUSION

The data of respondents suggest that while many respondents are engaging with digital financial products, there is a gap in their financial literacy, particularly regarding the management of debt. The most use of BNPL, this study suggests that a high level of accessibility to credit but could also show a lack of awareness about the potential risks of accumulating debt. Financial education initiatives could be targeted to help individuals better understand the long-term implications of online lending and encourage more responsible borrowing practices. This finding indicates that the respondents demonstrate some level of engagement with modern financial tools of online lending platforms. However, their financial literacy is insufficient to make informed, long-term financial decisions. While the majority have access to financial products, there is a potential risk of poor financial behavior, especially in managing debt and understanding the implications of credit use. This highlights the need for targeted financial literacy programs to improve understanding of debt management, the responsible use of online lending options, and budgeting strategies to promote better financial well-being.

Management Implications

This study underscores the importance of fostering a knowledge that emphasizes financial risks, products and basic numeracy of mathematics to support the basic knowledge among digital lending borrowers, particularly considering the ‘‘digitalization.’’ To enhance financial knowledge, we recommend collaborative efforts between regulators, educational institutions and financial institutions to encourage people allocate more time to learning financial knowledge. This collaboration should guide people in accessing diverse channels for acquiring financial knowledge, applying it to develop a financial attitude and behavior.

Limitation

This study has several limitations that should be taken into account. First, the geographic focus of our sample within the Java district, Indonesia, may limit the generalizability of our findings. While this is the first extensive financial literacy survey conducted among digital lending borrowers, including participants from various regions, the results should be interpreted with caution when applied to other contexts. Future research should aim to include a broader demographic to enhance the generalizability of the findings. Second, the correlational research design used in this study does not establish causality. This limitation emphasizes the need for future studies to explore causal relationships, particularly how financial literacy influences individuals' abilities to identify and prevent financial fraud. Third, our participant age range was confined to 18–55 years to align with similar studies in other countries, which resulted in a sample size of 201 participants from Indonesia. This age restriction and varying sample sizes have limited our ability to explore differences across diverse educational backgrounds, which future research should consider. Despite these limitations, the results of this study provide valuable insights into how financial literacy differs across cultural and educational contexts. They underscore the need for more tailored approaches in future financial literacy research to address these nuances effectively.

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APPENDIX

Variable	Code	Indicator
Financial Knowledge	SFK	Could you tell me how you would rate your overall knowledge about financial matters compared with other adults in your country? (1=Very low; 2=Quate Low; 3=About average; 4= Quate high; 5= very high.
	BOF1	You are going to be given a gift of Rp.1 million for an achievement that you have achieved. Now, imagine that if you have to wait for one year to get the Rp.1 million, and inflation stays at 10 percent. In one year's time, will you be able to buy: a) More than I could buy today (Score 0) b) The same amount (Score 0) b) Less than I could buy today (Score 1) d) It depends on the types of things that I want to buy (Score 0)
	BOF2	You lend Rp.1 million to a friend/acquaintance one evening and he gives you Rp.1 million back the next day. How much interest has he paid on this loan? a. 0% (score 1) b. More than 0% (score 0)
	BOF3	A digital financial contract requires the signature of a paper contract to be considered valid (True = score 1/False = score 0)
	BOF4	The personal data that I share publicly online may be used to target me with personalized commercial or financial offers (True = score 1/False = score 0)
	AOF1	What do you do if you are faced with a situation where you need emergency funds? I will borrow to meet emergency fund (score 0) I will not borrow to meet emergency fund, because I have prepared for it (score 1)
	AOF2	An investment with a high return is likely to be high risk (True = score 1/False = score 0)
	AOF3	High inflation means that the cost of living is increasing rapidly (True = score 1/False = score 0)
	AOF4	It is usually possible to reduce the risk of investing in the stock market by buying a wide range of stocks and shares (True/False)
Choosing and using digital financial products and services	DFA	In the last 12 months, how often have you done the following? (1=Never; 2=Rarely ;3= Sometimes; 4=Often; 5= Always)
	DFA1	Checking bank account balances and transactions online, recharged pre-paid cards, paid bills online, bought goods and services online, and transferred money to others online.
	DFA2	Managing online Financial Products and services (Savings, Investments, Credit, Insurance)
	DFA3	Paid for goods and services in a physical shop with a mobile phone (e.g. using a mobile wallet)
	DFA4	Used a website or app that aggregates several financial accounts
	DFA5	Used an online platform for trading stocks and shares
	DFA6	Consulted an online platform for automated financial advice
Planning and managing Finances:	ME ME1	Ability to cover a large, unexpected expense independently without borrowing money or asking for help from family or friends (yes = 1/No =

Expenditure Shock and Making ends meet (ME) Budgeting (PK) Saving behavior (SB)		0)
	ME2	Having Experience of Income Not Covering Living Costs in the Past 12 Months (yes = 1/No = 0)
	ME3	Actions Taken When Income Was Insufficient to Meet Living Costs a) Reduce spending/spending (Score 1) b) Use existing resources such as: Taking money from savings or selling something you own (Score 0) c) Borrowing from existing credit (top up credit) (Score 0) d) Finding and using additional resources by working overtime, taking on additional jobs, earning extra money (Score 0) e) Applying for government assistance, Asking for help from family, friends, or the community. Accessing additional credit (Score 0)
	ME4	Financial resilience if main source of income was lost a) Six months or more (Score 1) b) least three months, but not more than six months (Score 0) c) At least one month, but not more than three months (Score 0) d) At least a week, but not more than a month (Score 0) e) Less than a week (Score 0)
	PK	Do you do any of the following for yourself or your household? (Yes = Score 1; No = Score 0)
	PK1	Making a plan to manage income and expenses:Make a plan to manage your income and expenses
	PK2	Recording Expenses:Keep a note of your spending
	PK3	Separating Money for Bills and day-to-day spending money:Keep money for bills separate from day-to-day spending money
	PK4	Making a note of upcoming bills to make sure not to miss them:Make a note of upcoming bills to make sure you don't miss them
	PK5	Using Banking Apps or Money Management Tools to keep track of Expenses :Use a banking app or money management tool to keep track of your outgoings
	PK6	Arranging Automatic Payments for Regular Expenses:Arrange automatic payments for regular outgoings
	SB	In the past 12 months have you been [personally] saving money in any of the following ways, whether or not you still have the money? (Yes = Score 1; No = Score 0)
	SB1	Saving Cash at Home or in a Wallet
	SB2	Saving Money in a Savings or a Checking Account
	SB3	Giving Money to Family for Saving on Your Behalf
	SB4	Saving in Informal Groups or Organizations (e.g., Arisan, Office/School Treasurer)
	SB5	Saving Money in Government Bonds and/or Time Deposits
	SB6	Investing in Stocks and/or Long-Term Bonds
	SB7	Saving or Investing for Retirement
	SB8	Investing in High-Risk Financial Products (e.g., Forex, Cryptocurrency)
Attitude and Behavior	MM	Monitor personal finances as strictly=I keep a close personal watch on my financial affairs (1=strongly disagree; 2=disagree;3= netral ; 4=agree; 5= strongly agree)

	FR	The financial situation limits the individual's ability to do the things that are important to them=My financial situation limits my ability to do the things that are important to me (1=strongly disagree; 2=disagree;3= netral; 4=agree; 5= strongly agree)
	FG	Setting and Striving for Long-Term Financial Goals=I set long term financial goals and strive to achieve them (1=strongly disagree; 2=disagree;3= netral; 4=agree; 5= strongly agree)
	PP	How confident are Individuals who have made a good financial plan for their retirement (Pension Plan) (1=not at all confident; 2=Unconfident;3= netral; 4=Confident; 5= Very Confident)

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The Workforce's Judgement about a full Return to the Office Mandates: a transnational data analysis

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ABSTRACT

The workforce works in different work environments at the present time, but this is in the face of the managers' desire for a full return to the office. The main objective of this study is to examine the status quo of the modern workplace from the workforce's point of view, in particular how changes have been influenced by the COVID-19 pandemic and what the post-pandemic influence has been on the modern workplace culture. To understand the figured dynamics of judgement associated with shifting to a full return to office mandates, we conducted a transnational online survey (from 9 to 22 November 2024) of Austrian, Czech and Slovak (N=1467) workforces that worked in various working environments. A descriptive statistical method was used to analyse and describe the basic features of the data. At the time of the survey, 18.61% of firms were totally remote in their operations, while 47.65% were in hybrid mode and 33.74% were in the office. Flexibility characterised the state of most firms. Only 33.33% of the respondents were very enthusiastic about returning to the office, 47.44% were moderately and 19.22% not at all interested. Seven hypotheses were set. Hypotheses H1, H2, H3 and H7 were confirmed for all factors except gender, while H4, H5 and H6 were confirmed for all factors. The RTO state is already here, and it divides people and their organisations. RTO will not solve challenges in engagement. In fact, almost 63% of respondents choose flexibility even if their office seems to be available. The RTO trend as shown in this study is facing resistance and may not be a sustainable long-term solution.

INTRODUCTION

Many businesses are facing the great conflict brought about by the worker who refuses to return to the office. This simply means organisations have a full-return mandate that is being ignored by an e-employee. In addition, the employee who is returning to the office is not the same employee as the one who left the office during COVID-19. Workforce experiences have undoubtedly changed. The pandemic revealed new ways of working (Andrulli and Gerards, 2023) and affected the workplace culture in the business (De Lucas Ancillo et al., 2020; Spicer, 2020). Beno (2021, p. 332) highlighted that "workplace culture can be seen as the general nature of business, including values, beliefs, behaviours, goals, attitudes, work rules and practices." This relates to presenteeism, rigid attendance policies and micromanagement versus flexible work structure practices, which in turn means shifting the focus from where the workforce finishes its work

duties to what the workforce achieves in the various work environments. According to Ding and Ma (2024), the return to the office (RTO) is linked to reasserting control over the workforce. The pandemic demonstrated a change in the power dynamics where employees gained a small amount of extra power. RTO mandates seem to be another way for business to regain control.

In 2022, the usual working week for people aged 20-64 in Austria averaged 36 hours, in the Czech Republic it was 39.8 hours and in Slovakia 39.6 (Eurostat, 2024a). There is a clear decrease of working from home in the surveyed countries (Eurostat, 2024b). Recent data demonstrate that 38% of respondents envision the future workplace environment as fully on-site and 53% as hybrid (Envoy, 2024). But the trend of the RTO mandate is rising. The recent KPMG 2024 CEO Outlook revealed the following expected working environment: 79% in the office and 17% hybrid in 2027 (KPMG, 2024). White-collar workers enjoyed flexible work environment possibilities (Radstand, 2023). According to Kastle barometer data for 4 March 2020 to 13 November 2024, expected occupancy rates will continue to expand (Kastle, 2024).

The main objective of this study is to examine the status quo of the modern workplace from the workforce's point of view, in particular how changes have been influenced by the COVID-19 pandemic and what the post-pandemic influence has been on the modern workplace culture. First, there is the need to develop some criteria that will help to understand the changes that have affected the workplace. Secondly, this study will contextualise the workplace situation by reference to the return to the office mandates or the flexibility mandate, which will be done while trying to explain some of the most important aspects of workplace participation.

Years after the pandemic brought about an increase of the remote workforce, many businesses are still trying to find a comfortable and appropriate working model. Businesses have had to go from empty offices overnight, to becoming used to managing and communicating with the home to starting to ask workers to return to their desks. Will we spend more time in the office in future, or less? Flexible work will continue to be an important tool. The solution lies in flexibility. In view of this, the following research questions were explored:

RQ1: How do employees perceive a model of workplace participation?
RQ2: Does post-COVID-19 impact on employees' preferred work situation?
RQ3: What factors significantly determine the decisions of employees to return to work at the company's premises?
RQ4. What factors significantly determine the decisions of employees to continue working remotely?

This paper first reviews the relevant literature. Next, the quantitative method used in this study is described. The section after that presents the findings, followed by the authors' discussion. The last part contains the conclusion.

1. LITERATURE REVIEW

The workplace is a physical (working from the office, working from home, working from anywhere) or digital premises environment (virtual work environment) where the workforce completes its duties. Opperman (2002) identifies three subtypes of workplace environment, namely the technical, human and organisational environment. Work environments carry many capital items, elements or factors that may influence both the physical and psychological well-being of the workforce (Briner, 2000). The notion of the workplace is fluid, as the pandemic demonstrated, because "digital technologies have colonized other's locations and other aspects of life" (Doursih, 2006, p. 2). Chandrasekar (2011) identified important environmental factors among 12 workforce engagement and disengagement factors.

According to Appel-Meulenbroek et al. (2022, p. 1), "the choice between office and home will not only depend on workspace preferences, but also on the type of tasks planned for the day (concentration, communication, or a mixture of both)." Flynn and Ghent (2024) demonstrate that industry-specific remote work feasibility, office rents and firm size determine the level of in-person work that firms require.

Under RTO, the authors understand the shift by businesses to encourage their workforce to return to the in-person work mandate after the boom of work flexibility due to the pandemic. Jaqua (2022) stressed that it is not about whether or not to include an e-workforce but how to structure it appropriately. Many employees strongly resist a return to the office (Gibson et al., 2023). Authors further added that rigid RTO rules feel outdated, manipulative and controlling for many employees. Ding and Ma (2024) highlight that RTO mandates after COVID-19 do not result in a notable improvement in business performance. Van Dijcke et al.'s (2024) data suggest that RTO policies can cause an exodus of the senior workforce, resulting in a possible threat to productivity, innovation and competitiveness. Flexibility seems to be a high priority for knowledge workers with negative RTO perception. Note that Barhatov et al. (2020, p. 20) observe that "flexible forms of employment offer global opportunities to the companies." During the pandemic and in the post-pandemic time, different experiences led to different perspectives of the workplace. According to Ding and Ma (2024), RTO mandates did not improve stock returns or profitability. Workforce participation needs to be associated with perceptions of actual changes in daily work practices (Nielsen and Randall, 2012).

There is, however, no previous analysis involving the authors' study intention from the workforce's point of view as shown in a transnational survey of Austrian, Czech and Slovakian workforce. This raises questions around whether a transition to RTO would negatively affect intrafirm business and personal work output and life. Despite these ongoing discussions, we have very little evidence on how changes have been influenced by the COVID-19 pandemic and what the post-pandemic influence has been on the modern workplace culture. However, to the best of the authors' knowledge, there are no studies that document the extent to which working from the office rather than from home and vice versa affect patterns of intrafirm business and personal work output and life. In order to address these unexplored issues, four research questions served as part of the method of inquiry in this study (see Introduction and Methodology).

2. METHODOLOGY

Austria, the Czech Republic and Slovakia, as the surveyed countries, provide valuable insights and data. Firstly, their economy is dominated by the service sector with e-workability options. Secondly, the countries have a long common history. Thirdly, as a group, there is a higher ratio of men working than women (OECD, 2024).

The web-based app Google Forms was used to gather data for the present study. Quantitative research explains how different items interact, and this can be done by gathering numerical data that can be further analysed using statistical methods (Creswell, 2012). Google Form is a free application which emulates an online survey system (Kim and Park, 2012, p. 2).

The authors followed Beno et al.'s (2022) methodology using an ad hoc Google Forms questionnaire to collect data in the period 9 to 22 November 2024. The form of the questionnaire was two open-ended questions and 16 close-ended questions (Likert scale: agreement, attitude, desire, importance, periodicity and quality). In addition to demographic questions, the following questions were asked: On a scale of 1-3, how excited are you about returning to work? (extremely, moderately, not at all); Which work model do you prefer: fully remote, hybrid, or in-office?; How important is flexibility to you in your work schedule? (very important, moderately important, not at all important); Do you have any concerns or reservations about returning to the office?; In the recent past have you worked in an office at all?; How flexible would you like your schedule to be?; What are your major concerns about returning to the office? (Check all that apply). Other (please specify); Which of the following will motivate you to return to the office? Please specify; On a scale of 1-3, how conducive is your current home environment to working from home in the long term? Good-Fair-Poor; If you're prepared to return to the office, will you be available to work the same hours as you did before leaving the office? I prefer to visit the office: daily, weekly, monthly, never.

The authors contacted the organisations by telephone for the initial step of gathering potential respondents. After this approval had been obtained, the next step was to send an email with an invitation to

participate in the questionnaire, with a Google Forms link. The respondents represent a broad cross-section of service sectors with a total sample of 1467, 683 female (56.6%), and 784 male (53.4%). Most respondents were married, 678 (46.2%), and 44.1% had one child; 33.3% had no children. The age of the participants ranged from approximately 22 years to 69 years. More specifically 376 were Gen Z (25.6%), 369 were Millennials (25.2%), 394 Gen X (26.9%) and 328 Boomers II (22.4%). The sample consisted of 600 (40.9%) Austrians, 410 Czechs (27.9%) and 457 Slovaks (31.2%).

After an examination and synopsis of what had been written by others, the authors developed their own research questions and hypotheses. As a consequence of linking literature reviews to research issues, the following research questions were formulated for this survey:

RQ1: How do employees perceive a model of workplace participation?
RQ2: Does post-COVID-19 impact on employees' preferred work situation?
RQ3: What factors significantly determine the decisions of employees to return to work at the company's premises?
RQ4. What factors significantly determine the decisions of employees to continue working remotely?
Testable statements provided seven hypotheses stemming from these research questions to proceed with for empirical investigation and analysis:
RQ1 led to hypotheses H1 and H2;
RQ2 led to hypotheses H3 and H4;
RQ3 led to hypothesis H5, and
RQ4 led to hypotheses H6 and H7.

A descriptive statistical method was used to analyse and describe the basic features of the data. All respondents were informed about the aims of the survey. Participation was voluntary, and anonymity was guaranteed.

3. EMPIRICAL FINDINGS

There has been a mixed reaction to the RTO movement. At the time of this survey, the operating model in 18.61% of firms was totally remote, while 47.65% operated in a hybrid mode and 33.74% were in-office. Flexibility featured in the models of most firms. Only 33.33% of the respondents were very enthusiastic about returning to the office, 47.44% were moderately interested and 19.22% not at all.

3.1 The role of personal circumstances

Workforce participation is a key component of workforce involvement in decision-making, problem-solving and more autonomy in work processes. This is a procedure that allows employees to have some control over their work and the conditions under which they work. As demonstrated in this study, many employees are still working remotely. There has been an upside-down work environment in on-site, hybrid and the fully remote models since the pandemic. In fact, almost 63% of respondents chose flexibility even if their office seems to be available.

H1: How excited employees are about returning to work is influenced by gender, age, marital status, number of children and the country where employees work.

The data show that about one-third of men and one-third of women are very excited about returning to work. Fewer than half of both men and women are slightly excited. Therefore, we do not observe any major differences between men and women. Further analysis demonstrates that 40% of employees aged 22-27 and 60-69 are very excited about returning to work, while only 21.1% of employees aged 28-43 are very excited. About half of the employees aged 28-43 and 44-59 are slightly excited. A total of 40% of employees who are single or widowed are very excited about returning to work, while only 22% of employees who live separately are very excited. Employees who live separately are somewhat excited in 58% of cases. Over 40% of childless employees are very excited about returning to work. Employees with three children are

very excited only 26.5% of the time. Employees with three children are not excited at all in more than one-third of cases. Employees who are the most enthusiastic about returning to work are in the Czech Republic. In Slovakia and Austria, about half of the respondents are mostly slightly enthusiastic.

The hypothesis was verified using Pearson's chi-square test of independence at a significance level of 0.05. According to the test results, a statistically significant effect of age, marital status, number of children and country on how much employees are looking forward to returning to work was confirmed. The P-values of the tests for these factors are lower than the chosen significance level of 0.05. The effect of gender was not proven.

According to Cramer's V coefficient, which measures the extent of the effect of a given factor, age has the greatest influence on how much employees look forward to returning to work (V=0.149), and the lowest influence, although statistically significant, is country (V=0.078).
Employees aged 22–27 and 60–69 are therefore more excited about returning to work than employees in the 28–59 age category. Employees who are single or widowed are more excited about returning to work than employees in another family relationship. Childless employees are more excited about returning to work than employees with children. Czechs are more excited about returning to work than employees in Slovakia or Austria.

H2: There is no significant difference between men and women who are hesitant or have concerns about returning to work and who are influenced by gender, age, marital status, number of children and the country where employees work.

The hypothesis was verified using Pearson's chi-square test of independence at a significance level of 0.05. According to the test results, a statistically significant influence of age, marital status, number of children and country on whether employees are hesitant or have concerns about returning to work was confirmed. The P-values of the tests are lower than the chosen significance level of 0.05 for these factors. The influence of gender was not proven.

According to Cramer's V coefficient, which measures the extent of the effect of the given factor, the greatest influence on whether employees are hesitant or have concerns about returning to work is age (V=0.165), and the lowest influence, although statistically significant, is country (V=0.106).

According to the contingency data of frequency distribution, we can therefore state that employees aged 22–27 and 60–69 are less hesitant and have fewer concerns about returning to work than employees in the age category 28–59. Employees who are single or widowed are less likely to be hesitant or have concerns about returning to work than employees in other family relationships. Childless employees are less hesitant and have fewer concerns about returning to work than employees with children. Czechs are significantly less likely to be hesitant or have concerns about returning to work than employees in Slovakia or Austria.

3.2 The role of the work situation

Generally, workplace behaviour is modelled, taught and absorbed by being in the environment. Working remotely, or in a hybrid environment, is sometimes a matter of adjusting the way you worked before, but for a whole new generation of workers it will be their first real job, so for them there is no experience to draw on.

H3: Past office work is influenced by gender, age, family status, number of children of employees and the country where they work.

The hypothesis was again verified using Pearson's chi-square test of independence at a significance level of 0.05. According to the test results, a statistically significant effect of age, marital status, number of children and country on whether employees had worked in an office in the past was confirmed. The P-

values of the tests for these factors are lower than the chosen significance level of 0.05. The effect of gender was not proven.

According to Cramer's V coefficient, the number of children has the greatest influence on whether employees have worked in an office in the past (V=0.151), and the country has the lowest influence, although it is statistically significant (V=0.101).

A significantly smaller proportion of employees aged 22–27 than older employees worked in an office every day. Older employees have recently worked in an office to a greater extent than employees aged 22–27. A significantly smaller proportion of employees who are single than employees with another marital status worked in an office every day. A significantly smaller proportion of employees without children than employees with children worked in an office every day. Employees in Austria used to work twice a week significantly more often than employees in the Czech Republic.

H4: Employees' demand for flexible working hours is influenced by gender, age, family status, number of children of employees and the country where they work.

According to Cramer's V coefficient, age has the greatest influence on employees' demands for flexible working hours (V=0.126), and the lowest influence, although statistically significant, is again the country where employees work (V=0.089).

Employees aged 28-43 years are significantly more likely to request complete flexibility than employees aged 22-27 years. Employees who are single are significantly more likely to request fixed working hours than employees who are divorced, married or living separately. Employees with one child are significantly less likely to request fixed working hours than employees with more children or no children. Employees with one child are significantly more likely to request partially flexible working hours than employees with three children. Employees in Slovakia request fixed working hours significantly less often than employees in the Czech Republic. Employees in Slovakia request partially flexible working hours significantly more often than employees in the Czech Republic.

3.3 The role of favouring the office

The data obtained show that from the employees' point of view several reasons for a full return to the office can be identified.

One significant pro-office element is the introduction of a four-day work week (21%). Interestingly, 190 workers (12.9%) see the act of commuting as a pivotal mental transition point between their private and business lives. Further, 186 (12.7%) respondents recognise the benefit of the office noise factor. It seems that the e-workforce has found that office noise can help them to focus. This effect of office noise depends on a number of individual employee factors. In a so-called "always-on culture", 10.4% (153) of employees desired more rest breaks to find a balance between being effective and having optimal well-being. A total of 90 younger workers (6.1%) in mentorship were deemed to have successfully navigated the path forward. It seems as if workplace relationships are not vital in the surveyed organisations because only 4.3% of respondents see the socialising aspect as beneficial.

H5: Motivation to return to the office is influenced by gender, age, family status, number of children of employees and the country where they work.

According to Cramer's V coefficient, the number of children has the greatest influence on the motivation of employees to return to the office (V=0.222), and the lowest influence, although statistically significant, is again the country (V=0.078) where employees work.

Men see motivation significantly more often in commuter benefits than women do. Women see it significantly more often in hybrid world incentives. Employees aged 60-69 see motivation to return to the office significantly more often in having secured child/elderly care than employees aged 22-27 do.

Employees aged 22-27 see motivation to return to the office significantly more often in team collaboration than older employees do. Employees who are single see motivation to return to the office significantly less often in having secured child/elderly care than other employees do. Employees who are single or live separately see motivation significantly more often in commuter benefits than other employees do. Childless employees see motivation significantly less often in having secured child/elderly care and significantly more often in commuter benefits than employees with children do. Employees aged 60-69 see motivation to return to the office significantly less often in hybrid world incentives than younger employees do. Czechs see motivation to return to the office significantly less often in commuter benefits than employees in Slovakia and Austria do.

3.4 The role of favouring remote work

The workforce in this study favours the continuation of e-work with a re-evaluation of work and its role. A total of 426 respondents (29%) mentioned the absence of co-workers as a pro-remote element. Further analysis demonstrates that rigidity with strict requirements around which days to be present (378 respondents, 25.8%) increases demand to work remotely. Moreover, microaggression is extremely common in the workplaces of 287 employees (19.6%) in this study. According to this data, 231 workers (15.7%) mentioned that toxic work culture can wreak havoc.

H6: The friendliness of the home environment for work is influenced by gender, age, family status, number of children of employees and the country where they work.

According to Cramer's V coefficient, the greatest influence on the feeling of the home environment being favourable for work is age (V=0.215), and the lowest influence, although statistically significant, is again the country where employees work (V=0.092).

Men perceive the home environment as being favourable significantly more often than women do. Employees aged 60–69 perceive the home environment as being unfavourable significantly more often than younger employees do. Widowed employees perceive the home environment as being favourable significantly less often. Employees with three children perceive the home environment as being favourable for work significantly less often than employees with one child do. Czechs perceive the home environment as being favourable for work significantly less often than employees in Slovakia or Austria do.

H7: The same working hours after returning to the office as before are influenced by gender, age, family status, number of children of employees and the countries where they work.

According to the results of Pearson's chi-square tests, a statistically significant effect of age, marital status, number of children and country on the same working hours as before leaving the office was confirmed. The P-values of the tests are lower than the chosen significance level of 0.05 for all factors. The effect of gender was not confirmed.

According to Cramer's V coefficient, age has the greatest influence on the same working hours as when leaving the office (V=0.192), and the lowest influence is again the country where the employees work (V=0.115).

Employees aged 22-27 and 60-69 want to have the same working hours as before leaving the office significantly more often than employees aged 28-59 do. Employees who are single or widowed want to have the same working hours as before leaving the office significantly more often than employees who are married or living separately do. Employees with three children want to have the same working hours significantly less often than employees with fewer children or without children do. Employees in the Czech Republic want to have the same working hours as before leaving the office significantly more often than employees in Slovakia and Austria do.

4. DISCUSSION

RTO is already here and it divides people and their organisations. RTO will not solve challenges in engagement. In fact, almost 63% of respondents chose flexibility even if their office seems to be available. This confirms similar findings of a recent study which indicates increased localisation flexibility in addition to time flexibility (Krajčík et al., 2023). As stated by Chomatowska and Janiak-Rejno (2022, p. 651), "while young employees are open to flexible solutions in work organization, research has shown that it is difficult to define their unequivocal preferences in this regard." However, based on our data, employees aged 22-27 and 60-69 are more excited and have less hesitation or concern about returning to work than employees in the 28-59 age category do.

Older employees have recently worked in an office to a greater extent than employees aged 22-27 have. This means that as a parent worker demands flexible boundaries to attend to family responsibilities, non-parent workers desire shields to maintain boundaries around their private life (Kangas et al., 2023). Further analysis demonstrates that employees aged 28-43 years are significantly more likely to request complete flexibility than employees aged 22-27 years are. Employees who are single are significantly more likely to request fixed working hours than employees who are divorced, married or living separately are. This is similar to the situation in the IPSOS survey data (2021), where the workforce tends to have positive perceptions about e-work and desires more flexibility.

One significant pro-office element is the introduction of a four-day work week (21%). This is similar to Beno et al.'s (2022) study which demonstrates the greater preference for a shorter work week. The better the office environment, the higher the perceived work efficiency and the lower the amount of loss due to presenteeism (Arata et al., 2023). In this study, interestingly, 190 workers (12.9%) see the act of commuting as a pivotal mental transition point between their private and business lives. The so-called "pseudo commute" (an imaginary commute) can help to re-establish the work-home boundaries (Beňo, 2023). Furthermore, 186 (12.7%) respondents recognise the benefit of the office noise factor. In the past, 99% of respondents revealed that their concentration was impaired by various components of office noise (Banburry and Berry, 2024). In a so-called "always-on culture", 10.4% (153) of employees desired more rest breaks to find a balance between being effective and having optimal well-being. This is because being always-on seems to be a double-edged sword (The Myers-Briggs Company, 2019). A total of 90 younger workers (6.1%) in mentorship were deemed to have successfully navigated the path forward. As confirmed by Pietroń-Pyszczek and Borowska (2022, p. 54), "representatives of Generation Z should be targeted for mentoring support in the context of pursuing their careers." The individual's adjustment to the new environment may have unwanted consequences in the form of stress reactions (Glass et al., 1969). But the data obtained demonstrated that men see motivation significantly more often in commuter benefits than women do. Results show that opportunities for commuter parking and transit benefits not only increase the probability of workers using the subsidised travel mode to commute but also affects workers' non-commuting trips as well as their household members' travel behaviour (Shin, 2020). Women see this significantly more often in hybrid world incentives than men do. Employees aged 60-69 see motivation to return to the office significantly more often in having secured child/elderly care than employees aged 22-27 do. Employees aged 22-27 see motivation to return to the office significantly more often in team collaboration than older employees do. DiFonzo and Bordia (1998) highlight that during organisational change related facts provide a reason for change initiative which is interlinked with the possible reduction of negative outcomes of this change by the workforce.

A total of 426 respondents (29%) mentioned the absence of co-workers as a pro-remote element. Other findings even demonstrate higher percentages of workers missing being with their co-workers (IPSOS, 2021). Employees in their twenties who often need mentorship and those over forty who often provide mentorship are more likely to return to the office (Emanuel et al., 2023), which is comparable with the data gained showing that employees aged 22-27 and 60-69 wand to have the same working hours as before. Further analysis demonstrates that rigidity with strict requirements about which days to be present (378 respondents, 25.8%) increases the demand to work remotely. This is equivalent to the present findings that workspace flexibility and operational flexibility have significant positive relationships with employee engagement (Lee et al., 2024). Moreover, microaggression is extremely common in the workplaces of 287

employees (19.6%) in this study. According to the data, 231 workers (15.7%) mentioned that toxic work culture can wreak havoc. Hassan et al. (2012) revealed the positive effect of trust-building interpersonal relationships. Men perceive the home environment as being favourable significantly more often than women do. Employees aged 60-69 perceive the home environment as being unfavourable significantly more often than younger employees do. This is contrary to a recent study that RTO policies can lead to an outflow of senior employees (Van Dijcke et al., 2024).

Generally, Czechs are significantly less likely to be hesitant or have concerns about returning to work than employees in Slovakia or Austria are. Employees in Slovakia request partially flexible working hours significantly more often than employees in the Czech Republic do. Czechs perceive the home environment as being favourable for work significantly less often than employees in Slovakia or Austria do. Interestingly, a recent study shows that workers who are ready to accept a four-day work week are most frequent in Austria, followed by the Czech Republic and Slovakia (Beno et al., 2022).
The data in this study indicate that "a return to the office should not be a tug-of-war between leaders and employees" (Brodersen, 2024, p. 100).

CONCLUSION

The tendency to move back to the office raises discussion globally. The opportunity to RTO is not an all-or-nothing situation. RTO and the e-working strategy require a clear understanding of how a business structure both the flexibility and office mandates and what works best for employees. This is because the workforce is reluctant to move back to the office without flexibility, but at the same time businesses need employees to commit to office work.

The following research questions were explored:

RQ1: How do employees perceive a model of workplace participation?

The concept of workplace participation can be construed differently by employees. According to the test results, a statistically significant effect of age, marital status, number of children and country on how much employees are looking forward to returning to work was confirmed as having the greatest influence on how much employees look forward to returning to work (V=0.149), and the lowest influence, although statistically significant, is country (V=0.078).
According to the test results, a statistically significant influence of age, marital status, number of children and country on whether employees are hesitant or have concerns about returning to work was confirmed. The greatest influence on whether employees are hesitant or have concerns about returning to work is age (V=0.165), and the lowest influence, although statistically significant, is country (V=0.106).

RQ2: Does post-COVID-19 impact on employees' preferred work situation?

According to the test results, a statistically significant effect of age, marital status, number of children and country on whether employees had worked in an office in the past was confirmed. The P-values of the tests for these factors are lower than the chosen significance level of 0.05. The effect of gender was not proven. The number of children has the greatest influence on whether employees have worked in an office in the past (V=0.151), and the country has the lowest influence, although it is statistically significant (V=0.101).
Age has the greatest influence on employees' demands for flexible working hours (V=0.126), and the lowest influence, although statistically significant, is again the country where employees work (V=0.089).

RQ3: What factors significantly determine the decisions of employees to return to work at the company's premises?

One significant pro-office element is the introduction of a four-day work week (21%). Interestingly, 190 workers (12.9%) see the act of commuting as a pivotal mental transition point between their private and business lives. Further, 186 (12.7%) respondents recognise the benefit of the office noise factor. It seems that the e-workforce has found that office noise can help them to focus. This effect of office noise depends

on a number of individual employee factors. In a so-called “always-on culture”, 10.4% (153) employees desired more rest breaks to find a balance between being effective and having optimal well-being. A total of 90 younger workers (6.1%) in mentorship were deemed to have successfully navigated the path forward. It seems as if workplace relationships are not vital in the surveyed organisations because only 4.3% of respondents see the socialising aspect as beneficial.

The number of children has the greatest influence on the motivation of employees to return to the office (V=0.222), and the lowest influence, although statistically significant, is again the country (V=0.078) where employees work.

RQ4. What factors significantly determine the decisions of employees to continue working remotely?

A total of 426 respondents (29%) mentioned the absence of co-workers as a pro-remote element. Further analysis demonstrates that rigidity with strict requirements around which days to be present (378 respondents, 25.8%) increases demand to work remotely. Moreover, microaggression is extremely common in the workplaces of 287 employees (19.6%) in this study. According to this data, 231 workers (15.7%) mentioned that toxic work culture can wreak havoc.

The greatest influence on the feeling of the home environment being favourable for work is age (V=0.215), and the lowest influence, although statistically significant, is again the country where employees work (V=0.092).

According to the results of Pearson's chi-square tests, a statistically significant effect of age, marital status, number of children and country on the same working hours as before leaving the office was confirmed. The P-values of the tests are lower than the chosen significance level of 0.05 for all factors. The effect of gender was not confirmed. Age has the greatest influence on the same working hours as when leaving the office (V=0.192), and the lowest influence is again the country where the employees work (V=0.115).

H1, H2, H3 and H7 were confirmed for all factors except gender. H4, H5 and H6 were confirmed for all factors.

This survey captures attitudes at a certain point in time. The findings in this study should be considered more as a recapitulation than a definitive description.

Some limitations are associated with this study. The first is the sampling size for saturation, which is the result of the authors’ limitation on account of the novelty and trend of the RTO topic. Furthermore, since Google Forms is a web-based app in English it could represent a limitation to a certain extent because of the respondents not fully understanding the questions. Another limitation is the geographical scope of the study. Restricting the study to only Austria, the Czech Republic and Slovakia inevitably places some limitations on the results. Corporate organisational culture is different from country to country and nation to nation. Integrating quantitative and qualitative studies from more countries will provide more generalisable results.

Working remotely and the RTO move have been driven both by employers and employees. The question remains: “Home office, hybrid or office?” However, in line with the above discussion, future studies should investigate more closely the e-workforce preferences and reasons for leaving the organisation when RTO policies are instituted. Longitudinal studies can be conducted to track the outcomes over extended periods. Additionally, it is necessary to understand the impact fully and to determine if RTO and e-work policies are sustainable.

In conclusion, the findings of this study should be of practical benefit to organisations that are considering the values and needs of their own employees in order to encourage and retain them without forcing them to return to the office. The key message remains that e-work is here to stay. There is an alchemy

associated with being present in person that has not been replicated virtually yet, but there is also an alchemy in e-working, which has crystallised in the home and in other premises. To lure these workers back to the office, businesses will have to learn how to provide an in-office working space that the e-worker finds attractive.

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The Moderating Effect of Investor Trust on the Relationship between Disclosure of Environmental, Social, and Governance Practices and Sustainable Investment

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Investors' Trust

ABSTRACT

Sustainability issues globally have gained importance due to more objective and impartial sustainability reports, and investors' confidence in corporate reporting increases as they form opinions about their investments. The study aims to examine The Moderating Effect of Investor Trust on the Relationship between the Disclosure of Environmental, Social, and Governance (ESG) Practices and Sustainable Investment. A questionnaire survey of respondents from companies listed on the ASE in the Jordanian market was used to gather primary data. 169 of the respondents in the sample were deemed suitable for statistical examination. The study employed partial least squares structural equation modeling for data analysis and hypothesis testing. The findings show that disclosure of Environmental, Social, and Governance (ESG) practices positively affects sustainable investment (SI). Nonetheless, while investor trust (IT) directly influences firm value, it significantly moderates the relationship between environmental, social, and governance (ESG) disclosure and corporate sustainable investment (SI). The results provide credence to the notion that IT positively impacts corporate SI through the disclosure of ESG practices in sustainability reports. These indices are particularly relevant to emerging markets, where they can serve as a reference for company initiatives aimed at sustainability, attracting investors, and improving performance.

