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Technology, Trade, Foreign Direct Investment and Income Inequality Nexus in GCC Countries

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Abstract
The purpose of this study is to analyze the nexus between Technology, Foreign Direct Investment, Trade and Income Inequality in GCC countries. The study used the panel dataset of GCC countries from the period of 1990 to 2021. The dependent variable used in a model is Income Inequality as measured by the GINI coefficient, while explanatory variables are GDP per capita growth, GDP per capita squared, foreign direct investment, inflation rate, unemployment rate, secondary school enrollment, trade, and information and communication technology. Different econometric techniques such as ARDL, Cross-Section, and Granger causality test are applied for data analysis. The Panel ARDL technique is used to estimate the results in which GDP per capita growth, inflation rate, unemployment rate, and information and communication technology index are positively and significantly related to income inequality while the variables square of GDP per capita, FDI, secondary school enrolment, and trade are negatively and significantly associated to the income inequality in GCC countries. Panel ARDL short-run outcomes found that the coefficient of the ECT (-1) is negative and also statistically significant. This indicates that 33.51 percent of errors are corrected when moving from the short-run to the long-run equilibrium. Panel Granger causality analysis found that there is a unidirectional causality between income inequality and GDP Per Capita, trade. There is no evidence of a causal relationship between income inequality and foreign direct investment, inflation, unemployment, secondary school enrolment, trade, the information and communication technology index. Additionally, there is no evidence of a causal relationship between the latter two variables and income inequality. Considering the study's findings, it is determined that technology, economic growth, unemployment, and inflation are encouraging income inequality in GCC countries while FDI and trade are playing an imperative role in declining the level of income inequality in GCC countries.
Keywords: Technology, Income Inequality, FDI, GCC, Panel ARDL, Panel Granger Causality, ECM

1. Introduction

Inequality remains one of the most prevalent issues, even in developed countries. Policymakers have concentrated on economic growth and Income Inequality during the last few decades. It measures unequal income distribution but also affects governmental policies, economic growth, and institutional quality, among other aspects of society. It is the disparity in income between the wealthy and the poor. Rich people benefited more, while the poor were primarily denied (Yuldashev et al., 2023). Foreign direct investment also influences the host country's income disparity. On the one hand, economists and decision-makers contend that Foreign direct investment can reduce Income Inequality by promoting the host nation's growth and development through means like exporting management expertise and contemporary technology, market access, and increasing human capital. On the other hand, Foreign Direct Investment is also responsible for worsening income inequality, by increasing wage disparities in host nations and repatriating foreign direct investment firms' profits to their home countries, even though it has played a significant role in furthering economic development (Rezk et al, 2022). Such routes as the transfer of contemporary technology and management skills, the development of human capital, and exporting market access, foreign direct investment may help the host least developed countries grow and develop. These fundamental concerns remain unanswered, despite renewed interest in the potential role of Foreign Direct Investment in developing least-developed nations. The most complex and divisive of these concerns is how Foreign Direct Investment affects Income Inequality in the host nation. Due to global trade and investment, notably in the form of Foreign Direct Investment, economic activity has rapidly globalized in recent decades even as inequality has increased in the least developed countries (Ravinthira Kumaran and Ravinthira kumaran, 2018). Trade has emerged as one of the imperative aspects in boosting global economic growth by fostering competition and efficiency. The main factor that frequently contributes to income inequality is the high trade contract between nations, partially sparked by technological advancement (Dabla-Norris et al., 2015). Automation is growing, and technology can lower the cost of communication and transportation. Economic growth is enabled by trade openness in both developed and developing nations. It also results in a higher rate of income disparity. This fact resulted from an imbalance between technological expertise and other parts of the development process (Agusalim & Pohan, 2018). Through enhancing automation, expanding options for the formation of new products and services, reducing the cost of transportation, and enhancing the efficiency of information management and communication, technology generates potential for wellbeing. In general, it increases labor productivity, whether directly or indirectly, opening up new markets in terms of location and product differentiation. Higher productivity

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and more intensive labor sharing, made possible by the expansion of international trade, increase opportunities for personal and societal advancement (Kharlamova et al., 2018). Changes in inequality may be primarily driven by technological advancement. An increased trend in their relative supply and a quick increase in skilled employees' relative wages suggest that technological change has been skill-biased (Acemoglu, 1998). It is now possible to outsource work or employ technology to replace repetitive tasks thanks to the development of Information and Communication Technology. Such routine tasks used to be carried out by middle-skill individuals, but the demand for such skills has considerably declined. Low-educated workers engaged in manual tasks that computers cannot perform had minimal influence from the SBTC. However, the need for highly educated individuals performing abstract jobs increased, while the demand for middle-class workers performing monotonous duties decreased (Autor et al., 2003). Due to a change in demand in the labor market, the salaries of highly educated workers increased compared to the low-educated or low-skilled workers. This increased inequality in the upper tail of the distribution (Tica et al., 2022).

2. Literature Review

A literature review is essential to the research to provide existing knowledge and thus find a research gap. The primary aim of the study is to present the literature on the effect of Technology, Foreign Direct Investment and Trade Openness on Income Inequality.

Table 1: Summary of Empirical Studies

Author(s)	Dependent Variable	Data	Methodology	Variables	Results
Studies on the Effect of Foreign Direct Investment on Income Inequality					
Han et al. (2023)	Income inequality	1995-2018	Panel Quintile	Trade openness, capitalization, R&D expenditures, economic growth, FDI	Trade openness, capitalization negative effect on poverty while R&D expenditures put a positive effect on Income inequality moreover economic growth negative positive effect on Income inequality and FDI equalizes Income inequality
Pal (2023)		1991-2020	ARDL, PMG ARDL	Globalization, education, trade, financial openness	Globalization put negative impact on poverty while trade, financial openess positive impact on poverty.
Lee et al. (2022)	Income inequality	2001-2015	Panel Smooth Transition Regression Model	FDI	Foreign Direct Investment reduces income inequality but this favorable effect diminishes once the nation reaches a certain degree of financial development
Nguyen (2021)	Income inequality	2002-2018	Generalized Method of Moment Estimator	FDI	The outcomes showed that Foreign Direct Investment and governance both lessen income disparity while moderation of Foreign Direct Investment and governance increases income inequality
Ravinthirakumaran and Ravinthirakumaran (2018)	Income inequality	1990 to 2015	ARDL Model	FDI, human capital, GDP per capita, Trade openness	The panel ARDL results indicated that Foreign Direct Investment inflows reduce income inequality. Human capital narrows Inequality and gross Domestic Product Per Capita, and trade openness serves to narrow it.
Studies on the Effect of Trade Openness on Income Inequality					
Chowdhury et al. (2021)	Income inequality	1975-2016	Autoregressive Distributed	Exports, GDP	The outcome shows that exports and GDP worsen Income Inequality.

