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Department of Economics
Federal Urdu University of Arts Science and Technology
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ICT, Economic Prosperity and Financial Development: New Evidence from Nigeria

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Abstract

The inquiry investigates the influence of Information Communication Technology (ICT) variable and economic progress on financial development in Nigeria. The Autoregressive Distributed Lag (ARDL) was used to estimate data series from 1886 - 2021. The results revealed that the technology variable (ICT) measured by integrating mobile phone subscriptions and internet usage has a positive and important influence on financial development (FD). Thus, technology arising from enhanced ICT variable is instrumental in stimulating FD. The consequence is that financial markets require the use of internet and mobile broadband to be effective. Equally, the results of the impact of mobile subscriptions and the internet by excluding the ICT variable revealed that mobile phone subscriptions and the use of the internet have positive effects on FD. Moreover, the results revealed that economic growth positively and significantly impacts financial development. This implies that an advanced level of economic growth stimulates FD. Additionally, FDI also influenced FD. Thus, an increase in FDI facilitates financial development. Nevertheless, human capital has an inverse impact on FD. Policy implications were also provided.

Keywords: *Technology, Economic Progress, Financial Development*

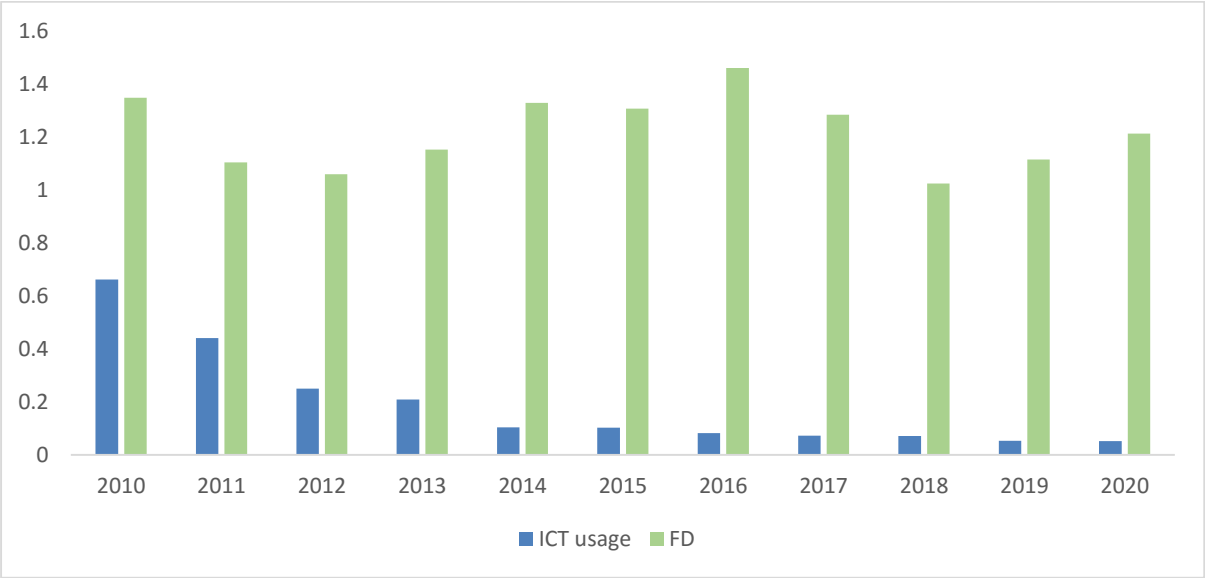
JEL Classification: 01, 02, 03, 04, G1, G2

1. Introduction

Digital technology such as information communication technology (ICT) has become more important in our daily lives. ICT facilitated smooth payment of bills, enhances digital banking, such as mobile transactions, and facilitates access to e-learning, online order of consumables and access to general information (Ofori et al., 2022). A recent development in this direction in Africa and Nigeria is the increasing link between financial development (FD), ICT access, its usage and ICT skills.

The financial institution of Nigeria has witness disruptive innovation in recent times from enhanced use of internet and mobile banking in financial transactions and the use Point of Sales Terminal (CBN, 2021). The improvement in the usage of mobile phones and internet for transactions witness a surge during the COVID-19 pandemic due to lockdown measures put in place by the Nigerian government. This has encouraged remote transactions from homes with the aid of internet and mobile phones. Since the pandemic period the use of internet and mobile facilities has continued to increase in financial transactions in Nigeria. Figure 1 presents the relationship between FD and ICT usage. Internet subscription is used to indicate ICT usage while average national credit to private organisation segment of gross domestic product (GDP) was used to indicate FD from 2010 – 2020. Compared to the ICT usage which is used to measure technology, the penetration of financial development in Nigeria is higher over the period under consideration.