INTRODUCTION

In the global financial environment, sustainability reporting has gained more significance as investors look for detailed information that goes beyond financial considerations in order for stakeholders to have the chance to ascertain whether the business has considered their interests in decision-making through this procedure (Ul Abideen and Fuling, 2024). As a result, businesses are increasingly being directed by

the concept of sustainable development, which pushes them to align their operations with the triple bottom line, sometimes known as the 3Ps: "profit, people, and planet" (Ul Abideen and Fuling, 2024) as the can social and environmental issues have the potential to undermine investor confidence and reduce company value, highlighting the urgent need for "corporate governance and sustainability reporting" (Suhartini et al., 2024). Extended external reporting engagements should serve the public interest by boosting user confidence in sustainability reports and in the credibility of extended external reporting, Grabowski explained, so that the users can trust and depend on it (Krasodomska et al., 2021). So, investors' growing interest and knowledge of ESG factors highlight how crucial sustainability is becoming to the investment landscape (Foley et al., 2024).

In today's business climate, an organization's dedication to "sustainability, environmental preservation, and social responsibility" is vitally reflected in ESG reports (Liu et al., 2024). So, ESG reports have emerged as a crucial element of the investing and business markets (Liu et al., 2024). Investors have become interested in ESG performance and want companies to be more accountable and transparent about their ESG policies (Grazia et al., 2022). Sustainability reporting encompasses more resources than financial accounting when it comes to the disclosures that are provided (Barker, 2024). Therefore, sustainability was defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" by the (UN's Brundtland Commission, 1987) (Barker, 2024). That is, businesses can better satisfy stakeholder interests by implementing sustainability measures (Lee et al., 2013).

Globally, in an effort to improve investors' ability to make informed investment decisions, the U.S. Securities and Exchange Commission has increased its efforts to guarantee that investors have access to comprehensive, trustworthy, and comparable climate-related information in business filings (Liu et al., 2024). On the other hand, for businesses with ESG investors, the benefits of ESG disclosure on financial performance are more noticeable (Chen and Xie, 2022). ESG investors also have a moderating effect that is good; ESG disclosure's impact on financial performance increases with the market value or shareholding ratio of ESG investors (Chen and Xie, 2022). Also, many nations have made sustainability disclosure compulsory in the past few years. The European Union (EU) is leading this shift by enacting laws governing how businesses disclose their sustainability (Hummel and Jobst, 2024). Also, on the level of Asia markets, trust in how businesses report their sustainability performance has risen to a record 51%, according to research conducted across 27 markets in 2020, with notable country-by-country variances. Asia had the most positive perceptions, with "Thailand (79%) having the highest levels of agreement, Vietnam (80%), and Indonesia (81%)" (Rowland and Whittles, 2020).

On the Jordanian level, the economic climate of Jordan is regarded as one of the most alluring in the Middle East for foreign investments, despite this lack of resources (Azzam et al., 2020). Also, Jordan's capital market, which has been around since 1930, is the second-largest in the Middle East and North Africa (MENA) area in terms of market value (Albawwat, 2022). In fact, according to data released by the ASE, the market capitalization of foreign-owned equities was roughly 46% in 2017, 50% in 2018, and 49% in 2019. What's more intriguing is that those investors come from 94 different countries, indicating that foreign investors are not just from Arab nations (Azzam et al., 2020). This means that the study is considered one of the most important studies that should be given space at the level of the Middle East, specifically Jordan. Interestingly, Jordan has recently responded to the interest of local and international investors and investment funds in disclosing sustainability across its three pillars: environment, social responsibility, and governance. In early 2025, the Amman Stock Exchange and the World Bank, through the International Finance Corporation (IFC), launched a regulatory framework for climate disclosure, which includes a framework for environmental, social, and corporate governance (ESG) disclosure. Disclosure of this information will be voluntary in its initial stages (Amman Stock Exchange, 2025).

On the other hand, MENA enterprises have demonstrated a low level of environmental disclosure (Akrout and Ben Othman, 2016), which makes it challenging for businesses to attain better ESG performance, where there are numerous uncertainties and obstacles (Bin-Feng et al., 2024). Also, ESG principles are hard to integrate into business processes due to "low data quality, a lack of standards, and economic constraints" (Leaders International, 2024), cited in (Al Frijat and Elamer, 2024). Moreover, due to the decline in trust in ESG reports, ESG variables have been challenging to incorporate into investment strategies

in recent years (Foley et al., 2024). Due to investor misconceptions that sustainable investing restricts options and puts important financial goals at risk (Foley et al., 2024). So, investor trust in many businesses and banks, particularly international ones, has been severely damaged as a result of the scandal involving Barclays "Bank's manipulation of the London Interbank Offered Rate (LIBOR), HSBC Bank's shortcomings in preventing money laundering, and most recently, the failure of Silicon Valley Bank and Credit Suisse Bank" (Abdelsalamet al., 2024). Thus, investors are becoming increasingly concerned with the need for improved information and the caliber of reporting of both financial and non-financial data. So, they emphasize the need for better information and quality in financial and non-financial information reporting (Krasodomska et al., 2021). So, Eastman, the "Director of Global Investor Engagement at PwC', started up by pointing out that investor interest in ESG information" has grown during the course of her six years of working with the Investment Community (Krasodomska et al., 2021).

Thus, this paper aims to close the gap in the literature by testing trust as a moderating variable in the relationship between ESG disclosure and achieving sustainable investment for companies. Therefore, this study adds several contributions: first, it offers a thorough explanation of the significance of corporate reporting, especially in view of the cultural misperception of sustainability reporting that businesses in developing nations face; second, it offers a prompt and initial evaluation of how businesses view the strategic measures of the significance of these disclosures. Lastly, no study has examined the significance of trust as a moderating variable in the relationship between sustainability reporting and attaining sustainable investment in Jordan, despite the growing interest in developed nations in corporate sustainability reporting and financial performance research.

1. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Over the last two decades, ESG has become a key ethical concept in contemporary economies (Shen et al., 2023). A key element in influencing investor opinions and a company's reputation are sustainability reporting (Ul Abideen & Fuling, 2024). According to Kummer and Lawless (2022), the ESG movement is at a turning point in its history, with investor interest reaching all-time highs, in part because of the expectations of a new generation of investors. So, ESG performance reporting, as measured by a set of globally comparable criteria, should be made mandatory, according to the overwhelming majority of investors (89%) polled worldwide (Kummer and Lawless, 2022). So, businesses using an ESG strategy to boost investor loyalty and boost financial performance may find value (Bukreeva and Grishunin, 2022).

As a literature review about ESG Disclosure and sustainable investment, ESG is an ensemble of standards intended to evaluate sustainability and its social effect on a business (Nathan, 2024). So, the two main investor groups that the sustainability information ecosystem aims to serve are people who are interested in financial risk or who are looking for relevant data about how sustainability-related aspects affect a company's bottom line (Kummer and Lawless, 2022). Investors can identify businesses that are more sustainable and better positioned for long-term success with the aid of ESG. ESG also assists investors in avoiding possible financial hazards associated with subpar social or environmental standards (Nathan, 2024). Therefore, companies must continue to offer goods, services, and other financial advantages as one of the three demands placed on the corporate sector by sustainability (Barker, 2024). This, in turn, necessitates that they be appealing to investors. Therefore, a company's "financial viability and profitability" are a prerequisite for reaching sustainability objectives (Barker, 2024). This is because Investors play a critical role in achieving sustainable development goals by ensuring that funds are generated and utilized appropriately (Principles for Responsible Investment 2017) cited in (Yadav et al., 2024; p.1).

Moreover, sustainability considerations are becoming more important to investors when making investment decisions (Bondar et al., 2024). Due to its significance to businesses, the emphasis is currently on the possible outcomes for financial investors' returns and risks (McNeil and Esser, 2002). So, more transparency through thorough and audited sustainability reports can boost investor confidence and draw in sustainable investments (Rose, 2024). According to Yadav et al. (2024), environmental, social, and governance (ESG) considerations are increasingly being used to evaluate an organization's long-term performance, attract investment, and guide business decisions toward sustainable growth. Additionally, Al Frijat et al. (2025) noted that focusing on sustainability measures enhances a company's sales growth, investments, and profitability. As well data indicates that businesses that implement thorough ESG

reporting get a 20% rise in investor trust (Rose, 2024). Therefore, it is reasonable to infer that investors' interests are generally in line with those of society at large (Barker, 2024). This is because it gives the information that would be used to fulfill the sustainability needs of all stakeholders (in light of investors' financial self-interest) (Barker, 2024). Also, Abdi et al. (2022) investigate how ESG scores affect a company's value and financial performance. It found that a company's market-to-book ratio improves when it contributes to governance activities. It also discovered that a company's involvement in environmental and social initiatives is favorably and significantly correlated with increased financial efficiency (Abdi et al., 2022).

Additionally, previous research indicates that developing strategic policies is a necessary step in luring successful investment (Shen et al., 2025). Consequently, in the face of fierce market competition, how to successfully draw in investments is a global concern (Shen et al., 2025). Given the size of the corporate sector in the majority of economies, it is inevitable that the corporation's economic prospects will be influenced by the overall economy as a whole (Barker, 2024). Therefore, ESG is the most important topic for company management to handle (Lee 2023) since investors are worried about the reliability and accuracy of accessible information on companies' ESG scores (Friede 2019).

Furthermore, Gillan et al. (2021), ESG activities have the potential to generate value in two ways: first, by increasing shareholder value through increased cash flow levels, and second, by optimizing the utility that shareholders derive from owning shares of a sustainable company. In addition, Boffo and Patalano (2020) indicate that the rise in ESG investments may be ascribed to investors' inclination for investments that provide not only financial gains but also favorable social and environmental effects. In the other study, compared to 20 per cent five years prior, 83 per cent of investors polled in the Bondar et al. 2024 study included sustainability information in their fundamental analysis, and 79 per cent of respondents had sustainability policies in place. Also, investors identify major obstacles to data clarity, consistency, and dependability, despite the increased need for sustainability information (Bondar et al., 2024).

A lack of trust between business owners and their agents can lead to an imbalance of information, which can cause some shareholders to assess a company's performance incorrectly (Riedl and Smeets, 2017, Xie et al., 2019). Also, businesses have a lot of chances to draw in investment funds from ecological and socially responsible investors through SR, which boosts stakeholder trust in businesses (Van Linh et al., 2022). Therefore, the more disclosures businesses make about sustainability issues, the more cues they send to stakeholders—particularly investors—that they are committed to being fully transparent about all sustainable issues. This makes businesses an appealing investment front for all investors.

The foundation of voluntary disclosure is the idea that improved sustainability performance offers businesses financial "e.g., lower future costs, easier access to resources" (Bendig et al., 2023). That means, businesses' performance on sustainability—that is, their capacity to sustain a certain level of financial resources over time without adversely impacting the environment or society—is of great interest to investors (Falconer and Saint-Martin, 2022). Therefore, depending on the levels of voluntary disclosure, stakeholders may be tempted to give some companies a higher rating and others a worse rating (Azzam et al., 2020). According to Chiu and Wang (2015), Sustainability disclosure reports can be utilized as a communication method to win over interest groups. Consequently, sustainability reports provide a chance to demonstrate an organization's strong financial performance, enhancing its reputation among its stakeholders (López-Santamaría et al., 2021). Also, ESG practices can improve quality control, increase resource productivity, reduce energy usage, and create greater prospects for new goods and markets (Bin-Feng et al., 2024). Additionally, its performance might increase operational effectiveness (Feng et al., 2022). Additionally, Abdi et al. (2022), investors, especially those who are interested in green investments, value comprehensive disclosure since it shows a dedication to sustainability, which could result in reduced risks and increased security for their capital.

As a literature review about the Moderating Role of Investors Trust, IFRS defines investors (shareholders and debtholders) as the "primary users" of financial reports, for whom "information is material if omitting, misstating, or obscuring it could reasonably be expected to influence investor decisions" (IFRS, 2024) (Barker, 2024). Therefore, A key component of treating stakeholders morally in the relationship between the organization and its stakeholders is trust (Greenwood and Van Buren III, 2010). According to Greenwood and Van Buren III (2010), stakeholders have faith that the organization will provide benefits or

safeguards against damage that are proportionate to their investments or stakes. That is, their participation in taking into account their interests, concerns, and needs is one of the forms of trust between the company and stakeholders. According to La Porta et al. (1997) and Long and Weibel (2018), trust not only creates and maintains societal standards but also encourages managers and businesses to act morally and ethically, which affects how they deal with stakeholders (Abdelsalam et al., 2024). According to this theory, the relationship between stakeholders must be strong, participatory, and continuous in setting and drawing real goals that serve both parties, whether the company or investors, through transparency and credibility of the information that must be included in the sustainability reports of companies so that the investor can benefit from it in his investment decisions and the company can benefit from it in improving its investment efficiency alike. So, stakeholders must trust the organization to execute its responsibilities in line with "Phillips' fairness principle (Business Ethics Quarterly 7(1), 1997, 51–66)", (Greenwood and Van Buren III, 2010).

In general, trust leads to positive results that satisfy both parties, whether the company or investor. In order to guarantee long-term stakeholder advantages, Soc suggested that the company make use of all available resources to foster loyalty and trust (Abdi et al., 2022). According to Narula et al. (2024), investors are drawn to companies that generate a profit; for this reason, the main goal of ESG investing is to raise market returns or valuation. Also, Trust increases the efficiency of investments (Fonseka et al., 2021). Also, finding innovative instruments for the operations of businesses is essential in the current environment, which is marked by mistrust regarding business contributions to sustainable development (Pizzi et al., 2024). So, the concept of trust has been thoroughly investigated by numerous social science disciplines, such as "political science, social psychology, and economics" (Lewicki and Tomlinson, 2003). Rousseau et al. (1998) show the definition of trust: "Trust is a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another".

To enhance investor trust in financial reporting (Shbeilat, 2024). Also, in order for users to have greater confidence in sustainability reporting, Peter Paul van de Weijs stated that if we are to maintain momentum and make further progress, we must require comprehensive, comparable, and reliable reporting using internationally recognized standards, such as those provided by the "Global Reporting Initiative" (Rowland and Whittles, 2020). Also, behavior that occurs when two parties (individuals or organizations) have access to disparate information can be described using signalling theory (Connelly et al., 2010). Usually, the sender has to decide whether and how to convey (or signal) that information, and the recipient has to decide how to evaluate the signal (Connelly et al., 2010). That means trust is based on mutually satisfactory standards of behavior (Sako and Helper, 1998). So, the market is given a variety of signals in the context of sustainability, including "corporate disclosures, trust marks, sustainability performance, and sustainability programs" (Zerbini, 2017). This explains or suggests that sustainability reports are more trusted by stakeholders and have higher quality reporting when they are independently and externally assured (Cohen and Simnett, 2015).

According to Abdelsalam et al. (2024), the study's findings on 45 banks demonstrate that social trust has a particularly significant risk-reducing effect on banks with headquarters located in countries with less investor protection. Also, the findings, trust reduces bank risk by acting as a substitute for formal institutions that are unsuccessful as a governance tool. These results have significant benefits for global financial regulation (Abdelsalamet al., 2024). Therefore, because intentions come before actions (Zeithaml et al., 2002), the theory of reasoned action can explain why an investor would want to make repeated investments, which builds trust. So, Angel investors who actively look for possibilities demonstrate "investor alertness," a state of heightened awareness of profitable agreements that are likely to optimize returns on cash and other resources (Maula et al., 2005). Prospective investors are more willing to invest in new companies when they are vigilant (Wong and Ho, 2007). Thus, the quality of sustainability reporting, therefore, influences the investor's behavior on investment, as explained by the theory of reasoned action framework.

Additionally, concentration on corporate market risk is crucial because a lack of trust deters investors from buying or holding onto a company's shares (Abdelsalam et al., 2024). So, companies looking to stay on top of the competition, increase their market value, and obtain access to finance must strategically cultivate trust with investors (Bondar et al., 2024). Thus, as the capital markets reach a turning point fueled by the shift to a world that is more sustainable, business executives have a strategic chance to improve their connection with investors (Bondar et al., 2024). Meqdadi et al. (2017) provide distinctive and

comprehensive insights into the role of power and trust in spreading sustainability as a change process that impacts various supply network actors. Findings indicate that trust has a big influence on how involved actors are in sustainability projects and how widely they are used in supply networks (Meqdadi et al., 2017).

The study aims to examine The Moderating Effect of Investor Trust on the Relationship between the Disclosure of Environmental, Social, and Governance Practices and Sustainable Investment. So, the trust that stakeholders have in the company's ability to disclose all relevant information—whether it be environmental, social, or governance—is essential to the presentation of sustainability reports. However, if the sustainability reports contain any misleading information, they may deter stakeholders—investors in particular—from funding these businesses, hinder the effectiveness of attracting investments, and increase risks. That means investors and other stakeholders are more likely to want to invest in these businesses when there is greater trust in sustainability reports. So, it's important to remember that investors' decisions to invest in these companies are influenced more by high-quality sustainability reports, which support corporate investment efficiency and improve performance. Therefore, Figure 1 shows the conceptual model for the investigation. To understand this link better, the following hypotheses were tested:

Hypothesis 1: A positive relationship exists between environmental, social, and governance (ESG) practice disclosure and sustainable investment (SI).

Hypothesis 2: A positive relationship exists between Investor Trust (IT) and sustainable investment (SI).

Hypothesis 3: Investor Trust (IT) moderates the link between environmental, social, and governance (ESG) practice disclosure and sustainable investment (SI).

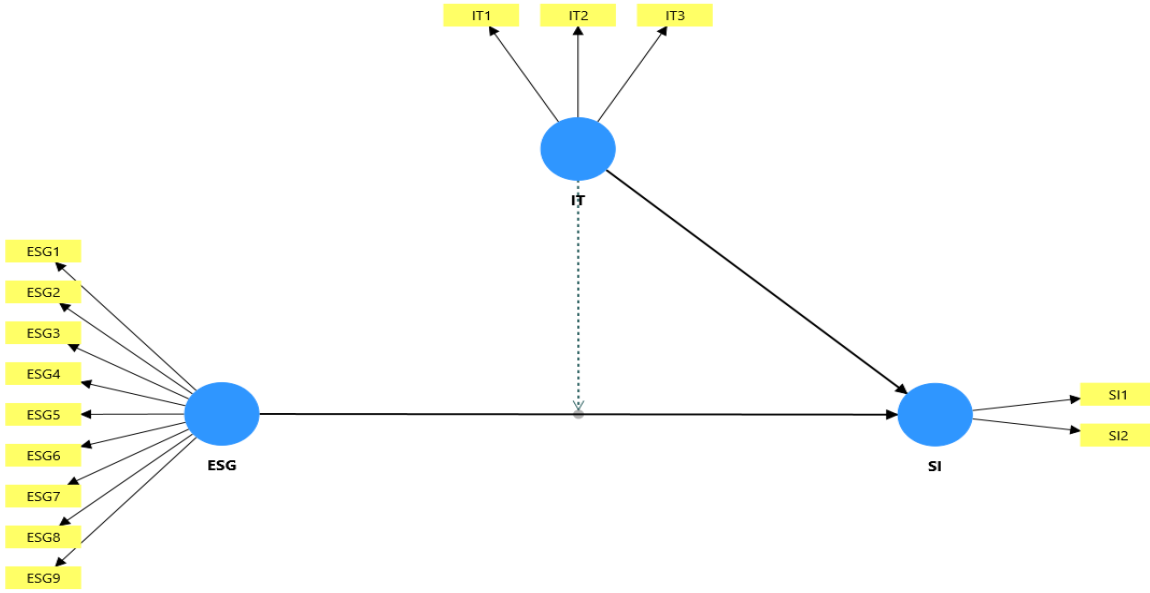

Figure 1. Research model

2. METHODOLOGY

2.1 Sample and Data Collection

As a study society, ASE lists a number of sectors, including banking, insurance, industry, and services. Since 56 industry businesses, 16 banking, 22 insurance, and 140 services companies make up the study population, there are 234 companies listed on the ASE. 39% of businesses are large, 38% are medium-sized, and 23% are small (Al Frijat et al., 2024). But, as a study sample, a diverse range of managers, analysts, executives, and board members who work for companies listed on the ASE are represented. The sample employed in this study was given a questionnaire, and 169 participants' replies were judged appropriate for detailed statistical analysis. To capture the subtleties of the participants' opinions, a Likert

scale with a range of 1 to 5 was used for data analysis. Particular interest is given to those who have a direct connection to sustainability reports within these companies, as they are familiar with ESG practices disclosure, which is crucial to the preparation and presentation of sustainability reports. The foundation for sustainability in Jordan is still being developed, nevertheless. This shows that, prior to 2019, most companies were not obligated to publish sustainability indicators in their financial statements because they were not legally required to do so or to recognise the importance of these indicators.

On the other hand, the methodology for response analysis, the study uses the PLS-SEM technique to validate the suggested connection between ESG practices disclosure, IT, and SI. Many different commercial domains make substantial use of PLS-SEM (Ringle et al., 2023). Additionally, many studies that integrate primary and secondary data make extensive use of SEM techniques (Rajesh, 2020).

2.2 Demographic Data Analysis

The study's demographic data revealed a 76% response rate. This group was chosen in particular because of their noteworthy contributions to "corporate sustainability reporting", which incorporates "governance, social, and environmental metrics". Thirty-four percent of respondents were between the ages of thirty and forty, thirty-one percent were between the ages of forty and fifty, and ten percent were beyond fifty. This indicates that this group has enough reporting experience in sustainability. Of the sample, 42% were administrative and financial managers, who made up the majority of the category. Gender-wise, 93% of the participants were men, making them the majority. Although there was a wide range in the educational backgrounds of the participants, 61% of them had bachelor's degrees in business.

2.3 Descriptive Analysis

The findings of the descriptive analysis make clear how crucial it is to Investor Trust (IT) as a moderating variable in its strategy and vision in relation to the relationship between disclosing environmental, social, and governance ESG practices and improving sustainable investments (SI). Additionally, the results of the descriptive statistics show how important ESG practice disclosures are to organizations' success, which benefits their sustainable investments indirectly. See Table 1.

Table 1. Descriptive Analysis

Construct	Items	Mean	Standards Deviation
Environmental, Social, and Governance (ESG) practices disclosure	ESG1	3.266	1.149
	ESG2	3.343	1.066
	ESG3	3.426	1.075
	ESG4	3.225	1.053
	ESG5	3.083	1.174
	ESG6	3.467	1.264
	ESG7	3.284	1.010
	ESG8	3.367	1.149
	ESG9	3.361	1.164
Investor Trust	IT1	3.213	1.232
	IT2	3.355	1.213
	IT3	3.320	1.101
Sustainable Investments	SI1	3.201	1.159
	SI2	3.420	1.271

Source: Own

2.4 Construct Measurement

According to Construct Measurement, the questionnaire included questions about ESG practice disclosures as the independent variable, IT as a moderating variable, and SI as the dependent variable in order to quantify the study variables. ESG practices disclosure items were measured as an independent variable

by corporate sustainability reporting: Firstly, Environmental practices disclosure includes Carbon Footprint (GHG Emissions), Energy Consumption, Waste Management, and Biodiversity Preservation. Secondly, the Social Report practices include Employee Satisfaction and Turnover Rates, Health and Safety Measures, Community Engagement, and Education and Training. Finally, the Governance Report includes Board Composition, Diversity Compliance and Ethics, and Risk Management. Also, Mordi's measurement of trust (2023) represented: "Engage Stakeholders; Set Ambitious Goals; and Share Success Stories; Be Transparent About Failures". In addition, the measurement of sustainable investment performance represented the prediction of future risks and opportunities (Vu, Thanh, et al., 2025) and the attraction of new investors.

3. RESULTS

3.1 Factor Loading and Collinearity

For the Factor Loading and Collinearity results, the measuring "model's validity and reliability are demonstrated" by the outer loadings of the constructs utilized in this study, which are displayed in Table 2. According to Hair et al. (2019), loading values between 0.4 and 0.7 are also considered appropriate, provided that removing markers that fall within this range does not negatively impact the "composite constructs' reliability or average variance extracted".

At this level, concerns of "collinearity" between independent latent variables are also examined. Using a "Variance Inflation Factor" measure, it may be difficult to determine the exact amount of change in the dependent latent variable caused by a single predictor variable because of the rising degree of collinearity (Hair et al., 2019). Also, "predictor constructs" must not be collinear, and the Variance Inflation Factor value must fall between 0.2 and 5.00. As a result, the results of the study's Variance Inflation Factor, which ranged from 0.2 to 5.00, demonstrated that the "prediction structures" are not parallel. As shown in Table 2, the study's results show no problems with associations related to the model that was employed.

Table 2. Factor Loading and Collinearity

Construct	Items	Loading	Variance Inflation Factor (VIF)
Environmental, Social, and Governance (ESG) practices disclosure	ESG1	0.799	2.498
	ESG2	0.798	2.775
	ESG3	0.775	2.530
	ESG4	0.799	2.790
	ESG5	0.839	2.839
	ESG6	0.831	2.750
	ESG7	0.752	2.637
	ESG8	0.878	4.385
	ESG9	0.775	2.552
Investor Trust	IT1	0.884	2.185
	IT2	0.854	1.893
	IT3	0.875	1.961
Sustainable investments	SI1	0.898	1.554
	SI2	0.889	1.554

Source: Own

3.2 Measurement Model Assessment

The "Measurement Model Assessment" demonstrates that "Cronbach's alpha", a widely used metric that looks at the intercorrelations between measures, was utilized to evaluate "internal consistency reliability". It is based on the notion that the loading on the related constructs should be equal for each indication. The study's continuously strong "Cronbach's alpha" scores for every variable demonstrated internal solid "consistency dependability". According to Hair et al. (2019), the reliability of internal consistency was confirmed by the fact that none of the Cronbach's alpha values were higher than one or fell below 0.70. See Table 3.

In addition to the "average variance" collected, each indication's dependability was considered. The degree of relationship between measuring indicators and their respective constructs is measured by the "average variance" retrieved. An outside loading value of 0.7 is typically acceptable due to its proximity to the necessary threshold. High loading levels indicate that a sizable portion of the indicator's variance can be explained by the underlying idea. "Convergent validity" was confirmed by the average variance recovered for each of the study's constructs, as shown in Table 3. Each displayed indices with values greater than 0.5.

Table 3. Measurement Model Assessment

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ESGPD	0.932	0.936	0.943	0.650
IT	0.841	0.843	0.904	0.758
SI	0.748	0.749	0.888	0.798

Note: ESGPD; Environmental, Social, and Governance (ESG) practices disclosure; IT; Investor Trust; SI; Sustainable Investments
Source: Own

Thus, as shown in Figure 2, the earlier evaluations significantly improved the validity and reliability of the measurement model, guaranteeing the data's resilience for ensuing route analysis and predictive modelling.

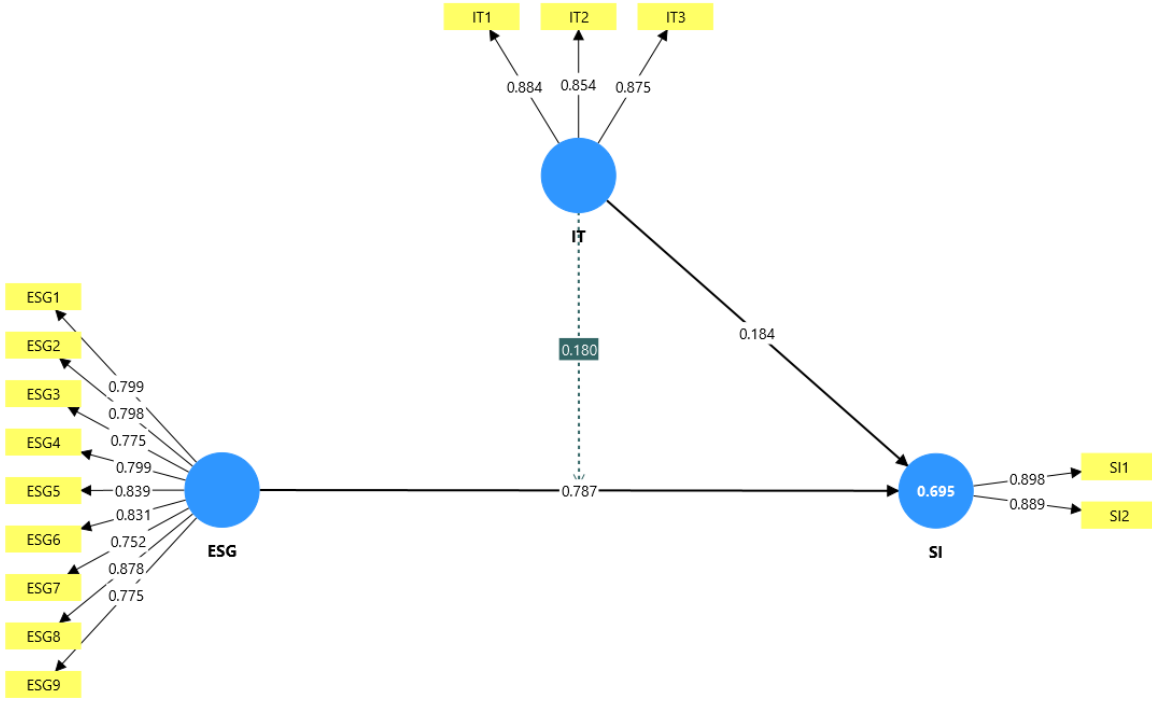

Figure 2. The Smart Pls model

3.3 Discriminant Validity

The "discriminant validity", an essential part of measurement model analysis, was thoroughly assessed using Fornell and Larcker's (1981) criteria. A modern standard for evaluating "discriminant validity in partial least squares (PLS)" models. It provides robust protection to ensure that structures are distinct. For discriminant validity, the test value must be smaller than 0.90. The results show the discriminant validity of the constructs. This bolsters the resilience of the "measurement model and the quality of the data" for additional analysis. By verifying that the constructs satisfied this requirement, the results show the discriminant validity of the constructs. See Table 4.

Table 4. Discriminant Validity

Construct	ESGPD	IT	SI
ESGPD	0.806		
IT	0.803	0.871	
SI	0.723	0.770	0.894

Note: ESGPD; Environmental, Social, and Governance (ESG) practices disclosure; IT; Investor Trust; SI; Sustainable Investments
Source: Own

3.4 Hypothesis Testing

For hypothesis testing, the results of the regression analysis for the proposed associations are shown in Table 5, indicating a positive correlation between disclosure of ESG practice and sustainable investments (SI). H1 is supported by "path coefficients of 0.787, a T value of 8.692, and a p-value of 0.000", which are significant at the 0.05 level, according to structural model test findings. This suggests that the disclosure of environmental, social, and governance practices and sustainable investments is positively correlated. H1 is, therefore, accepted. See Table 5 and Figure 3.

In addition, the analysis results of the suggested correlations to test H2. indicating a positive correlation between investor trust (IT) and sustainable investments (SI) is supported by "path coefficients of 0.184, a T value of 2.128, and a p-value of 0.033", which are significant at the 0.05 level. H2 is, therefore, accepted. See Table 5 and Figure 3.

Table 5 displays the analysis results of the suggested correlations to test H3. Through moderating variables relevant to investor trust, they demonstrate a favorable correlation between ESG practices disclosure and sustainable investments (H3). The findings of the structural model test show that H3 is supported by path coefficients of 0.180, T-values of 2.865, and P-values of 0.004, which are significant at the 0.05 level. This suggests that investor confidence adjustment has a major impact on the connection between ESG practices disclosures and persistent investment improvement. Thus, H3 is accepted. See Table 5 and Figure 3

Table 5. Hypothesis Testing

Hypotheses	Original sample (O)	Sample mean	Standard deviation	T statistics	P values	Decision
ESGPD -> SI **(H1)**	0.787	0.786	0.091	8.692	0.000	Accepted
IT -> SI **(H2)**	0.184	0.183	0.086	2.128	0.033	Accepted
IT x ESGPD -> SI **(H3)**	0.180	0.179	0.063	2.865	0.004	Accepted

Note: ESGPD; Environmental, Social, and Governance (ESG) practices disclosure; IT; Investor Trust; SI; Sustainable Investment
Source: Own

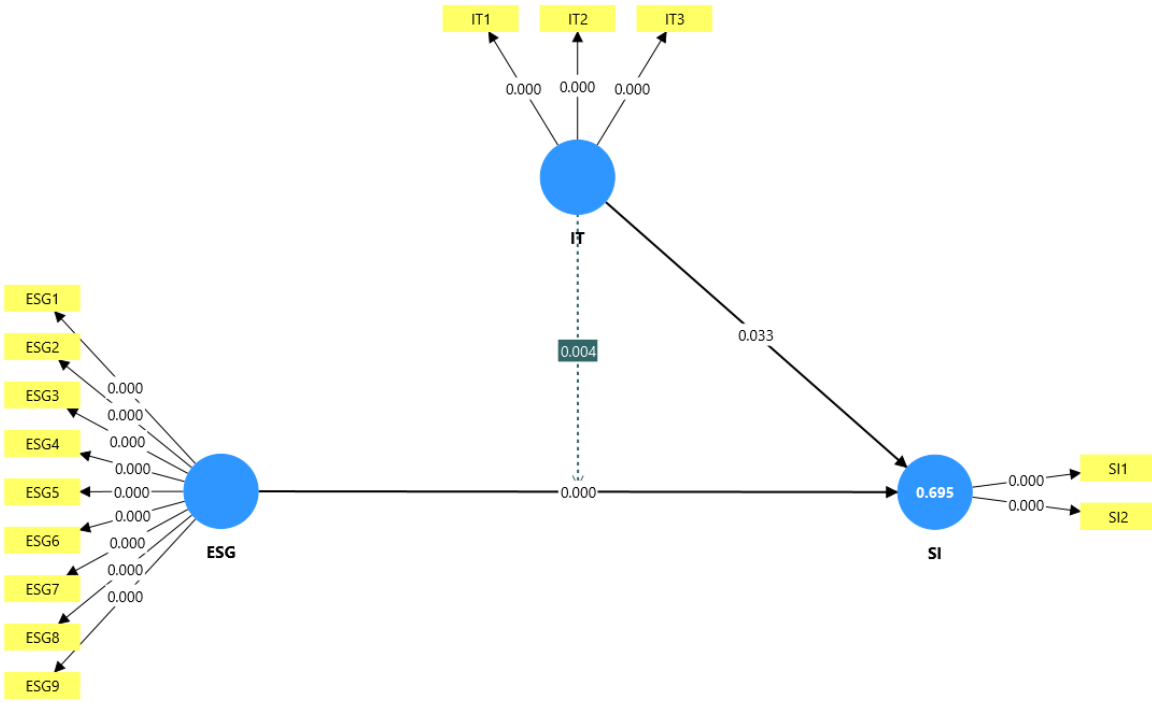

Figure 3. The Smart Pls model

Additionally, as a test of R-squared, Stone-Geisser's score is also frequently used to evaluate the "model's out-of-sample prediction power" and ability to predict unused data. 'The model's Q-squared should be greater than zero for every reflecting endogenous notion (Geisser, 1974; Hair et al., 2017). The results show the Q^2predict equal 0.535 for (SI1) and 0.511 for (SI2). Also, the R-squared values of the two reflecting endogenous constructs for sustainable investments (SI) = 0.695 and 0.689. Thus, the model has a significant predictive ability. See table 6.

Table 6. R-squared and Q^2predict

	R-square	R-square adjusted	Q^2predict	RMSE	MAE
SI	0.695	0.689	0.657	0.591	0.479

Source: own

4. DISCUSSION

In short, research offers a thorough understanding of the intricate connection between ESG practice disclosure, IT, and SI. This comprehensive understanding highlights the potential for high-impact contributions to the financial literature, particularly in emerging environments, and is crucial for investors, policymakers, and businesses navigating the shifting terrain of sustainable investments.

The study investigates the importance of disclosure of environmental, social, and governance practices in Enhancing Sustainable Investments in Jordan: the moderating role of Investor Trust-Building. To test H1, the study results showed that sustainable investments in companies are influenced by disclosure of environmental, social, and governance (ESG) criteria. This means that disclosure of environmental practices, including energy use, waste management, biodiversity conservation, and carbon footprint, as well as disclosure of social practices, including community engagement, health, and safety protocols, employee satisfaction, and volatility rates, is important and plays a key role in attracting new investors and mitigating investment risks. Furthermore, disclosure of governance measures, including risk management, compliance, ethics, board diversity and composition, and governance, plays a key role in predicting risks and creating more future opportunities and also contributes to attracting more new investors. Also, for test H2, a positive correlation between investor trust (IT) and sustainable investments (SI) is supported. Through

this, it demonstrates that there is a positive relationship between investor trust and sustainable investing, meaning that trust contributes to improving and enhancing sustainable investment for companies.