			Lag (ARDL) Model		
Aigheyisi (2020)	Income inequality	1981-2015	Dynamic Ordinary Least Square Estimator	Non-oil exports, financial development,	The growth of non-oil exports and financial economic development significantly lower income disparity.
Goh and Law (2019)	Income inequality	1984-2012	Generalized Method of Moment Estimator	Trade openness	Trade openness tends to widen income disparity. The marginal effect further demonstrated that institutional quality has a corrective impact on the link between trade openness and Income Inequality.
Muzammil et al. (2018)	Income inequality	1980-2014	Fixed Effects and Random Effect Model Fixed Effects and Random Effect Model	trade openness, education spending, labor	It was discovered that trade openness, education spending, and the ratio of skilled to unskilled labor in developed and emerging nations greatly reduce inequality.
Mahesh (2016)	Income inequality	1991-2013	GMM	Exchange rate	The findings show that an increase in the real effective Exchange Rate had caused the GINI Coefficient to rise.
Amjad (2015)	Income inequality	1980 to 2010	OLS	Trade, income distribution, GDP, Remittances, and Population Growth	Trade harms Income Distribution, and Gross Domestic Product, Remittances, and Population Growth all harm Income disparity.
Studies on the Effect of Technology and Income Inequality					
Rontos et al. (2024)	Income inequality	2005-2019	GINI	competitiveness	Competitiveness has positive effect on corruption and Income inequality.
Kakeu et al. (2024)	Poverty Reduction	2008-2019	fixed effects, Lewbel two stage least square mediating effects	Technological innovation	Technological innovation has negative and significant effects on poverty.
Amani and Ahmadzadeh (2022)	Income inequality	2008-2019	Quantile Regression Model	Technological innovation	Innovation and technology significantly worsened income disparity in the three-income quantile.
Jing et al.(2019)	Income inequality	2009-2017	GMM	Technological innovation	The outcomes showed that the volume of internet users was determined to have the biggest impact on income inequality among the Information Communication Technology variables

It was observed in the literature that technology, trade openness, and foreign direct investment were positively associated with income inequality. The effect of these variables on income inequality varied in different countries. Different factors that influence income inequality were also observed, such as economic growth, human capital, gross capital formation, fiscal decentralization, and poverty. To attain the study outcomes, different econometric techniques were applied in studies such as OLS, ARDL model, panel ARDL model, VECM, GMM, co-integration approaches and causality analysis. Regarding Gulf Cooperation Council (GCC) countries, limited literature was available that examines the effect of technology, trade openness, and foreign direct investment on income

inequality. on the contrary, limited literature was available that examines the link between technology and income inequality. so, this study analyzed the effect of technology, trade openness, and foreign direct investment on income inequality in GCC) countries. The outcomes of this study will contribute to the literature significantly and will provide important implications for the policymakers to design policies about Technology formation, Foreign Direct Investment, Trade Openness, and Income Inequality.

3. Model Specifications, Data and Methodology

To analyze the impact of Technology, Foreign Direct Investment, and Trade on Income Inequality with the help of the following model:

3.1. Functional Form of the Model

$$\mathbf{GINI_{it}} = f(GDPPC, GDPPC^2, FDI, INF, UN, SEE, TRADE, ICT) \quad (1)$$

Econometric Form of the Model

$$\mathbf{GINI_{it}} = \beta_0 + \beta_1 GDPPC_{it} + \beta_2 GDPPC^2_{it} + \beta_3 FDI_{it} + \beta_4 INF_{it} + \beta_5 UN_{it} + \beta_6 SEE_{it} + \beta_7 TRADE_{it} + \beta_8 ICT_{it} \quad (2)$$

3.2. Data: Measurement and Sources

To check the nexus among technology, trade and foreign direct investment on income inequality the study uses panel dataset of Gulf Cooperation Council countries from the period of 1990 to 2021. The data is collected from World Development Indicators (WDI). The following countries are included in GCC:

- Kuwait
- Saudi Arabia
- Qatar
- Oman
- United Arab Emirates
- Bahrain

Income Inequality is measured by the GINI Coefficient, while explanatory variables are Gross Domestic Product Per Capita Growth (GDP), Gross Domestic Product Per Capita Square (GDP^2), Foreign Direct Investment (FDI), Inflation Rate (INF), Unemployment Rate (UN), Secondary School Enrollment (SSE), Trade (TRADE), and Information and Communication Technology (ICT).

Table 2: Data: Measurement and Sources

Variables	Description	Source
GINI	GINI Index	
GDP	Gross Domestic Product Per Capita (Annual %)	
GDP^2	Gross Domestic Product Per Capita Square (Annual %)	
FDI	Foreign Direct Investment (Annual %)	
INF	Inflation (Annual %)	World Bank
UN	Unemployment, Total (% of Total Labor Force)	
SSE	School Enrollment, Secondary (% Gross)	
TRADE	Trade (% of GDP)	
ICT	Information and Communications Technology Index	

4. Results and Discussions

We explain the results of technology, trade, and foreign direct investment on income inequality in GCC countries.