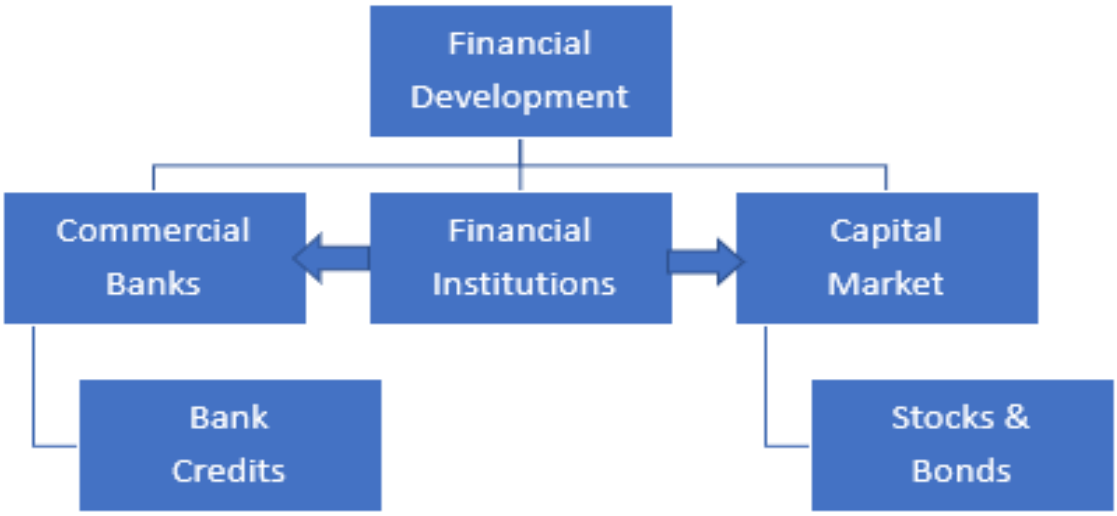
Figure 1: Average FD and ICT Usage in Nigeria, 2010-2020



Source: Author, using data from WDI

In spite of the acknowledged importance of financial development for economic progress, experts in the late 20th century highlighted that an excessive level of financial liberalization can have adverse effects on growth and development. They argued that an abundance of financial deepening may result in inflationary pressures, which could undermine the stability of the banking sector and potentially trigger a financial crisis (Islam et al., 2021). In Figure 2 it is evidenced that financial development emanates from the activities of financial institutions which include commercial Banks and stock markets. Commercial Banks can create asset by giving out credit or loans to households and firms while the stock market can be used to mop-up or increase liquidity in the economy through buying and selling financial securities respectively.

Figure 2: Financial Development Components



Source: IMF, 2015

According to Levine (1997), one of the main purposes of the financial system is to enable the efficient allocation of resources across time and space. It achieves this by performing essential functions such as resource allocation, mobilization of savings, facilitating trade and risk management, monitoring corporate control, and enabling the exchange of goods and services. These functions, mediated by financial market intermediaries, help reduce market inefficiencies by regulating information and transaction costs. Consequently, they have a significant impact on economic growth through the accumulation of capital and the promotion of technological innovation (Islam et al., 2021). This is in line with the endogenous growth models which contend that technological progress resulting from improvement in ICT research and development is among the internal factors that leads to economic growth. For instance, despite that Nigeria is lagging behind in technological progress, the technological improvement noticed in recent times has impacted positively in most economic activities (NBS, 2021; NCC, 2021) Therefore, technological progress resulting from improvement in ICT access, ICT usage and ICT skills in Nigeria has contribute to the recent improvement in economic activities in the post COVID-19 pandemic era. The utilization of internet and mobile broadband technology in Nigeria has had a beneficial influence on various sectors, including the financial sector, manufacturing sector, wholesale and retail sector, and transportation sector. The advancements in information and communication technology (ICT) have also contributed to Nigeria's recent economic growth rate of 2.5% according to the National Bureau of Statistics (NBS, 2022). Hence, this study aims to expand our understanding by examining the effects of ICT technology and foreign direct investment (FDI) on the development of the financial sector.

2. Review of Literature

The inclusion of ICT and FDI as an important variable that affect financial market and financial development has increasingly been discussed in the literature of economic prosperity in recent times. The use of ICT skills assists businesses to access social and economic information of the society there by assisting the businesses and firms to mitigate cost of production while increase the efficiency of productivity. Besides understanding the society need, the coming of ICT technology has further facilitated the interaction among companies and virous sector through digital networking that enable business to be carried out more efficiently. The efficiency of using the digital network also include reducing space and time constraint to facilitate financial development with the banking sector serving as intermediaries. The penetration of ICT has meaningfully improved in recent years, bringing about digital revolution by building up the infrastructure of ICT (Batool et al. 2023).