To bolster the results of the research hypotheses, in terms of long-term value generation, high ESG-rated businesses are seen to be better able to predict future risks and opportunities and are more inclined to longer-term strategic thinking (Vu, Thanh, et al., 2025). Thus, financial performance can become steadier and more predictable through the efficient management of social obligations, environmental hazards, and governance frameworks (Vu Thanh, et al., 2025). Foley et al. (2024) indicate that the investors' growing interest and knowledge of ESG factors highlight how crucial sustainability is becoming to the investment landscape. Also, Liu et al. (2024) show that ESG reports have emerged as a crucial element of the investing and business markets. Grazia et al. (2022) came to the conclusion that investors are interested in how well companies perform in terms of ESG and want them to be more accountable and open about their ESG practices.

On the other hand, Investor confidence as a moderator affects investment decisions, meaning that confidence modifies their view of investments in these companies. Therefore, the more companies disclose their environmental, social, and governance practices, the more sustainable investments there are. To discuss the results of H3, the results are supported by interaction terms, demonstrating that building trust moderates the association between disclosure of ESG practices and sustainable investments. This means that companies with high ESG ratings in sustainability disclosure are less exposed to risks and climate change events, which can lead to stable operations and financial gains, as well as lower risk, and attract new investors to acquire. These classifications represented the disclosure of environmental practices, including energy use, waste management, biodiversity conservation, and carbon footprint, which was the main focus of this interest. Additionally, it emphasized the disclosure of social practices, including community involvement, health and safety protocols, and employee satisfaction and volatility rates. Disclosure of environmental data improves the value offered to investors and lowers market uncertainty (Moser and Martin 2012).

Furthermore, the results indicated that corporations are interested in the disclosure of governance practices, which include risk management, compliance and ethics, board diversity and composition, and governance. This contributes to risk mitigation, financial performance enhancement, and investor attraction, bolstering both theoretical arguments in the realm of sustainability. Also, the results are in line with the stakeholder theory and signaling theory, which affirms that businesses that implement ESG practices improve long-term goals, resilience, and stakeholder trust by sending signals from their corporate ESG reports to investors. This, in turn, plays a crucial role in lowering risks and enhancing the performance and stability of businesses.

However, as the study results indicated, the relationship between disclosure of sustainability practices, whether environmental, social, or governance (ESG), and sustainable investments is positive and can only be achieved by building investor trust. In fact, the philosophy of building investor trust comes from engaging stakeholders in the decision-making process, providing feedback, and listening to their concerns. Setting ambitious goals is also a trust-building factor, demonstrating the organization's determination to create a sustainable and meaningful impact. Sharing success stories is also encouraged, as is incorporating case studies and real-life examples into the sustainability report, providing tangible evidence of commitment to sustainability. Lastly, since trust is a delicate balance that transcends achievements, results must be transparent. More significant than an organization's accomplishments is how it responds to its setbacks (Mordi, 2023). As a result, companies' adoption of these changes supports investor optimism and changes their perception of their investments, which in turn contributes to promoting sustainable investments. The diversity of nationalities of investors in Jordanian markets indicates investor trust in sustainability reports (ASE, 2025), cited in (Al Frijat et al., 2025).

To bolster the results of the research hypotheses, in the worldwide economy, ESG performance has grown in significance for businesses and investors since it shows a company's sustainability, and resilience (Clément et al., 2025). Suhartini et al. (2024) concluded that social and environmental issues have the potential to undermine investor confidence and reduce firm value. By generating value and reducing

uncertainty, ESG performance can support a company's long-term financial success and resilience, as demonstrated by Xueying et al. (2022). Also, Franks et al. (2009) show that informal trust connections were the primary driver of the expansion and prosperity of the "British equities markets in the early 20th century". Also, performance risk is shown to decrease when trust in a bank's abilities increases (Das and Teng, 2004).

CONCLUSION

This study aims to investigate The Moderating Effect of Investor Trust on the Relationship between the Disclosure of Environmental, Social, and Governance Practices and Sustainable Investment. Leveraging data collected through surveys at the level of Jordanian companies operating in the Jordanian market, findings reveal the importance of sustainability disclosure for environmental, social, and governance activities for its role in creating trust for inside and outside users. The study results first show a strong and statistically significant association between ESG practice disclosure and sustainable investments, highlighting that companies with high ESG practice levels tend to provide and attract highly sustainable investments. Second, research demonstrates a convincing and statistically significant positive association between ESG and IT, underscoring the potential benefits of sustainable corporate business practices. In addition, a moderation analysis is presented, exploring the ways in which the methods of IT impact the correlation between ESG practices and sustainable investments, not only as a means of addressing environmental and social challenges but also as a strategy to enhance performance and mitigate risks facing companies to provide sustainable investments.

For this reason, the study is significant because it encourages the companies that are listed on the Amman Stock Exchange to create a more appealing investment base, which will benefit the companies. This is accomplished by highlighting the transparency, legitimacy, and worth of the environmental, social, and governance reports that businesses release in an effort to boost investor confidence and entice them to make an investment or stay involved in the business with their money within the company. Hence, ESG reporting is important in fostering investor confidence to enhance firm value—especially in Jordan's developing market. According to the study's aim, stakeholder trust in sustainability reporting increases business value on its own. To put it another way, a company's dedication to creating and delivering sustainability reports with legitimacy and dependability may enhance the company's success by winning over several stakeholders.

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The Influence of External Auditors' Psychological Capital on the Application of International Standard on Auditing 610

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ABSTRACT

This study investigates the influence of external auditors' psychological capital upon their reliance behaviour on internal auditors, as specified by the International Standard on Auditing (ISA) 610. The study employed the Structural Equation Modelling using the Partial Least Squares (SEM-PLS) method to examine the proposed model's measurement and structural elements. The results indicate that external auditors' decisions to rely upon internal auditors, either through the utilisation of work previously accomplished by internal auditors or via engaging internal auditors for direct assistance, are positively connected to positive psychological capital. Specifically, reliance extent on internal auditors can be boosted when external auditors (1) demonstrate a high degree of self-efficacy, reflected in their confidence to perform multifaceted audit tasks and a commitment to employing the necessary effort to achieve audit objectives; (2) maintain optimistic expectations regarding current audit consequences; (3) exhibit a hopeful orientation characterised by perseverance toward goals and the flexibility to modify strategies in response to changing audit conditions; and (4) display psychological resilience by effectively coping with audit-related challenges, reassessing adverse situations, and re-engaging with determination. This research offers empirical evidence on the value of psychological capital in applying ISA 610 that may interest stakeholders, including auditees, external and internal auditors, and standard-setting authorities. These stakeholders are integral to affecting the functional role of internal auditors in the external audit practice, thereby contributing to its overall efficiency and effectiveness.

INTRODUCTION

The social cognitive theory illustrates the significance of efficacy and its direct impact on human behaviour, expectations, and outcomes. According to this theory, behaviour and task completion are enhanced through self-efficacy (internal efficacy) and external efficacy (Agars and Kottke, 2020; Hannah et al., 2010; Khelil, 2023; Bandura, 1999; Eden et al., 2010; Hannah et al., 2010; Khelil, 2023). Self-efficacy has been determined to be an essential element of successful performance. Prior research indicates that practitioners and researchers should value external efficacy as they regard its internal counterpart (Agars and Kottke, 2020; Khelil, 2023). External efficacy means that can be utilised in the execution of the job

involves human resources (e.g., leaders, peers, and subordinates), institutional mechanisms (processes, procedures), and tools (computers, equipment, and software) (Bandura, 1999; Eden et al., 2008; Yaakobi and Weisberg, 2020). Accordingly, internal auditors' work can be an external efficacy means for external auditors.

In line with the social cognitive theory and as utilisation of external efficacy means, the International Standard on Auditing (ISA) 610 permits that internal auditors be relied on by external auditors provided that particular quality criteria are met (Albawwat, 2022; IFAC, 2013; Bame-Aldred et al., 2012). The 2013 revised International Standard on Auditing (ISA) 610 supports that the work previously performed by internal auditors and their providing of direct support under the direction of external auditors can be relied on (IFAC, 2013). This reliance decreases the processes needed by independent auditors to gather audit evidence, so improving the efficiency of audits (Barr-Pulliam et al., 2024; Breger et al., 2019; Desai et al., 2017). Internal auditors usually have great awareness of the activities, internal controls, and operational procedures of the entity since they occupy a long period inside the company. Internal auditors' familiarity helps them to spot shortcomings and strengths in fields that might still be unknown to external auditors. Thus, using the expertise of internal auditors could improve the auditee-related knowledge among external auditors, resulting in creating more focused audit strategies and helping to provide more thorough audit coverage (Felix et al., 2001; Nkansa, 2023). Within the framework of worldwide auditing standards, it is abundantly evident how important it is for external auditors to rely on the internal auditing staff of their clients. This reliance helps greatly in minimising the effort needed to wrap up the external examination of the financial reports. Consequently, an important decrease in external audit fees has been observed (ame-Aldred et al., 2012; Felix et al., 2005; Al-Twaijry et al., 2004). Within this framework, internal auditors are considered a part of the external audit's means and operative engagement is conceptualised as a dimension of audit resource utilisation efficiency (Albawwat, 2022; Bame-Aldred et al., 2012; Barr-Pulliam et al., 2024; Felix et al., 2001). However, in certain developing economies, the degree to which external auditors incorporate the work of internal auditors remains limited. This insufficient integration weakens the potential of internal auditor contributions to function as one of the external audit fees determinant (Al-Twaijry et al., 2004; Albawwat, 2022; Said-Suwaidan and Qasim, 2010).

International Standards on Auditing 610 (Revised 2013) explicitly states that the external auditor's obligation towards the contents of the audit report remains intact, irrespective of any reliance placed on the work of internal auditors. In line with this, the standard delineates quality-related criteria that must be rigorously assessed before placing any reliance. The evaluation of internal audit quality and the subsequent reliance decision are subject to the influence of various organisational and individual-level factors, including the cognitive capacities of the external auditor (Brody, 2012; Mapuli, 2023). Among these cognitive resources, psychological capital has emerged as a critical determinant, as it has been empirically linked to variations in employee attitudes and behaviours within organisational settings (Da et al., 2021; Maykrantz et al., 2021). As such, variations in the psychological resources of external auditors could explain variations in the degree to which the internal auditors support the external audit process. This paper aims to add to the body of knowledge by investigating whether psychological capital has a major impact upon the degree of use external auditors make of internal auditors' output. More specifically, it offers concrete evidence of how psychological capital shapes external auditors' opinions of the reliability of internal audits and final reliance choices.

1. BACKGROUND

1.1 Social cognitive theory

Bandura developed Social Cognitive Theory, which is also known as a framework of efficacy beliefs, in 1986. According to this theoretical perspective, efficacy beliefs form a fundamental psychological mechanism affecting personal decision-making procedures and behaviour results. Through influencing behaviour plans, expectations, ambitions, and goal-setting, perceived self-efficacy is fundamental in human agency. Moreover, it affects how people view chances and limitations inside their social and professional settings (Agars and Kottke, 2020; Bandura, 1999; Eden et al., 2010; Hannah et al., 2010; Khelil, 2023). Later

developments in this concept have broad their reach to include a model combining internal as well as external efficacy. Task performance and behavioural execution are now shown to be influenced not only by self or internal efficacy but also by external types of efficacy. External efficacy includes means and group efficacy (Eden, 1996; Eden, 2001; Khelil, 2023; Yaakobi and Weisberg, 2020). Means-efficacy is a person's opinion of the value and efficiency of outside resources meant to help them perform tasks. This construct helps to explain the extent to which people credit the supportive function of outside resources for performance results, so either facilitating or hindering task completion (Eden, 1996). Like self-efficacy, means-efficacy is acknowledged as a major motivating factor deserving of consideration from professional practitioners as well as academic researchers (Agars and Kottke, 2020). It covers a spectrum of outside resources: human capital (e.g., supervisors, colleagues, and subordinates); legal frameworks (e.g., organisational processes and standardised procedures); and technological resources (e.g., software, equipment, and information platforms) (Bandura, 1999; Eden et al., 2010; Yaakobi and Weisberg, 2020). Internal auditors could be seen inside this conceptual framework as an example of means-efficacy to external auditors. That is to say, they are a useful outside resource that one can use to help external audit activities to be completed.

1.2 Reliance of External Auditors on Internal Auditors

In response to the growing focus on strong corporate governance systems, the collaboration among external and internal auditors is gaining ever more significance (Hazaea et al., 2022; Paape et al., 2003). The roles and responsibilities of external and internal audit functions are becoming continually interdependent in current audit practice, so deepening the professional connection among these two assurance suppliers (Calvin et al., 2023; Mubako and Mazza, 2023). The International Standard on Auditing 610 defines the circumstances under which internal auditors could participate in the external audit process. In particular, the International Standard on Auditing 610 permits external auditors to make use of the work accomplished by internal auditors, provided that the internal audit function satisfies established criteria relating to systematic and disciplined processes, competence, and objectivity (International Federation of Accountants, 2013). The standard further allows internal auditors to assist the external audit team directly under appropriate supervision. This reliance can influence the extent and character of external audit methods for evidence collection (Bame-Aldred et al., 2012). Nevertheless, since the audited entity employs internal auditors, concerns regarding independence and objectivity necessitate external auditors' heightened professional scepticism and due care when incorporating internal audit work into their procedures (Khalid et al., 2024). Ensuring audit quality requires carefully assessing the degree to which reliance upon the internal audit function is proper in each audit engagement (Bame-Aldred et al., 2012; Barr-Pulliam et al., 2024).

The responsibility for forming an audit opinion in audit engagements rests solely with the external auditor. Reliance upon the work of internal auditors, as anticipated by International Standard on Auditing 610 (Revised 2013), does not excuse the external auditor from accountability regarding the content of the audit report (International Federation of Accountants, 2013). Therefore, any decision to place reliance upon internal audit work must be informed by a rigorous assessment of specific quality criteria delineated within the standard. Among these evaluative criteria, objectivity is paramount. Objectivity is conceptualised as a balanced mental state that tolerates internal auditors to execute their duties with assurance in the integrity and reliability of their outputs, ensuring that audit quality is not compromised by undue influence. Internal auditors are expected to maintain independence in thought and action, resisting pressures that may impair professional judgment during audit activities. Competence constitutes another essential determinant in the evaluation process. This refers to the internal auditors possessing the requisite technical knowledge, professional skills, and behavioural attributes necessary to fulfill their responsibilities within the audit function effectively. Furthermore, for internal auditors to be considered suitable for reliance, the internal audit function must demonstrate the implementation of a systematic and disciplined methodology to its operations. This entails consistently applying structured processes in the planning, execution, supervision, review, and documentation of audit activities (Institute of Internal Auditors, 2015; International Federation of Accountants, 2013). International Standard on Auditing 610 further requires external

auditors to evaluate the extent and environment of reliance on the internal auditors' work, particularly concerning tasks significant to the external audit.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1 Psychological Capital Hope Aspect and External Auditors' reliance on Internal auditors

The evaluations conducted by external auditors concerning the quality of internal auditors are guided by the criteria outlined in the International Standard on Auditing 610. To mitigate the risk of inappropriate reliance that could compromise the integrity and quality of the external audit, the standard mandates that external auditors rigorously assess the internal audit function against the quality dimensions prior to incorporating any of its work into the external audit evidence base (International Federation of Accountants, 2013). Empirical investigations conducted within the Jordanian auditing environment have explored the connection between the quality of internal auditors and the degree of reliance placed upon them by external auditors. Some studies have specifically examined the extent to which external auditors in Jordan adhere to the stipulations of ISA 610 when evaluating internal audit functions, drawing upon perspectives from both external and internal audit practitioners. These studies also investigated the relative importance of external auditors to each quality attribute prescribed by ISA 610. The findings demonstrate that perceptions regarding the degree to which internal audit work conforms with ISA 610 vary significantly between internal audit personnel and external auditors (Albawwat, 2022; Said-Suwaidan and Qasim, 2010). Further research has been done to determine the relative significance of each quality assigned in the external auditors' selection process with reference to reliance upon internal auditors. Based on the outcomes of these investigations, Jordanian external auditors consider objectivity to be the most significant criterion influencing their choices regarding dependence (Al-Sukker et al., 2018).

The central focus of this study is psychological capital, which pertains to the role of positive individual attributes in facilitating effective and efficient job performance. Among various positive psychological constructs, hope, self-efficacy, optimism, and resilience have emerged as the most representative components aligning with the conceptual framework of positive organisational behaviour. These four constructs have been empirically validated as the core dimensions constituting psychological capital (Caldwell, 2004; Luthans et al., 2007; Martin et al., 2005; Luthans and Youssef, 2007;). Theoretically, hope is described as a positive motivational state that is predicated upon an interactively formed feeling of effective objective-directed dynamism and making plans to achieve aims. Hopeful people can create numerous routes to achieving their objectives (Luthans, 2002; Ribeiro et al., 2021). This psychological resource never stops giving hope that the objective will be reached. Maintaining hope in crises and change is essential for employee well-being and a key component of constructive organisational change. To navigate discontinuous and unpredictable change processes, in particular, creating new paths appears crucial (Wright and Cropanzano, 2004; Weick and Quinn, 1999). Moreover, people with a high hope level structure their work to motivate them to complete the task. Agency thinking in hope is significant when people face obstacles (Lupșa et al., 2019). Persons exhibiting a heightened degree of hope are more inclined to receive and interpret information in a manner that enhances the likelihood of desired outcomes materialising (MacInnis and Chun, 2006). In situations where external auditors rely upon the work accomplished by internal auditors, the psychological construct of hope may serve to improve the perceived trustworthiness of the internal audit function. As external auditors develop increasingly favourable attitudes toward the benefits of relying on internal auditors, they are more apparent to perceive the internal auditors as dependable and trustworthy, thereby satisfying the quality criteria outlined in the International Standard on Auditing 610. Consequently, external auditors may exhibit a greater propensity to utilise the work already performed by internal auditors or to engage internal auditors for direct assistance in the audit process. Based on this rationale, the next testable hypothesis is projected:

H1: The psychological capital hope aspect positively influences external auditors' reliance upon internal auditors.

2.2 Psychological Capital Self Efficacy Aspect and External Auditors' reliance on Internal auditors

Self-efficacy represents the second core capability of psychological capital. It denotes to a person's belief or confidence in their capability to organise the enthusiasm, cognitive resources, and paths of action required to successfully accomplish a particular duty within a given setting (Bandura, 1997). According to Avey et al. (2008), self-efficacy encompasses one's confidence in one's capacity to (a) create alternative paths, (b) initiate purposeful action concerning an objective, and (c) finally achieve the intended outcome. Substantial empirical evidence has confirmed a strong positive connection among self-efficacy and Job performance, particularly in organisational change and adaptation. Self-efficacy is developed through four widely recognised factors, each relevant to promoting constructive behaviour. The most influential factor is task mastery, which involves completing a task and reinforcing one's confidence in one's capability to replicate or adapt to similar challenges (Bandura, 1997). A second factor is arousal, referring to emotional and physiological activation that energises individuals to complete tasks or respond to change. Third, verbal persuasion through encouragement and affirmation from credible role models such as supervisors, mentors, or coaches, particularly when individuals are undertaking new responsibilities. Fourth, vicarious learning or modelling occurs when individuals observe others perceived as similar to themselves successfully performing a task. Organisations can foster self-efficacy by facilitating early experiences of task mastery, promoting social support mechanisms, and offering opportunities for role modelling (Gist and Mitchell, 1992). Personnel with high self-efficacy tend to exhibit persistent effort and sustained motivation toward goal achievement, driven by confidence in their capabilities (Li et al., 2019).

This psychological resource is especially critical in dynamic work environments, where employees are frequently required to assume new roles and navigate unfamiliar tasks (Kim et al., 2017). Self-efficacy provides insight into the antecedents of individual performance in situations characterised by ambiguity or difficulty (Bandura, 1997, 1999). Individuals with high self-efficacy perceive complex tasks as challenges to be mastered and are more likely to achieve superior outcomes. Low self-efficacy individuals, on the other hand, frequently react to uncertainty with hesitancy and anxiety, which can impair performance (Bandura, 1997). When relying upon internal auditors who perform services for the audited organisation, external auditors might view the task as complex and unpredictable, requiring a remarkable degree of self-efficacy to complete effectively. The confidence and perceived ability required to exercise this professional judgement and make well-informed reliance decisions are more likely to be possessed by external auditors who have high levels of self-efficacy. Accordingly, the following hypothesis is formulated:

H2: The psychological capital self-efficacy aspect positively influences external auditors' reliance upon internal auditors.

2.3 Psychological Capital Optimism Aspect and External Auditors' reliance on Internal auditors

The third factor of psychological capital is optimism, which is the broad expectation of favourable results. Pessimists are more likely to expect negative outcomes, while optimistic people are distinguished by their expectation of positive outcomes. This expectation framework sheds light on how optimism affects one's ability to effectively deal with uncertainty. Regardless of present competence or situational challenges, highly optimistic persons are more likely to expect success in a situation of ambiguity (Scheier et al., 2001; Guo et al., 2018). Employees who are more optimistic are more likely to act pro-actively at work, which improves task performance and increases organisational productivity. Their optimistic attitude serves as a driving force, inspiring them to aim high and see obstacles as chances for development and creativity (Broad and Luthans, 2020). Furthermore, by encouraging teamwork and others to adopt similarly positive attitudes, optimistic people commonly contribute to a positive atmosphere in organisations (Carver and Scheier, 2014; Hannah et al., 2010).

According to the reviewed literature (Broad and Luthans, 2020; Ziyae et al., 2015; Yu et al., 2019), optimism is a crucial psychological resource for maintaining motivation and perseverance in goal-oriented

tasks. People are more inclined to work hard and stick with their goals in the face of difficulty or adversity when they anticipate positive results. When assessing the competence, objectivity, and methodological rigour of internal auditors as set forth by the ISA 610 (Revised 2013), optimism may have an impact on an external auditor's sureness in the quality and utility of internal audit work in the external auditing of financial statements. The afterwards hypothesis is put forth in light of this theoretical foundation:

H3: The psychological capital optimism aspect positively influences external auditors' reliance upon internal auditors.

2.4 Psychological Capital Resilience Aspect and External Auditors' reliance on Internal auditors

The fourth essential component of psychological capital is resilience. Challenges, ambiguity, disagreement, disappointment, and even positive stressors like development, advancement, and increased responsibility can all be overcome by this positive psychological capacity (Avey et al., 2008; Luthans, 2002). This capability is especially relevant in contemporary organisational environments characterised by volatility, restructuring, and continuous change. The essential feature of resilience lies in one's ability to rebound from setbacks, adapt constructively, and thrive in the face of significant challenges (Luthans and Youssef, 2007). In the auditing context, external auditors may encounter uncertainty and complexity when determining whether to rely upon the work of internal auditors, particularly given concerns over objectivity and audit quality. External auditors who demonstrate high levels of resilience are more likely to manage such uncertainties effectively, remain adaptable, and confidently make professional judgments. Thus, resilience may be a facilitating factor in promoting reliance upon the internal auditors during the external audit process. In light of this theoretical reasoning, the following hypothesis is put forth.

H4: The psychological capital resilience aspect positively influences external auditors' reliance upon internal auditors.

3. RESEARCH METHOD

3.1 Data Gathering Technique

Data for this investigation were collected by a structured questionnaire survey. A total of 140 questionnaires were disseminated to external auditors auditing companies listed on the Amman Stock Exchange in Jordan. Of these, 120 completed observations were returned and considered suitable for statistical analysis, producing a response rate of almost 86 per cent. The Psychological Capital Questionnaire's 24-item survey assesses the psychological capital of external auditors. This questionnaire has been rigorously assessed through psychometric evaluations and validation using samples from various business sectors. Six items are graded on a Likert scale to test each of the psychological capital constructs: self-efficacy, optimism, hope, and resilience. Consent and a free copy of the measurements are available to researchers from www.mindgarden.com. The measurement items related to external auditors' estimation of internal auditors' quality aspects and their corresponding reliance decisions were developed in alignment with the guidance provided by the International Standards on Auditing. The construct denoting external auditors' reliance upon internal auditors was developed as a second-order construct. The theoretical foundation for modelling reliance as a second-order concept is grounded in the fact that external auditors need to evaluate four essential characteristics before relying upon internal auditors.

3.2 Analysis Method

Partial least squares structural equation modelling was harnessed in this study to analyse the data. Two steps are involved in the evaluation and analysis of the data using the PLS-SEM method. In the first step, it evaluates the measurement model to ensure its validity and reliability. For hypothesis testing, the structural model is examined in the second stage (Hair et al., 2017). The measurement and structural

design of the research model are shown in Figure 1. The numerous items measuring the underlying variables comprise the measurement model. Conversely, the routes illustrating the study hypotheses shape the structural model (see Figure 1). R^2 standards are inspected to appraise the research model's predictive power. It likewise displays the change in the endogenous components that external constructions can enlighten. A value nearer 1 denotes a higher predictive power. The range of values for R^2 is 0.00 to 1.00 (Esposito Vinzi et al., 2010). According to Hair et al. (2017), R^2 figures of 0.75 and higher, 0.25 to 0.75, and 0.25 to 0.25 should be regarded as having high, modest, and low predictive power, respectively. The endogenous components RD in the current investigation have an R^2 value of 0.592. These findings point to the study model's moderate predictive power.

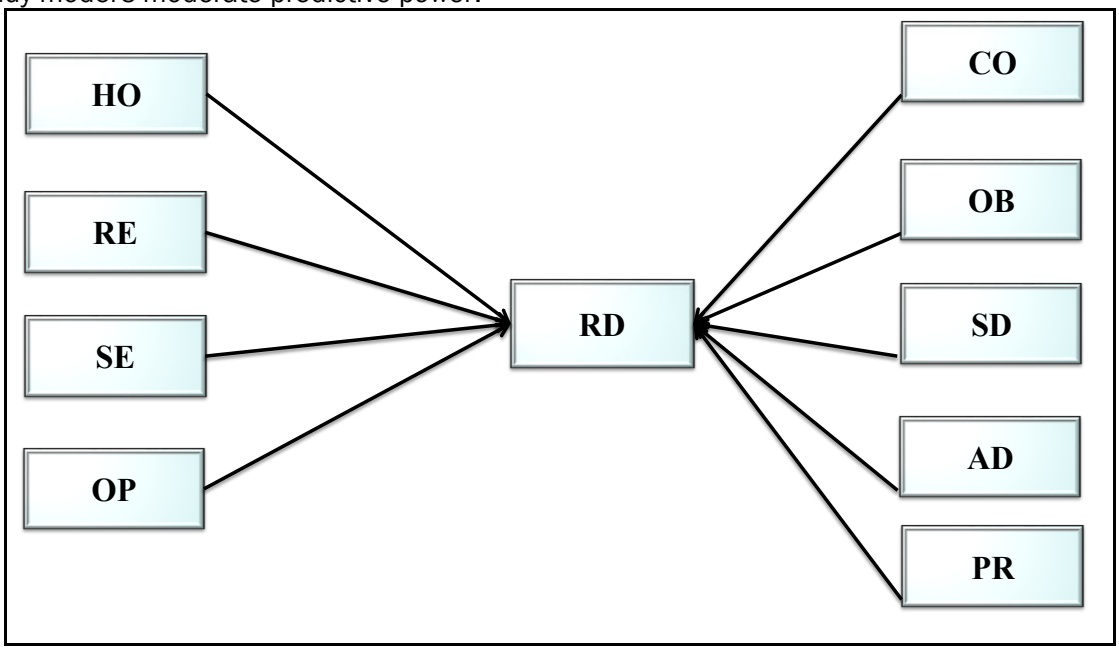

Figure 1. The study model
Note: HO = hope; RE = resilience; SE = self-efficacy; OP = optimism; RD = external auditors decision to rely on internal auditors; CO = competence; OB = objectivity; SD = internal auditors application of a systematic and disciplined approach; AD = the adequacy of internal auditors work for external audit; PR = Planned reliance on internal auditors

3.2.1 Evaluation of Measurement Model

The present analysis evaluates the internal consistency reliability of measurements using Cronbach's Alpha and Composite Reliability. The composite reliability and Cronbach's alpha values for all latent variables should surpass 0.7 to be within the acceptable range that is met for the current study (see Table 1) (Cronbach, 1951; Hair et al., 2017). In contrast, the validity is assessed through convergent validity benchmarks. Convergent validity is attained when a collection of items accurately describes a latent construct. To achieve this, the average variance extracted (AVE) value for each latent variable must be greater than 0.5 (Esposito Vinzi et al., 2010). As shown in Table 1, all latent constructs in the present investigation can account for higher than 0.5 of the average variance of their respective indicators. The loadings of the indicators on their latent variables were also looked at to examine reliability at the item level. Hair et al. (2017) assert that an item must have a loading of at least 0.7 on its construct. Table 1 indicates that the indicator loadings on the corresponding latent variables exceed 0.7. Similarly, to guarantee that each latent variable only captures indicators not represented by other latent variables in the model, the discriminant validity criterion (cross-loadings) was utilised (Henseler and Chin, 2010). Hair et al. (2013) assert that an item's loading on its latent variable must exceed its loadings on all other latent constructs, whereas loadings on unrelated latent constructs or cross-loadings should be below 0.4. The cross-loading for each indicator in the present analysis was below 0.4.

Contrasting the square root of the Average Variance Extracted (AVE) for each construct with its connections with all other constructs helps one to investigate discriminant validity even more. The AVE value of

every latent variable had a square root higher than its correlated values with other structures (Hair et al., 2017). As the prerequisites were satisfied; thus, the discriminant validity is, by default, met. Furthermore, the variance inflation factor (VIF) measure was applied to the collinearity inspection between predictor latent constructs. A valid VIF figure must lie between 0.2 and 5.00 (Henseler et al., 2009). The model evaluation outcomes revealed that collinearity is not of concern for this study and that the VIF values are reasonable.

Latent variables and items	Loading	Alpha	CR	AVE
Self-Efficacy (SE)		**0.726**	**0.741**	**0.519**
SE item 1	0.719			
SE item 2	0.724			
SE item 3	0.750			
SE item 4	0.768			
SE item 5	0.802			
SE item 6	0.788			
Optimism (OP)		**0.743**	**0.765**	**0.552**
OP item 1	0.754			
OP item 2	0.709			
OP item 3	0.731			
OP item 4	0.784			
OP item 5	0.748			
OP item 6	0.810			
Hope (HO)		**0.795**	**0.807**	**0.510**
HO item 1	0.782			
HO item 2	0.769			
HO item 3	0.711			
HO item 4	0.803			
HO item 5	0.791			
HO item 6	0.796			
Resilience (RE)		**0.768**	**0.781**	**0.583**
RE item 1	0.752			
RE item 2	0.763			
RE item 3	0.768			
RE item 4	0.752			
RE item 5	0.772			
RE item 6	0.784			
Competence (CO)		**0.737**	**0.762**	**0.601**
CO item 1	0.813			
CO item 2	0.824			
CO item 3	0.808			
CO item 4	0.825			
CO item 5	0.807			
Objectivity (OB)		**0.815**	**0.824**	**0.613**
OB item 1	0.810			
OB item 2	0.788			
OB item 3	0.786			
OB item 4	0.787			
OB item 5	0.768			
Application of a systematic and disciplined approach (SD)		**0.750**	**0.767**	**0.586**
SD item 1	0.743			
SD item 2	0.748			
SD item 3	0.741			
SD item 4	0.753			
SD item 5	0.733			
Adequacy of internal audit work for external audit (AD)		**0.804**	**0.821**	**0.611**
AD item 1	0.812			
AD item 2	0.815			
AD item 3	0.820			

AD item 4	0.806			
AD item 5	0.831			
Planned reliance on internal auditors (PR)		**0.742**	**0.751**	**0.581**
PR item 1	0.805			
PR item 2	0.780			
PR item 3	0.768			
PR item 4	0.795			

Table 1. Reliability and validity of measurement model
Source: Own

Ensuring that the related measuring indicators together and precisely determine the underlying conceptual subject depends on the evaluation of validity convergent for the second-order construct. This study assessed convergent validity in line with Hair et al. (2017), who suggest incorporating a reflective global question reflecting the general essence of the second-order construct. Thus, the global item was included in the questionnaire to represent the extent to which external auditors believe internal auditors' operations of client companies satisfy the criteria of the ISA 610. The convergent validity of the construct assessing external auditors' reliance upon internal auditors was assessed using this global indicator as a criterion. Establishing the connection among an exogenous construct and an endogenous construct symbolised by a global item was the first step in evaluating convergent validity for the high-order latent variable. Convergent validity is maintained, in accordance with Hair et al. (2017), when there is a significant and statistically significant connection among these two constructs, as indicated by a path coefficient greater than 0.80 and an associated coefficient of determination (R^2) higher than 0.64. The reliance upon internal auditors (RD) construct, which was modelled as a formative-reflective second-order construct, was found to have convergent validity empirically, as evidenced by the results of the bootstrapping procedure used in this study, which showed a path coefficient of 0.826 and an R^2 figure of 0.66.

3.2.2. Evaluation of Structural Model

The strength, significance, and positivity or negativity of the research relationships are assessed using the pathway coefficients (Frijat and Al-Hajaia, 2025). A relationship is deemed positive if the path coefficient is greater than zero and negative if it is less than zero. Path coefficient figures range from -1 to +1. As a result, the path coefficient value departs from zero more when the link is more important. Each path coefficient's t-value reveals how significant it is. That is, t-values more than 1.65, 1.96, and 2.57 show a relationship significance at $P < 0.10$, 0.05, and 0.01, respectively (Hair et al. 2017; Hair et al. 2013). Table 2, which contains the outcomes of the structural model evaluation, displays that the psychological capital of external auditors positively influences the reliance on internal auditors. To be more precise, pathways coefficients of 0.562, 0.515, 0.482, and 0.597 with corresponding t-values of 10.841, 11.461, 11.250, and 11.769, respectively, support H1, H2, H3, and H4 at $P < 0.01$. These findings indicate that the dimensions of psychological capital, namely resilience, optimism, hope, and self-efficacy, positively influence external auditors' reliance upon internal auditors.

Hypothesis	Path	Path coefficient	T-value	P-value	H supported?
H1	HO → RD	0.562	10.841	0.000	Yes
H2	SE → RD	0.515	11.461	0.000	Yes
H3	OP → RD	0.482	11.250	0.002	Yes
H4	RE → RD	0.597	12.769	0.010	Yes

Table 2. Results of structural model evaluation
Note: HO = hope; RE = resilience; SE = self-efficacy; OP = optimism; RD = external auditors decision to rely on internal auditors
Source: Own

4. DISCUSSION

The primary objective of this study was to examine the degree to which external auditors' reliance upon internal auditors is influenced by the psychological capital dimensions, specifically self-efficacy, optimism, hope, and resilience. The empirical results provide support for all proposed hypotheses. More precisely, each component of psychological capital was found to be positively linked with external auditors' assessments of internal auditor quality aspects and their willingness to incorporate internal audit work as part of the external audit process. In addition, the model's predictive power analysis demonstrated that the psychological capital dimensions collectively account for a substantial proportion of the variance in external auditors' intentions to either utilise previously completed internal audit work or directly engage internal auditors during the external audit. Resilience emerged as the most influential dimension of psychological capital, positively affecting external auditors' reliance upon internal auditors. The result can be explained by resilience's ability to help external auditors unlock the hidden value of human capital in the audit setting by enabling them to manage the uncertainties and difficulties that come with depending solely on internal audit work. Furthermore, experience and flexible reactions to unfavourable circumstances build resilience, which enables external auditors to go beyond traditional performance standards and participate in creative auditing techniques and constructive deviation.

According to the study, effective reliance necessitates more than just innate technical proficiency; these skills must be combined with an innate feeling of self-efficacy and an optimistic view of possible results. The findings also propose that external auditors' tendency to rely upon internal auditors may be further explained by their optimistic and positive moods. This is because optimistic people believe that they or others can work together to achieve success in the future. As a result, people are more inclined to take chances and investigate novel strategies for handling challenging problems. Hope-filled people remain confident in their skills, stay motivated, and put forth consistent effort while also having faith in others to help achieve common objectives.

CONCLUSION

The primary conclusion of the current study is that the psychological capital of external auditors has a positive impact on their dependence on internal auditors, which enhances the process's overall efficacy and efficiency. By emphasising the psychological capital's positive function in enhancing the relationship among internal and external audit functions, the findings offer insightful information to a number of stakeholders, including governance structures, internal audit functions, and external auditors. These stakeholder groups play a crucial role in determining how much internal auditors contribute to the external audit, which eventually improves the audit's efficiency. The study outcomes also highlight how vital it is to offer external auditors the tools, instruction, and institutional support they need to develop and maintain an elevated level of psychological capital. Such investment promotes a collaborative audit atmosphere and enables more effective professional judgements. Furthermore, the results might be useful to academics and professionals working on theoretical frameworks or multifaceted measurement models that attempt to evaluate the extent of reliance made by external auditors upon internal auditors using a thorough and organised approach.

Although the present study makes an important addition to the corpus of knowledge already in existence, it has several shortcomings, many of which present chances for further investigation. The development of the hypotheses established the theoretical foundations for the connections among psychological resources and external auditors' reliance upon internal auditors; however, the empirical testing required the use of several latent constructs, which are inferred from indicators and are by nature unobservable. This study assessed the individual effects of each psychological capital component separately. As such, future research could advance this work by modelling psychological capital as a higher-order latent construct, thereby enabling a more holistic examination of its aggregated effect on reliance decisions. Additionally, further investigation may explore the relationships between each psychological capital sub-dimension and external auditors' reliance behaviours, possibly through a moderated or mediated model based on the conceptual foundations established herein. The data for the current investigation were gathered

exclusively from external auditors auditing companies operating in Jordan and listed on the Amman Stock Exchange. While various characteristics of Jordan's institutional and economic context reflect broader conditions in other developing countries, suggesting some degree of generalisability, the applicability of these findings to more developed economies remain uncertain. Therefore, future research is encouraged to replicate and extend the current model in more advanced economic settings to assess the consistency and transferability of the observed relationships across different regulatory, cultural, and institutional environments.