4.1. Descriptive Statistics and Correlation Analysis

Table 3 presents descriptive statistics for key variables from 1990 to 2021. The Gini coefficient (GINI) has a mean of 38.44, indicating moderate income inequality, with a range from 31.49 to 51.00 and a standard deviation of 3.99. GDP per capita (GDPPC) has a mean of 4.58, but shows high variability (standard deviation of 5.60), ranging from -7.08 to 33.99, and is positively skewed (skewness of 2.16). Foreign Direct Investment (FDI) has a mean of 2.92 and exhibits extreme variability, ranging from -5.29 to 33.57, with a standard deviation of 4.58 and a high positive skewness of 3.59. Inflation (INF) averages 2.99 but has a wide range from -25.96 to 33.75 and a high standard deviation of 11.32, showing near symmetry (skewness of 0.06). Unemployment (UN) averages 2.41, with a range from 0.45 to 7.45 and a standard deviation of 1.70, showing positive skewness (1.01). Secondary school enrollment (SSE) is high, averaging 92.97, ranging from 46.79 to 116.46, and shows moderate variability (standard deviation of 13.85) with negative skewness (-1.19). Trade (TRADE) as a percentage of GDP has a mean of 106.37, ranging from 52.08 to 191.87, with a standard deviation of 31.29 and positive skewness (0.91). Information and communication technology (ICT) averages 37.06, ranges from 0.09 to 100.00, and has high variability (standard deviation of 36.95) with slight positive skewness (0.52). The Jarque-Bera test indicates that all variables except inflation significantly deviate from a normal distribution.

Table 3: Results of Descriptive Statistics of Key Variables (1990-2021)

Variables	GINI	GDPPC	FDI	INF	UN	SSE	TRADE	ICT
Mean	38.44	4.58	2.92	2.99	2.41	92.97	106.37	37.06

Median	37.00	4.11	1.24	2.66	1.80	96.20	94.75	21.55
Maximum	51.00	33.99	33.57	33.75	7.45	116.46	191.87	100.00
Minimum	31.49	-7.08	-5.29	-25.96	0.45	46.79	52.08	0.09
Std. Dev.	3.99	5.60	4.58	11.32	1.70	13.85	31.29	36.95
Skewness	1.30	2.16	3.59	0.06	1.01	-1.19	0.91	0.52
Kurtosis	3.92	11.35	22.00	3.24	3.08	4.18	3.14	1.64
Jarque-Bera	33.33	386.67	1804.44	0.31	17.80	31.04	14.61	12.85
Probability	0.00	0.00	0.00	0.86	0.00	0.00	0.00	0.00
Observations	105	105	105	105	105	105	105	105

Table 4 provides the correlation matrix for Gulf Cooperation Council (GCC) nations, where GINI is the dependent variable. The sign of the correlation coefficient indicates both a positive and a negative relationship. The correlation coefficient values range between -1 and 1. The positive side ranges from 0 to 1, while the negative side ranges from -1 to 0. There is no correlation between two variables when their values are zero. A correlation between variables is strong when the value is close to one and weak when the value lies between 0 and 0.299. The correlation matrix for key variables from 1990 to 2021 reveals several notable relationships. Income inequality (GINI) shows a moderate positive correlation with unemployment (0.37) and a weak correlation with ICT (0.34) and trade (0.32), indicating that higher inequality is associated with higher unemployment, increased technology adoption, and trade activity. GDP per capita (GDPPC) has a weak inverse relationship with GINI (-0.05) and unemployment (-0.29), suggesting that higher economic output per person is linked to lower income inequality and unemployment.

Table 4: Results of Correlation Matrix of Key Variables (1990-2021)

Correlation	**GINI**	**GDPPC**	**FDI**	**INF**	**UN**	**SSE**	**TRADE**	**ICT**
GINI	1.00							
GDPPC	-0.05	1.00						
FDI	-0.01	0.05	1.00					
INF	0.03	0.16	0.06	1.00				
UN	0.37	-0.29	-0.16	-0.06	1.00			
SSE	0.21	-0.16	0.19	0.07	-0.05	1.00		
TRADE	0.32	0.17	0.49	0.07	-0.39	0.26	1.00	
ICT	0.34	-0.26	-0.05	-0.15	0.19	0.60	0.09	1.00

Foreign Direct Investment (FDI) is moderately correlated with trade (0.49), implying that higher FDI coincides with increased trade. Unemployment is negatively correlated with GDPPC (-0.29) and trade (-0.39), indicating that higher unemployment rates are associated with lower GDP per capita and trade. Secondary school enrollment (SSE) is positively correlated with ICT (0.60), highlighting a connection between education levels and technology use. Overall, the matrix shows weak to moderate correlations, suggesting complex interrelationships among these economic and social variables.

4.2. Unit Root Analysis

The table 5 provides the stationarity tests which shows the mixed results applying on different economic variables from 1990 to 2021. The results show that GDP Per Capita, GDP Per Capita Square, FDI, Inflation Rate, Trade and Information, and Communication Technology Index are stationarity at level while the variables Income Inequality, Secondary School Enrollment, and Unemployment Rate are stationarity at first difference. The Panel ARDL model is suggested to be suitable to estimate the long-run estimation of parameters by the mixed order of integration of variables.

Table 5: Results of Unit Root Test of Key Variables (1990-2021)

At Level

Variables	**Intercept**				**Intercept & Trend**				**None**				**Conclusion**
	LLC Test	**IPS Test**	**ADF - Fisher Chi Square**	**PP-Fisher Chi Square**	**LLC Test**	**IPS Test**	**ADF - Fisher Chi Square**	**PP-Fisher Chi Square**	**LLC Test**	**ADF - Fisher Chi Square**	**PP-Fisher Chi Square**		
GINI	-2.2877 (0.0111)	0.8038 (0.7893)	11.7854 (0.4631)	18.0707 (0.1136)	-2.0880 (0.0184)	-0.6634 (0.2535)	14.8724 (0.2485)	26.3816 (0.0095)	-1.1565 (0.1237)	34.6180 (0.0005)	66.2386 (0.0000)		I(1)