In the financial wing, the banking industry is one of the well-known sectors that use the ICT technology. The banking industry provide payments services through electronic system like the use of android phones and internet services to carry out electronic transaction between the banks or its representative and their customers (Alshubiri et al., 2019). ICT can be defined as a comprehensive set of technologies that encompass the gathering, organization, and distribution of information. This includes hardware, software, and internet networks that facilitate the efficient transmission and processing of data. The primary objective is to minimize business costs, mitigate risks, and improve the productivity of manufacturing goods and services, leading to overall economic growth and development (Rodríguez-Crespo and Martínez-Zarzoso, 2019). ICT plays a crucial role in enabling financial transactions and facilitating capital market financing in today's globalized world. An example of this is seen in the organized financial markets, such as stock markets in different countries, which heavily rely on ICT and digital technology to ensure precise and efficient operations. Hence, without the ICT facilities the financial market cannot be able to systematically key in to the globalization development of recent times

while other financial firms or businesses will not be able leave up to societal expectation (Alshubiri et al, 2019).

In their study, Mushtaq and Bruneau (2019) investigated the impact of ICT on poverty reduction, income inequality, and financial development. They analyzed data from 62 countries over a 12-year period, specifically examining microfinance institutions and commercial banks. The findings indicate a positive relationship between ICT penetration and financial development, a negative relationship between ICT and income inequality, and ultimately conclude that the adoption of ICT devices in the financial sector can contribute to economic prosperity by reducing poverty and income inequality.

According to Rodríguez-Crespo and Martínez-Zarzoso (2019) the world economy progress can be seen from two perspectives which are technological disruptive innovations and globalization. Out of these two elements of growth, ICT has demonstrated its importance by integrating economies through the use of internet and increasing flow of business among countries of the world. When ICT channels and products like internet and ICT gadget are used, the financial positioning of countries tend to improve which further enhances productivity of the economy. To add to the debate, Thanh-Ha (2022) assessed the influence of globalization on FD on a group of European countries. Several ICT measurements like the internet usage, e-governance and e-commerce were used along with several financial development measurements to ascertain the efficiency, access and depth of financial market of 27 European countries. The findings suggest that the use of ICT in commerce, government and other agencies played important role in promoting FD and the progress of financial market.

The emergence of ICT has led to the growth and expansion of global markets. This is achieved by improving the efficiency of communication, reducing cost and risk of transaction and enable some developing nation to transit from traditional approach of carrying out transaction to a more modern approach. ICT has been also conceived as the modern activity that facilitates the receipt, processing and storage of useful information vial electronic gadgets like mobile phones, internet, computers and other wireless signals (Lee et al., 2019). ICT facilitate the efficient running of services online and avails good data to financial market like the commercial banks, stock exchange markets and provident funds. ICT development has led to the growth of e-commerce in early decades that generated several opportunities that include online banking and the recent proliferation of financial technology (fintech). This ICT development has represented technological progress that has expand access to target customers, increase access to customers data and preferences, increase efficiency at a minimal cost and introduce variety of product to customers (Bhunia, 2011).

Afshan et al. (2021) conducted a study exploring the impact of ICT on the performance of stock markets in ten Asian economies. They utilized quantitative correlation methods and discovered that the development of ICT enhances the effectiveness of stock markets. Similarly, Lee et al. (2019) examined the influence of ICT on the transparency of stock exchanges using data from seventy-one countries. Their findings demonstrated that countries with advanced ICT technology have more efficient and transparent stock markets compared to those with limited ICT technology. Furthermore, Bhunia (2011) investigated the effects of ICT on the development of the Indian stock exchange market. The study revealed that ICT usage significantly influenced the financial market by facilitating stock trading and providing shareholders with easy access to share prices. Additionally, ICT was found to increase the number of stockbrokers in the market and enable real-time online visualization of market and company's shares information.

In line with the Nigerian perspective for year 2030, despite that the country is among the countries with high penetration in the region, in relation to other continents of the globe the Nigerian economic is lagging behind in terms of ICT development. Therefore, the government is committed to invest in ICT sector to enhance financial market development and overall economic prosperity. Equally, expanding the ICT networks of the nation will further improve security and attract companies to invest in the countries and thereby increasing the volume of trade and the foreign exchange earning of the nation. There is consensus among ICT experts that that its penetration helps in reducing cost of transaction, minimize transportation cost and reduce risk of doing business. ICT assist businesses and companies to enhance the value of their supply chain and operation (Mozayani and Moradhasel, 2019).

ICT development has equally assisted in reducing the stress of startup business in the financial sector by reducing the asymmetry of information needed to be successful in starting and growing a new business as most innovative business ideas are often constraint with financial challenges as a result of gaps in information. Thus, financial markets that have developed their ICT can facilitate innovative business ideas through reducing the cost of financing and reduce the challenges that new business startups might face. Therefore, in the era of globalization, financial development of countries in the developing world like Nigeria will not progress without an efficient structure for ICT infrastructure in place. This study investigates the role of technology as measured by access to ICT facilities, usage of the ICT facilities and ICT skills and that of economic progress on FD in Nigeria.