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Revisiting the link between trade openness and economic growth in Saudi Arabia: a nonlinear ARDL approach

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ABSTRACT

This research investigates the effect of trade openness on Saudi Arabia's economic growth from 1970 to 2022. The main goal is to determine whether the relationship between trade openness and growth is nonlinear and how trade liberalization impacts long-term economic performance. To achieve this, the study utilizes the Nonlinear Autoregressive Distributed Lag (NARDL) model, which differentiates between positive and negative shifts in trade openness and their asymmetric influences on GDP growth. The hypothesis being tested suggests that increasing trade openness, particularly through rising exports, boosts economic growth, while trade restrictions can have negative consequences.

The empirical evidence supports a notable long-term nonlinear connection between trade openness and economic growth. In particular, the findings reveal that positive shocks to trade openness affect GDP growth more strongly and persistently than negative shocks. Additionally, the research indicates that gross capital formation positively and significantly influences economic development, underscoring the importance of domestic investment. In contrast, foreign direct investment and higher education enrollment exhibit a negative correlation with growth, pointing to structural challenges linked to labor market issues and the alignment of the educational system.

These findings highlight the critical importance of trade liberalization in promoting economic growth in Saudi Arabia and endorse policy suggestions designed to further minimize trade barriers. The study also emphasizes the need to reform educational outcomes to better match labor market needs, especially in technical and professional fields. Addressing these discrepancies is essential for improving human capital productivity and realizing the goals outlined in Saudi Arabia's Vision 2030.

INTRODUCTION

Trade openness is a crucial driver of economic growth, particularly in developing countries. An increase in trade openness means the ability to access and integrate the latest technologies, thereby improving competitiveness and promoting growth (Hye et al., 2022; Iamsiraroj, 2015; Jouini, 2014; Lawal et al., 2016; Madsen, 2009; Makki & Somwaru, 2004; Musila & Yiheyis, 2015; Nannicini & Billmeier, 2011; Singh, 2010; Wacziarg & Welch, 2008). Additionally, a higher volume of trade generates capital formation, a crucial step in the production process within the economy (Sriyana & Afandi, 2020). As the world economy becomes more integrated, the global trading system evolves into a more progressive and competitive one. International trade promotes economic growth through some channels. First, introducing new technological innovations will increase productivity, as it will increase demand for outputs, leading to higher levels of income per capita. Second, it generates capital formation as a crucial step in the production process of the economy (Sriyana & Afandi, 2020).

This finding aligns with the views of Neoclassical economists, who confirm that trade growth is a key driver of economic growth, often referred to as the "engine of growth." They also emphasize the strong relationship between trade and economic growth. Therefore, an open economy has a greater impact on promoting economic growth compared to a closed economy (Raghutla, 2020). The empirical evidence regarding the effect of trade openness on economic growth remains inconclusive and mixed. The prevailing consensus in the literature found a positive and significant relationship between trade openness and economic growth; however, some studies suggest that this positive relationship may be conditional on various factors, including the measurement of trade openness, the quality of exports, human capital accumulation, income level, and the level of development, among other institutional factors (Fetahi-Vehapi et al., 2015; Haddad et al., 2012; Huchet, 2017; Keho, 2017; Kim and Lin (2009); Kim et al., 2011; Yanikkaya, 2003). These conditions mean that some countries may experience a negative impact on economic growth due to the lower quality of their exports. Trade openness subjects the country to an external source of volatility in economic growth, particularly in less-developed countries (Giovanni & Levchenko, 2009).

Studies on the relationship between trade openness and growth employ various econometric approaches and methodologies, which can influence the conclusions. Most studies used panel data analysis utilizing different methodologies such as Generalized Method of Moments (GMM), Autoregressive Distributed Lag (ARDL) cointegration, and instrumental variable threshold regressions (Fatima et al., 2020; Sarkar, 2008; Giovanni and Levchenko (2009); Yanīkkaya, 2003; Makki & Somwaru, 2004; Keho, 2017; Kim et al., 2011; Dowrick and Golley, 2004 Kim and Lin, 2009; Fetahi-Vehapi et al., 2015; Lawal et al.,2016; Huchet et al., 2017; Jouini, 2014). Others used time series analysis (Belloumi, 2014; Musila & Yiheyis, 2015) or synthetic control methods (SCMs) (Nannicini & Billmeier, 2011).

This study examines the impact of trade openness and other key economic factors— including foreign direct investment, gross capital formation, and higher education enrollment—on economic growth in Saudi Arabia. Utilizing annual data from 1970 to 2022, this study employs the Nonlinear Autoregressive Distributed Lag (NARDL) model to investigate whether the relationship between trade openness and economic growth is asymmetric. While previous research on Saudi Arabia has predominantly analyzed this relationship under the assumption of symmetry, this study offers a novel contribution by focusing on potential asymmetries. It provides a perspective on the dynamics of trade openness and its differentiated effects on economic growth. The research questions can be summarized as follows:

Q1: What is the nature of the long-term relationship between trade openness and economic growth in Saudi Arabia?

Q2: To what extent does trade openness have an asymmetric impact on long-term economic growth in Saudi Arabia?

This study proposes the following hypotheses to examine the long-term relationship and the potential asymmetric effects of trade openness on economic growth:

H1: A long-term relationship exists between economic growth and trade openness in Saudi Arabia.
H2: There is an asymmetric effect of trade openness on long-term economic growth in Saudi Arabia

The remainder of this paper is organized as follows. Section 1 reviews the relevant literature. Section 2 provides an overview of Saudi Arabia's economy and trade policy. Section 3 describes the data, defines the variables, and presents the empirical analysis. Section 4 summarizes the main empirical findings. Finally, the study concludes, discusses its limitations, and outlines directions for future research.

1. LITERATURE REVIEW

Developing economies must rely on trade to access international markets, leverage technology, and attract investment. Trade openness provides an incentive for higher productivity levels and competition. Regarding comparative advantage theory, which is based on the work of economist David Ricardo, who demonstrated that countries benefit from trade when they specialize in producing goods in which they have a comparative advantage. This specialization enhances production efficiency, leading to increased GDP. Additionally, trade-opened countries can better allocate resources and specialize in areas where they are most productive, generating a higher level of output and economic growth (Krugman, 2009). Concerning Endogenous Growth Theory, this theory asserts that international trade contributes to the accumulation of human capital, the transfer of technology, and the promotion of innovation by integrating the economy into global markets (Grossman & Helpman, 1993).

Classical neoclassical growth models, such as the Solow-Swan model, have demonstrated that the accumulation of capital, labor, and technology is a key driver of economic growth. International trade enhances this process by providing access to capital goods and advanced technologies, thereby increasing productivity and accelerating economic growth. Trade openness also facilitates the transfer of technology from developed to developing countries, which enhances production efficiency. Through access to advanced technology and capital goods, the productivity of labor and capital increases, resulting in faster economic growth (Barro & Sala-i-Martin, 2004).

In conclusion, the theoretical framework indicates that trade openness can significantly contribute to economic growth by enhancing efficiency, innovation, and access to international capital. However, the benefits depend on complementary factors, such as strong institutions, sound macroeconomic policies, and competitive markets (Frankel & Romer, 2017).

In empirical studies, many have examined the relationship between trade openness and economic growth, yielding conflicting or at best mixed results. Some studies have found a positive relationship, while others have found a negative one. We will review a group of studies that have shown a positive relationship between trade openness and economic growth. For instance, Jabbar et al. (2024) examined the Impact of Financial Development and Trade Openness on economic growth in Luxembourg from 1980 to 2020 using the ARDL model. The study finds that trade openness, financial development, and capital stock have a significant and positive impact on Luxembourg's economic growth. Trade openness is the strongest driver of economic growth, followed by financial development and capital stock Kurteš et al. (2023) examined the relationship between trade openness and human capital as explanatory variables, and GDP as the dependent variable, in a sample of eight Balkan countries from 2000 to 2019. They collected panel data, testing both a panel model with fixed effects and a panel model with random effects. The results showed a positive impact of trade openness and human capital on GDP. Oppong-Baah et al. (2022) reviewed the impact of trade openness on economic growth in Ghana and Nigeria, using the Pooled OLS, Fixed Effects (FE), Random Effects (RE), and Hausman tests from 1998 to 2017. The Pooled OLS results show that trade openness has a significant impact on economic growth.

Additionally, based on the fixed effects (FE) test, evidence suggests that trade openness has a significant impact on economic growth. Furthermore, trade openness has a positive and significant impact on economic growth, as indicated by the random effects (RE) test. In summary, openness to trade and

economic growth in Ghana and Nigeria have a significantly positive impact. Jalil et al. (2021) revisited the trade-growth nexus using heterogeneous panel methods that account for cross-sectional dependence and endogeneity in 82 countries, which employ different measures of trade openness from 1960 to 2017. The econometric results support the idea that trade openness induces economic growth.

Mallick and Behera (2020) confirm the evidence of asymmetric cointegration between economic growth and trade openness in India from 1960 to 2018. Amna Intisar et al. (2020) investigated the impact of trade openness and human capital on economic growth in Asia for 19 countries from Western Asia and Southern Asia, spanning the period 1985 to 2017. The study employed fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) models. The study revealed a significant and positive relationship between trade openness and human capital, as well as their impact on economic growth. Raghutla (2020) investigated the impact of trade openness on economic growth in a panel of five emerging market economies from 1993 to 2016. The results showed that trade openness plays a positive and substantial role in promoting economic growth while also fostering economic development in these five emerging market economies. Wiredu et al. (2020) reviewed the relationship between Trade openness and foreign direct investment on economic growth for a panel of four countries (Côte d'Ivoire, Ghana, Nigeria, and Senegal) from 1998 to 2017. They concluded that trade openness, investment, and inflation do have a positive and significant impact on economic growth.

Malefane et al. (2018) examined the impact of trade openness on economic growth in South Africa using the autoregressive distributed lag (ARDL) for the period 1975-2014, by using four proxies of trade openness, the first proxy of trade openness is derived from the ratio of trade to gross domestic product, the second proxy is the ratio of exports to GDP, while the third proxy is the ratio of imports to GDP and the last proxy is an index of trade openness. The study concluded that trade openness has a positive and significant impact on economic growth when the ratio of total trade to GDP is used as a proxy; however, this effect is not observed when the three other proxies are employed. However, in the short run, when the first three proxies of openness are used, the study finds that trade openness has a positive impact on economic growth; however, this is not the case when the trade openness index is employed. Yakubu et al. (2018) examined the impact of openness on economic growth in Nigeria, using GDP as the dependent variable and degree of openness, foreign exchange, and per capita income as independent variables for the period 1981-2017. The study concludes that openness had a positive impact on economic growth in Nigeria. Iyoha and Okim (2017) analyzed the impact of trade on economic growth for the 15 ECOWAS countries using panel data regression analysis from 1990 to 2013. The study concluded that trade had a significant positive impact on economic growth in ECOWAS countries.

Some studies have also shown a negative impact of trade openness on economic growth. Rasoanomenjanahary et al. (2022) examined the relationship between trade Openness and economic growth in Madagascar from 1993 to 2020 using different econometric methods. Studies concluded that trade openness harms economic growth in Madagascar. Additionally, Adu-Gyamfi et al. (2020) examined the impact of trade openness and inflation on GDP growth for nine West African countries, employing pooled Ordinary Least Squares (OLS), Fixed Effects, and Random Effects tests with panel data for the period from 1998 to 2017. The results showed that Trade Openness has a significant and negative impact on GDP, using the pooled OLS, but an insignificant impact using the fixed and Random effects tests. In addition, Bendjelloul et al. (2021) sought to investigate the long-term causal relationship between trade openness and economic growth in Algeria using the TYDL methodology from 1990 to 2018. The study found that Algeria's economic growth does not benefit significantly from trade openness, particularly given its unitary export structure. Additionally, Malefane et al. (2021) investigated the dynamic impact of trade openness on economic growth in Lesotho using the autoregressive distributed lag (ARDL) model from 1979 to 2013. The study found that trade openness has no significant impact on economic growth in both the short and long run.

There are also some studies shown that the relationship between trade openness and economic growth depends on the quality of products as Huchet-Bourdon et al. (2018) studded the links between trade openness and economic growth Based on the estimation of an endogenous growth model on a panel of 169 countries between 1988 and 2014 using a generalized method of moments estimator. The study's results

indicated that trade openness has a positive impact on economic growth when countries specialize in producing high-quality products. In contrast, trade openness hinders economic growth when countries specialize in producing low-quality products. While other studies have shown that the relationship between trade openness and economic growth depends on the progress of countries in adopting technology, Kim et al. (2012) investigated the impact of foreign trade openness on economic growth using panel data for 61 countries from 1960 to 2000. The study revealed that trade openness has a positive impact on economic prosperity in more technologically advanced countries, whereas trade openness hinders growth in countries with the opposite characteristics.

Examining the literature review helps discern the complex relationship between trade openness and economic growth. Although some studies have found a positive association, others have found that the effectiveness of trade openness as a driver of economic growth is affected by contextual factors. There is a need for an improved understanding that takes into account the country's unique economic and export structure. Further research should observe the various pathways through which trade openness affects economic outcomes and the effect of other development variables.

2. THE RELATIONSHIP BETWEEN TRADE OPENNESS AND ECONOMIC GROWTH IN SAUDI ARABIA

Historically, Saudi Arabia has maintained several international trade agreements and embraced a trade openness approach to drive economic growth. This approach means implementing substantial economic reforms and lowering tariffs long before it accedes to the World Trade Organization (WTO) in 2005. During this lengthy accession process, numerous complex economic and geopolitical circumstances had the potential to alter national priorities and disrupt the reform trajectory (Ghulam, 2012). Nevertheless, the Kingdom has progressively adopted economic liberalization, thereby enhancing its access to international markets and attracting foreign investment (Aliedan, 2022).

Saudi Arabia has continued this trajectory; however, it has recently been marked by increasingly ambitious objectives. Since 2016, the Kingdom has initiated the implementation of a comprehensive reform plan titled Saudi Arabia's Vision 2030. This initiative establishes ambitious goals aimed at diversifying the national economy and reducing dependence on crude oil, thereby promoting sustainable growth. As one of the major global producers and exporters of crude oil and petrochemicals, its substantial oil dependency makes the nation particularly susceptible to fluctuations in energy markets (Saudi Arabia, 2024). This vulnerability is one of the main drivers of Saudi Arabia's Vision 2030. This is particularly evident in the goal of increasing the share of non-oil exports in non-oil GDP from 16% in 2016 to 50% by 2030, with a current achievement of 24.1% as of 2023 (Vision 2030, 2016; Vision 2030 (Annual Report, 2023). In addition, the kingdom is actively planning to exploit its distinctive geographic positioning as a vital trade route by implementing advancements in logistics. This initiative is expected to enhance the flow of goods through the kingdom, benefiting from the effects of trade liberalization.

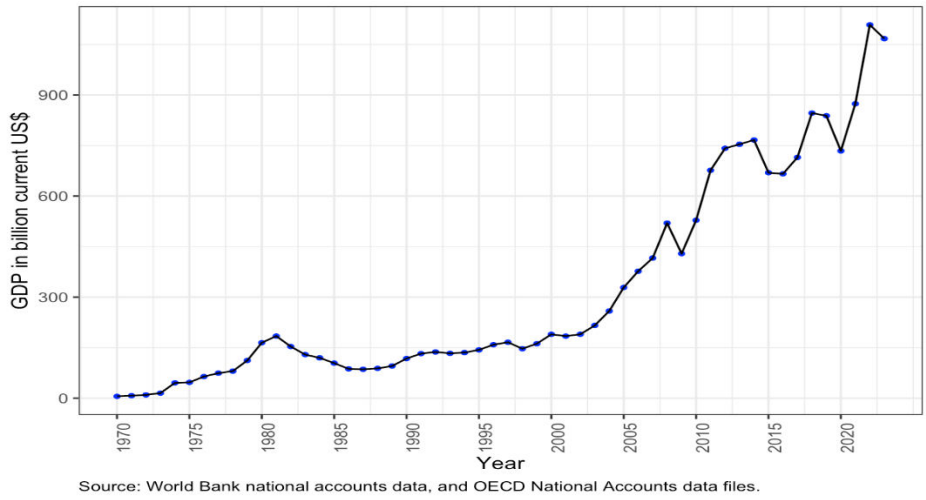

Figure 1. GDP in Billion Current US Dollars from 1970 to 2023

Figure 2. Trade Openness in Saudi Arabia from 1970 to 2023

3. DATA AND METHODOLOGY

3.1 Data description

The study utilizes annual time series data spanning 1970–2022, employing the Nonlinear Auto Regressive Distributed Lag (NARDL) model applied to Saudi Arabia. All data are sourced from the World Development Indicators, published by the World Bank. The primary dependent variable is economic growth, which the study employs a simple production function to analyze, in addition to traditional inputs (capital and labor). The study also incorporates independent variables such as trade openness and foreign direct investment. The study chooses these variables based on previous studies by Mallick & Behera (2020), Syriana & Afandi (2020), and Regula (2020). The data description is presented in Table 1.

Table 1. Data description

Variables	Definition	Abbreviation	Unit
Dependent Variable			
Economic growth	Annual GDP growth	GDPGR	%
Independent Variables and Controls			
Trade openness	The total volume of exports & imports of goods & services	TRADE	% of GDP

Foreign direct investment	Net inflows of foreign direct investment	FDI	% of GDP
Gross capital formation	Gross capital formation	GCF	% of GDP
Enrollment in higher education	Enrollment in higher education	ENR	% of total

Source: Own

Table 2 presents the descriptive statistics for the variables used in the study. The variables generally exhibit normal distributions, supporting the validity of parametric statistical techniques for subsequent empirical analysis.

Table 2. Descriptive statistics of the variables

	Lngdpgr	LnGCF	LnENR	LnFDI	LnTRADE
Mean	1.554799	20.95788	2.952848	-0.123321	4.301838
Median	1.545464	21.21729	2.981126	0.057568	4.313471
Maximum	4.071542	29.99077	4.187729	1.260167	4.565417
Minimum	-0.582106	8.834236	0.464306	-2.111903	4.026929
Std. Dev.	1.070287	4.278270	0.904622	0.978308	0.172326
Skewness	0.189550	-0.577232	-0.820732	-0.511084	-0.077356
Kurtosis	2.966944	3.618117	3.522191	2.309729	1.653396
Jarque-Bera	0.150843	3.786972	3.090717	1.584689	1.913831
Probability	0.927353	0.150546	0.213235	0.452782	0.384076

Source: prepared by authors. Using EViews 12

3.2 Model Specification

This study explores the existence of an asymmetric effect, or nonlinear relationship, between trade openness and economic growth. Analyzing this asymmetric effect enables a distinction between the impacts of increasing and decreasing trade openness on economic growth. Most previous studies utilized the ARDL model to investigate the linear relationship between trade openness and economic growth. However, according to Shin, Yu, and Greenwood-Nimmo (2014), the NARDL model accounts for partial sums of decompositions, thus capturing the long-run relationship between dependent and independent variables. This relationship can be formally expressed as follows:

$$GDPGR = f(ENR, GCF, TRADE, FDI)$$

To understand the relationship between trade openness and economic growth, as shown in Equation 1. The Cobb-Douglas Production function was modified into an expanded trade production function and estimated econometrically using NARDL.

$$GDPGR_t = ENR_t^{\beta_1} GCF_t^{\beta_2} TRADE_t^{\beta_3} FDI_t^{\beta_4} \quad (1)$$

Taking the natural logarithm of all variables in Equation (1) yields Equation (2):

$$LnGDPGR_t = \beta_1 LnENR_t + \beta_2 LnGCF_t + \beta_3 LnTRADE_t + \beta_4 LnFDI_t + U \quad (2)$$

For applying NARDL many Steps were performed, first, determine the stationarity of the series based on augmented Dicky- Fuller (ADF) and Philips Perron (PP), the hypothesis of this test:

$$H0: \sigma = 0 \ (unit\ root\ /not\ stationery)$$
$$H1: \sigma \neq 0 \ (no\ unit\ root\ /\ stationery)$$

If the null hypothesis is not rejected, the series is deemed non-stationary; if it is rejected, the series is deemed stationary. If a series is non-stationary at the level, first differencing is applied to convert it to a stationary series (Shaari, 2014). The NARDL model is suitable when the variables are integrated in

different orders, specifically a combination of I(0) and I(1) series. If any variable is integrated of order I(2), the NARDL model cannot be applied. One of the primary advantages of the NARDL model is its ability to handle variables of different integration orders, as long as none are I(2).

After checking for stationarity, we must decompose the Independent Variable, LnTRADE, into its positive and negative partial sums to capture the asymmetric effects of increases and decreases in trade openness on economic growth.

Positive partial sum of $LnTRADE$:

$LnTRADE^{+}$= Sum of all positive changes in $LnTRADE$
$LnTRADE^{+} = \max \sum(\Delta LnTRADE, 0)$

This explores the cumulative effect of increases in $LnTRADE$[insert relevant variable].

Negative partial sum of $LnTRADE$:

$LnTRADE^{-}$= Sum of all negative changes in $LnTRADE$
$LnTRADE^{-} = \min \sum(\Delta LnTRADE, 0)$

This explores the cumulative effect of a decrease in $LnTRADE$. A positive change may have a different magnitude of impact than a negative change, by splitting the trade openness variable into two components—one that indicates positive changes and the other that expresses negative changes (Ghazouani, 2021; Turay et al., 2022). The previous connection can be represented in its non-linear form as shown in equation (3).

$$\begin{aligned}\Delta LnGDPGR_t \; = C_0 + \sum_{i=1}^{p} \gamma_{1i}\, \Delta\, LnGDPGR_{t-i} + \sum_{i=1}^{q1} \gamma_{2i}\, \Delta\, LnENR_{t-i} \; + \sum_{i=1}^{q2} \gamma_{3i} \Delta\, LnGCF_{t-i} \\ + \sum_{i=1}^{q3} \gamma_{4i}\; \Delta\, LnFDI_{t-i} + \sum_{i=1}^{q4} \gamma_{5i}\; \Delta\, LnTRADE^{+}_{t-i} \; + + \sum_{i=1}^{q5} \gamma_{6i}\; \Delta\, LnTRADE^{-}_{t-i} \\ + \beta_1 LnGDPGR_{t-i} \; + \beta_1 LnENR_{t-i} + \beta_2 LnGCF_{t-i} \; + \; \beta_3 LnFDI_{t-i} \\ + \beta_4^{+} LnTRADE^{+}_{t-i} \; + \beta_5^{-} LnTRADE^{-}_{t-i} \; + \; U \quad (3)\end{aligned}$$

Where Δ denotes the first difference operator, γ_{1i} to γ_{5i} represent the short-term dynamic coefficients of the corresponding variables with lag lengths p, q_1, q_4, respectively. The coefficients β_1 to β_5 capture the long-term relationship among the variables in the cointegrating set, while U denotes the error term (Cahyono, 2025).

A NARDL model is divided into long-run and short-run equations (Degu et al, 2023). To examine the existence of a cointegration relationship, the bounds test is used to capture the short-run dynamics. We will estimate a restricted Error Correction Model (ECM):

$$\begin{aligned}\textstyle\sum_{i=1}^{p} \gamma_{1i}\, \Delta\, LnGDPGR_{t-i} + \sum_{i=1}^{q1} \gamma_{2i}\, \Delta\, LnENR_{t-i} \; + \sum_{i=1}^{q2} \gamma_{3i} \Delta\, LnGCF_{t-i} \; + \sum_{i=1}^{q3} \gamma_{4i}\; \Delta\, LnFDI_{t-i} + \\ \textstyle\sum_{i=1}^{q4} \gamma_{5i}\; \Delta\, LnTRADE^{+}_{t-i} \; + \; + \sum_{i=1}^{q5} \gamma_{6i}\; \Delta\, LnTRADE^{-}_{t-i} \; + \psi\, EC_{t-1} \; + \mu_t \quad (4)\end{aligned}$$

The Wald test verifies the presence of an asymmetric (nonlinear) relationship between the variables (Hossain et al., 2021).

The null hypothesis for the Wald test:

$$Ho: 0^{+} = 0^{-} \quad \text{(No asymmetry)}$$

If the null hypothesis is rejected, it indicates that the impact of trade openness on economic growth is asymmetric.

Several diagnostic tests are performed to ensure the robustness and reliability of the estimated model, including LM test, the Breusch-Pagan-Godfrey heterogeneity test, as well as the Jarque-Bera Test for the normal distribution of the residuals, and the Ramsey test finally CUSUM test to examine the stability of the model (Wadström, et al, 2023)

4. EMPIRICAL RESULTS AND DISCUSSION

4.1 Unit root test

After taking the first difference, the Unit Root test results show that the GDP growth rate (GDPGR), trade openness (TRADE), and energy (ENR) become stationary. The findings of the ADF and PP tests in Table 3, on the other hand, demonstrate that gross capital formation (GCF) and foreign direct investment (FDI) are stationary at the level.

Table 3. Unit root test

Variables	ADF		PP	
Intercept	At level (0)	At first difference (I)	At level (0)	At first difference (I)
LnGDPGR	0.1969	0.0000	0.4297	0.0000
LnTRADE	0.1116	0.0000	0.1354	0.0000
LnFDI	0.0001	--------	0.0001	-------
LnGCF	0.0000	--------	0.0000	--------
LnENR	0.4430	0.0000	0.4238	0.0000
trend & Intercept				
LnGDPGR	0.8219	0.0058	0.5632	0.0002
LnTRADE	0.1417	0.0000	0.1632	0.0000
LnFDI	0.0002	-------	0.0002	--------
LnGCF	0.0397	--------	0.0001	---------
ENR	0.0010	--------	0.0002	---------
None				
LnGDPGR	0.6861	0.0000	0.6799	0.0000
LnTRADE	0.5932	0.0000	0.5850	0.0000
LnFDI	0.0000	-------	0.0000	--------
LnGCF	0.7729	0.0000	0.3525	0.0000
LnENR	0.4629	0.0000	0.4629	0.0000

Source: Author using EViews 12

4.2 NARDL Estimates

Table 4. NARDL Estimates

Panel A: Short-run estimates

Variable	0	1	2
GCF		-0.0008	-0.0085***
LENR	-0.0047		
FDI	-0.0074	0.0255***	0.0207***

Panel B: Long-run estimates

C	GCF	LENR	LTRADE_POS	LTRADE_NEG	FDI

10.85* **	0.031***	-0.252***	0.708***	0.378**	-0.197***

Panel C: Diagnostics

F bounds	ECt	Serial correlation	Jarque-Bera	Heteroskedasticity	Ramsey Test	Adj. R2
9.20* **	-0.2784***	0.93	0.672	0.95	0.90	0.70
AIC criteria	(1,2,1,0,0,3)					

Note: ***, **, and * indicate significance at the 1%, 5%, and 10%, respectively.
Source: Own

The optimal lag times for the NARDL model are 1, 2, 1, 0, 0, 3, as indicated in Table 4. The (AIC) criteria were used to choose this model. The computed F-statistic is greater than the crucial value of the upper limit at the 1% level of significance, based on the results of the cointegration test using the Bound test. As a result, the null hypothesis that there is no cointegration between the variables under consideration is rejected. This implies a long- term equilibrium relationship between the variables, allowing for the estimation of long- term relationships between them.

According to Panel B in Table 4, there exists a long-term relationship between trade openness and economic growth. This supports the acceptance of the study's first hypothesis. Furthermore, the findings provide evidence of an asymmetric long-run relationship between trade openness and economic growth, thereby confirming the second hypothesis. Specifically, positive shifts in trade openness significantly boost economic growth, suggesting that increased trade liberalization contributes to sustained economic expansion in Saudi Arabia. This is particularly evident as rising exports are associated with rising income levels, aligning with the findings of Akuffo (2012). Conversely, negative changes in trade openness exert a significant adverse effect on economic growth, which is consistent with Udeagha & Ngepah (2021). The analysis also reveals a significant negative long-term relationship between foreign direct investment (FDI) and economic growth, indicating that FDI inflows in Saudi Arabia have not effectively facilitated technology transfer or the development of productive sectors. This finding concurs with Akuffo (2012).

In addition, there is a negative and statistically significant relationship between higher education enrollment and long-run economic growth, consistent with Kamal (2020). Prior research, including Hanushek (2016), suggests that disparities in cognitive skills—or a nation's knowledge capital—account for much of the variation in economic growth across countries. Merely increasing schooling years, without enhancing cognitive capabilities, has historically shown a limited impact on growth outcomes.
On a more positive note, gross capital formation is positively and significantly linked to economic growth, highlighting the critical role of domestic investment in supporting economic expansion. This finding is in line with traditional neoclassical growth theory, which emphasizes investment as a primary engine of growth. As capital accumulation increases, so does a nation's production capacity, which in turn drives higher output levels (Sriyana & Afandi, 2020).

Diagnostic tests of the NARDL model (Panel C) support the validity of the estimation. The Jarque-Bera test yields a p-value of 0.672, indicating normally distributed residuals. The LM test fails to reject the null hypothesis, suggesting no serial correlation. Similarly, the Breusch-Pagan test produces a p-value of 0.9473, exceeding the 5% threshold, indicating no heteroskedasticity. Finally, the Ramsey RESET test confirms that the functional form of the model is correctly specified.

4.3 Wald test & multiplier graph

As reported in Table 5, the results of the Wald test for asymmetry confirm the presence of a significant long-term asymmetric relationship between trade openness and economic growth.

Table 5. Testing for Asymmetry

Test Statistic	Value	df	Probability
F-statistic	4.574715	(2, 37)	0.0168
Chi-square	9.149429	2	0.0103

Source: Author using EViews 12

Figure 3 reinforces the findings of the Wald test, illustrating an asymmetric relationship between trade openness and long-term economic growth, as depicted in the dynamic multiplier graph.

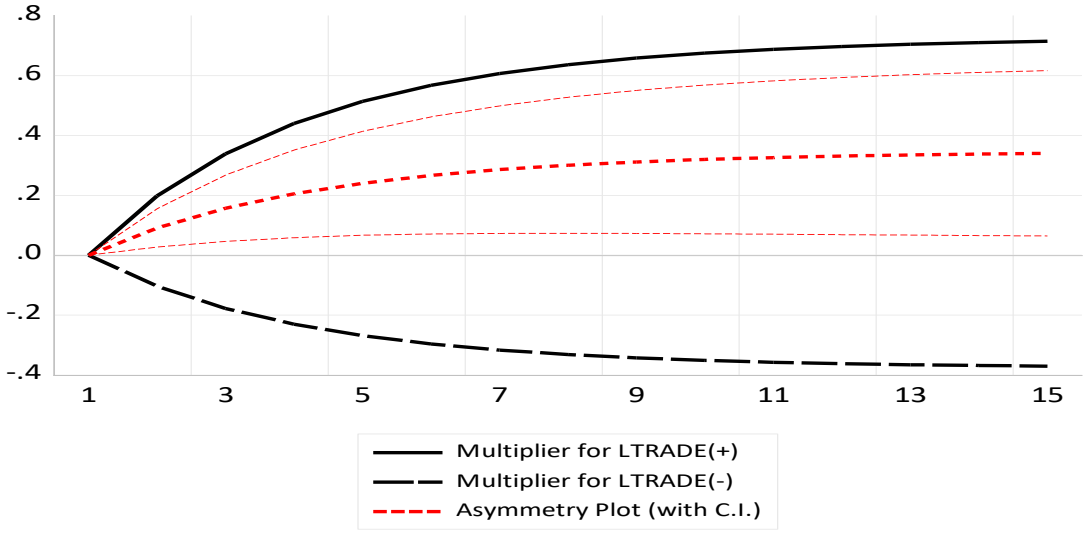

Figure 3. multiplier graph
Source: Author using EViews 12

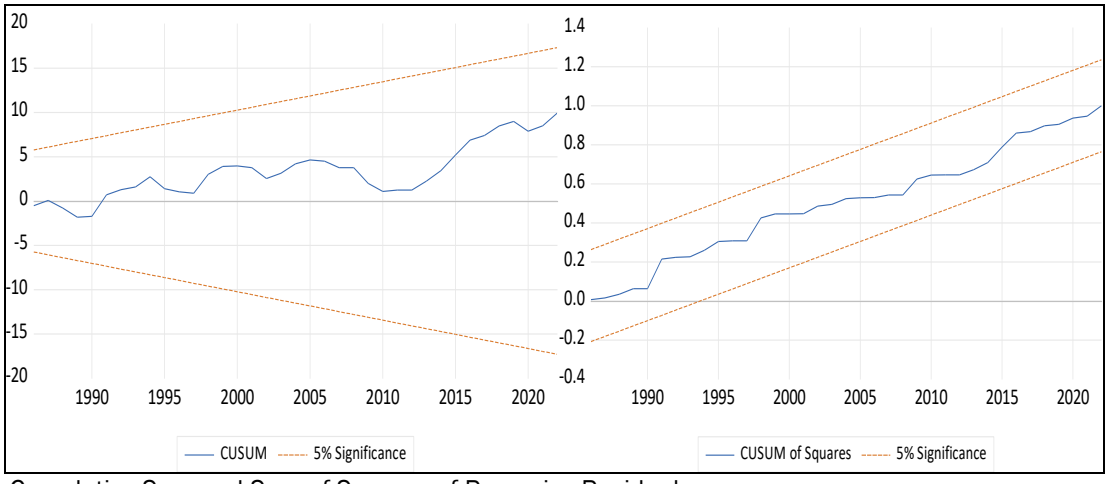

Figure 4. Cumulative Sum and Sum of Squares of Recursive Residuals
Source: Author using EViews 12

CONCLUSION

This study investigates the influence of trade openness on economic growth in Saudi Arabia over the period 1970 to 2022, utilizing the Nonlinear Autoregressive Distributed Lag (NARDL) model. The findings underscore the significant role of domestic investment and export expansion in driving economic growth within the country. Empirical evidence reveals the presence of a long-run asymmetric relationship between trade openness and economic growth. In light of these results, the study recommends strengthening Saudi Arabia's integration into the global economy as a strategic path to stimulate economic activity and boost growth performance. The positive effect of trade openness is primarily attributed to its ability to enhance trade flows, enable technology transfer, and improve productivity. Therefore, the study advocates for the adoption of open trade policies that encourage export growth, manage imports effectively, and support investment in high-value-added, export-driven industries.

Moreover, the research highlights the importance of attracting foreign direct investment (FDI), particularly through the development of skilled human capital and by channeling FDI into sectors that create tangible economic value. The success of FDI in contributing to growth depends not only on capital inflows but also on aligning investments with national development goals.

To enhance future analysis, the study recommends improving data collection on qualitative aspects of trade openness, including tariff structures, non-tariff measures, and trade- restrictive regulations. This would allow for more accurate assessments of openness and its economic impact.

Finally, the study encourages future research to expand the scope of analysis by incorporating a wider array of trade openness indicators or by exploring both linear and non-linear dynamics using alternative econometric approaches. These could include time series models for individual countries or panel data techniques applied to a group of countries. Further research is also needed to explore how trade openness influences sustainable development and contributes to poverty reduction.

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Price discovery and volatility spillovers in the Indian currency futures and spot markets: Before and during the COVID pandemic

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ABSTRACT

This research aims to examine the price discovery and volatility spillover effect in Indian currency spot and futures prices. The study uses minute-wise data of spot and futures prices of USD/INR traded on the National Stock Exchange (NSE), India. The sample data is divided into two sub-periods: pre-COVID-19 (August 1, 2019 to January 24, 2020) and COVID-19 (January 25, 2020 to August 31, 2020). Data is analysed using the Autoregressive Distributed Lag (ARDL) approach and multivariate MGARCH Diagonal VECH model. The ARDL results reveal a bidirectional causation between the two markets for both sample periods, with a greater lead of the spot market in price discovery. Further, the MGARCH model shows a two-way volatility spillover between the markets. The spillover effect from the currency spot to the futures market is more substantial during the prior outbreak of the COVID-19 pandemic. Results indicate no asymmetric effect in the volatility dynamics of spot and futures prices. The study suggests that the currency spot market contributes to price discovery and volatility spillover effects in the pre-and COVID-19 pandemic. These findings provide crucial insights for hedgers, arbitrageurs and speculators to form trading strategies that mitigate against downside risk in their investment portfolios.

INTRODUCTION

Futures markets serve as vital tools for hedging and price discovery. Hedging reduces risks from price fluctuations by offsetting losses in the spot market with futures profits, as both markets typically move together. Price discovery in futures reflects information from underlying markets, resulting in a temporal relationship between spot and futures prices. Determining how quickly one market reacts to new information originating from the other becomes crucial. It is widely viewed that the futures markets are

dominated by the price discovery mechanism due to the lower margin requirements and greater liquidity (Garcia et al. 2014). This helps hedgers take a competitive advantage over future prices and reduce risk. Furthermore, the new information is incorporated into spot prices faster than future prices (Rosenberg and Traub, 2007). The price discovery process would assist hedgers in formulating better trading and hedging strategies to manage risks against adverse price movements. Arbitrageurs can gain from short-term disequilibrium by exploiting the price discrepancy between the spot and futures markets. Speculators develop more profitable trading strategies, while regulators can implement corrective measures to enhance market integrity and efficiency.