GDPPC	-1.9162 (0.0277)	-2.7754 (0.0028)	28.7596 (0.0043)	42.6237 (0.0000)	-1.7272 (0.0421)	-2.1064 (0.0176)	23.8806 (0.0000)	86.3601 (0.0000)	-3.5896 (0.0014)	31.8889 (0.0014)	46.8678 (0.0000)	I(0)
GDPPC^2	-3.8651 (0.0001)	-4.7282 (0.0000)	46.5605 (0.0000)	69.8352 (0.0000)	-2.9896 (0.0014)	-4.2711 (0.0000)	39.9627 (0.0001)	70.1702 (0.0000)	-7.6598 (0.0000)	76.6861 (0.0000)	99.5786 (0.0000)	I(0)
FDI	-1.9162 (0.0277)	-2.7754 (0.0028)	28.7596 (0.0043)	42.6237 (0.0000)	-1.7272 (0.0421)	-2.1064 (0.0176)	23.8806 (0.0000)	86.3601 (0.0000)	-3.5896 (0.0014)	31.8889 (0.0014)	46.8678 (0.0000)	I(0)
INF	-9.1478 (0.0000)	-7.8246 (0.0000)	6.05489 (0.0000)	9.5245 (0.0000)	-5.9964 (0.0001)	-7.2511 (0.0000)	9.9729 (0.0000)	-9.1586 (0.0000)	-7.6856 (0.0000)	6.6561 (0.0000)	9.5563 (0.0000)	I(0)
UN	1.0310 (0.8487)	2.0675 (0.9807)	6.4032 (0.8944)	3.9856 (0.9837)	0.3237 (0.6269)	0.2962 (0.6165)	13.5462 (0.3306)	3.3054 (0.9930)	0.2847 (0.6121)	6.1307 (0.9093)	6.7777 (0.8719)	I(1)
SSE	-2.8751 (0.0020)	-3.2501 (0.0006)	28.4005 (0.0016)	38.3449 (0.0000)	-1.0817 (0.1397)	0.01561 (0.5062)	9.9442 (0.2690)	10.3764 (0.2396)	0.8305 (0.7969)	3.3513 (0.9925)	2.8710 (0.9964)	I(1)
TRADE	-2.4717 (0.0067)	-3.7859 (0.0001)	44.5383 (0.0000)	31.8293 (0.000)	-5.7517 (0.0000)	-0.8799 (0.1895)	-3.7059 (0.0001)	52.9416 (0.000)	19.0475 (0.0874)	0.0619 (0.5247)	8.5961 (0.7370)	I(0)
ICT	-6.7783 (0.0000)	-6.3204 (0.000)	61.6667 (0.000)	92.3997 (0.0000)	-5.4697 (0.0000)	-5.0964 (0.0000)	46.1534 (0.0000)	71.9650 (0.0000)	-8.0580 (0.0000)	75.2257 (0.0000)	117.170 (0.000)	I(0)

4.3. Long-Run ARDL Results

Table 6 presents the panel ARDL long-run results. The dependent variable used in a model is income inequality measured by the GINI coefficient (GINI) and explanatory variables are GDP per capita growth, GDP per capita squared, foreign direct investment, inflation rate, unemployment rate, secondary school enrollment, trade, and information and communication technology index.

The relationship between GDP per capita growth and income inequality is positive and statistically significant. The square of GDP per capita is negative and significantly linked to income inequality. It is evident from this relationship that there is an inverse correlation between GDP and income inequality. Particularly income disparity rises initially in tandem with GDP growth and then declines with more GDP growth. This result relates to Kuznets (1955) and Barro (2000) theory. These outcomes are also confirmed by Le et al., (2021); Deyshappriya (2017).

Table 6: Long-Run ARDL Results

Dependent Variable: GINI Coefficient				
Variables	**Coefficient**	**S.E.**	**T.test**	**Prob.**
GDPPC	0.2069	0.0909	2.2756	0.0245
GDPPC^2	-1.5107	0.2236	-6.7542	0.0000
FDI	-0.6655	0.2375	-2.8023	0.0058
INF	0.3641	0.1442	2.5243	0.0127
UN	0.1421	0.0437	3.2466	0.0015
SSE	-1.3454	0.3202	-4.2011	0.0000
TRADE	-0.0782	0.0120	-6.4903	0.0000

ICT	0.0196	0.0110	1.7864	0.0771
C	0.0445	0.0575	0.7749	0.4403

Foreign direct investment has a negative and statistically significant relationship with income inequality. This suggests that FDI inflows can aid countries in gaining financial resources, technology, and export markets, which fosters economic growth and subsequently reduces income disparity (Mihalache-O'Keef and Li 2011). These results are also matched with the findings of Rezk et al., (2022). Theoretically, these empirical findings are consistent with Heckscher–Ohlin's standard trade theory, which holds that foreign direct investment (FDI) reduces inequality in developing nations.

The inflation rate is positive and significantly related to the income inequality. These results are also found in the studies of Thalassinos et al., (2012); Sieroń, (2017). This suggests that inflation is a factor contributing to the rise in income inequality because the relatively poor spend a larger proportion of their income on consumer items than on financial assets or goods with slower price increases linked with income inequality. Unemployment restricts the access to income to the lower income groups and further enhances income inequality. These outcomes are also found by Deyshappriya (2017); and Cysne (2009).

Secondary school enrolment is negatively and significantly linked to income inequality. Higher education reflects the improvement in human capital. Educated workers can effectively reduce income disparities. An economy with a high level of human capital and high population quality will theoretically and practically aid in reducing income disparity (Le et al., 2021). These results are related to Lee & Lee (2018); Suhendra et al., (2020).

The relationship between the Trade of goods and services with income inequality is negative and significant. There are two reasons why trade liberalization may be linked to declining income inequality. The first is that increased trade openness can boost economic growth. If higher incomes resulting from that growth are distributed fairly, then overall inequality may decline as trade becomes more liberalized. As evidence, commerce between developed and developing nations can entice technological inflows into the later economies, lowering manufacturing costs and resulting in stronger economic growth. The efficiency advantages of increasing international trade are the second-way trade liberalization might be linked to declining income disparity. International and domestic businesses compete when markets are open to trade. This forces domestic firms to adopt production techniques and technology that are more effective. Industries that focus on exporting are typically more productive and profitable than those that produce for the domestic market (Chen & Tang, 1987; Clerides et al., 1998). Increased salaries for all workers due to efficiency improvements from international trade can help reduce inequality (Naanwaab, 2022). These outcomes are also found by Ravinthirakumaran and Ravinthirakumaran (2018); Le et al., (2021); Fazaalloh (2019); Naanwaab (2022).