3. Methodology

In line with variables of the study which include financial development (FD), technology, FDI and economic growth, the model specification is as follows. The modified estimation technique is in line with the work of Anwar and Sun (2011) and Nguyen and Lee (2021). To investigate FD and economic prosperity Anwar & Sun (2011) used a production function to emphasis on the role of FD on economic progress. This study is different in these respects: (i) the study develops a model for FD with economic growth as control (ii) the study interacts two different indicators of technology such as mobile subscription and the internet. Hence, the model specification is specified in functional and econometric form in equations 1 & 2 respectively.

$$FD = f(MOB * INT, GDP, FDI, HC) \quad (1)$$

$$FD = \pi_0 + \pi_1 MOB * INT + \pi_2 GDP + \pi_3 FDI + \pi_4 HC + \mu) \quad (2)$$

Where $\mathrm{FD}, \mathrm{FDI}, \mathrm{MOB} * \mathrm{INT}, \mathrm{GDP}$ and HC stand for financial development, foreign direct investment, technology variables of ICT, economic progress and human capital. MOB stands for mobile phone subscriptions while INT stands for internet usage. Related studies (Osie & Kim, 2020; Athreye et al., 2021; Castellani et al., 2022) have also used interactive terms in their studies. However, interacting ICT measures in the investigation of technology, FD and economic performance is not common in existing studies. Hence this investigation contributes to knowledge. Equation 2 will be tested to reveal the effect of $\pi_1 - \pi_4$, on FD. π_0 is intercept while μ is the disturbance term. Hence, we envisage that the size of the elasticities will exceed zero in the presence of good technology.

The Autoregressive Distributed Lag (ARDL) estimation strategy of Pesaran et al. (2001) was used as the main estimation strategy. This is due to some of its advantages and benefits that include allowing the use of variable unit root tested at level and first difference; ability to estimate both the long run and short run result instantaneously; possessing good property for series of variables with small samples size among others (Pesaran et al., 2001).

4. Results and Discussions

The result presentation commences with descriptive statistics and correlation matrix. The outcome of the descriptive statistics is offered in Table 1. The result deliberates on the statistics that check normality of data distribution. The dependent variables considered in this study are financial development, while the independent variables are ICT variable measured by mobile phone subscription and internet, economic growth, FDI and human capital. In the descriptive statistics, foreign direct investment has lowest average and middle values; ICT variable has highest average and median values while other dependent and explanatory variables' mean and median values fall with these two extreme values.

Furthermore, in determining the range, the ICT variable possess the highest value while mobile subscriptions have the lowest value. The values of the standard deviation for all the variables revealed that deviation of the observation data is cluster around the mean value. Human capital exhibits lesser deviation from the average value while the ICT variable exhibits the highest deviation from the mean value. The statistics of Jarque-Bera and probability values show that the observation of variables is normally and independently distributed with most of the Jarque-Bera statistics greater than 2 while the probability values greater than 0.10.

Table 1: Descriptive Data

	Financial development	Foreign direct investment	Economic growth	Mobile phone x Internet	Mobile	Internet	Human capital
Mean	2.205	0.236	1.265	10.357	1.246	0.843	4.503
Median	2.131	0.3470	1.612	11.655	3.304	2.079	4.498
Maximum	2.975	1.7562	2.729	20.679	4.585	3.569	4.626
Minimum	1.598	-1.693	-2.797	-0.501	-4.732	-4.729	4.365
Std. Dev.	0.348	0.735	1.127	5.810	3.726	2.775	0.069
Skewness	0.238	-0.197	-1.880	-0.427	-0.665	-0.790	-0.001
Kurtosis	2.544	3.123	6.930	2.267	1.666	2.093	2.250
Jarque-Bera	0.633	0.255	38.219	1.322	4.288	3.462	0.748
Probability	0.728	0.879	0.000	0.516	0.117	0.177	0.687
Observations	35	36	31	25	29	25	32

The result of the correlation matrix is offered in table 2. Correlation in econometrics is a situation where two or more variables are strongly associated. Thus, in econometric analysis, it is required that variables that are considered for analysis should not be strongly correlated. Order wise there will be potential problem of multicollinearity where most independent variables will be correlated (Sulaiman et al., 2015). The correlation results reveal interesting outcomes in terms of magnitude and sign or direction of the variables. For example, there exists positive correlation between financial development and ICT variable, FDI and economic growth while human capital revealed a negative correlation. FDI has a direct correlation with economic progress and human capital and negative correlation with other variables. Economic growth has positive connection with mobile subscriptions and human capital and inversely related with ICT variable and internet. ICT variable is positively correlated with mobile subscriptions and internet and negatively correlated with human capital. Importantly, the absolute values of virtually all the correlation coefficients are less than 0.8 which is the rule of thumb that ensures that variables in an estimated model are not correlated (Maji and Wazir, 2020).