Volatility spillovers between spot and futures markets play a crucial role in forecasting future volatility. The volatility spillover hypothesis posits that the volatility spillovers are coupled with asymmetries; a bad news shock in either market can increase volatility and its persistence in both markets (Tao & Green, 2012; Gkillas et al. 2021). Futures prices react to new information quickly during the price discovery process, leading to increased volatility in the underlying spot market price due to the arbitrage mechanism (Malhotra & Sharma, 2016). If the spot market is informationally efficient, spot price changes will increase volatility in the futures market. Therefore, volatility spillover serves as a significant source of information, enabling the examination of how volatility in the futures market affects the spot market or vice versa (Seghal et al., 2015). Besides, the various macroeconomic factors, including GDP growth, RBI rates, interest rates, trade balances, fiscal policies, and inflation, influence the spillover effects in currency derivatives markets. By considering these indicators, market participants can better understand the fundamental drivers of currency values, anticipate leading markets, and make informed trading decisions in currency derivatives markets (Chatrath and Song., 1998). Moreover, the price discovery process and spillover effects observed in the spot and futures markets necessitate the utilization of a volume-based sentiment index to justify the reactions of the market participants. Investor sentiment strongly influences the dynamics of these markets at any given moment (Corredor et al., 2015).

According to the RBI Bulletin (2020), the COVID-19 pandemic, much like previous episodes of extreme volatility in financial markets—such as the global economic crisis, the Eurozone crisis, and the Taper Tantrum—led to significant foreign exchange outflows from emerging markets, including India. In March 2020, India experienced unprecedented foreign portfolio investment outflows, amounting to US$15.92 billion across debt and equity instruments and led to increased volatility in the Indian Rupee (INR). Daily depreciation of upto 1 percent was observed multiple times during March 2020. Besides, the COVID-19 pandemic has triggered unprecedented disruptions in global trade, leading to currency depreciation due to market sentiments in India (Padhan & Prabheesh, 2021). The continuous weakening of the US Dollar/INR due to COVID-19 has raised investor concerns about the dynamics of the price discovery process and spillover effect of currency futures and spot markets in India. Understanding the periodic nature of price discovery and volatility spillover effects is essential for market participants, particularly in assessing the direction of information transmission between spot and futures prices. Moreover, analyzing the dynamics of these markets during the pre-COVID and COVID pandemic periods is crucial for regulators and policymakers to respond to any future pandemic. This research adds to the body of knowledge in several ways. First, the study explores price discovery and volatility spillover effects of the Indian currency market using minute-by-minute data. It provides fresh insights into the existing domain of scholastic literature, apart from contributing to the policy dimension of price risk management to facilitate market participation. Second, unlike other studies, the research has considered the macroeconomic news announcements and market sentiment factors to explore a clear connection between the price discovery mechanism of currency spot and futures markets of USD/INR. To our knowledge, this is the first study to explore the price discovery and volatility spillover effects of spot and futures market prices for the two intervals, i.e. pre-COVID and COVID periods. Moreover, the study employed an asymmetric Multivariate GARCH model to examine the existence of volatility persistence and asymmetric effects and to discriminate the effects of positive and negative news for both sample periods.

In regard to this, the study is organized as follows: Section 2 provides the literature review. Section 3 describes the data and methodology. Section 4 outlines the results and discussion, and the final section concludes the paper.

1. LITERATURE REVIEW

1.1 The theoretical framework

Efficient market theory postulates that all available information is promptly incorporated into asset prices. Thus, any new information arrivals in the market should be reflected simultaneously in both spot and futures prices. This situation results in perfect positive contemporaneous comovement between the two markets, eliminating arbitrage opportunities. Accordingly, the Cost of Carry (COC) futures pricing model postulates that.

$$F_t = S_t e^{(r-y)(T-t)} \quad (1)$$

where Ft is the futures price at time t, St is the spot price at time t, r is the interest rate foregone while carrying the underlying asset, y is the dividend yield and T − t is the remaining life of the futures contract. A no-arbitrage assumption justifies equation (1) since $F_t > S_t e^{(r-y)(T-t)}$ would enable investors to profit by selling futures and buying stocks. $S_t e^{(r-y)(T-t)} > Ft$ would allow profits by buying futures and short-selling stocks. The underlying assumptions are that both the futures and spot markets operate with perfect efficiency and that transaction costs are nonexistent. This simplified model also assumes that interest rates and dividend yields remain constant throughout the futures contract. However, market frictions—such as transaction costs, margin requirements, short-sale constraints, differences in liquidity, and non-synchronous trading—can create a lead-lag relationship between the futures contracts and their underlying spot markets. Therefore, the price discovery mechanism revolves around whether new information reflects changes in futures or spot prices. The dissemination of information establishes a lead-lag relationship between the spot and futures markets.

The futures market leads the spot market due to its advantages, including higher liquidity, lower transaction costs, lower margins, ease leverage positions, rapid execution and greater flexibility for short positions. Such advantages attract informed traders and make the futures market more responsive to market-wide or major firm-specific information. Thus, futures prices will lead to spot market prices. Moreover, the benefits in the futures market will attract larger speculative traders from a spot market and reduce informational asymmetries. This results in better price discovery by lowering the noise trading and improving the market depth, efficiency, and liquidity. This makes the spot market react first when market-wide information or major information arrives. Besides, there is a possibility for the bidirectional causality between futures and spot prices, with spot to futures market prices or vice versa, signifying that both spot and futures markets respond simultaneously to new information.

1.2 Empirical literature review

Prior studies have documented the dominance of futures markets in the price discovery mechanism, highlighting that futures prices often lead to spot prices across various currency pairs. Hong (2010) found that futures markets lead spot markets for several currencies, including the British Pound, Australian Dollar, Canadian Dollar, Brazilian Real, and Won/Dollar, with a robust effect of currency futures on spot markets. Sehgal et al. (2015) and Kharbanda and Singh (2017) showed that futures prices tend to precede the movements in the spot prices in the short run for currencies, viz. British Pound, Euro, US Dollar, and Japanese Yen against the Indian Rupee. The GARCH-BEKK model results confirmed short-term volatility transmission from futures to spot prices, with longer-term volatility transmission from spot to futures markets. Sharma and Chotia (2019) demonstrated unidirectional causality from futures to spot markets for currencies, including the Euro, British pound and Yen against the Indian rupee, reinforcing the role of futures in price discovery. Koilada and Sk (2019) found that futures prices lead the spot prices for USD/INR, GBP/INR, and EUR/INR, whereas for JPY/INR, the spot market led the futures market. Kaur et al. (2020) confirmed that futures markets lead spot markets for GBP/INR and EUR/INR, with bidirectional causality observed in the case of JPY/INR, supporting the idea that futures markets are crucial in the process of price discovery for some currencies. Devan et al. (2022) found that spot price is led by future price, thus contributing substantially to the price-discovery process in the Indian Foreign Exchange Market.

In contrast, the authors have found evidence that spot markets lead futures markets, indicating that spot prices contribute more prominently to the price discovery process for certain currencies. For example, Sharma (2011) suggested that the spot market influences the futures market for USD/INR, providing further support for the lead of spot markets in some cases. Raghavendra and Velmurugan (2013) found that the spot market influences the futures market in GBP/INR, suggesting that the spot market plays a leading role in price discovery. Sriram and Senthil (2013) showed a one-way causality and volatility flowing from the spot market to futures prices for GBP/INR and JPY/INR. Chen et al. (2016) studied price discovery between spot and futures rates for the EUR–USD and JPY–USD markets and found that the spot rates provide more price discovery than the futures rate. Saktivel et al. (2017) provided evidence of one-way causality and volatility transfer from the spot to the futures market for GBP/INR, JPY/INR, and EUR/INR.

Some studies indicate a bidirectional relationship between spot and futures markets, where both markets simultaneously influence each other, while others report mixed evidence regarding the direction of price discovery. For instance, Unlu and Ersoy (2012) found a two-way causal relationship between the futures and spot markets in Turkish currency markets. This indicates a complex dynamic where both markets influence each other in the short and long term. Boyrie et al. (2012) identified mixed evidence in the price discovery process for the South African Rand, Brazilian Real and Russian Ruble. They found that futures markets lead the spot market for the Brazilian Real, while for the Russian Ruble, the spot market is the leading market, and the South African Rand showed mixed evidence. Ivanov et al. (2013) suggested that the spot market significantly contributes to price discovery but also highlighted the complex relationships between spot, futures, and exchange-traded funds (ETFs), showing that both markets influence each other. Martinez and Tse (2017) established bidirectional causality in the USD-MXN market, with the spot market partially leading the futures market. This suggests that both markets have a role in price discovery. Raju and Manohar (2018) used cointegration and causality tests to examine the price discovery mechanism for EUR/INR, USD/INR, GBP/INR, and YEN/INR. Their findings showed bidirectional causality for USD/INR and GBP/INR, while futures markets lead the spot market for YEN/INR and EUR/INR. Nath and Pacheco (2018) observed a two-way volatility spillover between the USD/INR spot and the currency futures market. Kumar (2018) demonstrated that the spot market consistently leads the futures market for the Indian rupee and South African rand, while the futures market leads the spot market for the Brazilian real.

It is evident from existing research that the price discovery function in emerging markets is well-documented. However, the studies related to the Indian currency market are meagre. Moreover, the question of which market price is the pioneer in price discovery and volatility spillover remains unresolved, especially in the Indian context. The inter-connectedness between the futures and spot markets is intertwined with other macroeconomic factors and market sentiments. Furthermore, the relationship is time-varying and behaves differently at various time intervals and crisis periods. Therefore, considering the macroeconomic news announcements and market sentiment factors, the study aims to explore the price discovery and volatility spillover between currency spot and futures market prices for the two intervals, i.e., pre-COVID and COVID periods. Accordingly, the research proposes the following hypotheses:

H1: Futures markets serve as an effective price discovery instrument, which supports the hypothesis that futures prices lead to spot prices (futures prices contain helpful information about the underlying spot market).

H2: Spot markets serve as an effective price discovery instrument, which supports the hypothesis that spot prices lead to futures prices (spot prices contain helpful information about the futures spot market).

H3: Bidirectional causality exists between the two-price series, and spot and futures are important in price discovery.

2. METHODOLOGY

2.1 Data

The study uses minute-wise data of spot and futures prices of USD/INR traded on the National Stock Exchange (NSE), India. The time-series data is classified into two sub-periods: the pre-COVID-19 Phase (1st August 2019 to 24th January 2020) and the COVID-19 Phase (25th January 2020 to 31st August 2020). This paper used macroeconomic news announcements and futures and spot market sentiment indices as the control variables to examine price discovery and volatility spillover effect. Following Wang (2004) and Safa and Maroney (2012), the sentiment index is related to the open interest (measures the liquidity) and trading activity of the futures market. Hence, we compute the volume-based sentiment index for the futures market (VBSI_F) based on the natural logarithm of the ratio of open interest to the traded volume of the futures market. Similarly, the market sentiment index for the spot market (VBSI_S) is computed by taking the natural logarithm of the open interest ratio to the spot market's traded volume. A ratio of more than one implies substantial trading pressure, whereas less than one suggests negligible trading pressure. A ratio of one signifies that the trading pressure in the respective market is balanced. The macroeconomic schedule announcements on Gross Domestic Product (GDP), Fiscal Policy, Inflation, RBI Policy Rates and Trade Deficit are collected from the Bloomberg database. The tick-by-tick data on the currency spot and futures markets are retrieved from Accelpix Solutions Pvt. Ltd., the NSE Authorised Vendor in Equity, Index, Futures and Options.

2.2 Model Specification

2.2.1 Autoregressive Distributed Lag Model (ARDL)

The ARDL technique proposed by Pesaran et al. (2001) takes the following form:

$$\Delta \ln SP_t=\alpha_o+\sum_{i=1}^{n}\alpha_1\Delta \ln SP_{t-1}+\sum_{i=1}^{n}\alpha_2\Delta \ln FP_{t-1}+\beta_1 \ln SP_{t-1}+\beta_2 \ln FP_{t-1}+\beta_3 \ln VBSI\_F_{t-1}$$
$$+\gamma_1 D_1+\gamma_2 D_2+\gamma_3 D_3+\gamma_4 D_4+\gamma_5 D_5+\varepsilon_{1t} \quad (2)$$

$$\Delta \ln FP_t=\alpha_o+\sum_{i=1}^{n}\alpha_1\Delta \ln FP_{t-1}+\sum_{i=1}^{n}\alpha_2\Delta \ln SP_{t-1}+\beta_1 \ln FP_{t-1}+\beta_2 \ln SP_{t-1}+\beta_3 \ln VBSI\_S_{t-1}$$
$$+\gamma_1 D_1+\gamma_2 D_2+\gamma_3 D_3+\gamma_4 D_4+\gamma_5 D_5+\varepsilon_{1t} \quad (3)$$

where ln is the natural log and Δ is the first difference operator. As stated in Pesaran and Pesaran (1999), the F-statistic is employed to test the presence of a long-run relationship under the hypothesis. *γD*sare dummy variables included accounting for macroeconomic news announcements viz. Fiscal Policy*(D_1)*, Gross Domestic Product *(D_2)*, Inflation *(D_3)*, RBI Policy Rates *(D_4)* and Trade Deficit *(D_5)*. It takes the value 'one' on announcement days. Otherwise, it is 'zero'.

The *ARDL* specification of the error correction model is formulated as follows:

$$\Delta \ln SP_t=\alpha_o+\sum_{i=1}^{n}\alpha_1\Delta \ln SP_{t-1}+\sum_{i=1}^{n}\alpha_2\Delta \ln FP_{t-1}+\beta_1 \ln VBSI\_F_{t-1}$$
$$+\gamma_1 D_1+\gamma_2 D_2+\gamma_3 D_3+\gamma_4 D_4+\gamma_5 D_5+\delta_1 Z_{t-1}+\varepsilon_{1t} \quad (4)$$

$$\Delta \ln FP_t=\alpha_o+\sum_{i=1}^{n}\alpha_1\Delta \ln FP_{t-1}+\sum_{i=1}^{n}\alpha_2\Delta \ln SP_{t-1}+\beta_1 \ln VBSI\_S_{t-1}$$
$$+\gamma_1 D_1+\gamma_2 D_2+\gamma_3 D_3+\gamma_4 D_4+\gamma_5 D_5+\delta_1 Z_{t-1}+\varepsilon_{2t} \quad (5)$$

Where $\delta_1$is the error correction term, *a*s are the short-run parameters.

2.2.2 Volatility persistence and Asymmetric volatility test

We tested for ARCH and GARCH effects in the returns series by employing univariate GARCH models. The GARCH (1,1) process is *in the following form:*

$$h_t=\alpha_0+\sum_{i=1}^{q}\alpha_i u_{t-i}^2+\sum_{i=1}^{p}\beta_i h_{t-i} \quad (6)$$

where h_t is the conditional variance. α_1 and β_1 represent ARCH and GARCH effects, respectively, suppose the sum of $\alpha_1+\beta_1$ is close to unity. In that case, any shock will permanently change all future values of conditional variance, i.e., a shock to the conditional variance is persistent. It takes a long time to die out. Moreover, we employed the sign and size bias tests Engle and Ng (1993) proposed to evaluate the effect of volatility changes due to a negative or positive return shock. The squared residual term is regressed against a dummy variable that reflects the sign of the residual term. Using ε_{it}, *i = spot price (SP), futures price (FP)* to indicate the residual of asset *i* at time *t*; we conduct each test by ordinary least squares (OLS) estimates (7) – (10):

Sign bias test: $\varepsilon_{i\,t}^2 = a + b_1 SP^{-}_{i\,t-1} + u_{it}$ (7)

Negative size bias test: $\varepsilon_{i\,t}^2 = a + b_2 SP^{-}_{i\,t-1}\varepsilon_{i\,t-1} + u_{it}$ (8)

Positive size bias test: $\varepsilon_{i\,t}^2 = a + b_3 SP^{+}_{i\,t-1}\varepsilon_{i\,t-1} + u_{it}$ (9)

Joint bias test: $\varepsilon_{i\,t}^2 = a + b_1 SP^{-}_{i\,t-1} + b_2 SP^{-}_{i\,t-1}\varepsilon_{i\,t-1} + b_3 SP^{+}_{i\,t-1}\varepsilon_{i\,t-1} + u_{it}$ (10)

2.2.3 The Multivariate GARCH Model

The Multivariate Asymmetric GARCH (Diagonal VECH) is employed to examine the volatility transmission across the markets. Suppose there are more than two variables in the conditional variance-covariance matrix. In that case, the model permits the conditional variance-covariance matrix of market returns to change over time and offers maximum flexibility than the Baba, Engle, Kraft, and Kroner (BEKK) model (Scherrer and Ribarits, 2007). In matrix notation, the dimensions of the conditional variance-covariance matrix *(H_t)* are shown by equation (11):

$$\begin{bmatrix} h_{ss,t} \\ h_{sf,t} \\ h_{ff,t} \end{bmatrix} = \begin{bmatrix} c_{ss,t} \\ c_{sf,t} \\ c_{ff,t} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \end{bmatrix} \begin{bmatrix} \varepsilon_{s,t-1}^2 \\ \varepsilon_{s,t-1}, \varepsilon_{f,t-1} \\ \varepsilon_{f,t-1}^2 \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \\ \beta_{31} & \beta_{32} & \beta_{33} \end{bmatrix} \begin{bmatrix} h_{ss,t-1} \\ h_{sf,t-1} \\ h_{ff,t-1} \end{bmatrix} \quad (11)$$

where h_{ss}, h_{ff} are the conditional variance of the errors $(\varepsilon_{st}, \varepsilon_{ft})$ from the mean equations. As the model has numerous parameters to be estimated, Bollerslev et al. (1988) proposed a restricted version of the above model with α and β matrixes and diagonal elements, which allow for a time-varying conditional variance. The diagonal representation of the conditional variance elements "h" _"ss" and "h" _"ff" and the covariance element "h" _"sf" takes the following forms and are shown in equations (12) – (14):

$h_{ss,\,t} = c_{ss} + \alpha_{11}\varepsilon_{s,t-1}^2 + \beta_{11}\, h_{ss,t-1}$ (12)

$h_{sf,\,t} = c_{sf} + \alpha_{22}\varepsilon_{s,t-1}\varepsilon_{f,t-1} + \beta_{22} h_{sf,t-1}$ (13)

$h_{ff,\,t} = c_{ff} + \alpha_{33}\varepsilon_{ft-1}^2 + \beta_{33}\, h_{ff,t-1}$ (14)

where h_s is a conditional variance at time t of spot market return, and h_f is at the time t of futures market return. h_{sf} denotes the conditional covariance between the spot and futures market returns at time t.

The diagonal VECH model can be written as follows:

$$VECH(H_t)=C+AVECH(\varepsilon_{t-1}\varepsilon_{t-1}^{1})+BVECH(H_{t-1}) \quad (15)$$

Where A and B are $\frac{N(N+1)}{2}$ x $\frac{N(N+1)}{2}$ parameter matrices and C is a $\frac{N(N+1)}{2} x1$ vector of constants. The diagonal elements of matrix A $(a_{11,}\ a_{22,}\ a_{33,}\ a_{44})$ capture the effect of own-volatility shocks while non-diagonal elements $(a_{ij}$ *where* $i \neq j)$, measure the cross-volatility shocks. The diagonal elements of matrix B $(b_{11,}\ b_{22,}\ b_{33,}\ b_{44})$ measure the own-volatility spillovers, and non-diagonal elements $(b_{ij}$ *where* $i \neq j)$ measure the cross-volatility spillovers. The study included a threshold term in the variance-covariance equation to capture the asymmetric volatility spillover. The model used in this study is expressed as:

$$VECH(H_t)=C+A.VECH(\in_{\downarrow t-1}(t-1)\in_{\downarrow t-1}(t-1)^{\uparrow})+B.VECH(H_{t-1})+D.VECH(\in_{\downarrow t-1}(t-1)\in_{\downarrow t-1}(t-1)<0)*$$

$$\left(\left(\in_{\downarrow t-1}(t-1)\in_{\downarrow t-1}(t-1)^{\uparrow'}\right)<0\right)'D^{*}VECH\left(\in_{\downarrow t-1}(t-1)\in_{\downarrow t-1}(t-1)^{\uparrow'}\right)<0^{*}\left(\in_{\downarrow t-1}(t-1)\in_{\downarrow t-1}(t-1)^{\uparrow'}\right) \quad (16)$$

where, A, B *and* C are $\frac{N(N+1)}{2}$ x $\frac{N(N+1)}{2}$ parameter matrices and C is a $\frac{N(N+1)}{2}$ vector of constant. a_{ij}in matrix A, i.e., diagonal elements indicate their innovation effect, and the cross-diagonal terms $(a_{ij}, i \neq j)$ indicate the cross-innovation effect. Besides, b_{ii} in matrix B indicates its volatility effect, and b_{ii} represents the cross-volatility effect. d_{ii} measures the asymmetry volatility spillover effect from the i^{th} market to itself. d_{ii} shows the asymmetric volatility spillover effect from the i^{th} market to the j^{th} market.

3. RESULTS AND DISCUSSION

3.1 Price discovery in the currency futures market

Figures 1 and 2 show the time-series plot of currency spot and futures prices of the United States dollar/Indian rupee (USD/INR) for the pre-COVID and COVID phases. It is observed that the price movements during the COVID period rose more than those in the pre-COVID Phase. Both markets had a high degree of comovement, which would aid portfolio managers in diversifying their portfolios and risk managers in hedging them through an effective price discovery mechanism.

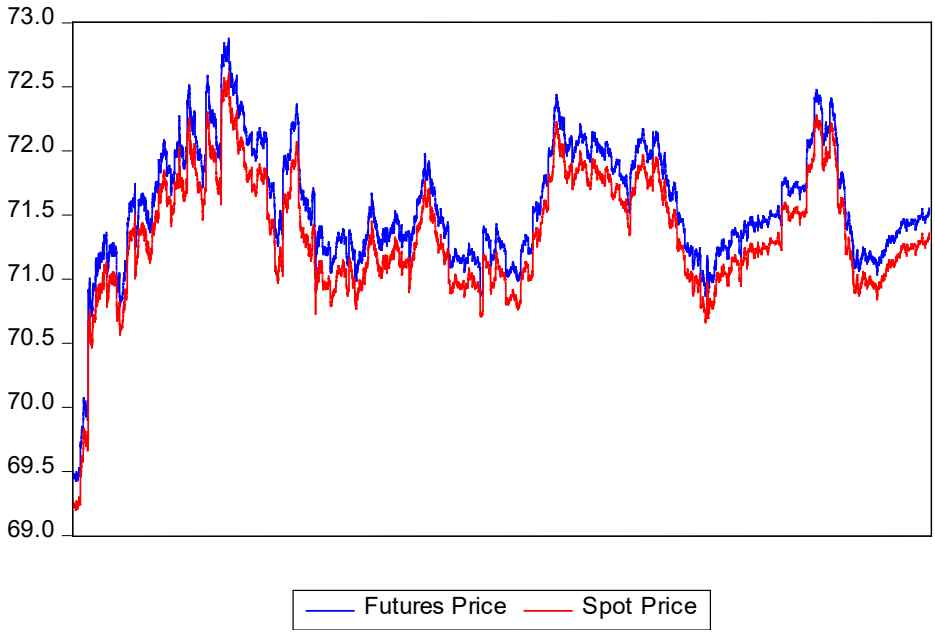

Figure 1. Time-series plot of currency spot and futures prices
Source: Own

Figure 2. Time-series plot of currency spot and futures prices
Source: Own

Table 1 reports the descriptive statistics of the returns, trading volume, and volume-based sentiment index of currency spot and futures markets of USD/INR for the pre-COVID and COVID phases. The mean returns and standard deviations during both phases are close to zero, and the non-zero skewness value indicates that both returns are positively skewed. Higher kurtosis values indicate that both the return series are fat-tailed. Moreover, the Jarque-Bera test rejects the null hypothesis of normally distributed returns. The average volume-based sentiment index of spot and futures markets of USD/INR for both sample periods is greater than one, suggesting sufficient trading pressure and positive sentiments.

Table 1. Descriptive statistics

	Spot Return	Futures Return	VBSI_S	VBSI_F
Pre-COVID-19 Phase				
Mean	0.0000155	0.0000152	1.924483	2.677370
Std. deviation	0.0000414	0.0000419	0.314621	1.822498

Skewness	13.41945	13.10628	4.959627	5.919033
Kurtosis	1047.171	1017.536	111.0577	47.22541
J-B statistics	2.05E+09* (0.0000)	1.93E+09* (0.0000)	22117101* (0.0000)	3937037* (0.0000)
Observations	45080	45080	45080	45080
COVID-19 Phase				
Mean	0.0000116	0.0000118	1.869480	2.662546
Std. deviation	0.0000504	0.0000505	0.243183	1.753425
Skewness	6.886236	9.941547	1.457228	6.199197
Kurtosis	1281.301	1633.290	9.131034	51.63977
J-B test	3.81E+09* (0.0000)	6.20E+09* (0.0000)	107497.8* (0.0000)	5877265* (0.0000)
Observations	55984	55984	55984	55984

Source: own

First, the order of integration of the variable of interest is examined by employing the Kwiatkowski–Phillips–Schmidt–Shin test *(KPSS)* test, and the results are shown in Table 2. The results for the pre-COVID Phase show that spot and futures market returns series are stationary at levels. The volume-based sentiment index series of spot and futures markets are stationary at their first differences. The COVID phase results show that spot and futures market returns and volume-based sentiment index series of spot market series are stationary at levels. The futures markets' volume-based sentiment index series are stationary at first difference. This indicated that the series was integrated at various levels during the pre-COVID and COVID phases. Thus, the Autoregressive Distributed Lag *(ARDL)* bounds test approach is appropriate for analysing the long-run association between the underlying variables.

Table 2. KPSS unit root test results

Variables	Level	First Difference	Order of Integration
Pre-COVID-19 Phase			
Spot Return	0.2345*	--	I(0)
Futures Return	0.2384*	--	I(0)
VBSI_S	3.6377	0.0057*	I(1)
VBSI_F	1.6782	0.0229*	I(1)
COVID-19 Phase			
Spot Return	0.5133*	--	I(0)
Futures Return	0.5424*	--	I(0)
VBSI_S	0.1484*	--	I(0)
VBSI_F	5.3464	0.0811*	I(1)

Source: own

Note: * shows significance at 1% level. Critical values for the KPSS statistic are 0.7390, 0.4630, and 0.3470 at the 1%, 5%, and 10% significance levels, respectively.

As shown in Table 3, the F-statistics are greater than the upper bound critical value at a 1% significance level, indicating a stable long-run equilibrium relationship between currency spot and futures market prices of USD/INR. Therefore, the markets are weak-form inefficient, and there are arbitrage opportunities.

Table 3. ARDL bounds test for cointegration

Pre-COVID-19 Phase		
Specification		F-Statistics
SP/FP, VBSI_F, $D_{1Fiscal\_rates}$, D_{2GDP}, $D_{3Inflation}$, D_{4RBI}, $D_{5Trade\_deficit}$		9.5010*
FP/SP, VBSI_S, $D_{1Fiscal\_rates}$, D_{2GDP}, $D_{3Inflation}$, D_{4RBI}, $D_{5Trade\_deficit}$		9.0984*
Significance level	Lower bound	Upper bound
10%	3.02	3.51
5%	3.62	4.16
2.5%	4.18	4.79
1%	4.94	5.58
COVID-19 Phase		

Specification		F-Statistics
SP /FP, VBSI_F, $D_{1Fiscal\_rates}$, D_{2GDP}, $D_{3Inflation}$, D_{4RBI}, $D_{5Trade\_deficit}$		7.3547*
FP /SP, VBSI_S, $D_{1Fiscal\_rates}$, D_{2GDP}, $D_{3Inflation}$, D_{4RBI}, $D_{5Trade\_deficit}$		7.0493*
Significance level	Lower bound	Upper bound
10%	3.02	3.51
5%	3.62	4.16
2.5%	4.18	4.79
1%	4.94	5.58

Source: own
Note: An asterisk (*) indicates statistical significance at the 1% level.

The cointegration analysis enables us to apply an error correction model to examine the lead-lag relationship between currency futures and spot prices for both sample periods. Panel A and B in Table 4 depict the results of the causality test based on the ARDL-ECM approach for the pre-COVID and COVID phases, respectively. The empirical evidence from the pre-COVID-19 Phase (Panel A) reveals that the error correction coefficients of spot and futures prices are negative and statistically significant at a one percent level, implying that a long-term equilibrium relationship binds both markets. The lagged coefficients of changes in futures prices in the spot equation are positive and significant, indicating that the futures market leads the spot market. Consequently, the futures equation's lagged changes in spot prices are positive and statistically significant, implying that the spot market leads to the futures market. Notably, the magnitude of changes in spot prices is relatively greater than in futures prices. Hence, the currency spot market of USD/INR contains valuable information about futures prices and plays a price discovery role. Spot market prices are informationally more efficient than futures market prices during the pre-COVID-19 Phase. Moreover, the negative and significant effect of VBSI on futures market returns suggests that investors' sentiment in the currency spot market reduces futures market return due to increased interest in the spot market. The macroeconomic announcements on fiscal policy and trade deficit significantly influenced the currency spot market returns. Besides, fiscal policy announcements, trade deficits, and inflation-related news significantly affected futures market returns during the pre-COVID-19 Phase.

Table 4. ARDL-ECM estimates

Panel A: Pre-COVID-19 Phase			
Selected Model: ARDL (4, 4)			
Dependent Variable: $\Delta(lnSP_t)$		Dependent Variable: $\Delta(lnFP_t)$	
Variables	Coefficient	Variables	Coefficient
$\Delta(lnSP_{t-1})$	-0.677192* (0.004647)	$\Delta(lnFP_{t-1})$	-0.684620* (0.004619)
$\Delta(lnSP_{t-2})$	-0.437511* (0.005247)	$\Delta(lnFP_{t-2})$	-0.437820* (0.005232)
$\Delta(lnSP_{t-3})$	-0.216326* (0.004617)	$\Delta(lnFP_{t-3})$	-0.217576* (0.004583)
$\Delta(lnFP_t)$	0.956135* (0.001240)	$\Delta(lnSP_t)$	0.972158* (0.001261)
$\Delta(lnFP_{t-1})$	0.670801* (0.004607)	$\Delta(lnSP_{t-1})$	0.690603* (0.004661)
$\Delta(lnFP_{t-2})$	0.430171* (0.005195)	$\Delta(lnSP_{t-2})$	0.445251* (0.005283)
$\Delta(lnFP_{t-3})$	0.213592* (0.004548)	$\Delta(lnSP_{t-3})$	0.220532* (0.004653)
VBSI_F	4.58E-08 (6.80E-08)	*VBSI_S*	-3.63E-07* (1.32E-07)
$D_{1Fiscal\_policy}$	5.27E-05** (2.33E-05)	$D_{1Fiscal\_policy}$	-4.89E-05** (2.35E-05)
D_{2GDP}	1.26E-05 (2.69E-05)	D_{2GDP}	-2.14E-05 (2.71E-05)
$D_{3Inflation}$	1.74E-05 (1.48E-05)	$D_{3Inflation}$	-3.64E-05** (1.49E-05)
D_{4RBI}	1.93E-06	D_{4RBI}	-1.23E-06

	(3.30E-05)		(3.32E-05)
$D_{5Trade\_deficit}$	3.81E-05** (1.91E-05)	$D_{5Trade\_deficit}$	3.62E-05*** (1.92E-05)
Z_{t-1}	-0.002853* (0.000534)	Z_{t-1}	-0.002836* (0.000543)
Panel B: COVID-19 Phase			
Selected Model: ARDL (4, 4)			
Dependent Variable: $\Delta(lnSP_t)$		Dependent Variable: $\Delta(lnFP_t)$	
Variables	Coefficient	Variables	Coefficient
$\Delta(lnSP_{t-1})$	-0.255031* (0.004124)	$\Delta(lnFP_{t-1})$	-0.264256* (0.004129)
$\Delta(lnSP_{t-2})$	-0.074851* (0.004243)	$\Delta(lnFP_{t-2})$	-0.074343* (0.004256)
$\Delta(lnSP_{t-3})$	-0.034440* (0.004117)	$\Delta(lnFP_{t-3})$	-0.039316* (0.004120)
$\Delta(lnFP_t)$	0.918804* (0.001569)	$\Delta(lnSP_t)$	0.935443* (0.001594)
$\Delta(lnFP_{t-1})$	0.251748* (0.004119)	$\Delta(lnSP_{t-1})$	0.266112* (0.004136)
$\Delta(lnFP_{t-2})$	0.070650* (0.004234)	$\Delta(lnSP_{t-2})$	0.078137* (0.004266)
$\Delta(lnFP_{t-3})$	0.035559* (0.004139)	$\Delta(lnSP_{t-3})$	0.037383* (0.004099)
$VBSI\_F$	2.37E-07** (1.17E-07)	$VBSI\_S$	-1.56E-06* (3.98E-07)
$D_{1Fiscal\_policy}$	4.83E-05 (3.60E-05)	$D_{1Fiscal\_policy}$	2.30E-05 (3.63E-05)
D_{2GDP}	-0.000506* (5.71E-05)	D_{2GDP}	0.000195* (5.75E-05)
$D_{3Inflation}$	-2.44E-05 (2.34E-05)	$D_{3Inflation}$	1.49E-05 (2.35E-05)
D_{4RBI}	0.001977* (3.61E-05)	D_{4RBI}	-0.001718* (3.66E-05)
$D_{5Trade\_deficit}$	-4.89E-05** (2.44E-05)	$D_{5Trade\_deficit}$	-3.65E-05 (2.46E-05)
Z_{t-1}	-0.001158* (0.000246)	Z_{t-1}	-0.001083* (0.000235)

Source: own
Note: Significance levels are marked by *, **, and *, corresponding to 1%, 5%, and 10%, respectively.

Panel B results for the COVID-19 Phase indicate that the error correction coefficients of spot and futures prices are negative and statistically significant, confirming the long-run relationship between the markets. The lagged coefficient of spot and futures returns are statistically significant, implying the bidirectional causation between the two markets. The magnitude of changes in spot prices is relatively greater than in futures prices. Hence, the currency spot market of USD/INR contains valuable information about futures prices and plays a price discovery role during COVID-19. The sentiment index significantly impacted spot and futures market returns during the COVID-19 pandemic. Further, macroeconomic announcements related to GDP, RBI policy rates, and trade deficits had significant responses to the currency spot market. The GDP and RBI policy rate announcements significantly influenced futures market returns.

3.2 Volatility persistence, Asymmetric response, and spillover effect

Before analyzing the volatility spillover between spot and futures markets for both sample periods, we tested for ARCH and GARCH effects in the return series using univariate GARCH models. The results in Table 5 indicate that both the currency spot and futures returns of USD/INR show time-varying persistence in their conditional variances.

Table 5. Univariate GARCH model estimates

	Spot Market Return	Futures Market Return
Pre-COVID-19 Phase		
c	-1.13E-06* (4.18E-08)	-8.14E-07* (3.16E-08)
r_{t-1}	0.061712* (0.0011)	0.014902* (0.0008)
$\alpha_i u_{t-i}^2$	0.812680* (0.0021)	0.812624* (0.0022)
$\beta_i h_{t-i}$	0.104066* (0.0011)	0.101560* (0.0010)
COVID-19 Phase		
c	-5.19E-06* (4.33E-08)	-4.53E-06* (1.29E-08)
r_{t-1}	-0.207404* (0.0015)	-0.098784* (0.0003)
$\alpha_i u_{t-i}^2$	0.982148* (0.0025)	0.984210* (0.0014)
$\beta_i h_{t-i}$	0.006548* (0.0001)	0.006888* (0.0004)

Source: own
Note: Values in () represent probability levels. * indicate significance at the 1%.

Following Park et al. (2020), the study examines the volatilities of the spot and futures markets asymmetry using the sign and size bias tests proposed by Engle and Ng (1993). Table 6 depicts the bias test results for the spot and futures market returns residuals. The findings indicate that the spot and futures markets demonstrate asymmetric volatility, suggesting that the USD/INR exchange rate is more sensitive to negative than positive news during the pre-COVID period. Besides, the volatility of both markets is more sensitive to positive shocks during the COVID phase. This suggests that investors feel optimistic due to confidence in vaccination efforts, the easing of lockdown restrictions, and government and central bank stimulus measures worldwide. As a result, they are reacting strongly to positive news, which has led to increased market volatility.

Table 6. Bias test results

	Spot market return	Futures market return
Pre-COVID-19 Phase		
Sign bias test	1.79E-10 (0.7352)	3.36E-10 (0.5306)
Negative size bias test	-2.94E-05* (0.0062)	-1.83E-05*** (0.0870)
Positive size bias test	3.53E-06 (0.6783)	6.78E-06 (0.4259)
Joint bias test	2.733** (0.0421)	1.389 (0.2439)
COVID-19 Phase		
Sign bias test	-2.42E-09* (0.0017)	-1.83E-09** (0.0360)
Negative size bias test	3.40E-06 (0.7764)	--5.10E-06 (0.7104)
Positive size bias test	2.59E-05** (0.0156)	2.63E-05** (0.0290)
Joint bias test	4.088* (0.0065)	2.624** (0.0487)

Source: own

Note: significance levels denoted by *, **, and *** at 1%, 5%, and 10%, respectively.