The information and communication technology index is positive and significantly related to income inequality. An increase in technology may increase income inequality because the use of technology requires only trained and qualified laborers so the income of these workers increases substantially and increases the income inequality in a country These outcomes are also consistent with Mnif (2016); Kharlamova et al., (2018); Sieroń, (2017); Le et al, (2021).

4.4. Short-Run ARDL Results

Table 7 illustrates the Panel ARDL short-run Error Correction Model. In the short-run Error Correction Model, it is vital to analyze the error correction term (ECT). This term should be negative and statistically significant. The negative ECT term indicates convergence to the equilibrium from the short-run to the long-run. It is found that the coefficient of the ECT (-1) is negative (Coefficient =-0.3351) and also statistically significant (t-test =-2.2155; Prob. =0.0284). This indicates that 33.51 percent of errors are corrected when moving from the short-run to the long-run equilibrium. The model emphasizes the dynamic character of adaptations to income disparity and the important role that unemployment plays in the short-term results of income distribution.

Table 7: Short-Run ARDL Results

Dependent Variable: GINI Coefficient				
Variables	**Coefficient**	**S.E.**	**T.test**	**Prob.**
ECT(-1)	-0.3351	0.1512	-2.2155	0.0284
D(GDPPC)	-0.1861	0.1067	-1.7433	0.0836
D(GDPPC^2)	-0.0112	0.0059	-1.8958	0.0602
D(FDI)	-0.0647	0.0601	-1.0754	0.2841
D(INF)	-0.0892	0.0610	-1.4630	0.1458
D(UN)	-0.3378	0.1462	-2.3100	0.0222
D(SSE)	-0.1504	0.1061	-1.4164	0.1587
D(TRADE)	-0.0117	0.0063	-1.8404	0.0676
D (ICT)	-0.0663	0.0606	-1.0937	0.2758
C	3.8273	2.3209	1.6490	0.1012

4.5. Cross-Section Analysis

In table 8 short-run coefficients for individual GCC countries are discussed. The short-run ECM term is negative for all GCC countries except the United Arab Emirates (UAE). The ECT exhibits the speed of adjustment to the long-run equilibrium. Table 5.6 displays the cross-section short-run analysis in the case of Bahrain. The variables foreign direct investment and information and communication technology index shows significant association with INQ in the short-run. It is found that the coefficient of the ECT (-1) is negative (Coefficient =-0.0470) and also statistically significant (t-test =-4.8471; Prob. =0.0168). This indicates that 4.70 percent of errors are corrected when moving from the short-run to the long-run equilibrium.

Table 8: Cross-Section Short-Run Analysis of Bahrain

Dependent Variable: GINI Coefficient				
Variables	**Coefficient**	**S.E.**	**T**	**Prob.**
ECT(-1)	-0.0470	0.0097	-4.8471	0.0168
D(GDPPC)	0.0204	0.0158	1.2900	0.2875
D(GDPPC^2)	0.0040	0.0031	1.2797	0.2906
D(FDI)	0.0096	0.0013	7.3788	0.0051
D(INF)	1.4996	19.6129	0.0764	0.9439
D(UN)	2.2941	16.4438	0.1395	0.8979
D(SSE)	0.0199	0.0154	1.2927	0.2867
D(TRADE)	-0.0589	0.0198	-2.9664	0.0592
D (ICT)	-0.0064	0.0008	-7.8126	0.0044
C	-4.0187	31.6994	-0.1267	0.9071

Table 9 displays the cross-section short-run analysis in the case of Kuwait. The variables GDP per capita, GDP per capita squared, FDI, rate of inflation, unemployment rate, secondary school enrolment, trade, and information and communication technology index show significant association with income inequality in the short-run. It is found that the coefficient of the ECT(-1) is negative (Coefficient =-0.0105) and also statistically significant (t-test =-208.0811; Prob. =0.0000). This indicates that 1.05 percent of errors are corrected when moving from the short-run to the long-run equilibrium.

Table 9: Cross Section Short Run Analysis of Kuwait

Dependent Variable: GINI Coefficient				
Variables	**Coefficient**	**S.E.**	**T**	**Prob.**
ECT (-1)	-0.0105	5.09E-05	-208.0811	0.0000
D(GDPPC)	-0.0020	1.63E-06	-1245.488	0.0000
D(GDPPC^2)	-0.0104	2.32E-05	-451.9942	0.0000
D(FDI)	0.0002	2.64E-07	1085.447	0.0000
D(INF)	-0.0460	0.000622	-73.99622	0.0000
D(UN)	0.3084	0.064196	4.804778	0.0172
D(SSE)	0.0003	1.57E-06	249.9845	0.0000
D(TRADE)	0.0005	6.08E-06	91.83767	0.0000
D (ICT)	0.0023	9.56E-06	243.9267	0.0000
C	-0.2245	0.040020	-5.610778	0.0112

Table 10 displays the cross-section short-run analysis in the case of Oman. The variables GDP per capita, GDP per capita squared, FDI, secondary school enrolment, trade and information and communication technology index shows significant association with INQ in the short-run. It is found that the coefficient of the ECT (-1) is negative (Coefficient =-0.0350) and also statistically significant (t-test =-48.6563; Prob. =0.0000). This indicates that 3.50 percent of errors are corrected when moving from the short-run to the long-run equilibrium.