Table 2: Correlation matrix

	Financial development	Foreign direct investment	Economic growth	Mobile phone x Internet	Mobile	Internet	Human capital
Financial development	1						
Foreign direct investment	0.061	1					
Economic growth	0.070	0.522	1				
Mobile phone x Internet	0.086	-0.621	-0.604	1			
Mobile	0.662	-0.228	0.098	0.052	1		
Internet	0.660	-0.307	-0.028	0.158	0.984	1	
Human capital	-0.430	0.429	0.401	-0.749	-0.205	-0.236	1

Additionally, the unit root test outcomes are presented in table 3. The unit root test tries to ascertain the level of integration of variables. If the mean and variance of a variable are time-invariant then the variable can be said to be integrated and free of a unit root. In testing the unit root problem, the null hypothesis which states that data of a variable has no unit root is the desired result. As such, the alternative hypothesis which is the occurrence of a unit root is not a wanted outcome. This investigation used the ADF and PP to test the level of integration of the series. The reason for integrating the two methods is to ensure robustness of result. The outcome of the integration test in table 3 shows that all the variables are integrated as such are unit root free. For example, financial development is integrated at first difference, ICT variable is integrated at first difference, mobile phone subscriptions and internet are both integrated at level, FDI is integrated at both levels and first difference, economic growth is integrated at both levels and first difference, while human capital is integrated at first difference. In general, we obtained an integration at first difference and at level. If such combination of variable integrations is obtained, the Autoregressive Distributed Lag (ARDL) can be applied as suitable method of long-run estimation (Pesaran et al., 2001; Sulaiman et al., 2015).

Table 3: Unit Root Tests

Variables	ADF		PP	
	Level	1st Difference	Level	1st Difference
Financial development	-1.548 (0.497)	-5.442*** (0.000)	-1.4139 (0.564)	-8.286*** (0.000)
Foreign direct investment	-3.546** (0.012)	8.666*** (0.000)	-3.643*** ()0.009	-10.297*** (0.000)
Economic growth	-6.6266*** (0.000)	-2.857* (0.069)	6.495*** (0.000)	-8.669*** (0.000)
Mobile phone x Internet	-2.432 (0.146)	-5.280*** (0.000)	-1.862 (0.343)	-1.990 (0.288)
Mobile	-3.544** (0.016)	-2.485 (0.129)	-1.424*** (0.555)	-2.424 (0.144)
Internet	-2.362 (0.162)	-1.312 (0.604)	-3.322** (0.025)	-2.338 (0.169)
Human capital	-2.035 (0.270)	-2.683* (0.090)	-1.740 (0.401)	-3.882*** (0.006)

*, ** and *** represent level of significance at 10%, 5% and 1%. Mobile x Internet is the ICT variable values in parenthesis (.) are P-values.

The next step is to presents the result of the impact of technology variable (ICT) and economic prosperity on FD. Before presenting the main outcome, the cointegration link between the dependent variable FD and the independent series, technology variable, mobile subscriptions, internet, economic progress and human capital was carried out. The cointegration which tries to find out the equilibrium link among these variables was tested using the Pesaran et al. (2001) ARDL bound test. It is necessary to confirm that equilibrium association exists amongst the variables before estimating the main ARDL long-run results. The result of the ARDL cointegration outcome is contained in table 4. Besides model 1 which is the main model, we have further conducted a robustness test for the cointegration to ensure strength of the result using models (2-6).

Therefore, a null hypothesis representing absence of cointegration $\pi_i = 0$ was tested in contrast to the alternate hypothesis $\pi_i \neq 0$ of the occurrence of cointegration. The findings as presented in table 4 did not consent with the null hypothesis but accept the alternate hypothesis. The rule for determining cointegration is as follows: if the F-statistic is below the lower bound I(0), it indicates that there is no cointegration. If the F-statistic falls between the lower and upper bounds I(1), the results are inconclusive, but cointegration may still exist. However, if the F-statistic exceeds the upper bound critical value at a 5% significance level, it suggests the presence of cointegration. We establish the presence of cointegration when the F-statistics for each model exceed the upper bound critical values at the 5% significance level. It's important to note that our analysis follows the conventional significance level of 5%. Therefore, equilibrium link exists between FD and the explanatory variables. This is proven by the values of F-statistics 3.59 (model 1), 4.29 (model 2), 50. 02 (model 3), 4.77 (model 4) and 5.37 (model 6) that are greater than their upper bounds critical values at 5% significance level. The upper critical values are 3.49 (model 1), 3.76 (model 2), 3.7 (model 3), 3.67 (model 4) and 3.49 (model 6). Therefore, cointegration and long-run equilibrium connection exists between financial development and its explanatory variables. Hence, we can continue to calculate the long-run results.