The volatilities of USD/INR spot and futures market returns demonstrate ARCH and GARCH effects with asymmetrical characteristics. To examine the volatility spillover between these markets, we utilized a Multivariate GARCH model. Furthermore, we estimated the time-varying conditional variance-covariance of the spot and futures market returns using the diagonal VECH model for both sample periods, as illustrated in Figures 3 and 4. These figures suggest that the Multivariate GARCH-type model is well-suited for analyzing the spillover effects of the return series.

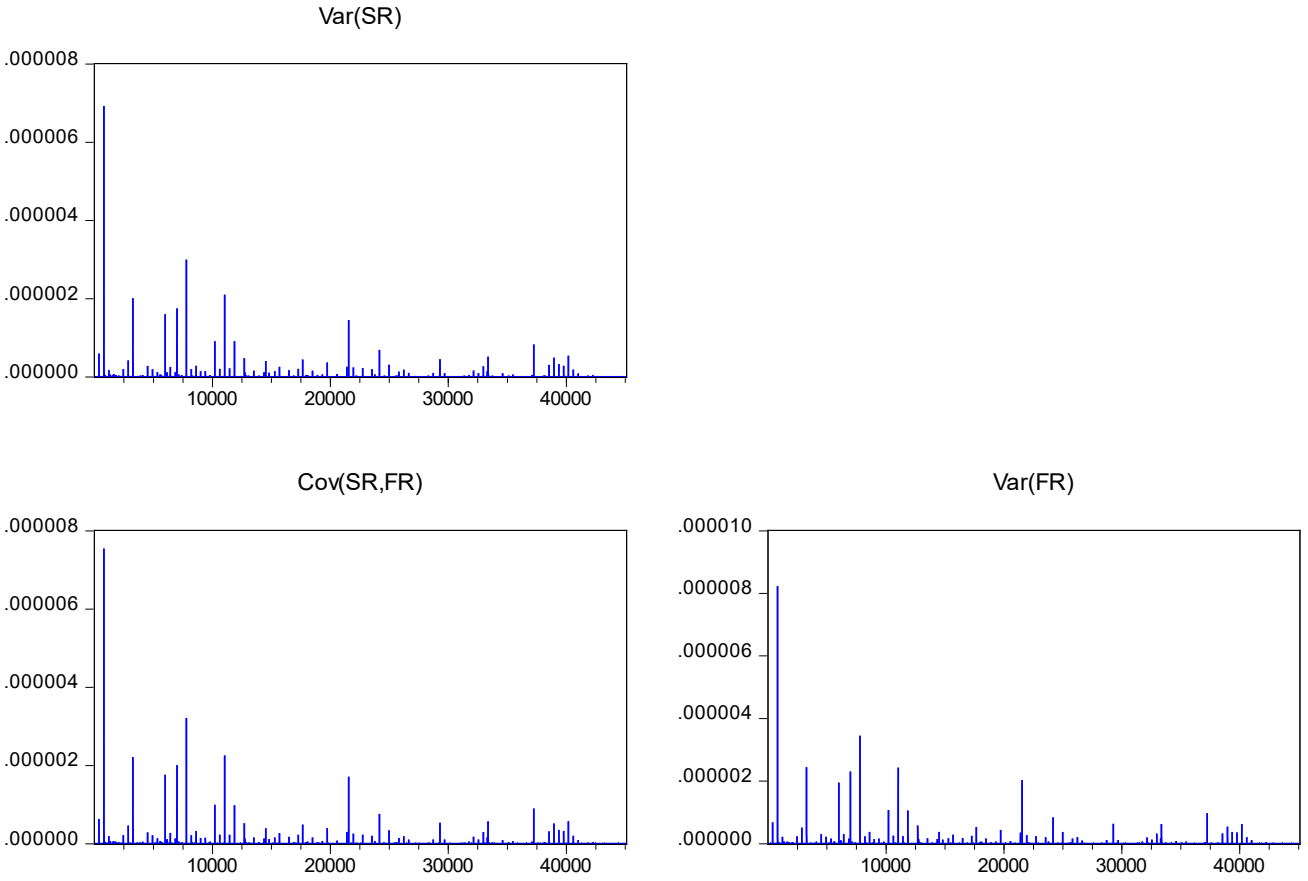

Figure 3. Conditional Variance-Covariance for the Pre-COVID-19 Phase
Source: own

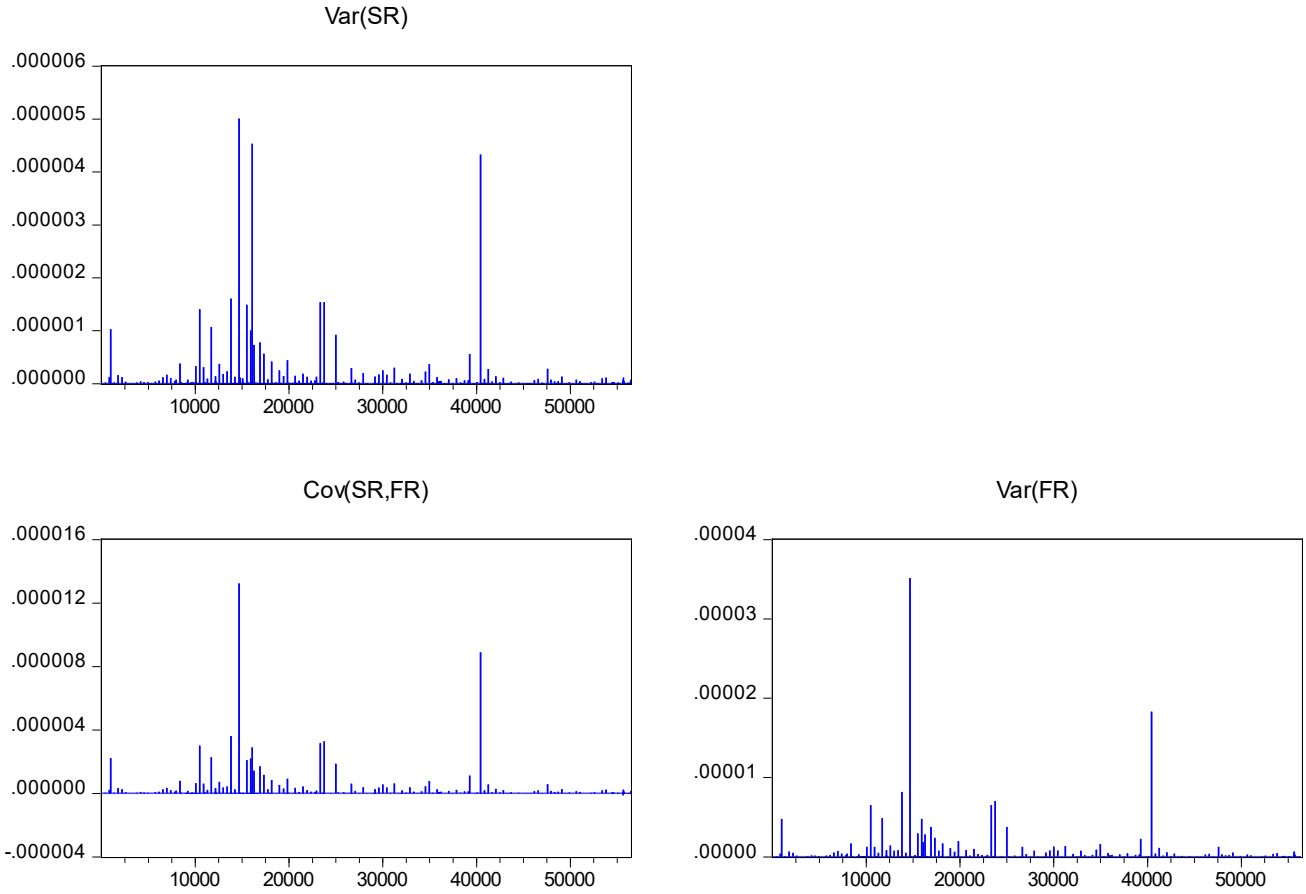

Figure 4. Conditional Variance-Covariance for the COVID-19 Phase
Source: own

The evidence in Table 7 indicates that the diagonal parameters ($A_{1,1}$ and $B_{1,1}$) are positive and statistically significant in both sample periods. This suggests a strong ARCH and GARCH (1,1) process, which confirms that past shocks and volatility influence volatility in both the spot and futures markets. The cross-market volatility spillover coefficients in matrices A *($A_{1,2}$ and $A_{2,1}$)* and B *($B_{1,2}$ and $B_{2,1}$)* are statistically significant at one percent level, indicating bidirectional volatility spillovers between the spot and futures markets during the pre-and COVID phase. The unidirectional linkage from the spot to futures markets is more pronounced, where shocks are transmitted from the spot markets to the futures markets for USD/INR. Furthermore, the asymmetric coefficients found in matrix D *($D_{1,1}$, $D_{1,2}$ and $D_{2,1}$)* are statistically insignificant, indicating no asymmetric response in the volatility of the spot and futures markets to positive or negative shocks during both sample periods.

Table 7. Parameters estimates of asymmetric diagonal VECH model

Pre-COVID-19 Phase				COVID-19 Phase		
Panel A: Conditional mean						
Variable	Co-efficient	Std. error	Prob. value	Co-efficient	Std. error	Prob. value
Dependent Variable: spot market return						
c	-8.12E-07	-8.12E-07	0.1356	-2.10E-05	8.07E-07	0.0000
r_{st-1}	-0.0421	-0.0421	0.0000	-0.2443	0.0036	0.0000
r_{ft-1}	0.1134	0.1134	0.0000	0.1509	0.0030	0.0000
$VBSI\_F_{t-1}$	-1.05E-09	-1.05E-09	0.9885	5.60E-09	8.12E-08	0.9450
$VBSI\_S_{t-1}$	-5.61E-08	-5.61E-08	0.8546	9.26E-06	4.61E-07	0.0000
Dependent Variable: futures market return						

c	-9.59E-07	5.33E-07	0.0718	-1.87E-05	5.20E-07	0.0000
r_{st-1}	0.4415	0.0040	0.0000	0.2894	0.0026	0.0000
r_{ft-1}	-0.3430	0.0041	0.0000	-0.4012	0.0029	0.0000
$VBSI\_F_{t-1}$	1.97E-08	6.78E-08	0.7718	1.24E-08	5.21E-08	0.8122
$VBSI\_S_{t-1}$	-9.73E-09	2.92E-07	0.9734	8.15E-06	3.04E-07	0.0000
Panel B: Conditional variance						
$C_{1,1}$	7.38E-10	1.12E-12	0.0000	1.61E-09	7.28E-12	0.0000
$C_{1,2}$	6.73E-10	7.34E-13	0.0000	1.42E-09	3.40E-12	0.0000
$C_{2,2}$	6.51E-10	1.19E-12	0.0000	1.27E-09	2.28E-12	0.0000
$A_{1,1}$	0.7584	0.0037	0.0000	0.4254	0.0030	0.0000
$A_{1,2}$	0.8209	0.0030	0.0000	0.8736	0.0058	0.0000
$A_{2,1}$	0.8907	0.0035	0.0000	0.9808	0.0128	0.0000
$D_{1,1}$	1.11E-06	0.0084	0.9999	3.38E-06	0.0079	0.9997
$D_{1,2}$	4.86E-07	0.0077	0.9999	-3.40E-08	0.0130	0.9995
$D_{2,1}$	1.11E-06	0.0080	0.9999	1.02E-06	0.0260	0.9994
$B_{1,1}$	0.3160	0.0007	0.0000	0.2049	0.0033	0.0000
$B_{1,2}$	0.3426	0.0001	0.0000	0.1994	0.0017	0.0000
$B_{2,1}$	0.3708	0.0008	0.0000	0.2154	0.0011	0.0000
LB	9.7986 (0.549)			9.8715 (0.627)		
LB^2	0.0766 (0.782)			0.0817 (0.960)		

Source: own

Note: Matrix A represents both the within-market and cross-market ARCH effects, whereas Matrix B accounts for the corresponding GARCH effects. Matrix D is designed to capture asymmetric impacts. The Ljung-Box statistics for the standardized residuals and their squares are denoted by LB and LB2, respectively.

The parameter estimates provided similar evidence for both sample periods. The Ljung-Box statistics for standardized and standardized squared residuals indicated no autocorrelation or heteroskedasticity, suggesting that the estimated Multivariate GARCH models are stable.

CONCLUSION

Price discovery and spillover effect are essential indicators for arbitrageurs and hedgers in the currency futures market to protect their interests from price swings. The lead-lag relationship between currency futures and spot markets is analysed through the ARDL approach for the pre-and COVID-19 Phase. The cointegration test results confirm the long-run association between the futures and spot market for INR/USD. The ARDL-based error correction model result highlights a bidirectional relationship between both markets, with a greater lead for the spot market. This result confirms that spot prices dominate price discovery in the currency market during both sample periods. Moreover, the study results reveal that the volatility spillover occurs from the spot to the futures market for both sample periods. There is no significant evidence of asymmetric behaviour of the currency spot and futures market returns.

The study reveals no difference in the outcome of the price discovery mechanism and a volatility spillover effect in the currency market between the pre-and COVID pandemic periods. It suggests a more substantial flow of information from the spot market to the futures market, highlighting the role of the spot market in price discovery and volatility spillover. From a policy perspective, this study provides valuable insights for investors and policymakers, helping them navigate and regulate the market effectively, especially in future pandemics. The findings could aid portfolio management, market structure design, arbitrage, and hedging practices. Regulators, such as the Securities and Exchange Board of India (SEBI) and the Reserve Bank of India (RBI), should pay close attention to the relationship between currency spot and futures markets. They should monitor the volatility transmission between these markets, particularly during pandemic outbreaks.

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Confirmatory Factor Analysis (CFA) for The Sustainability Disclosure Index (SDI) in Higher Education Institutions (HEIs)

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ABSTRACT

Purpose - The goal of this study is to employ Confirmatory Factor Analysis (CFA) to create a Holistic Sustainability Disclosure Index (SDI) that stakeholders may use to gauge responsibility in Indonesian Higher Education Institutions (HEIs)

Design/methodology/approach - The target population for this research is Indonesian HEIs, both Public and Private HEIs registered at the University of Indonesia Green Metrics (UIGM) in 2022, totalling 126 HEIs. The census method used in this research which was processed using three-step confirmatory factor analysis and processing 66 respondents.

Findings - The first finding is the formation of a holistic SDI is more representative which closes the gap in previous methods by using CFA. The second finding is supporting the legitimacy theory, especially substantively related to SDI development. Both of Public and Private HEIs, give priorities that are not much different for SDI indicators. The final finding is the majority of HEIs in Indonesia (48 HEIs) are not satisfactory in making disclosures. Meanwhile, there are 19 HEIs in the superior; 25 HEIs in the good/above average; 34 HEIs in the satisfactory/average category. Private HEIs shows that the majority of results are in an unsatisfactory position; while Public HEIs shows that the majority of results are in a good/above average position.

Originality - Novelty of this research is closes the gap in previous methods by using Three-Step Confirmatory Factor Analysis (CFA) for developing SDI especially in HEIs.

INTRODUCTION

The development of an existing Sustainability Assessment Tools (SATs), the majority were carried out before 2015 so that the dimensions measured do not yet accommodate efforts to achieve the Sustainable Development Goals (SDGs). Several previous studies provide evidence that some SATs have limitations because they only focus on one or several dimensions of sustainability (Araci et al., 2025; Casarejos et al., 2017). The existence of that weaknesses have been developed implies major challenges for educators to implement integrated strategies and more holistic measurements (Alhazemi, 2024; Liu et al., 2019; Shrestha, 2024).

There are various methods for preparing indexes and show the weaknesses. The Inclusive Examination of Guideline (IEG) method, for example fraud (Joseph et al., 2020); anti-corruption (Joseph; et al., 2015); accountability (Ling Wei et al., 2008) only uses secondary data in the form of content analysis/disclosure index. The other two methods, namely the Analytical Hierarchy Process (AHP) (Harker & Vargas, 1987; Saaty, 1991; Sodhi & Yatskovskaya, 2014), and the Modified Delphi (MD) (Grime & Wright, 2016; Pawlowski, 2004), only use primary data. Therefore, in the previous research, the researchers developed a Sustainability Disclosure Index (SDI) using a combination of secondary data and primary data as data triangulation, namely Modified Analytical Hierarchy Process (MAHP). This method fills the gap related to data triangulation. The development of the index that has existed so far only relies on one method, namely qualitative. This study uses quantitative analysis instruments to use Confirmatory Factor Analysis (CFA) to demonstrate the validity of the indicator.

This research is a follow-up study conducted to validate the results of the SDI development in HEIs that has been conducted previously. Thus, "What is a holistic SDI which are comprehensive and relevant using CFA that can be used by stakeholders to measure the accountability of Indonesian HEIs?" is the research question that will be addressed in this study. The goal of this study is to employ Confirmatory Factor Analysis (CFA) to create a Holistic Sustainability Disclosure Index (SDI) that stakeholders may use to gauge responsibility in Indonesian HEIs

The concept of developing the SDI in this research is to design a holistic SDI that are comprehensive and relevant according to the needs and sustainability practices that exist in the HEIs so that users can choose the best priority indicators and suit the needs and interests of each HEIs. SDI was developed with the Indonesian context in mind, with the hope that it is more in line with the conditions of HEIs in Indonesia and has the value of comparability between HEIs in Indonesia (Sari et al., 2020, 2022; Sari & Faisal, 2022; M. Sari et al., 2021; M. P. Sari, 2019). It is hoped that by developing a holistic SDI which are comprehensive and relevant, it will be able to increase awareness of sustainability for HEIs in Indonesia, as evidenced by the increasing number of HEIs that pay attention and care about sustainability issues.

The benefit of this research is to provide mapping, benchmarking, guidance and best practice for the Indonesian HEIs related to SDI which can be used by future researchers, policy makers and especially HEIs in Indonesia, as well as other stakeholders. This research makes several contributions. First, this research develops a holistic SDI is more representative which closes the gap in previous methods by using CFA. The second contribution of this research is supporting the legitimacy theory, especially substantively related to SDI development.

1. LITERATURE REVIEW

The most frequently cited theory in sustainability disclosure is legitimacy theory (Campbell, 2003). Empirical research indicates that the primary driving force behind sustainability disclosures is institutional legitimacy (Deegan, 2004). According to legitimacy theory, institutions must behave in a way that is socially acceptable in order to obtain resources, secure approval for their objectives and position in society, and secure their survival (Sordo et al., 2016). Since the idea of institutional legitimacy is dynamic, shifts in community expectations and/or institutional performance may result in gaps in legitimacy. The legitimacy gap is a challenge to institutional legitimacy that arises when there are real or potential discrepancies between the two value systems (Dowling & Pfeffer, 1975). There are two sources causing the legitimacy gap. First, institutional

performance remains unchanged, but society's expectations about performance have changed. This is caused by society's values changing as a result of growing social awareness about a particular issue. The second source, known as the legitimacy gap, arises when exposure of hitherto undiscovered information about an organization for example in the mass media (Sethi, 1977). Therefore, legitimacy theory suggests that to survive, institutions need to manage societal expectations and legitimacy gaps. This process is called legitimacy (Dowling & Pfeffer, 1975). The social contract is the main premise of legitimacy theory (Deegan, 2002).

Institutions will use various legitimation techniques and communication strategies to minimize legitimacy gaps. The choice of approaches and strategies to maintain, obtain, or improve legitimacy is carried out through sustainability disclosures (Goswami & Lodhia, 2012). Institutions are expected to make sustainability disclosures to foster the perception that they behave in a way that is acceptable to the society in which they operate (O'Donovan, 2002). One of the tactics for legitimation is the revelation of sustainability. Strategies for legitimacy might be either symbolic or substantial. In order to gain legitimacy, institutions employ substantive management, which entails actual and tangible adjustments to institutional managerial procedures, and symbolic management, which entails selecting strategies that will appear to be in line with societal norms and expectations in order to close legitimacy gaps. An institution frequently uses symbolic management to increase its legitimacy, but this is especially true while preserving it (Ashforth & Gibbs, 1990).

Related to sustainability disclosure as one of the legitimacy strategies, several previous research literature studies related to the development of new indexes were adopted for the development of SDI in accordance with the goals of this study. The MAHP method with the advantage of data triangulation between secondary data resulting from content analysis/disclosure index and primary data resulting from surveys with AHP questionnaires. Researcher have developed the MAHP, namely a method for compiling an index using secondary data as well as primary data as data triangulation. MAHP consists of two stages, namely stage 1 of hierarchical preparation/decomposition to answer the first special goals related to the comprehensive SDI of HEIs and stage 2 of hierarchical evaluation to answer the second special goals related to the relevant SDI. Stage1 of preparing the hierarchy/decomposition consists of identifying levels and indicators; breakdown of indicators from international standards and national regulations; content analysis/disclosure index; delete irrelevant items; validation from experts; final indicator design. From the references above, the development of the SDI was carried out in the following stages. See Figure 1.

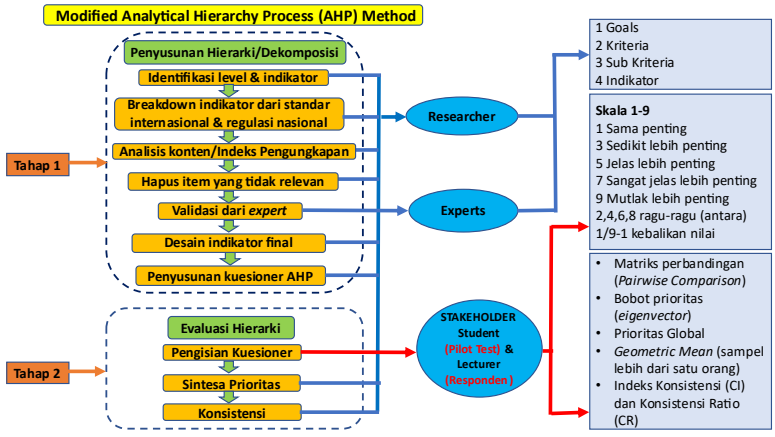

Figure 1. Modified Analysis Hierarchy Process (MAHP)

The construct of a collection of tools, surveys, or questionnaires is tested for validity and reliability using confirmatory factor analysis, or CFA. A statistical method for confirming the factor structure of a collection of observed variables is called CFA. Researchers can test the hypothesis that there is a relationship between the underlying latent components and the observable variables by using CFA. CFA as explained by (Fernandez et al., 2012) is "... sophisticated techniques used in the advanced stages of the research process to test a theory about latent process". According to (Moore & Neimeyer, 1991), "confirmatory factor analysis aims to evaluate patterns of relationships between several constructs. Each construct is built by indicators. The confirmatory

analysis model usually does not assume the direction of the relationship between constructs, but only the existence of a correlative relationship between constructs".

CFA is a factor analysis that is used to evaluate or validate the measurement model of one or more constructs empirically. According to a specific theoretical study, a measurement model, also known as a descriptive model (Obst & White, 2004) is the operationalization of latent variables or constructs into one or more indicators or multiple manifest variables. Accordingly, CFA is meant to test a measurement model created based on a specific theoretical study rather than to create a model (Byrne, 2005).

SDI consists of various dimensions (multidimensional) or indicators so that this study uses third order confirmatory analysis. The approach to analyzing third order analysis uses the hierarchical component model (HCM) (Hair et al., 2018). The analysis tool used is SEM PLS because SDI consists of multidimensional and small sample size. This study uses third order confirmatory factor analysis, namely reflective first order; reflective second order and formative third order.

In this case, construct validity is carried out to determine the extent to which the measuring instrument can be said to measure a construct or its theoretical properties. The purpose of conducting this construct validity test is to determine the extent to which an object has several properties as measured by the measuring instrument. The types of construct validity used are convergent validity and nomological validity. Convergent Validity is a type of high correlation with other measuring instruments that measure the same attribute. Nomological Validity is a type that assesses significant correlations between constructs as predicted by theory (Hair et al, 2020).

Based on the research goals, the prepositions in this study are:

Preposition: A holistic SDI which are comprehensive and relevant using CFA can be used by stakeholders to measure the accountability of Indonesian HEIs.

2. RESEARCH METHOD

2.1 SDI Development Method

From the six stages carried out, a relevant and comprehensive SDI in HEIs was obtained. The details are as follows. There are four hierarchies, namely goals, criteria, sub criteria and indicators. Goals of SDI is SDI in HEIs. Criteria of SDI are Economic; Environment; Social (Figure 2). Economic criteria consist of four sub criteria which are E1 Economic Performance and Growth; E2 Industrial Infrastructure and Innovation; E3 Inequality; E4 Products and Waste.

a. Sub Criteria E1 Economic Performance and Growth consist of 8 indicators which are E101 Inclusive Economy; E102 Decent Employment; E103 Sustainable GDP; E104 Institutional Income; E105 Research Funding; E106 Economic Performance; E107 Market Existence; E108 Monopoly.
b. Sub Criteria E2 Industrial Infrastructure and Innovation consist of 10 indicators which are E201 Road Infrastructure; E202 Broadband; E203 New Technology; E204 Infrastructure Facilities; E205 Open Space; E206 Sustainability Budget; E207 Smart Building; E208 Green Buildings; E209 Innovative Programs; E210 Procurement Practices.
c. Sub Criteria E3 Inequality consist of 2 indicators which are E301 Low Per Capita Income; E302 Public Finance.
d. Sub criteria E4 Products and Waste consist of 8 indicators which are E401 Impact on the Atmosphere; E402 Resource Management; E403 Waste Recycling; E404 Paper and Plastic Reduction; E405 Organic and Inorganic Waste; E406 Toxic Waste; E407 Sewerage Line; E408 Impact on Biodiversity

Environmental criteria consist of L1 Water and Sanitation (8); L2 Climate (2); L3 Land Ecosystems (6); L4 Marine Ecosystems (2).

a. Sub criteria L1 Water & Sanitation consist of 8 indicators which are L101 Water and Sanitation Availability; L102 Water Quality; L103 Water Efficiency; L104 Water Conservation; L105 Water Recycling; L106 Wastewater refers; L107 Water Pollution; L108 Water Disposal.
b. Sub criteria L2 Climate consist of 2 indicators which are L201 Greenhouse Gas Emissions; L202 Disaster Resilience and Climate Change.
c. Sub criteria L3 Terrestrial Ecosystem consist of 6 indicators which are L301 Restrictions on Forest and Wetland Conversion; L302 Sustainable Forests; L303 Sustainable Land Ecosystems; L304 Nature Conservation; L305 Habitat Restoration; L306 Protection of Land Resources.
d. Sub criteria L4 Marine Ecosystem consist of 2 indicators which are L401 Marine Ecosystem Conservation; L402 Marine Pollution

Social criteria consist of S1 Poverty (2); S2 Hunger (5); Doctoral Degree in Health (7); S4

Education and Research (13); S5 Gender (5); S6 Energy (6); S7 Sustainable Cities and Communities (6); S8 Peace, Justice and Institutions (15); S9 Partnership (10).

a. Sub criteria S1 Poverty consist of 2 indicators which are S101 Extreme Poverty; S102 Financial Access.
b. Sub criteria S2 Hunger consist of 5 indicators which are S201 Minimizing Hunger; S202 Food Security; S203 Balanced Nutrition; S204 Stunting; S205 Sustainable Food Production.
c. Sub criteria S3 Health consist of 7 indicators which are S301 Birth and Death; S302 Quality Health; S303 Healthy Food Patterns; S304 Sexual and Reproductive Health; S305 Disability; S306 Maternity; S307 Occupational Health and Safety
d. Sub criteria S4 Education and Research consist of 13 indicators which are S401 Quality Early Childhood; S402 Quality Primary and Secondary Education; S403 Young Workforce Working; S404 Student is characterized; S405 Staff; S406 Lecturer; S407 Sustainability Teaching; S408 Sustainability Research; S409 Community Service Sustainability; S410 Sustainability Publications; S411 Citations; S412 Intellectual Property Rights (IPR); S413 Sustainability Student Institution.
e. Sub criteria S5 Gender consist of 5 indicators which are S501Violence against women; S502 Violence against Children; S503 Diversity and Equal Opportunity; S504 Child Labor; S505 Forced Labor.
f. Sub criteria S6 Energy consist of 6 indicators which are S601 Clean Energy; S602 Energy Efficiency; S603 Decarbonization of the Energy System; S604 Renewable Energy; S605 Energy Conservation; S606 Energy Intensity
g. Sub criteria S7 Sustainable Cities and Communities consist of 6 indicators which are S701 Improving Living Standards; S702 Low-Carbon Transportation; S703 Campus Bus; S704 Campus Transportation Policy; S706 Bicycle and Pedestrian Facilities
h. Sub criteria S8 Peace, Justice and Institutions consist of 15 indicators which are S801 Public Service Discrimination; S802 Integrated Reports; S803 State Conflicts; S804 Regulatory Reform; S805 Goals and Strategies; S806 Governance; S807 Cultural Activities; S808 Institution Profile; S809 Ethics and Integrity; S810 Anti-Corruption; S811 Environmental Regulation Compliance; S812 Rights of Indigenous Peoples/Local Peoples; S813 Human Rights; S814 Complaint; S815 Freedom of Association
i. Sub criteria S9 Partnership consist of 10 indicators which are S901Sustainability Reporting; S902; Strategic Cooperation; S903 International Collaboration; S905 Sustainability Start Up; S906 Stakeholder Engagement; S907 Tax; S908 Public Policy; S909 Political Contribution; S910 External Assurance/Audit

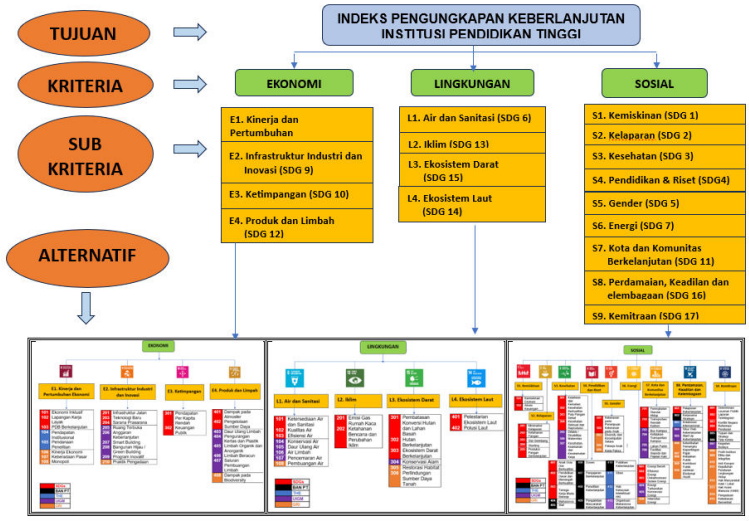

Figure 2. The Final SDI

2.2 Data collection technique

The research was conducted in Indonesia on the grounds that UIGM is one of the SATs used as the basis for developing SDI originating from Indonesia. UIGM is an initial step that can motivate HEIs to implement sustainability. So it is expected to be more in line with the context of HEIs in Indonesia. This study uses all elements of the population (census), namely HEIs registered in the 2022 UIGM ranking of 126 HEIs. The data used in this research comes from Indonesian HEIs that carry out sustainability disclosures that are published on each HEIs website. This aims to ensure that there is conformity with the SDI, so that they play an optimal and significant role in achieving the SDGs. The reason for choosing 2022 because it is the time the data was collected.

2.3 Operational definition

Based on the research goals, a comprehensive and relevant operational definition of SDI will be described in Table 1 below:

Table 1. Operational Definition

SDI	Description	Criteria
Comprehensive	SDI at HEIs which includes the academic aspect refers to the Tri Dharma of HEIs (UU. 12 of 2012); 1. The sustainability aspect refers to the Triple Bottom Line (Elkington, 1986)	SDI which covers **Tri Dharma of HEIs** Education; Research; Community Service **Triple Bottom Line** Economy; Social; Environment
Relevan	SDI in HEIs which is in accordance with the characteristics of HEIs; reflects sustainable practices in HEIs and is in line with the expectations of actors and society so that the social contract as a proxy for legitimacy is fulfilled (Dowling dan Pfefer, 1975)	Compatible SDI between information that has been disclosed through the media (website) and information that is considered important (preferences) by sustainability actors in HEIs

Source: Research Data, 2024

2.4 Data Analysis

A statistical technique called confirmatory factor analysis (CFA) is used to verify and evaluate the factor model that has been suggested in studies. The structure of the link between latent variables—which are not directly measured—and observable variables is examined using CFA. In CFA, the connection between latent

variables (factors) and observed variables is estimated using a measurement model. The underlying premise of this paradigm is that observation variables are markers of a more general latent construct. We can test and gauge how well the suggested model matches the available empirical data thanks to CFA.

Data preparation, choosing the appropriate CFA model, estimating model parameters, assessing model quality, and interpreting CFA results are some of the crucial processes in the CFA analysis process. To be more specific, the first stage in the CFA process is getting the data ready for utilization. The observational data gathered from respondents is what CFA need. For the outcomes of the CFA analysis to be trusted, this data must be legitimate and trustworthy. Selecting the appropriate CFA model is the second step. The link between latent variables and observable variables is hypothetically represented by the CFA model. Choosing pertinent latent variables and establishing the connection between latent and observation variables are essential steps in choosing the best model.

The third step entails estimating the model parameters, which involves determining the unobservable parameters within the model using techniques such as Maximum Likelihood Estimation (MLE) or the Least Squares Method. Once the estimation is completed, the fourth step is to evaluate the quality of the CFA model. This evaluation employs various statistics and metrics, including the chi-square test, Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA), to assess how well the proposed model fits the empirical data. The final phase, the fifth, is to interpret the CFA analysis's findings. The estimated parameters, the model fit metric, and the importance of the correlation between latent and observable variables must all be interpreted.

3. RESULTS AND DISCUSSION

CFA is used to test the construct validity and reliability of a set of instruments, questionnaires or questionnaires. SDI consists of various dimensions (multidimensional) or indicators so this research uses third order confirmatory analysis. The analytical tool used is SEM-PLS because the SDI consists of multidimensional and small sample sizes. This research uses third order confirmatory factor analysis, namely reflective first order; reflective second order and formative third order.

According to the findings, the convergent validity value is strong since the AVE value is higher than 0.50. No indicators are dropped since all of them have high loading factor values. The composite dependability of the first, second, and third orders is rather strong, with Cronbach alpha values exceeding 0.70. The significance value of each loading factor—first, second, and third order—is then ascertained using bootstrapping. A p-value < 0.05 and a T-statistic over 1.96 imply that the loading factors for first order, second order, and third order are significant at 0.05. In summary, the SDI was developed based on three criteria: environmental, social, and economic.

Table 2. Confirmatory Factor Analysis Result

Criteria	Cronbach's Alpha	Composite Reliability	Rho_A	AVE	T Statistic	P Values
Economic	0.822	0.882	0.826	0.652	6.084	0.000
Economic 1	0.913	0.929	0.920	0.622	6.937	0.000
Economic 2	0.899	0.917	0.901	0.526	8.547	0.000
Economic 3	0.845	0.865	0.857	0.762	7.257	0.000
Economic 4	0.881	0.906	0.882	0.550	10.633	0.000
Environment	0.848	0.897	0.879	0.686	10.692	0.000
Environment 1	0.879	0.905	0.881	0.545	4.092	0.000
Environment 2	0.766	0.824	0.876	0.701	10.309	0.000
Environment 3	0.823	0.868	0.825	0.877	3.532	0.000
Environment 4	0.733	0.882	0.738	0.789	5.753	0.000
Social	0.884	0.907	0.884	0.525	2.234	0.000
Social 1	0.716	0.875	0.723	0.788	6.898	0.000
Social 2	0.879	0.912	0.899	0.676	10.245	0.000
Social 3	0.903	0.924	0.913	0.636	11.413	0.000

Social 4	0.915	0.927	0.916	0.824	17.404	0.000
Social 5	0.843	0.892	0.859	0.629	21.814	0.000
Social 6	0.929	0.945	0.933	0.740	19.714	0.000
Social 7	0.805	0.860	0.811	0.508	6.708	0.000
Social 8	0.941	0.948	0.946	0.548	12.185	0.000
Social 9	0.909	0.925	0.911	0.554	14.591	0.000

Source: Research Data, 2024

The results in Table 2 demonstrate that the convergent validity value is high since the Average Variance Extracted (AVE) value is greater than 0.50. No indicators are eliminated because all of them have significant loading factor values (Appendix). Cronbach alpha values above 0.70 indicate a reasonably strong composite dependability for first, second, and third order. The significance value of each loading factor—first, second, and third order—is then ascertained using bootstrapping. A p-value <0.05 and a T-statistic over 1.96 suggest that the loading factor, first order, second order, and third order, has a significance of 0.05, according to the data. We might conclude that the three economic, social, and environmental elements that make up SDI.