Table 10: Cross Section Short Run Analysis of Oman

Dependent Variable: GINI Coefficient				
Variables	**Coefficient**	**S.E.**	**T**	**Prob.**
ECT(-1)	-0.0350	0.0007	-48.6563	0.0000
D(GDPPC)	-0.0214	0.0001	-189.8941	0.0000
D(GDPPC^2)	0.0025	0.0004	6.0340	0.0091
D(FDI)	0.0013	3.94E-06	337.0363	0.0000
D(INF)	0.0359	0.0164	2.1869	0.1166
D(UN)	1.0261	0.8778	1.1689	0.3268
D(SSE)	-0.0245	0.0001	-180.1703	0.0000
D(TRADE)	-0.0340	0.0004	-75.6024	0.0000
D (ICT)	0.0028	2.46E-05	114.8884	0.0000
C	1.6214	1.6503	0.9824	0.3983

Table 11 displays the cross-section short-run analysis in the case of Saudi Arabia. The variables GDP per capita, FDI, secondary school enrolment, trade and information and communication technology index shows significant association with INQ in the short-run. It is found that the coefficient of the ECT (-1) is negative (Coefficient =-0.8000) and also statistically significant (t-test =-19.6920; Prob. =0.0003). This means that when transitioning from the short-run to the long-run equilibrium, 80.0 percent of errors are fixed.

Table 11: Cross Section Short Run Analysis of Saudi Arabia

Dependent Variable: GINI Coefficient				
Variables	**Coefficient**	**S.E.**	**T**	**Prob.**
ECT (-1)	-0.8000	0.0406	-19.6920	0.0003
D(GDPPC)	-0.1034	0.0101	-10.1923	0.0020
D(GDPPC^2)	-0.1110	0.0577	-1.9211	0.1505
D(FDI)	0.0369	0.0014	26.1386	0.0001
D(INF)	-0.7738	2.3047	-0.3357	0.7592
D(UN)	24.7877	40.3924	0.6136	0.5828
D(SSE)	0.0032	1.46E-06	2251.671	0.0000
D(TRADE)	-0.0003	1.04E-05	-29.8801	0.0001
D (ICT)	-0.0006	3.23E-06	-213.6824	0.0000
C	-0.5918	0.2339	-2.5294	0.0855

Table 12 displays the cross-section short-run analysis in the case of the United Arab Emirates. The variables GDP per capita, GDP per capita squared, FDI, inflation rate, unemployment rate, secondary school enrolment, trade, and information and communication technology index show significant association with INQ in the short-run. It is found that the coefficient of the ECT(-1) is positive (Coefficient =0.0053) and also statistically significant (t-test =181.4916; Prob. =0.0000). This indicates a divergence of short-run equilibrium to long-run equilibrium.

Table 12: Cross section short run Analysis of the United Arab Emirates

Dependent Variable: GINI Coefficient				
Variables	**Coefficient**	**S.E.**	**T**	**Prob.**
ECT(-1)	0.0053	2.96E-05	181.4916	0.0000
D(GDPPC)	0.0005	3.82E-06	156.7225	0.0000
D(GDPPC^2)	0.0056	4.98E-05	113.7452	0.0000
D(FDI)	-9.98E-05	6.47E-07	-154.1920	0.0000
D(INF)	-0.0120	0.0005	-22.9570	0.0002
D(UN)	-0.2161	0.0509	-4.2405	0.0240
D(SSE)	-0.0007	1.26E-05	-60.3816	0.0000
D(TRADE)	0.0170	2.72E-05	625.7043	0.0000
D (ICT)	-0.0059	8.55E-06	-692.5822	0.0000
C	-0.2332	0.5284	-0.4413	0.6888

Table 13 displays the cross-section short-run analysis in the case of Qatar. The variables GDP per capita, GDP per capita squared, FDI, rate of inflation, unemployment rate, secondary school enrolment, trade and information and communication technology index shows significant association with INQ in the short-run. It is found that the coefficient of the ECT (-1) is negative (Coefficient =-0.0323) and also statistically significant (t-test =-60.4505; Prob. =0.0000). This shows that errors are rectified by 3.32 percent while transitioning from the short-run to the long-run equilibrium.

Table 13: Cross Section Short Run Analysis of Qatar

Dependent Variable: GINI Coefficient				
Variables	**Coefficient**	**S.E.**	**T**	**Prob.**
ECT(-1)	-0.0323	0.0005	-60.4505	0.0000
D(GDPPC)	-0.0040	7.39E-06	-549.3913	0.0000
D(GDPPC^2)	0.0286	0.0001	184.6364	0.0000
D(FDI)	0.0019	1.39E-06	1388.249	0.0000
D(INF)	-0.07427	0.0174	-4.2537	0.0238
D(UN)	1.3083	0.8462	1.5460	0.2198
D(SSE)	-0.0007	1.26E-05	-60.3816	0.0000
D(TRADE)	0.0170	2.72E-05	625.7043	0.0000
D (ICT)	-0.0059	8.55E-06	-692.5822	0.0000
C	-0.2332	0.5284	-0.4413	0.6888

4.6. Pair-Wise Granger Causality Tests

The causation between two variables as one-way, two-way, or no causation is analyzed using the panel Granger causality test. Before the application of the Granger causality test, the lag length criteria for Granger causality is analyzed. Table 14 shows the VAR lag length selection criteria. The result shows that the optimal lag length is 4.

Table 14: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
1	-978.3984	700.8868	49877602	40.39994	43.10166*	41.43572
2	-910.5622	91.31802	51068269	40.25239	45.35564	42.20886
3	-840.1956	73.07299	65394448	40.00752	47.51231	42.88468
4	-712.8982	93.02504*	17927438*	37.57301*	47.47932	41.37085*

Table 15 shows the panel Granger causality estimates. It is originated that there is a unidirectional causality between GDP per capita and income inequality, no causality between FDI and income inequality, no causality between the rate of inflation and income inequality, no causality between the unemployment rate and income inequality, no causality between secondary school enrolment and income inequality, unidirectional causality between trade and income inequality, and no causality between information and communication technology index and income inequality.