Table 4: ARDL Cointegration and Bond Test

Bound test results					
			Level of Significance		
Model 1	F-statistics	Bound test critical values	10%	5%	1%
$FD = f(MOB\text{x}INT, GDP, FDI, HC)$	3.59	I (0)	2.2	2.56	3.29
		I (1)	3.09	3.49	4.37
Model 2					
$FD = f(MOB\text{x}INT, GDP, FDI)$	4.29	I (0)	2.37	2.79	3.65
		I (1)	3.2	3.67	4.66
Model 3					
$FD = f(MOB\text{x}INT, FDI, HC)$	50.02	I (0)	2.37	2.79	3.64
		I (1)	3.3	3.7	4.7
Model 4					
$FD = f(MOB\text{x}INT, GDP, HC)$	4.77	I (0)	2.37	2.79	3.65
		I (1)	3.2	3.67	4.66
Model 5					
$FD = f(MOB, GDP, FDI, HC)$	2.65	I (0)	2.2	2.56	3.29
		I (1)	3.09	3.49	4.37
Model 6					
$FD = f(INT, GDP, FDI, HC)$	5.37	I (0)	2.2	2.56	3.29
		I (1)	3.09	3.49	4.37

Table 5 presents the main result of the effect of technology variable of ICT on FD in Nigeria. The Table contains the long-run, short-run and the diagnostics results. Models 1-4 present the long-run results of ICT variable and exclude variables of mobile subscriptions and the internet while models 5 and 6 present the result of mobile subscriptions and internet respectively and exclude ICT variable. The wisdom of presenting the results in this format is to avoid the problem of multicollinearity.

The long-run results of ICT variable which measures technology in models 1-4 revealed a positive connection between FD and technology in Nigeria. The finding shows that if mobile phone subscription is integrated with the use of internet, FD will increase. Therefore, technology arising from improved ICT variables is important in stimulating financial development in Nigeria. This is justified by the statistically significant coefficients of ICT variable 0.011 and 0.042 of models 1 and 3 respectively. The interpretation of these coefficients is that an upsurge in ICT variable by 1% will increase in FD by a minimum of 0.01% and a maximum of 0.04%. This finding is intuitive as development in financial markets requires the use of internet and mobile communication to be efficient. Additionally, models 5 and 6 also present the long-run results of the impact of mobile subscriptions and internet by excluding ICT variables to avoid multicollinearity. The findings are consistent in that mobile phone subscriptions and the use of internet can facilitate the growth of financial development. Concisely, an increase in mobile phone subscriptions by 1% increase FD by 0.06% and an increase in internet usage growth FD by 0.07%.

Table 5: Technology Variable (ICT), Economic Growth and Financial Development

Variable	ARDL estimations					
	Dependent variable: Financial Development (FD)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Long- run results						
Mobile x Internet	0.011**	0.024	0.042***	0.010	-	-
	(0.006)	(0.037)	(0.006)	(0.012)		
Mobile	-	-	-	-	0.062***	-
					(0.015)	
Internet	-	-	-	-	-	0.076***
						(0.016)
FDI	0.105**	0.534	0.349***	-	0.146	0.152*
	(0.035)	(0.455)	(0.019)		(0.086)	(0.078)
Economic growth	0.125**	-0.302	-	0.197**	-0.027	0.003
	(0.055)	(0.682)		(0.083)	(0.067)	(0.059)
Human capital	-3.290***	-	-0.551	-2.996***	-1.246*	1.341**
	(0.354)		(0.328)	(0.687)	(0.637)	(0.573)
Constant	16.949***	2.4136*	4.392**	15.537***	7.855**	8.284***
	(1.641)	(1.218)	(1.526)	(3.171)	(2.851)	(2.561)
Short-run results						
FD (-1)	0.609**	0.603**	0.456***	0.425	0.117	0.197
	(0.187)	(0.190)	(0.051)	(0.258)	(0.240)	(0.244)
Mobile x Internet	0.034**	0.072*	0.032**	0.028*	-	-
	(0.0108)	(0.035)	(0.007)	(0.015)		
Mobile	-	-	-	-	0.026	-
					(0.042)	
Internet	-	-	-	-	-	-0.005
						(0.061)
FDI	0.077	0.025	0.116***	-	0.052	0.068
	(0.043)	(0.092)	(0.012)		(0.069)	(0.069)
Economic growth	0.096**	0.204**	-	0.171**	0.055	0.0629
	(0.035)	(0.074)		(0.055)	(0.053)	(0.051)
Human capital	-4.247***	-	-2.029***	-3.657***	-2.961**	-2.728**