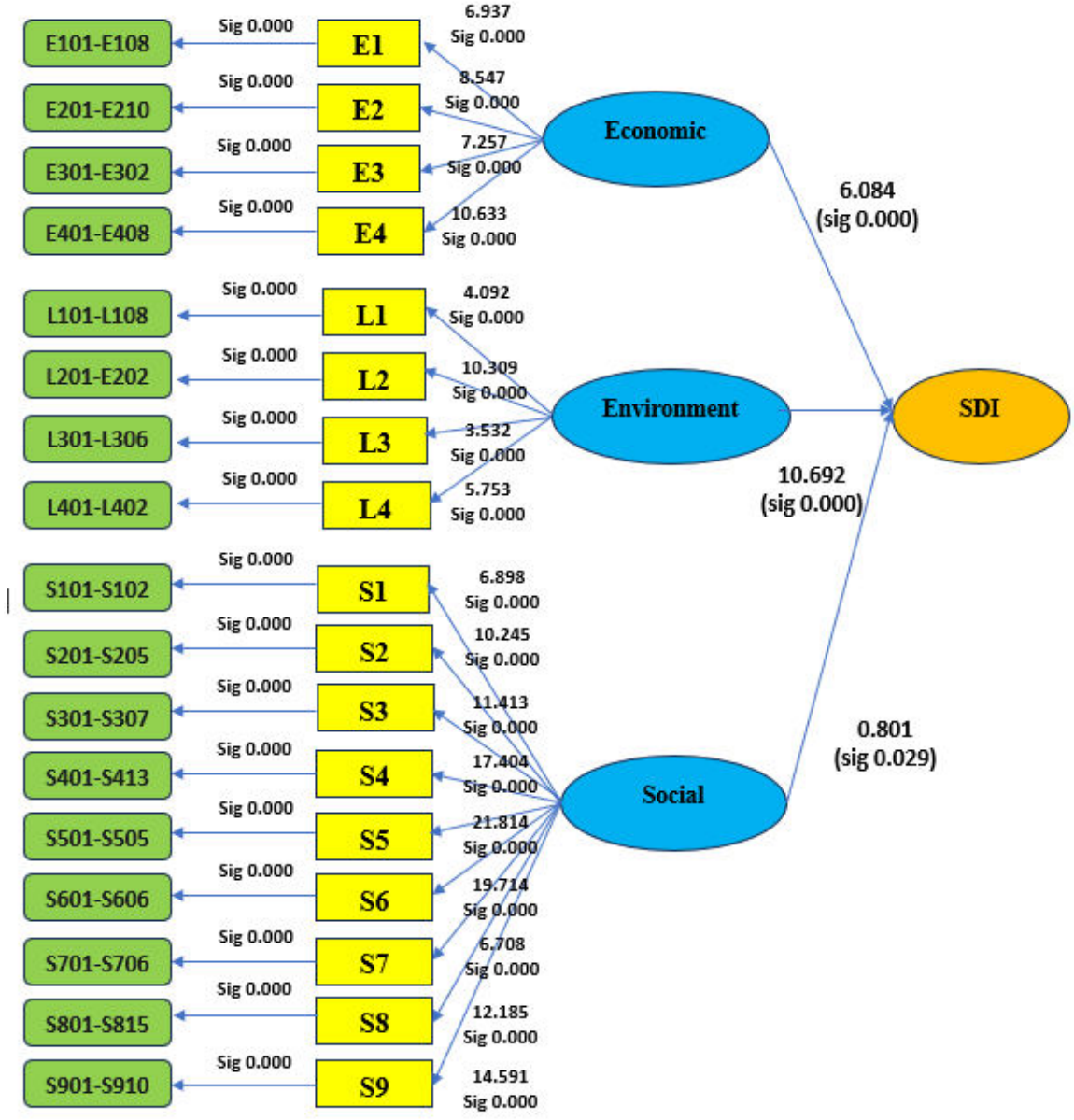

Figure 3. Confirmatory Factor Analysis

3.2 The additional analysis

The results show that the majority of HEIs in Indonesia, numbering 48 HEIs are not satisfactory in making disclosures based on the sustainability disclosure index that researchers have developed. Meanwhile, there are 18 HEIs in the excellent category; 25 HEIs in the good/above average category; 35 HEIs in the satisfactory/average category. Private HEIs shows that the majority of results are in an unsatisfactory position; while Public HEIs shows that the majority of results are in a good/above average position. In detail, Satker shows that the majority of results are in an average/satisfactory and unsatisfactory position. Meanwhile, BLU showed that the majority of results were in an unsatisfactory position; BH shows that the majority of results are in a good position/above average (Table 3).

Table 3. Report Card Classification

Percentage of compliance	Grade	Private HEIs	Public HEIs				Total HEIs		Category
			Satker	BLU	BH	Total			
66 - 100 %	A	6	1	1	6	8	14	18	Excellent
60 - 65 %	A-	0	0	2	2	2	4		
54 - 59 %	B+	2	0	3	1	4	6	25	Good/ Above average category
46 - 53 %	B	3	0	1	1	2	5		
40 - 45 %	B-	3	1	6	4	11	14		
34 – 39 %	C+	4	2	0	3	5	9	35	Average/ Satisfactory
26 – 33 %	C	9	0	3	0	3	12		
20 -25 %	C-	9	1	4	0	5	14		
Less than 20%									
14 -19 %	D+	7	2	4	1	7	14	48	Not Satisfactory
6 – 13 %	D	17	1	4	1	6	23		
1 – 5 %	D-	10	0	1	0	3	11		
0%	F	0	0	0	0	0	0	0	Failed
Total		70	8	29	19	56	126		

Source: Olah Data 2023

There are several findings in this study. The first finding is the formation of the development of the SDI based on GRI (2020), UIGM (2020) and THE (2022) by considering the SDGs (2014) and BAN-PT (2020) indicators consisting of 115 indicators including sustainability indicators (economic, environmental and social) and academic indicators (education, research and community service). The researcher have developed a more representative SDI measurement because it uses triangulation between secondary and primary data in the form of the MAHP which closes the gap in the previous method, namely the IEG, AHP and MD (Grime & Wright, 2016b; Joseph & Taplin, 2011; Saaty, 1991). To answer the research goals, the researcher using CFA to validate the indicators that have been developed using the MAHP method.

a. Comprehensive SDI

The results show that the research goals of developing a comprehensive SDI with criteria including sustainability indicators (economic, social and environmental) as well as academic indicators (education, research and community service) was met. The SDI consists of one hundred and fifteen (115) indicators that use GRI, UIGM, THE as references by considering the SDGs and BAN-PT indicators.

b. Relevant SDI

The results show that the research goals is to develop a relevant SDI with criteria in accordance with the characteristics of HEIs; reflects sustainable practices in HEIs and is in line with the expectations of actors and society so that the social contract as a proxy for legitimacy is fulfilled. Of the seventeen sub-criteria, there are nine sub-criteria that are supported by data triangulation. There is a match between the information that has been disclosed through the media (website) and the information that is considered important (preference) for sustainability actors at HEIs. Apart from that, it is supported by the results of additional analysis, namely sensitivity analysis of the results of the MAHP analysis calculations in the development of the SDI.

The second findings HEIs both Private and Public HEIs give similar priority to SDI indicators. The results of further analysis show that the disclosures made by Private and Public HEIs have the same trend. There are ten sub-criteria where Private and Public HEIs give similar results, namely the sub-criteria of performance and economic growth (E1); inequality (E3); water and sanitation (L1); terrestrial ecosystem (L3); marine ecosystem (L4); health (S3); education and research (S4); energy (S6); peace, justice, and institutions (S8); and partnership (S9). There is the same trend between Private HEIs and PTN-BH. There are nine sub-criteria where Private HEIs give similar results to PTN-BH, namely the sub-criteria of performance and economic growth (E1); industrial infrastructure and innovation (E2); climate (L2); terrestrial ecosystem (L3); marine ecosystem (L4); health (S3); energy (S6); peace, justice, and institutions (S8); and partnership (S9). This study also explores the opinions of the actors responsible for SDGs or UIGM in each university. A total of 50 respondents stated that sustainability regulations are needed, 13 respondents stated that they really need them and 3 respondents stated that they quite need sustainability regulations. Regarding the sustainability index, 57 respondents stated that a sustainability index is needed, 3 respondents stated that they really need them, 3 respondents quite need them and 3 respondents do not need them. This shows that this study closes the existing gap both theoretically and practically. Respondents stated that the majority of obstacles related to the implementation of sustainability in each university were mostly caused by the unavailability and integration of sustainability regulations for universities; limited budget, human resources and sustainability infrastructure; low understanding of sustainability among academics, and low commitment from leaders. Regarding these obstacles, solutions are needed in the form of regulations that are relevant to universities; changes in the mindset and awareness of academics regarding sustainability; strengthening leadership commitment, governance and collaboration; and improving the quality and quantity of human resources, budget and infrastructure.

The last findings, HEIs both Public and Private HEIs, give priorities that are not much different for SDI indicators. The final contribution is the majority of HEIs in Indonesia (48) are not satisfactory in making disclosures. Meanwhile, there are 19 HEIs in the superior; 25 HEIs in the good/above average; 34 HEIs in the satisfactory/average category. Private HEIs shows that the majority of results are in an unsatisfactory position; while Public HEIs shows that the majority of results are in a good/above average position. It can be concluded that the results show the purpose of the study to develop SDI that is relevant to the criteria according to the characteristics of HEIs; reflecting sustainable practices in HEIs and in accordance with the expectations of actors and the community so that the social contract as a proxy for legitimacy is fulfilled. This supports the substantive legitimacy theory.

CONCLUSION

The study's findings show that the objectives pertaining to the creation of a holistic (all-encompassing and pertinent) SDI have been effectively developed. Because it takes into account three indicators of HEIs education, research, and community service and covers the environmental, social, and economic facets of sustainability, HEIs are deemed comprehensive. Apart from that, it also considers international standards (SDGs) and national regulations (BAN-PT). The development of SDI is said to be relevant because it is in accordance with the characteristics of HEIs; reflects sustainable practices in HEIs and is in line with the expectations of actors and society so that the social contract as a proxy for legitimacy is fulfilled. Sustainability disclosure has proven to be one of the legitimacy strategies, which has proven to be one way in which institutions can try to convince stakeholders that their existence and operations are legitimate.

The theoretical implications are the SDI is a form of accountability and legitimacy strategy that provides motivation for sustainability disclosure in order to improve the reputation of HEIs. This is done to meet the demands of the wider community regarding social contracts through efforts to minimize the legitimacy gap. This study found evidence that HEIs disclose more substantive information than symbolic actions. This is indicated by the conformity between the results of disclosure index and the preferences of sustainability actors in HEIs. On the other hand, community expectations are met as an impact of HEIs being proactive about sustainability which includes all aspects of the SDGs. Moreover, this research can be extended to other theories that can explain sustainability practices in HEIs, for example stakeholder and institutional theory.

The practical implications are to provide mapping, benchmarking, guidance and best practice of SDI in Indonesian HEIs that can be used by future researchers, policy makers especially HEIs in Indonesia, and other stakeholders. In detail as follows (1) Future researchers can use the index compilation method using MAHP to compile other indexes with CFA validation, such as fraud, satisfaction, corruption and so on; (2) Policy makers in HEIs and the government can use SDI as a reference in making regulations and policies that are relevant to sustainability in HEIs; (3) Other stakeholders, especially leaders and managers, change the mind-set and awareness of the academic community regarding sustainability; strengthen the leaders commitment, governance and collaboration; improve the quality and quantity of human resources, budget and infrastructure.

There are some limitations of this research. First, only considers GRI, UIGM and THE for developing SDI to measure HEIs accountability that is more holistic (comprehensive and relevant) and in line with stakeholder needs. Second, the selection of SDI is limited to previous research and developments in HEIs policies and regulations in Indonesia. Third, SDI is limited to the disclosure index (disclosure occurrence) calculating the diversity of the number of items in the checklist so it does not focus on weighting indicators in the form of abundance of disclosure. Forth, CFA has several advantages CFA is that it allows us to test and validate previously proposed hypothetical models in terms of strengthening the validity and reliability of the findings. In addition, it allows us to measure latent variables that cannot be observed directly. However, there are several limitations of CFA, (1) it requires a large enough sample size to obtain valid results; (2) it relies on strong assumptions about the distribution of data and the relationship between variables. If the assumptions are not met, the results will be inaccurate or cannot be interpreted correctly. (3) CFA is not always the right choice in factor analysis, there are other alternative methods, such as Exploratory Factor Analysis (EFA). Another limitation is that the SATs used are limited to the period 2022-2024.

The SATs that has been developed by researchers, namely the SDI, can be used for a longer period in the future as a holistic SDI for Indonesia and internationally. Future research is also needed to see the impact of factors that influence SD, especially related to regulatory factors relevant to HEIs; changes in the mindset and awareness of the academic community regarding sustainability; strengthening the commitment of leaders, governance and collaboration; improving the quality and quantity of human resources, as well as budget and infrastructure. Last but not least, important to analyze the weighting (frequency of disclosure) by conducting content analysis.

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Impacting Intellectual Capital on Business Performance of SMEs: The Mediating Role of Innovation, Competitive Advantage and Brand Value

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ABSTRACT

This study explores the impact of intellectual capital on the business performance at small and medium enterprises in Vietnam, with a specific focus on the mediating roles of innovation, competitive advantage, and brand value. Based on the resource-based view and knowledge-based theory, the research conceptualizes intellectual capital as a second-order construct comprising human capital, structural capital, and relational capital. A mixed-method approach was employed, including qualitative interviews with 20 economic experts to refine measurement scales and a quantitative survey of 700 SME managers in Dong Nai province, of which 683 valid responses were analyzed using Partial Least Squares Structural Equation Modeling. The results demonstrate that intellectual capital has a strong positive effect on innovation ($\beta = 0.967$, $p < 0.001$) and significant indirect effects on competitive advantage, brand value, and business performance. Both innovation and brand value play critical mediating roles, indicating that SMEs transform intangible resources into performance outcomes through knowledge-driven innovation and brand enhancement. Furthermore, brand value ($\beta = 0.383$) exhibits a stronger influence on business performance than competitive advantage ($\beta = 0.316$). The findings enrich the theoretical understanding of intellectual capital within the SME context and provide practical implications for managers to leverage innovation and branding as strategic mechanisms for sustainable performance improvement.

INTRODUCTION

In the knowledge-based economy, intellectual capital (IC) has emerged as one of the most valuable assets for firms seeking sustainable growth and competitive advantage. Unlike traditional physical and financial resources, intellectual capital, encompassing human, structural, and relational capital, constitutes the primary driver of innovation, learning, and long-term value creation (Varma & Dutta, 2023). For small and medium-sized enterprises (SMEs), which often face resource constraints and market

uncertainties, effectively managing intellectual capital can determine their ability to survive and compete in increasingly dynamic environments (Saraswati et al., 2024).

Over the past two decades, numerous studies have examined the relationship between intellectual capital and firm performance (Zhu & Newman, 2023). However, most of these studies have focused on large corporations or firms in developed economies, where intangible asset management is relatively mature. Research in developing countries, particularly in the context of SMEs, remains limited. In emerging markets such as Vietnam, SMEs account for more than 97% of all enterprises and play a crucial role in job creation, innovation, and economic resilience. However, many Vietnamese SMEs still struggle to leverage intangible resources effectively to enhance competitiveness and brand value. This gap underscores the need to examine how intellectual capital contributes to SME performance through mediating mechanisms. Drawing upon the Resource-Based View (RBV) and the Knowledge-Based Theory (KBT), this study argues that intellectual capital enhances firm performance not directly, but through its influence on innovation, competitive advantage, and brand value. According to RBV, firm resources that are valuable, rare, inimitable, and non-substitutable (VRIN) form the foundation of sustainable competitive advantage (Gashe et al., 2024). Intellectual capital meets these criteria as it represents unique knowledge, capabilities, and relationships embedded in the organization. Meanwhile, KBT emphasizes that the firm's capacity to create, share, and apply knowledge drives innovation and performance (Jie et al., 2023). Therefore, innovation serves as a conduit through which intellectual resources are translated into tangible business outcomes, such as brand equity and superior performance.

Although several scholars have explored aspects of this relationship, the integrated mediating mechanisms of innovation, competitive advantage, and brand value have received limited empirical attention, particularly within the SME sector of developing economies. Most previous research treated innovation or competitive advantage as a single mediator (Kiranantawat & Ahmad, 2023), overlooking the sequential process by which intellectual capital generates market performance through innovation-driven brand development. Additionally, few studies have validated these relationships using advanced structural equation modeling (SEM) techniques capable of testing higher-order constructs such as intellectual capital.
To address this knowledge vacuum, this study takes a look at how intellectual capital affects the bottom line of small and medium enterprises in Vietnam, with a focus on how innovation, competitive advantage, and brand value play a mediating role. The researchers used a mixed-methods approach, soliciting input from a large group of economic experts to fine-tune the measurement scales before administering a quantitative survey to a large number of SME managers in the province of Dong Nai. PLS-SEM was used to analyze the data collected from this survey.

The findings reveal that intellectual capital significantly influences innovation, which, in turn, enhances competitive advantage, brand value, and, ultimately, business performance. Among the mediators, brand value has the most potent effect on performance, indicating that intangible assets such as reputation, trust, and customer loyalty are critical for sustaining long-term success in SMEs.
This research contributes to the intellectual capital literature by providing empirical evidence from a developing economy and by integrating innovation and branding as key strategic mechanisms. From a managerial perspective, the study highlights the importance of developing human expertise, strengthening organizational systems, and fostering an innovation culture as foundations for achieving superior brand positioning and competitive outcomes.

1. THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

1.1 Business Performance (BP)

Business performance reflects the extent to which a firm achieves its strategic and financial objectives through efficiency, profitability, and market success. In the context of SMEs, performance encompasses both financial outcomes and non-financial indicators such as customer satisfaction, innovation capability, and competitive positioning (Aidoo et al., 2021). Prior research emphasizes that intangible assets,

particularly intellectual capital, innovation, and brand value, play crucial roles in driving superior and sustainable business performance.

1.2 Innovation (IN)

Innovation refers to a firm's ability to create and implement new ideas, products, or processes that enhance organizational performance and competitiveness. It serves as a critical mechanism for transforming intellectual capital into tangible outcomes (Subramaniam & Youndt, 2005). Within SMEs, innovation reflects adaptability and responsiveness to environmental changes and market demands. Empirical studies confirm that firms with more substantial intellectual capital demonstrate higher innovation capability, thereby improving efficiency, differentiation, and long-term business success (You et al., 2023).

1.3 Competitive Advantage (CA)

Competitive advantage refers to a firm's ability to achieve superior market positioning and performance relative to competitors by utilizing unique resources and capabilities. Rooted in the Resource-Based View (RBV), it arises when a company effectively combines valuable, rare, inimitable, and non-substitutable resources, such as knowledge and innovation, to deliver superior value (Byukusenge & Munene, 2017). For SMEs, competitive advantage often manifests through agility, innovation, and strong relationships, enabling them to respond quickly to market changes and sustain business growth.

1.4 Brand Value (BV)

Brand value represents the overall perception, trust, and emotional connection that customers associate with a firm and its offerings (Sisodia et al., 2021). It embodies the intangible equity derived from consistent quality, reputation, and customer experience. In SMEs, substantial brand value enhances differentiation, customer loyalty, and long-term profitability, serving as a key mediator between innovation and business performance. Previous studies suggest that innovation-driven branding strategies significantly improve brand equity and organizational success (Intara & Suwansin, 2024). Therefore, brand value plays a strategic role in converting intangible knowledge assets into sustainable market performance.

1.5 Intellectual Capital (IC)

Intellectual capital encompasses the collective knowledge, experience, relationships, and organizational capabilities that create value and drive firm performance. It is generally structured into three dimensions: Human Capital (HC), which reflects employees' skills and expertise; Structural Capital (SC), referring to organizational systems and processes; and Relational Capital (RC), denoting external relationships with customers and partners. Within the Resource-Based View (RBV) and Knowledge-Based Theory (KBT), intellectual capital is considered a strategic, inimitable asset that fosters innovation and competitive advantage. In SMEs, effective utilization of intellectual capital enhances adaptability, innovation capability, and sustainable performance (Schulze & Dada, 2024; Asiaei et al., 2021).

1.6 Hypotheses Development

Intellectual capital is widely recognized as a multidimensional construct comprising human capital (HC), structural capital (SC), and relational capital (RC). These components represent the knowledge, organizational systems, and relationships that collectively enhance firm capabilities (Vithana et al., 2021). Effective management of these components strengthens innovation potential and long-term value creation. Thus, intellectual capital is modeled as a second-order construct, reflected by its three key dimensions.

H1: Intellectual capital has a positive effect on human capital.

H2: Intellectual capital has a positive effect on structural capital.
H3: Intellectual capital has a positive effect on relational capital.

The Resource-Based View (RBV) and Knowledge-Based Theory (KBT) suggest that firms rich in intellectual capital are better able to generate innovative ideas and technologies (Holland & Scullion, 2021). Human knowledge and structural processes enable firms to exploit opportunities and adapt to change, while relational capital fosters external collaboration. Therefore, intellectual capital acts as a primary driver of innovation.

H4: Intellectual capital positively affects innovation.

Firms with substantial intellectual capital can transform knowledge resources into market-oriented capabilities such as brand differentiation and competitive positioning (Adu-Ameyaw et al., 2022). The organizational learning and accumulated expertise support superior product quality and brand recognition. Thus, intellectual capital contributes directly to both competitive advantage and brand value.

H5: Intellectual capital positively affects competitive advantage.
H6: Intellectual capital has a positive effect on brand value.

Innovation serves as a critical link between intellectual capital and performance outcomes. It enhances a firm's ability to create new value propositions, improve efficiency, and respond proactively to market needs (Datta et al., 2020). Innovation-driven firms tend to build stronger brands and more sustainable advantages, ultimately improving performance.

H7: Innovation has a positive effect on competitive advantage.
H8: Innovation has a positive effect on brand value.
H9: Innovation has a positive effect on business performance.

According to RBV, sustainable performance results from leveraging unique resources that competitors cannot easily replicate (Aboramadan et al., 2020). Competitive advantage enhances efficiency, market share, and profitability. Likewise, brand value, as a key intangible asset, reinforces customer loyalty and firm reputation, further driving superior performance.

H10: Competitive advantage has a positive effect on business performance.
H11: Brand value positively affects business performance.

The proposed research model, therefore, posits that Intellectual Capital (IC) indirectly influences Business Performance (BP) through Innovation (IN), Competitive Advantage (CA), and Brand Value (BV). This integrated mediation mechanism aligns with both the RBV and KBT, illustrating how SMEs can transform intangible knowledge resources into tangible business outcomes.

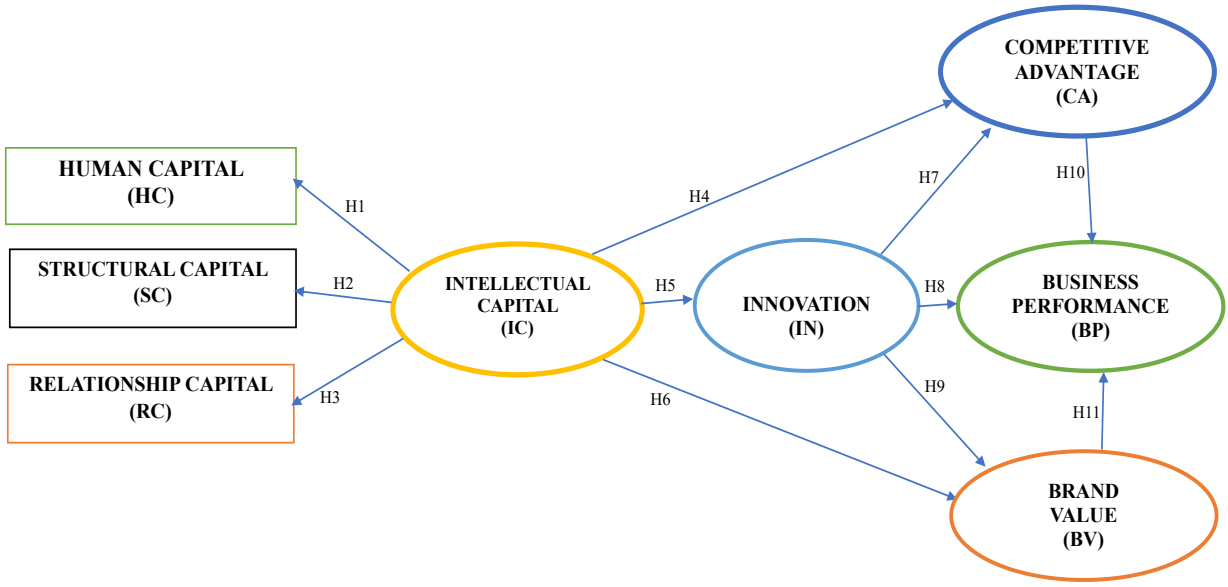

Figure 1. Impact of intellectual capital on the business performance of SMEs
Source: own

Figure 1 illustrates the conceptual model depicting how Intellectual Capital (IC) influences Business Performance (BP) of SMEs through the mediating roles of Innovation (IN), Competitive Advantage (CA), and Brand Value (BV). The model is grounded in the Resource-Based View (RBV) and Knowledge-Based Theory (KBT), emphasizing that intangible resources, such as human, structural, and relational capital, are essential for sustainable competitive advantage. Intellectual capital is a second-order construct that integrates knowledge-based assets that foster innovation and organizational learning. Innovation serves as a key mechanism for transforming intellectual resources into new capabilities, products, and processes that enhance brand value and market competitiveness. In turn, competitive advantage and brand value jointly strengthen overall business performance. The model provides a holistic framework for understanding how SMEs can leverage intangible knowledge assets to achieve superior performance and long-term growth in dynamic and competitive environments.

2. RESEARCH METHODOLOGY

2.1 Qualitative Research Method

The qualitative phase of this study was conducted to develop, refine, and validate the measurement scales used in the quantitative survey. This approach ensured the conceptual clarity and contextual appropriateness of constructs related to intellectual capital, innovation, competitive advantage, brand value, and business performance within the context of small and medium-sized enterprises (SMEs) in Vietnam.

The qualitative research relied on in-depth expert interviews and focus group discussions with a total of 20 participants, including university professors, economic researchers, senior managers, and policy-makers specializing in entrepreneurship and SME development. Participants were selected using purposive sampling to ensure diversity in expertise and experience. Each discussion lasted between 60 and 90 minutes, conducted both in person and online between January and March 2025. The aim was to collect professional insights into how Vietnamese SMEs understand, manage, and leverage intellectual capital to improve innovation and performance (Hair et al., 2019).

The interview guide was structured around five main themes: (1) the conceptualization of intellectual capital and its components (human, structural, and relational capital); (2) the mechanisms through which intellectual capital enhances innovation capacity; (3) the linkages between innovation, competitive

advantage, and brand value; (4) the determinants of business performance for SMEs; and (5) recommendations for adapting measurement items to local business culture and management practices. Each theme was accompanied by open-ended questions to allow flexibility and depth in responses.

With the participants' permission, we audio-recorded each interview and transcribed it word-for-word so we could do theme analysis. A content analysis approach was used to analyze the data, according to the protocols outlined by Hair et al. (2019). This included data reduction, data display, and conclusion drawing. Recurrent patterns and concepts were coded and categorized to refine the constructs and ensure the indicators' content validity. This iterative process helped identify overlaps among items, eliminate ambiguous statements, and adapt terminology to fit the Vietnamese SME context.

Results from the qualitative phase confirmed that intellectual capital should be modeled as a second-order construct comprising human capital (HC), structural capital (SC), and relational capital (RC). Experts emphasized that the development of innovation capability serves as the bridge between intellectual capital and competitive advantage. Furthermore, they noted that substantial brand value and market reputation are crucial mediators that translate innovation and knowledge into measurable business outcomes.

Finally, the qualitative findings provided both theoretical and empirical justification for the research model. They reinforced the idea that SMEs' business performance depends not only on tangible resources but also on the strategic use of intangible assets. The insights obtained guided the refinement of the questionnaire used in the subsequent quantitative phase, ensuring construct reliability, content validity, and contextual relevance.

2.2 Quantitative Research Method

The study's conceptual model and hypotheses were empirically tested by quantitative research, which followed the qualitative phase. Structural Equation Modeling with an enhanced methodology based on SmartPLS 4.0's Partial Least Squares was used in this phase. With this quantitative study, we set out to verify, within the Vietnamese context of SMEs, the links between IP, innovation, competitive advantage, brand value, and financial success.

Sampling and Data Collection: The target population comprised SME managers and executives operating in Dong Nai Province, Vietnam, a region known for its industrial dynamism and concentration of manufacturing and service-oriented SMEs. A total of 700 questionnaires were distributed between April and August 2025 using both online and direct distribution methods. After screening for completeness and consistency, 683 valid responses were retained for analysis, yielding a valid response rate of 97.6%.

Measurement Scales and Variables: All constructs were measured using established scales adapted from prior studies and refined through the qualitative phase. Each item was rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The constructs included:

(1) Human Capital (HC): 4 items measuring employee knowledge, skills, and creativity. (2) Structural Capital (SC): 5 items capturing organizational systems, databases, and procedures. (3) Relational Capital (RC): 4 items reflecting customer, supplier, and partner relationships. (4) Intellectual Capital (IC): modeled as a second-order construct derived from HC, SC, and RC. (5) Innovation (IN): 4 items measuring product, process, and managerial innovation. (6) Competitive Advantage (CA): 4 items assessing cost efficiency, differentiation, and market responsiveness. (7) Brand Value (BV): 4 items measuring brand recognition, trust, and perceived quality. (8) Business Performance (BP): 4 items representing profitability, growth, and customer satisfaction.

Methods for Analyzing Data: For this study, we opted to use Partial Least Squares Structural Equation Modeling (PLS-SEM) since it is well-suited to complicated models and predictive analysis in the field of management research. We used Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE) to evaluate the reliability and validity of the test. The fact that all the constructs were higher

above the suggested limits (α > 0.7; CR > 0.7; AVE > 0.5) proves that there is validity and internal consistency.

The structural model was then tested to evaluate path coefficients, t-statistics, and p-values through bootstrapping (5.000 subsamples). The results demonstrated strong, significant relationships among the constructs. The quantitative results provided robust empirical evidence supporting all eleven hypotheses proposed in the conceptual model. The findings confirmed that intellectual capital serves as a fundamental resource that enhances innovation capability, which in turn strengthens brand value and competitive advantage, ultimately improving SME business performance.

3. RESEARCH RESULTS

3.1 Descriptive Statistics

The descriptive analysis provides an overview of the demographic characteristics of respondents and the profile of the surveyed small and medium enterprises in Dong Nai Province, Vietnam. A total of 683 valid responses were analyzed after eliminating incomplete or inconsistent questionnaires. The demographic and firm characteristics offer important contextual information for interpreting the relationships between key factors.

In terms of gender, the sample included 404 males (59.2%) and 279 females (40.8%), reflecting a relatively balanced gender distribution among SME managers. Regarding marital status, 62.1% of respondents were single, while 37.9% were married. This composition indicates a dynamic and young managerial workforce, which aligns with the entrepreneurial and flexible nature of SMEs in Vietnam.

Regarding age, the largest group (53.3%) was aged 30-40, followed by 24.0% aged 25–30, 15.4% aged 40+, and 7.3% aged < 25. This distribution shows that most respondents were in their early to mid-career stages, a demographic associated with adaptability, creativity, and openness to innovation, key attributes for effectively leveraging intellectual capital.

In terms of monthly income, 38.1% earned between 20 and 25 million VND, 35.9% above 25 million VND, 21.4% between 15 and 20 million VND, and only 4.7% below 15 million VND. The relatively high-income levels of respondents suggest that the managers surveyed hold significant responsibility and decision-making authority within their organizations.

Firm Characteristics: Regarding business type, the sample consisted of 33.4% single-member limited liability companies, 29.0% private enterprises, 20.6% joint-stock companies, and 17.0% multi-member limited liability companies. This distribution reflects the predominance of small, privately owned enterprises in the Vietnamese SME landscape, where owners often play a central role in strategic management and innovation.

In terms of firm age, 39.8% of enterprises had been operating for 10–15 years, followed by 33.5% for more than 15 years, 20.9% for 5-10 years, and 5.7% for less than 5 years. The majority of firms thus demonstrated considerable operational maturity, implying accumulated managerial experience and established organizational structures capable of sustaining intellectual capital development.

The descriptive statistics for the primary constructs showed mean values ranging from 3.25 to 3.61 (on a five-point scale), indicating moderately high perceptions across the measured variables. Specifically, Intellectual Capital (mean = 3.612, SD = 0.935) was rated highest, followed closely by Structural Capital (mean = 3.552) and Brand Value (mean = 3.486). Business Performance (mean = 3.381) and Innovation (mean = 3.317) also achieved relatively high averages, suggesting that SMEs perceive strong alignment between knowledge-based assets and innovation-driven growth.

These descriptive findings confirm that the surveyed firms possess well-developed intangible resources and recognize their strategic importance. The demographic structure of respondents, mostly

experienced managers in well-established firms, provides a solid foundation for interpreting the causal relationships tested in the SEM model. Overall, the descriptive statistics reinforce the data's reliability and contextualize the subsequent empirical analysis.

3.2 Testing for factors affecting business performance

Table 1. Cronbach's Alpha and composite reliability testing for factors affecting business performance

Factors	Code	Items	Mean	Std. Deviation	Cronbach's alpha	Composite reliability	Composite reliability	Average variance extracted
1. Human Capital	HC	4	3.425	0.925	0.965	0.966	0.975	0.906
2. Structural Capital	SC	5	3.552	0.945	0.974	0.974	0.979	0.905
3. Relationship Capital	RC	4	3.253	0.954	0.966	0.966	0.975	0.907
4. Intellectual Capital	IC	4	3.612	0.935	0.963	0.963	0.973	0.901
5. Innovation	IN	4	3.317	0.932	0.971	0.971	0.979	0.920
6. Brand Image	BI	4	3.486	0.966	0.967	0.967	0.976	0.910
7. Competitive Advantage	CA	4	3.482	0.961	0.984	0.984	0.988	0.954
8. Business Performance	BP	4	3.381	0.972	0.986	0.986	0.989	0.959

Source: own

Table 2 presents that the Cronbach's Alpha results demonstrate excellent internal consistency across all constructs examined in the study. To ensure the measurement quality and robustness of the constructs used in the research model, a comprehensive reliability and validity analysis was conducted. This involved testing internal consistency reliability, composite reliability, and convergent validity based on the data presented in Table 1.

All constructs exhibited alpha coefficients significantly above the recommended threshold of 0.70 (Amoa-Gyarteng & Dhliwayo, 2024), indicating excellent internal reliability. Specifically, Cronbach's Alpha values ranged from 0.963 for Intellectual Capital (IC) to 0.986 for Business Performance (BP), demonstrating that the items within each construct consistently measure the same underlying concept. The relatively high reliability across constructs such as Competitive Advantage (0.984) and Structural Capital (0.974) reflects substantial homogeneity and internal coherence in the measurement items.

Composite reliability provides a more refined estimate of reliability by accounting for different indicator loadings. Both coefficients were used for robustness. The CR values ranged from 0.973 (IC) to 0.989 (BP), all well above the 0.70 benchmark suggested by Hair et al. (2019). This confirms that the constructs demonstrate strong internal consistency and that the indicators share a high level of variance in representing their latent factors. The nearly identical values for each construct further indicate measurement stability across samples.

All constructs achieved AVE values above 0.90, substantially exceeding the recommended threshold of 0.50 (Cowling et al., 2018). For example, Innovation (IN) recorded an AVE of 0.920, Brand Image (BI) 0.910, and Business Performance (BP) 0.959. These high AVE scores indicate that the measurement indicators explain a large proportion of the variance in their latent constructs, thereby confirming strong convergent validity.

The results summarized in Table 1 clearly indicate that the measurement model achieved an exceptionally high level of reliability and validity. This robustness can be attributed to the rigorous scale adaptation and expert validation processes during the qualitative phase. The consistency across Cronbach's Alpha, composite reliability, and AVE demonstrates that all constructs are empirically sound and theoretically coherent.

Moreover, the high reliability and validity scores indicate the appropriateness of using these measurement items in the Vietnamese SME context. Constructs such as Intellectual Capital, Innovation, and Brand Value, traditionally conceptualized in developed economies, proved valid and reliable in capturing similar dynamics in emerging markets.

In conclusion, the results from Table 1 confirm that the measurement model meets all statistical requirements for reliability and convergent validity. These findings present the results of testing, assessing the hypothesized relationships among intellectual capital, innovation, competitive advantage, brand value, and business performance.

Table 2. SEM testing for factors affecting business performance

Factors	Original sample	Sample mean	Standard deviation	T statistics	P values
BI → BP	0.383	0.381	0.047	8.147	0.000
CA → BP	0.316	0.319	0.051	6.186	0.000
IC → BI	0.456	0.456	0.037	12.426	0.000
IC → CA	0.425	0.425	0.085	5.021	0.000
IC → HC	0.965	0.966	0.003	368.839	0.000
IC → IN	0.967	0.966	0.003	361.561	0.000
IC → RC	0.970	0.970	0.002	462.839	0.000
IC → SC	0.972	0.972	0.002	509.829	0.000
IN → BI	0.532	0.532	0.036	14.583	0.000
IN → BP	0.302	0.301	0.050	6.004	0.000
IN → CA	0.447	0.447	0.086	5.192	0.000

Source: own

Table 2 presents the results of the Structural Equation Modeling (SEM) analysis, showing the relationships among the constructs and their statistical significance. All path coefficients are positive and statistically significant at $p < 0.001$, confirming strong empirical support.