Table 15: Results of Pairwise Granger Causality Test

Null Hypothesis	Obs	F-Statistic	Prob.
GDPPC does not Granger Cause GINI	180	0.16687	0.0464
GINI does not Granger Cause GDPPC		0.92174	0.0997
FDI does not Granger Cause GINI	180	2.85191	0.0604
GINI does not Granger Cause FDI		0.43551	0.6476
INF does not Granger Cause GINI	165	0.10399	0.9013
GINI does not Granger Cause INF		1.55095	0.2152
UN does not Granger Cause GINI	174	1.68635	0.1883
GINI does not Granger Cause UN		1.15289	0.3182
SSE does not Granger Cause GINI	86	0.07808	0.9250
GINI does not Granger Cause SSE		0.25318	0.7769
TRADE does not Granger Cause GINI	180	5.34147	0.0056
GINI does not Granger Cause TRADE		0.96535	0.3829
ICT does not Granger Cause GINI	179	0.61959	0.5393
GINI does not Granger Cause ICT		0.08389	0.9196

5. Conclusions and Policy Recommendations

This analysis attempts to analyze the nexus between Technology, Foreign Trade, Foreign Direct Investment, and Income Inequality in GCC countries. For this purpose, this study uses the Panel Dataset of GCC countries from the period of 1990 to 2021. The data is collected from World Development Indicators (WDI). The Gulf Cooperation Council (GCC) countries selected for analysis are Kuwait, Saudi Arabia, Qatar, Oman, United Arab Emirates, and Bahrain. The dependent variable used in a model is income inequality as measured by the GINI Coefficient, while explanatory variables are gross domestic product per capita growth, gross domestic product per capita squared, foreign direct investment, inflation rate, unemployment rate, secondary school enrollment, trade, and information and communication technology. Different econometric techniques are applied for data analysis. To assess the degree of stationarity of variables, unit root analysis is performed. The order in which the variables of a model are integrated must be determined using this model. The best technique for log-run parameter estimate can be chosen based on the integration order. Various panel unit root tests, including the LLC test, IPS test, ADF Fisher chi square test, and PP-Fisher chi square test, are employed for this purpose. Panel ARDL model is employed for parameter long-run estimation. This model is also referred to as the Pooled Mean Group Model. Panel ARDL model is useful when variables have mixed order of integration.

Correlation analysis found that income inequality is positively correlated to the inflation rate, unemployment, secondary school enrollment, trade and information and communication technology while negatively correlated to the gross domestic product per capita growth rate, and foreign direct investment. Unit root analysis show that the variables gross domestic product per capita, GDP per capita square, foreign direct investment, inflation rate, trade and information and communication technology index are stationarity at level while the variables income inequality, secondary school enrollment, and unemployment rate are stationarity at first difference. The Panel ARDL model is suggested to be suitable to estimate the long-run estimation of parameters by the mixed order of integration of variables. Panel ARDL long-rum outcomes show that the variables GDP per capita growth, inflation rate, unemployment rate, and information and communication technology index are positively and significantly related to income inequality while the variables GDP per capita squared, FDI, secondary school enrolment, and trade are negatively and significantly associated to the income inequality in Gulf Cooperation Council (GCC) countries. Panel ARDL short-run outcomes found that the coefficient of the ECT(-1) is negative and also

statistically significant. This indicates that 33.51 percent of errors are corrected when moving from the short-run to the long-run equilibrium. Panel Granger causality analysis found that there is a unidirectional causality between GDP per capita and income inequality, no causality between foreign direct investment and income inequality, no causality between inflation rate and income inequality, no causality between the unemployment rate and income inequality, no causality between secondary school enrolment and income inequality, unidirectional causality between trade and income inequality, and no causality between information and communication technology index and income inequality. considering the study's findings, it is determined that technology, economic growth, unemployment, and inflation are encouraging income inequality in Gulf Cooperation Council (GCC) countries while Foreign Direct Investment and trade are playing an imperative role in declining the level of income inequality in Gulf Cooperation Council (GCC) countries.

Based on the outcomes of the study following recommendations are suggested:

- Prioritize policies that aim to achieve sustainable and inclusive economic growth. This includes investing in sectors that have high potential for job creation and ensuring that growth benefits all segments of society, especially marginalized and vulnerable groups.
- It is found that foreign direct investment is negatively related to income inequality so government suggested that foreign direct investment inflows should be encouraged because foreign direct investment inflows increase the Employment opportunities in an economy and also raise the Income level of the people and may lead to decline the Income Inequality.
- The government may invest in projects that increase Employment opportunities so the unemployment Level can be reduced and Income Inequality may decline.It is found that Technology is positively related to Income Inequality in Gulf Cooperation Council (GCC) countries so policymakers suggested that the technology level should be enhanced but its access should be maintained to the whole society in this way Income Inequality may be reduced.
- The government may promote Technical Education, especially in rural areas so the Income Level of the people may increase and Income Inequality may be declined.
- It is found that foreign trade is negatively related to Income Inequality so government suggested that the level of trade should be increased because it enhances the Income level of the people and may lead to a decline in Income Inequality.
- It is found that Technology is positively related to Income Inequality in Gulf Cooperation Council (GCC) countries so policymakers suggested that the technology level should be enhanced but its access should be maintained to the whole society in this way Income Inequality may be reduced

References

Acemoglu, D. (1998). Why do new technologies complement skills? Directed technical change and wage inequality. The quarterly journal of economics, 113(4), 1055-1089.

Agusalim, L., &Pohan, F. S. (2018). Trade openness effect on income inequality: Empirical evidence from Indonesia. Signifikan: JurnalIlmu Ekonomi, 7(1), 1-14.

Aigheyisi, O. (2020). Non-Oil Trade and Income Inequality in Nigeria. The Empirical Economics Letters, 19(6).

Amani, R., & Ahmadzadeh, K. (2022). Investigating the Impact of Technology, Innovation and Globalization on Income Inequality. Journal of Economic Research (Tahghighat-E-Eghtesadi), 57(2), 221-257.

Amjad, Z. (2015). Trade and income distribution in Pakistan. Global Journal of Management and Business Research, 15(B8), 19-25.

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. The Quarterly journal of economics, 118(4), 1279-1333.

Chen, T. J., & Tang, D. P. (1987). Comparing technical efficiency between import-substitution-oriented and export-oriented foreign firms in a developing economy. Journal of Development Economics, 26(2), 277-289.