	(0.565)		(0.148)	(0.735)	(0.956)	(0.951)
ECT (-1)	-0.046***	-0.645**	-1.583***	-0.381***	-0.588**	-0.670**
	(0.346)	(0.175)	(0.065)	(0.041)	(0.233)	(0.242)
Serial correlation	2.392	1.816	0.989	1.930	0.241	0.591
LM test	[0.172]	[0.255]	[0.579]	[0.214]	[0.789]	[0.568]
Heteroscedasticity	0.561	0.476	0.322	0.802	1.346	1.040
test	[0.797]	[0.869]	[0.939]	[0.616]	[0.301]	[0.440]

*, ** and *** represent level of significance at 10%, 5% and 1%. Mobile x Internet is the technology variable of ICT. Values in parenthesis (.) are standard errors. Values in bracket [.] for serial correlation and heteroscedasticity are p-values. ECT (-1) is the coefficient of the error correction for estimated models.

Figure 3a: CUSUM Test

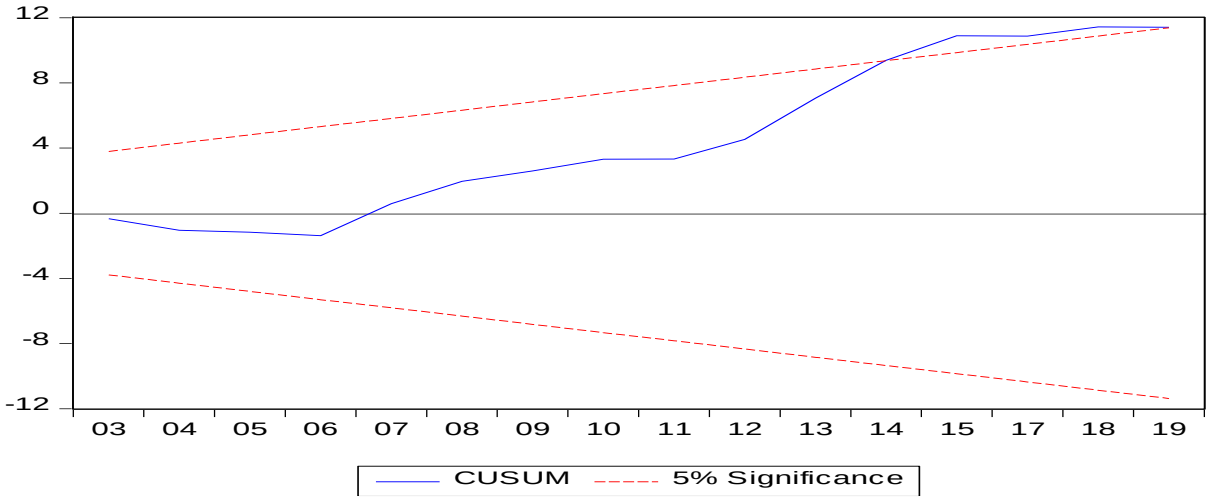
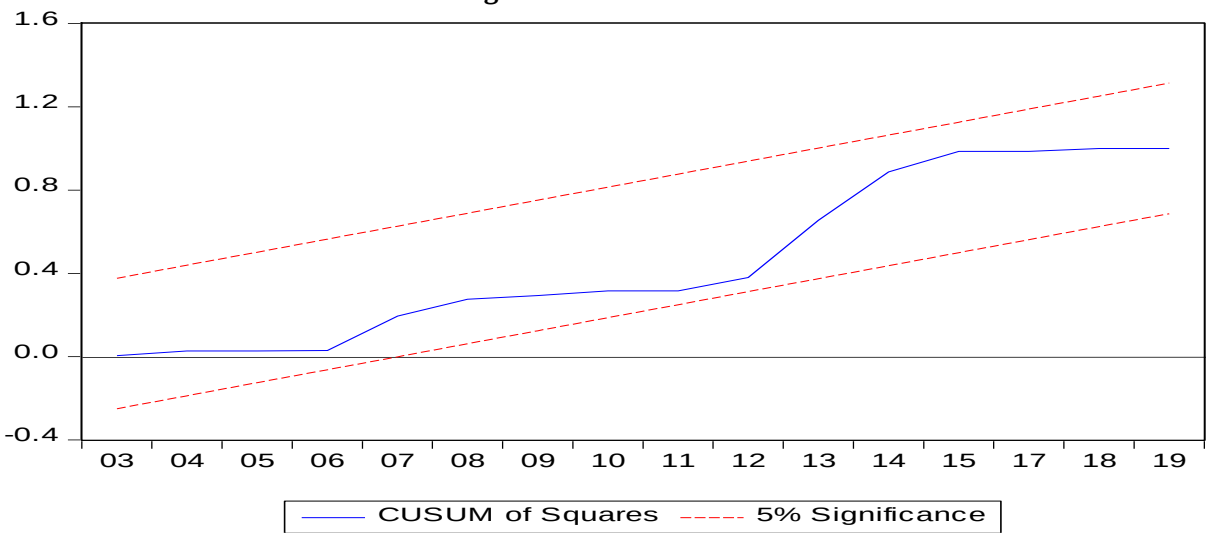