The findings indicate that IC significantly influences its three dimensions: Human Capital (HC) ($\beta = 0.965$, $t = 368.839$), Structural Capital (SC) ($\beta = 0.972$, $t = 509.829$), and Relational Capital (RC) ($\beta = 0.970$, $t = 462.839$), validating IC as a second-order construct. Moreover, IC has substantial direct effects on Innovation (IN) ($\beta = 0.967$, $t = 361.561$), Competitive Advantage (CA) ($\beta = 0.425$, $t = 5.021$), and Brand Image (BI) ($\beta = 0.456$, $t = 12.426$), highlighting its pivotal role as a foundational intangible asset that drives strategic outcomes.

Innovation also exerts a strong mediating influence, positively affecting Competitive Advantage ($\beta = 0.447$, $t = 5.192$), Brand Image ($\beta = 0.532$, $t = 14.583$), and Business Performance (BP) ($\beta = 0.302$, $t = 6.004$). These results confirm that innovative capability serves as a crucial mechanism through which intellectual resources are transformed into superior market positioning and brand differentiation.

Finally, both Competitive Advantage ($\beta = 0.316$, $t = 6.186$) and Brand Image ($\beta = 0.383$, $t = 8.147$) significantly enhance Business Performance, underscoring their mediating and direct impacts on firm success. The SEM results strongly support the proposed theoretical framework, demonstrating that Intellectual Capital indirectly improves Business Performance through the mediating effects of Innovation, Competitive Advantage, and Brand Image. This provides robust empirical evidence that leveraging intangible assets is essential for achieving sustainable competitiveness among SMEs in emerging economies.

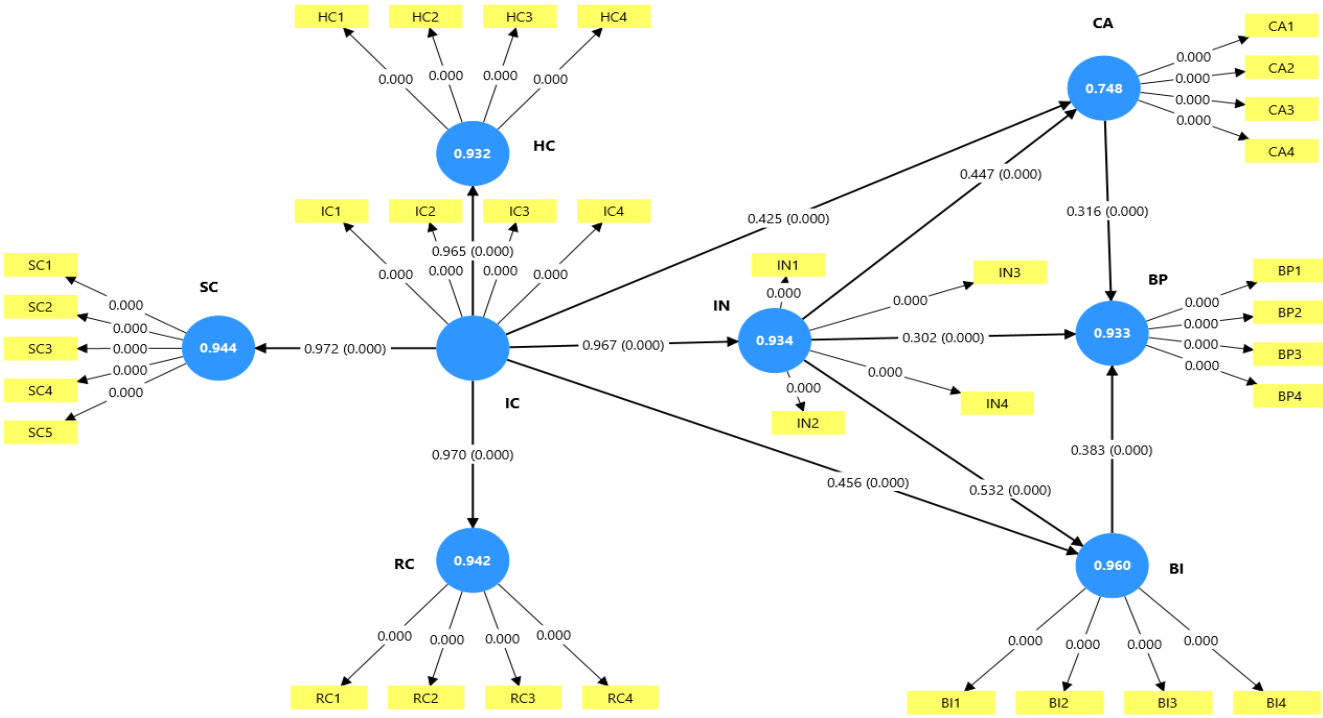

Figure 2. Testing factors influencing business performance

Figure 2 presents the structural equation model illustrating the relationships among intellectual capital, innovation, competitive advantage, brand value, and business performance. The diagram highlights intellectual capital (IC) as a second-order construct, composed of human capital (HC), structural capital (SC), and relational capital (RC). Each of these dimensions significantly contributes to the overall intellectual capital, confirming their strong internal coherence and conceptual validity.

The model demonstrates that IC has a direct and substantial effect on innovation (IN), which, in turn, enhances both competitive advantage (CA) and brand image (BI). Innovation serves as a key mediator, transforming intellectual resources into value-creating processes and capabilities that lead to improved organizational outcomes. Moreover, both CA and BI exert significant positive effects on business performance (BP), reinforcing the argument that sustained competitiveness and substantial brand equity are critical drivers of success for SMEs.

Finally, Figure 2 visualizes how intellectual capital indirectly affects business performance through a chain of mediating effects from innovation to competitive advantage and brand image. This integrated pathway confirms the importance of knowledge-based assets in shaping innovation capacity and sustaining superior performance in the dynamic SME environment.

Table 3. Hypotheses testing summary for factors affecting business performance

Hypothesis	Path	β	t-value	p-value	Result
H1	IC → HC	0.965	368.839	0.000	Supported
H2	IC → SC	0.972	509.829	0.000	Supported
H3	IC → RC	0.970	462.839	0.000	Supported
H4	IC → IN	0.967	361.561	0.000	Supported
H5	IC → CA	0.425	5.021	0.000	Supported
H6	IC → BI	0.456	12.426	0.000	Supported
H7	IN → CA	0.447	5.192	0.000	Supported
H8	IN → BI	0.532	14.583	0.000	Supported
H9	IN → BP	0.302	6.004	0.000	Supported

H10	CA → BP	0.316	6.186	0.000	Supported
H11	BI → BP	0.383	8.147	0.000	Supported

Source: own

Table 3 summarizes the hypothesis-testing results from the Structural Equation Modeling (SEM) analysis. All eleven hypotheses (H1–H11) were statistically supported at the $p < 0.001$ significance level, confirming the robustness of the proposed theoretical framework.

The results indicate that Intellectual Capital (IC) strongly and positively influences its three components, Human Capital (HC) (β = 0.965), Structural Capital (SC) (β = 0.972), and Relational Capital (RC) (β = 0.970), validating the multidimensional structure of IC. Moreover, IC significantly enhances Innovation (IN) (β = 0.967), Competitive Advantage (CA) (β = 0.425), and Brand Image (BI) (β = 0.456), emphasizing its foundational role in driving organizational capabilities and market performance.

Innovation acts as a critical mediating variable, exerting significant positive effects on Competitive Advantage (β = 0.447), Brand Image (β = 0.532), and Business Performance (β = 0.302). These results highlight innovation as the mechanism through which intellectual assets are transformed into tangible organizational outcomes.

Finally, both Competitive Advantage (β = 0.316) and Brand Image (β = 0.383) contribute positively to Business Performance, confirming their importance as final mediators. Overall, the findings strongly support the proposed model, demonstrating that intellectual capital indirectly enhances SME performance through innovation-driven competitive and branding pathways.

4. DISCUSSION

The study's findings offer credence to the idea that IC plays a pivotal role in helping SMEs improve their business performance. Findings align with RBV and KBT, which state that firms' strategic assets that facilitate innovation, build sustainable advantages, and strengthen brand value are intangible knowledge resources, particularly human, structural, and relational capital.

(1) The significant relationships between IC and its dimensions (H1–H3) validate IC as a second-order construct, integrating human, structural, and relational elements into a cohesive framework. These findings align with Gianiodis et al. (2022), who emphasized that effective interaction among knowledge assets determines an organization's capacity for learning and innovation. In particular, the high path coefficients indicate that Vietnamese SMEs have developed relatively mature systems for managing knowledge and relationships, reflecting growing professionalism in the sector.

(2) The positive influence of IC on Innovation (H4) underscores the importance of knowledge-driven creativity as a mechanism for translating intellectual resources into practical outcomes. This result supports Nakku et al. (2020), who argued that intellectual capital underpins firms' innovative capabilities. The findings demonstrate that when SMEs invest in training, process improvement, and relational networks, they are more likely to generate and apply new ideas that enhance competitiveness.

(3) Innovation's mediating role is clearly confirmed through its effects on Competitive Advantage (H7), Brand Value (H8), and Business Performance (H9). These relationships reveal that innovation acts as the bridge between knowledge and market outcomes. This aligns with previous research (Juergensen et al., 2020), which shows that innovation converts intellectual capital into tangible business success through new products, improved processes, and enhanced customer experience.

(4) The direct effects of Competitive Advantage (H10) and Brand Value (H11) on Business Performance highlight how differentiation and reputation translate into superior results. SMEs with unique capabilities and strong brand images tend to achieve higher customer loyalty, market share, and profitability.

This is consistent with Wong & Kee (2022), who emphasized that sustained advantage and brand equity are central to long-term success.

(5) The integrated model confirms that Intellectual Capital indirectly affects Business Performance through the joint mediating roles of Innovation, Competitive Advantage, and Brand Value (Bilgin & Kethüda, 2022).

This finding contributes to the growing literature on knowledge-based management by providing empirical evidence from an emerging economy context. It illustrates that Vietnamese SMEs, when strategically leveraging intellectual resources, can achieve outcomes comparable to those of firms in more developed economies. This study reinforces the theoretical link between knowledge assets and firm performance, demonstrating that intellectual capital is not merely a support function but a strategic driver of competitiveness and growth. The results provide both academic and managerial insights into how SMEs can systematically manage and transform intangible assets into measurable performance gains.

CONCLUSION

The purpose of this research was to identify the factors that mediate the relationship between SMEs' intellectual capital and their business performance, through the examination of innovation, competitive advantage, and brand value. The results, which draw from RBV and KBT, give strong empirical evidence that intellectual capital is an important factor in achieving long-term success in fast-paced, cutthroat industries. The results confirmed that IC, comprising HC, SC, and RC, functions as a second-order construct that underpins innovation and long-term competitiveness. Intellectual capital exerts a strong direct influence on innovation and, indirectly, enhances business performance through its effects on brand value and competitive advantage. Among the mediating variables, innovation plays a central role, acting as a conduit that transforms intangible knowledge resources into tangible business outcomes.

These findings affirm that firms with well-developed intellectual capital systems are better positioned to innovate, differentiate their offerings, and strengthen their market reputation, ultimately leading to superior performance. The study contributes theoretically by integrating intellectual capital, innovation, and brand management into a unified model of SME performance. It extends the RBV and KBT frameworks by empirically demonstrating that knowledge-based resources, when effectively managed, can be transformed into competitive capabilities and brand equity that directly enhance profitability and growth. From a methodological perspective, the use of PLS-SEM with a large and diverse sample of 683 SME managers adds empirical rigor and generalizability to the findings.

Based on the findings, several key recommendations emerge for SME managers and policymakers:

(1) Firms should prioritize continuous training, skill enhancement, and leadership development to strengthen creativity and knowledge application. Building a learning culture enhances innovation capacity and organizational resilience. Although businesses are developing in a modern 4.0 technology environment, with many recruitment support tools, the labor supply rate has increased significantly but still does not meet the actual needs of businesses. In addition, the solution to retain employees and develop talent in the organization through training and development has not been invested in a systematic and in-depth manner.

(2) Managers should formalize organizational knowledge through databases, digital systems, and standardized processes that support innovation and knowledge sharing. A strong structural foundation enables the effective utilization of human and relational capital. Strengthen relational capital: SMEs should cultivate long-term partnerships with customers, suppliers, and research institutions. These relationships not only facilitate trust and collaboration but also accelerate the diffusion of innovation. Managers must encourage experimentation, risk-taking, and cross-functional teamwork. Innovation should be embedded in daily operations and strategic planning, linking intellectual capital to tangible outcomes.

(3) Managers should encourage continuous innovation and quality improvement to enhance brand reputation. Firms should invest in marketing communication and customer experience to reinforce perceived value and loyalty. Developing the management team through professional improvement, training management skills for the current management team, training additional soft skills such as leadership skills, training skills for managers, training motivational skills through applying psychology...; Developing and building a successor team, developing talent in the organization; building a learning model associated with work efficiency, business efficiency, monitoring and evaluating the learning path and personal development through learning management software.

(4) Intellectual capital plays an important role as a core asset that creates sustainable competitive advantage for businesses by generating wealth, promoting development, and improving operational efficiency. The study demonstrates that intellectual capital is a strategic resource that significantly drives innovation, competitive advantage, and brand value, key determinants of business performance in SMEs. The findings highlight the need for Vietnamese SMEs to view knowledge assets not as abstract concepts but as measurable, manageable, and value-generating resources. Future research could extend this work by exploring cross-country comparisons or examining the moderating role of digital transformation in the IC-performance relationship.

Limitations and future research: First, the study's data were collected from SMEs located in Dong Nai Province, Vietnam, which, while economically dynamic, may not fully represent all regions or industries. Future studies could expand the geographical scope and include comparisons across different provinces or countries to enhance generalizability. Second, the research design employed a cross-sectional survey, capturing perceptions at a single point in time. As intellectual capital and innovation evolve continuously, future research should consider longitudinal designs to examine causal relationships and dynamic changes in intellectual capital utilization and performance over time. Third, the study relied primarily on self-reported data from SME managers, which may introduce response bias or subjective interpretation. Future research could incorporate objective performance indicators, e.g., financial metrics or innovation outputs, to triangulate results and improve accuracy. Fourth, while this study focused on the mediating roles of innovation, competitive advantage, and brand value, other potential mediators, such as digital transformation, organizational learning, or strategic agility, could be explored in future models to capture additional mechanisms linking intellectual capital to performance.

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The Auditor's Capacity to Employ Cybersecurity for Fraud Detection: The Influence of Training and Experience

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ABSTRACT

Indonesia, being a developing nation, possesses legislation regulating the compilation of financial accounts and requirements pertinent to auditors. The legislative system governing financial reporting is also evident in developed countries. Auditors in the Fourth Industrial Revolution possess cybersecurity expertise. This study seeks to clarify the influence of auditor experience and training on the auditor's ability to implement cybersecurity measures for identifying financial fraud, with professional skepticism acting as a moderating variable. The investigation encompassed 61 auditors from the Audit Board of Indonesia (BPK) Representative Office in North Sumatra Province. The results indicate a significant influence of auditor experience and training on the auditor's ability to utilize cybersecurity for identifying financial crime; however, professional skepticism does not operate as a moderating variable. This study's distinctiveness is rooted in the claim that auditors must have cybersecurity competencies to detect fraud in financial reporting. The auditor's proficiency in handling and reporting client money greatly affects their ability to detect fraud. Nonetheless, auditors must augment their competencies, especially considering the digital improvements in accounting, to provide high-quality reports relevant to both current and future contexts. This will also serve as auditor branding in clients' perceptions and maintain the auditor's professional skepticism.

INTRODUCTION

Indonesia is always dedicated to bolstering the social economy in every way. In order to verify the financial viability and application of financial trends in a local, national, or international organization and/or business, the Indonesian government entrusts its trust to a group of financial analysts known as auditors. Lower political risk while revealing and discussing every budget transaction. Indonesia has stringent laws in place to avoid fraud in the preparation of financial statements. These regulations ensure transparency

and accountability, which are crucial for maintaining investor confidence and fostering economic growth. By upholding these standards, Indonesia aims to create a stable financial environment that supports sustainable development and encourages both domestic and foreign investment. Investment in various sectors, such as infrastructure and technology, will be prioritized to stimulate economic activity and enhance competitiveness. As the country continues to strengthen its regulatory framework, it is poised to attract a diverse range of investors seeking opportunities in a stable and transparent market. This proactive approach not only benefits investors but also contributes to job creation and poverty alleviation, ultimately leading to a more resilient economy. By fostering an environment of trust and accountability,

Indonesia is setting the stage for long-term prosperity and growth. Growth is further supported by investments in infrastructure and technology, which are essential for boosting productivity and enhancing the overall quality of life for citizens. As these developments take shape, Indonesia's position as a regional economic powerhouse becomes increasingly solidified, attracting even more global interest and collaboration.Many research studies examine the importance of enhancing auditors' abilities in preparing financial statements by understanding the developments in science and technology so that financial usage patterns can be presented in a financial report, and one important aspect is the presence of auditors in a healthy and objective environment.

The audit profession emphasizes the importance of understanding the audit environment, particularly the prevalence of fraud, in the auditor's efforts to successfully detect and uncover fraud in the use of funding. The audit profession emphasizes the importance of understanding the audit environment, particularly the prevalence of fraud, in the auditor's efforts to successfully detect and uncover fraud in the use of funding.This has become a weakness for the Kingdom of Saudi Arabia in presenting the professional perception of auditors (Al-Dhubaibi and Sharaf-Addin 2022)Another point raised by the United Kingdom is that the establishment of the Audit Commission issues Public Interest Reports (PIR; legally privileged reports commenting on unacceptable or potentially illegal behavior) by providing funds and facilities for behavioral networks and fraud prevention, promoting anti-fraud work among all external board auditors, including private sector companies, and violations regulated by the Public Interest Disclosure Act (PIDA) (Sahdan, Cowton, and Drake 2020). and the same was done with the law Benford cannot predict the risk of financial statement fraud in companies; in other words, Benford's law cannot distinguish between companies at risk of fraud and those not at risk of fraud in their financial statements (Rad et al. 2021).

The regulations implemented by developed and developing countries are reflected in the auditor's experience in communicating financial statements. Research conducted by Malaysia emphasizes that the tenure and busyness of the audit committee chair are significant factors influencing auditor choice, while the ethnicity, expertise, and qualifications of the audit committee chair do not have a significant impact on auditor choice (Wang et al. 2021); (Alsayani, Mohamad Nor, and Al-Matari 2023). The auditor's ability to collaborate with other auditors becomes an experience in detecting financial reports and is one way to build the personal branding of an experienced auditor with a good reputation (Li and Ma 2020). This will create a skeptical attitude of an auditor in the eyes of the public, and clients will be more confident in the auditor (Nolder and Kadous 2018); (Siew 2018).

Human resources as auditors become one of the strengths of both developed and developing countries to be ready to achieve the SDGs, especially the economic prosperity of the country. This aligns with the development of an integrated theoretical framework, institutional theory, stakeholder theory, and management theory, thereby offering concrete insights to policymakers and practitioners to enhance integrity and efficiency in public sector governance through the integration of ethics, corporate social responsibility, and advanced methodologies (Yanuarisa et al. 2025). The objective of this research is (a) to analyze the impact of auditor experience on the auditor's capacity to utilize cybersecurity for the detection of financial statement fraud; (b) to examine the influence of auditor training on the auditor's proficiency in employing cybersecurity for identifying financial statement fraud; and (c) to investigate the moderating effect of professional auditors' skepticism on the use of cybersecurity in detecting financial statement fraud. This research will investigate cybersecurity capabilities as a specialization national and international stages.

1. LITERATURE REVIEW

1.1 Auditor Experience in Using Cyber Security to Detect Fraud in Financial Statements

Presenting strong evidence that political skills and big data significantly improve fraud detection capabilities in Indonesian public sector institutions, auditors with advanced political skills excel in navigating complex organizational dynamics, thereby enhancing their ability to uncover fraudulent activities, which in turn improves auditor performance in a more thorough and timely detection process, facilitating insights and faster identification of anomalies (Junaidi, Hendrian, and Syahputra 2024). In this case, it is also explained that the auditor's work experience as a committee member and audit chair is a major consideration for clients in determining the ability to detect financial statement fraud (Alsayani, Mohamad Nor, and Al-Matari 2023); (Abouelela, Diab, and Saleh 2025); (Dong, Jiang, and Kumar 2021).

1.2 Auditor Training to Use Cyber Security to Detect Fraud in Financial Statements

The implementation of training as an increase in the credibility of auditors in examining financial statements and the ability to quickly identify errors in concluding financial statements. In this case, internal auditors must have the ability to assist in PHEIS audits and improve the PHEIS that currently exist in Indonesia so that they are able to guide internal auditors in the HEIS internal control unit and internationally competitive institutions (Yazid et al., 2025). This also applies in Nigeria, which explains that special skills and abilities are needed to detect fraud reduce banking fraud (Odukoya & Samsudin, 2021). This reinforces that education and training will show the auditor's readiness to identify discrepancies in communicating financial statements and handle the complexity of many clients better than less educated auditors (Ocak, 2018).

1.3 The Moderating Effect of Auditor's Professional Skepticism Attitude with Cybersecurity in Detecting Fraud in Financial Statements

Attribution theory and personality type theory are among the supporters of the auditor's attitude in achieving professional skepticism, so professional skepticism and personality type have a positive and significant impact on fraud detection (Wahidahwati and Asyik, 2022). In this case, it also emphasizes that a skeptical attitude as a form of moderation illustrates that the more training and experience an auditor has, the easier it will be to detect fraud in financial statements (Kwock, Ho, and James, 2016). This becomes a depiction of cooperation with clients, reflecting the auditor's maturity in presenting each transaction position with clear and accurate evidence (Hardies, 2020), and emphasizes that auditors, with the development of insights into the characteristics of auditor skepticism, lead to better fraud detection, thereby improving the quality of audits in Malaysia (Siew, 2018).

2. RESEARCH METHODOLOGY

This study employs generally referred to as SEM-PLS. SEM-PLS, or Structural Equation Modeling using Partial Least Squares, is a powerful statistical tool that allows researchers to analyze complex relationships among variables. This method is particularly useful in situations where traditional parametric assumptions may not hold, enabling a more flexible approach to data analysis. This flexibility makes SEM-PLS an ideal choice for researchers dealing with small sample sizes or non-normally distributed data. Additionally, it provides the capability to model both measurement and structural relationships simultaneously, enhancing the depth of insights gained from the analysis. The SmartPLS statistical program will facilitate the statistical analysis in this investigation. The utilized version of SmartPLS is 3.2.9.

The research sample was obtained using purposive sampling to refine the sample according to the researcher's requirements, specifically targeting auditors with a maximum of 5 years of employment and a minimum of 5 years of work experience. The sample size consists of 61 auditors. Data were gathered via a questionnaire survey. The questionnaire survey aimed to collect relevant information regarding the

auditors' experiences, perceptions, and challenges in their roles. This data will be analyzed to identify key trends and insights that can inform best practices in the auditing profession. This analysis will not only enhance understanding of the current landscape of auditing but also provide valuable recommendations for training and development programs. Ultimately, the findings aim to contribute to the ongoing improvement of audit quality and effectiveness within the industry. By leveraging this data, we can create a framework that supports auditors in navigating their challenges and their skills. This proactive approach will ensure that the auditing profession continues to evolve and meet the demands of a dynamic business environment.

Table 1. Validity and Reliability Test Results

No	Variabel	Indicator
1	Auditor Experience (X1)	a. Working for More than 10 Years b. Behavior of Public Accountants c. Collaboration of Public Accountants with International Financial Services d. Personal Branding Auditor e. Value of Auditor's Honest Service
2	Auditor Training (X2)	a. Attending workshops twice a year b. Development of fraud detection technology capabilities c. Professional degrees according to the needs of the auditor d. Cibercognitiv e. Understanding the changes in science and technology to complete financial reports f. The ability to communicate effectively to win clients' trust
3	Cyber Security to Detect Fraud (Y)	a. Clear, Concise, and Accurate Financial Report Information b. The report results are per the Standard Regulations. c. Security Log Analysis d. Using Multi-Factor Authentication and applications or AI that help check e. Role-Based Access Control Role
4	Professional Skepticism (Z)	a. Verification of Financial Evidence b. Evaluating the Reasonableness of Managerial Estimates c. Transaction Pattern Analysis d. Reassessing the Report Conclusion

Source: own

3. EMPIRICAL RESULTS

Based on the data that has been analyzed using SmartPLS used is 3.2.9, it can be explained as follows:

3.1 Research Results

The research results were obtained by testing survey data or distributing questionnaires to auditors in cyber security fraud, with the following analysis results obtained:

Table 2. Construct Reliability and Validity

	Cronbach's Alpha	Composite Reliability
Auditor Experience	0,714	0,807
Auditor Training	0,727	0,778
Cyber Security to Detect Fraud	0,734	0,825
Moderating Effect 1	1,000	1,000
Professional Skepticism	0,811	0,710

Source: own

Table 2 explains that the validity test in SEM-PLS uses the convergent method, and the results can be concluded as follows:

1. The reliability testing in this study will use Cronbach's Alpha and composite reliability methods. The use of Cronbach's alpha is used to measure the lower bound of the reliability value of a construct variable. The results can be explained as follows: Auditor Experience is 0.714; Auditor Training is 0.727; Cyber Security to Detect Fraud is 0.734; Moderating Effect 1 is 1.000; and Professional Skepticism is 0.811.

2. The expected Cronbach's Alpha value is >0.7, and composite reliability, this construct variable is declared reliable if it >0.7 with a reliability coefficient value between 0 and 1; the results can be explained as follows: Experience Auditor Experience is 0.807; Auditor Training is 0.778; Cyber Security to Detect Fraud is 0.825; Moderating Effect 1 is 1.000; and Professional Skepticism is 0.710.

The following explanation states that all indicators have good reliability and validity values. This is clarified with the following image:

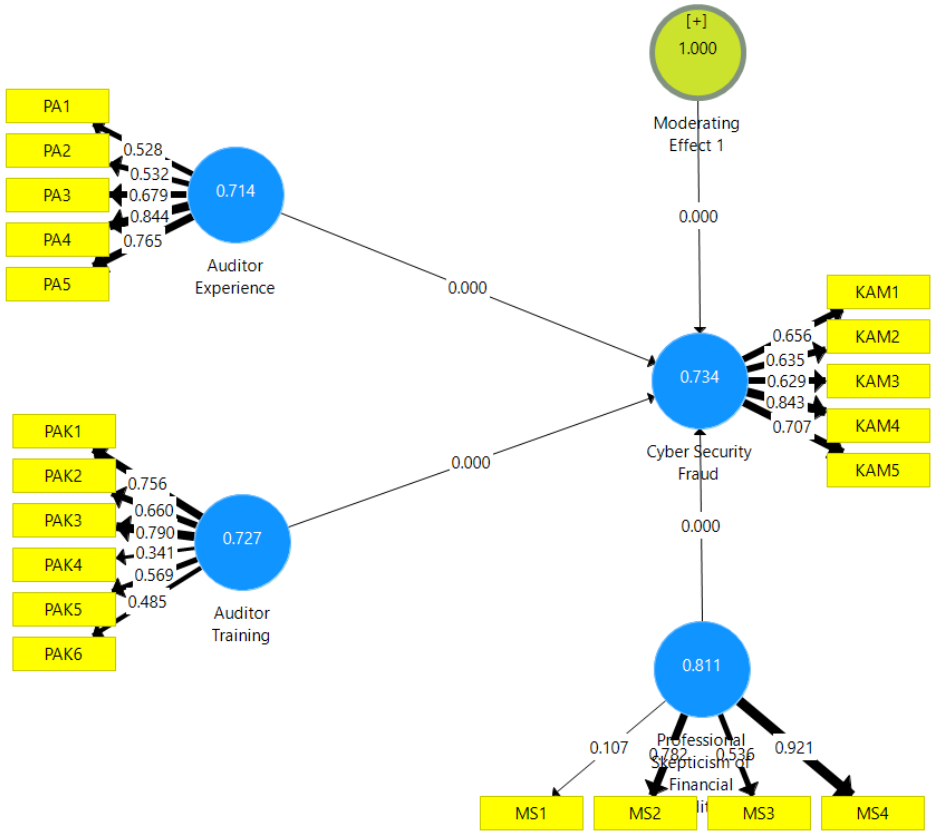

Figure 1. Analysis of Reliability and Validity Values

Next, a determination coefficient test was conducted to measure the extent to which the model can explain the variation of the dependent variable, with the results obtained in the following tables 3 and 4:

Table 3. MV Prediction Summary (PLS)

	RMSE	MAE	MAPE	Q²_predict
KAM1	0,641	0,530	18,888	0,037
KAM2	0,598	0,519	16,400	0,012
KAM3	0,574	0,462	14,841	0,041
KAM4	0,636	0,483	17,735	0,122
KAM5	0,565	0,469	14,404	0,102

Source: own

Table 4. R Square

	R Square	R Square Adjusted
Cyber Security to Detect Fraud	0,920	0,932

Source: own

From tables 3 and 4, it is clearly indicated that the R square data above 0.25 – 0.49 (low moderate influence level); 0.50 – 0.74 (medium moderate influence level); and 0.75 – 1.00 (high moderate influence level), the data is stated to have a good model (including external data) or the contribution of exogenous variables to endogenous variables with an Adj R2 value > 0 and is stated to have a strong model with a Q2 value > 0.3. In this case, it is confirmed that the magnitude of the dependent variable, namely the auditor's ability to detect fraud in financial reports, is influenced by the auditor's experience and auditor training as shown in Table 4 with an R square value of 0.920 (92.0%) a high moderate influence level, it is stated that.

Table 5. Path Coefficients (Mean, STDEV, T-Values, P-Values)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Auditor Experience -> Cyber Security to Detect Fraud	0,267	0,296	0,116	2,300	0,022
Auditor Training -> Cyber Security to Detect Fraud	0,300	0,338	0,143	2,100	0,036
Moderating Effect 1 -> Cyber Security to Detect Fraud	-0,043	0,004	0,099	0,432	0,666
Professional Skepticism -> Cyber Security to Detect Fraud	-0,210	-0,149	0,186	1,132	0,258

Source: own

In Table 5, the above results reflect the Path Coefficients, which are the results of testing the direct effect, so it can be concluded as follows:

a. Auditor Experience has a positive effect on the Cyber Security to Detect Fraud with a t-statistic of 2.300 (p = 0.022)

b. Auditor Training has a positive effect on the Cyber Security to Detect Fraud with t-statistic of 2.100 (p = 0.036)

c. Moderating Effect 1 (Variable Skepticism of Professional Auditors as Moderating) is unable to moderate Cyber Security to Detect Fraud with a t-statistic of 0.432 (p = 0.666)

d. Skepticism of Auditors does not affect Cyber Security to Detect Fraud with a t-statistic of 1.132 (p = 0.258)

This can also be described as follows:

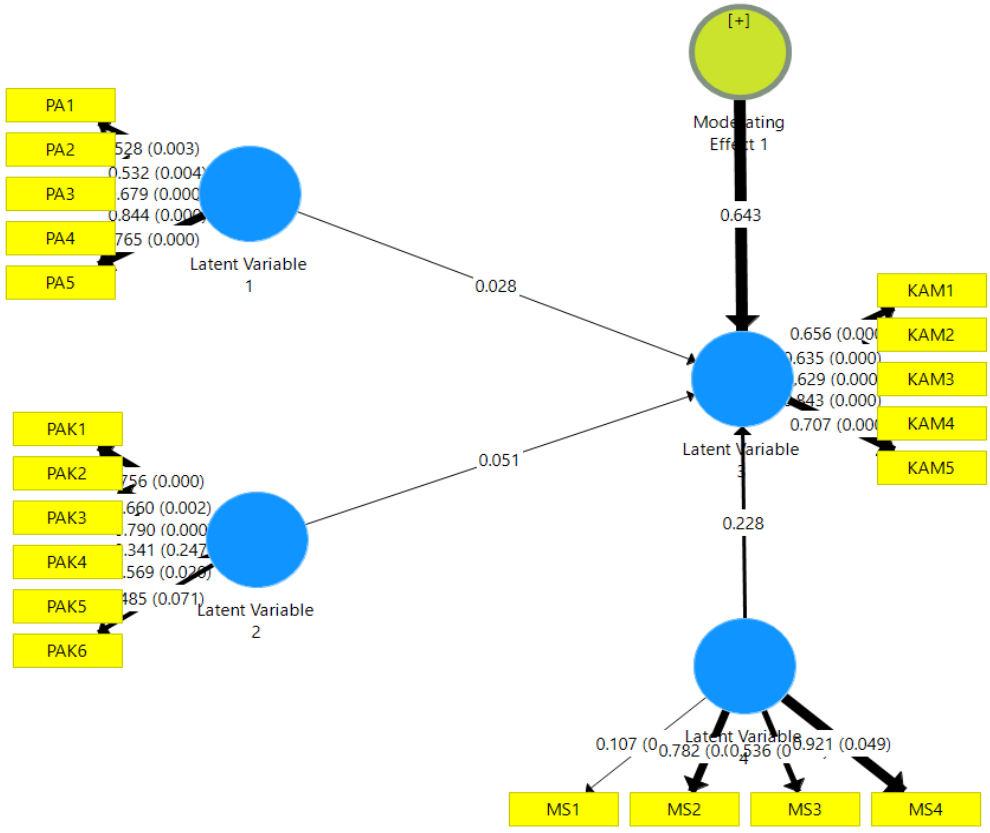

Figure 2. SEM Model in T-Test

From Figure 2, it is clear that in completing financial reports, cyber security skills are essential for accuracy and compliance with Indonesian financial regulations. The most relatively influential factors from the figure are (1) the auditor's experience, particularly the aspect of work experience reaching 10 years and the value of honesty in reflecting transaction patterns using the budget; (2) auditors participate in training, including attending workshops twice a year, developing fraud detection technology skills, and effective communication skills to gain client trust; and (3) although the auditor's professional skepticism attitude does not have a moderating influence, it can provide value in detecting financial reports, especially in evaluating the reasonableness of managerial estimates, analyzing transaction patterns, and reassessing report conclusions. Thus, the novelty in this research is that auditors must possess cybersecurity skills to detect fraud in financial reporting. The ability to detect fraud is greatly influenced by the auditor's experience in handling and reporting client finances. However, even with experience, auditors are required to develop their skills, especially with the digital advancements in accounting, so that they can produce high-quality reports that are relevant both now and in the future. This will also enhance the auditor's branding in the eyes of clients and maintain the auditor's professional skepticism.

3.2 Discussion

Auditors possess cybersecurity competencies if they have over 10 years of experience and exhibit appropriate professional conduct; nonetheless, they also necessitate training to keep pace with contemporary technological advancements. Conversely, prior studies in Saudi Arabia have indicated that behavioral factors, including the enforcement of organizational values or ethical standards, diminished morale among senior management, and dissatisfaction with the organization, are challenging to

quantify and inherently subjective. Thus explaining why both external and internal auditors exhibit comparatively low perceptions of significance (Al-Dhubaibi and Sharaf-Addin, 2022).

The ability to detect fraud in financial reporting requires auditor experience, thereby enhancing sensitivity in identifying budget usage patterns and margin analysis, particularly the ability to analyze current political pathways both nationally and internationally. Presenting strong evidence that political skills and big data significantly enhance fraud detection capabilities in Indonesian public sector institutions, auditors with advanced political skills excel in navigating complex organizational dynamics, thereby improving their ability to uncover fraudulent activities, enhancing auditors' performance in a more thorough and timely detection process, facilitating deeper insights and faster anomaly identification, and requiring proper governance when using certain laws (Rad et al., 2021; Junaidi, Hendrian, and Syahputra, 2024). The auditor's ability also supports the auditor's attitude in determining the appropriate report to be delivered, even though over time there will be many adjustments, especially during the past and present COVID-19 period due to digital developments (Sugeng Wiyantoro, Yan, and Yuanyuan, 2023).

The ability to detect fraud through cybersecurity serves as a guide for both central and regional governments to develop and enact legislation that delineates right from wrong, thereby preventing any disputes between internal and external auditors of an institution (Solichin et al., 2021). The implementation of clear regulations is not the only focus of this study; it emphasizes that auditors in Indonesia greatly need training that will support their work performance with clients. This finding is very different from other research results, which indicate that training does not affect auditor performance (Munajat and Suryandari, 2017). This will illustrate the professional auditor's attitude of skepticism in presenting the client's financial statements, and self-improvement by the auditor will have a positive effect (Hai et al., 2020; Ta et al., 2022).

Consequently, the capacity to identify financial statement fraud should facilitate auditors in fostering collaboration with both internal and external customers. Auditors must possess proficiency in accounting technology to avoid obsolescence due to emerging applications or advanced technologies. It is essential for auditors to exhibit diligence, responsibility, and integrity in accurately conveying all transaction patterns of budgetary inflows and outflows.

CONCLUSION

The research study factors in effectively communicating financial reports. The most notable difference compared to other countries such as the UK, Saudi Arabia, Malaysia, Italy, and others is that the ability to detect fraud is greatly influenced by the auditor's experience in handling and reporting client finances. However, even with experience, auditors must develop their skills, especially with the digital advancements in accounting, to produce high-quality reports that are relevant to the present and future. Evaluating the reasonableness of managerial estimates, analyzing transaction patterns, and reassessing report conclusions. Future research to measure and examine ethics, resilience, and responsibility in completing financial reports, and most importantly, to study applications that emerge with the help of AI with menus capable of detecting financial reports, auditors must be able to improve quality so that they do not lag behind technological developments and do not replace the professional performance of financial report completion.

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