Chowdhury, M. A., Nijhum, H. R., & Uddin, K. M. K. (2021). Disintegrated impact of trade openness on income inequality: empirical evidence from Bangladesh. Chowdhury, MA, Nijhum, HR, & Uddin, KMK (2021). Disintegrated Impact of Trade Openness on Income Inequality: Empirical Evidence from Bangladesh. Business and Economic Research, 11(3), 1-18

Clerides, S. K., Lach, S., &Tybout, J. R. (1998). Is learning by exporting important? Micro-dynamic evidence from Colombia, Mexico, and Morocco. The quarterly journal of economics, 113(3), 903-947.

Cysne, R. P. (2009). On the positive correlation between income inequality and unemployment. The Review of Economics and Statistics, 91(1), 218-226.

Dabla-Norris, M. E., Kochhar, M. K., Suphaphiphat, M. N., Ricka, M. F., &Tsounta, M. E. (2015). Causes and consequences of income inequality: A global perspective. International Monetary Fund.

Deyshappriya, N. P. (2017). Impact of macroeconomic factors on income inequality and income distribution in Asian countries. ADBI Working Paper Series.

Fang, L., & Qamruzzaman, M. (2021). An Asymmetric Investigation of Remittance and Trade Openness Impact on Inequality: Evidence from Selected South Asian Countries. Frontiers in Psychology, 12, 720887.

Fazaalloh, A. M. (2019). Is foreign direct investment helpful to reduce income inequality in Indonesia?. Economics & Sociology, 12(3), 25-36.

Goh, L. T., & Law, S. H. (2019). The effect of trade openness on income inequality with the role of institutional quality. Indonesian Journal of Economics, Social, and Humanities, 1(2), 65-76.

Han, V., Ocal, O., & Aslan, A. (2023). A revisit to the relationship between globalization and income inequality: are levels of development really paramount?. Quality & Quantity, 57(1), 973-990.

Hosseinidoust, E., Sepehrdoost, H., Khodabakhshi, A., & Massahi, S. (2021). Investigating interactions among health care indicators, income inequality and economic growth: A case study of Iran. Journal of Applied Economics Studies in Iran, 10(38), 69-94.

Jing, A. H. Y., Ab-Rahim, R., & Ismail, F. (2019). Information and communication technology (ICT) and income inequality in ASEAN-5 countries. International Journal of Academic Research in Business and Social Sciences, 9(9), 359-373.

Kakeu, C. B. P., Wendji, C. M., Kouhomou, C. Z., & Kamdoum, G. C. M. (2024). Can technological innovations contribute to more overcome the issue of poverty reduction in africa?. Technology in Society, 76, 102463.

Kharlamova, G., Stavytskyy, A., &Zarotiadis, G. (2018). The impact of technological changes on income inequality: the EU states case study. Journal of international studies, 11(2).

Le, Q. H., Do, Q. A., Pham, H. C., & Nguyen, T. D. (2021). The impact of foreign direct investment on income inequality in Vietnam. Economies, 9(1), 27.

Lee, C. C., Lee, C. C., & Cheng, C. Y. (2022). The impact of FDI on income inequality: Evidence from the perspective of financial development. International Journal of Finance & Economics, 27(1), 137-157.

Lee, J. W., & Lee, H. (2018). Human capital and income inequality. Journal of the Asia Pacific Economy, 23(4), 554-583.

Mahesh, M. (2016). The effects of trade openness on income inequality-evidence from BRIC countries. Economics Bulletin, 36(3), 1751-1761.

Mihalache-O'Keef, A., & Li, Q. (2011). Modernization vs. dependency revisited: Effects of foreign direct investment on food security in less developed countries. International Studies Quarterly, 55(1), 71-93.

Mnif, S. (2016). Bilateral relationship between technological changes and income inequality in developing countries. Atlantic Review of Economics: RevistaAtlántica de Economía, 1(1), 4.

Naanwaab, C. (2022). The Impact of Trade Liberalization on Income Inequality: Does the Direction of Trade Matter?. International Economic Journal, 36(3), 307-338.

Nguyen, V. B. (2021). The Relationship Between FDI and Income Inequality: Does Governance Environment Matter?. Applied Economics Journal, 28(1), 63-77.

Pal, S., Villanthenkodath, M. A., Patel, G., & Mahalik, M. K. (2022). The impact of remittance inflows on economic growth, unemployment and income inequality: An international evidence. International Journal of Economic Policy Studies, 16(1), 211-235.

Ravinthirakumaran, K., &Ravinthirakumaran, N. (2018). The impact of foreign direct investment on income inequality: a panel Autogressive Distributed Lag approach for the Asia-Pacific Economic Cooperation developing economies. Asia-Pacific Sustainable Development, 57.

Rezk, H., Amer, G., Fathi, N., & Sun, S. (2022). The impact of FDI on income inequality in Egypt. Economic Change and Restructuring, 55(3), 2011-2030.

Rontos, K., Syrmali, M. E., & Salvati, L. (2021). Unravelling the role of socioeconomic forces in the early stage of COVID-19 pandemic: a global analysis. International Journal of Environmental Research and Public Health, 18(12), 6340.

Sieroń, A. (2017). Inflation and income inequality. Prague Economic Papers, 26(6), 633-645.

Suhendra, I., Istikomah, N., Ginanjar, R. A. F., & Anwar, C. J. (2020). Human capital, income inequality and economic variables: A panel data estimation from a region in Indonesia. The Journal of Asian Finance, Economics and Business, 7(10), 571-579.

Thalassinos, E., Ugurlu, E., &Muratoglu, Y. (2012). Income Inequality and Inflation in the EU. European Research Studies,15(1), 127-140.

Tica, J., Globan, T., &Arčabić, V. (2022). Managing the impact of globalization and technology on inequality. Economic Research-EkonomskaIstraživanja, 35(1), 1035-1060.

Yuldashev, M., Khalikov, U., Nasriddinov, F., Ismailova, N., Kuldasheva, Z., & Ahmad, M. (2023). Impact of foreign direct investment on income inequality: Evidence from selected Asian economies. Plos one, 18(2), e0281870.