Figure 3b: CUSUM Test



Furthermore, the result of the impact of other explanatory variables: economic progress, FDI and human capital are also presented in Table 5. The result of the effect economic progress on FD is positive and significant as justified by the statistical significance of its coefficients of models 1 and 4. This infers that an advanced level of economic progress can stimulate financial development in Nigeria. The result shows that an increase in economic growth by 1% will facilitate an improvement in financial

development by up to 0.19%. Similarly, the results show that FDI impact positively on FD. Meaning that an increase in FDI facilitates financial development in Nigeria. Financial development will increase by maximum of 0.35% when FDI increases by 1%. This finding is also in agreement with economic theory that a causal relationship can run from FDI to financial development and vice versa. However, the result of the impact of human capital on financial development has consistently revealed a significant inverse relationship between human capital and FD. This suggests that the amount of human knowledge, training, skills and innovation required to stimulate financial development is not sufficient and thus the level of human capital is having an adverse effect on FD in Nigeria. This finding may not be surprising as there is large number of the country's workforce population that is unskilled or semi-skill.

Again, Table 5 also presents the short-run results of effect of ICT variable, economic progress, FDI and human capital on financial development. The findings are also consistent. ICT technology variables revealed a constructive effect on FD, economic progress and FDI also have a positive effect on FD as such, support the long-run results. Human capital in the short-run also has an adverse effect on FD. Moreover, lower part of the Table also presents diagnostic tests of the results. These include serial correlation test to ensure that error term in one period is not correlated with that of another period; and heteroscedasticity test which ensures the constancy of the error term. The diagnostic test shows that all the model 1-6 have passed both the serial correlation tests and the heteroscedasticity test. To strengthen the reliability of the results, a stability test has further been estimated employing test of CUSUM and CUSUM of squares in Figures 3a & 3b. The results show that the estimated model is within the acceptable bounds at 5% significance level as such, we can conclude that the estimated models are stable and reliable.

5. Conclusions and Policy Implications

The study investigates impact of ICT technology variable on financial development. The long-run results revealed a positive link between technology variable and FD. This suggests that when mobile phone subscriptions are integrated with the use of internet, the level of financial development will increase. Thus, technology arising from enhanced ICT variable is instrumental in stimulating financial development in Nigeria. This is informed by the statistically significant elasticity of ICT-financial development variables (0.011 and 0.042) in models 1 and 3. Hence, an increase in ICT technology variables by 1% will increase financial development by a maximum of 0.04%. This finding is not surprising since financial markets require the use of internet and mobile broadband to be effective. Equally, the long-run results of the impact of mobile subscriptions and internet by excluding the ICT variable revealed that mobile phone subscriptions and the use of internet have positive effect on financial development, as such, consistent with early findings. An upsurge in mobile phone subscriptions by 1% increase FD by 0.06% and an improvement in internet increase FD by 0.07%. The implication of this finding is that ICT is instrumental in financial development of any country as such policy makers should pay attention to the all recent development in the ICT sector of the economy.

Again, the outcomes shows that economic growth has positive and important impact on FD as justified by the statistical significance of its coefficients. This implies that an advancement in economic progress stimulates FD. A surge in economic progress by 1% will enable an improvement in financial development by up to 0.19%. Also, FDI positively impact FD. Meaning that increasing FDI facilitates FD. FD will surge by 0.35% when FDI increases by 1%. Nevertheless, human capital has adverse effect on FD. This is no unconnected with number of human capital knowledge levels, training, skills and innovation requirements to stimulate financial development in the country. Thus, we concluded that interactive technology variable of ICT improves FDI in Nigeria. The implication is that FDI, human resources and economic prosperity are strongly correlated as such policy makers must be attentive in controlling one of these variables in terms of the other.

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The data that support the findings of this study are available from the corresponding author upon reasonable request.
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Tax-Spend or Spend-Tax Hypotheses: A Case Study of Pakistan using Threshold Cointegration with Asymmetric Adjustment

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Abstract

Revenue-spending nexus has significant inferences for the political economy to understand the fiscal policies particularly in context of Pakistan economy. In the current study, the traditional tax-spend versus spend-tax view of fiscal policy is investigated based on asymmetrical TAR and M-TAR tests of cointegration. For this, we have used annual data on taxes and government spending for Pakistan over the period 1976 to 2019. The results show some evidence in favor of traditional tax-spend view. It implies that catering revenue from tax side results in more spending and increases the fiscal deficit. Hence, the devastating effect on fiscal balance is evident, if it is targeted through taxes. Therefore, it is required that fiscal adjustment should be from spending side rather than tax. Furthermore, the results indicate that both taxes and government spending are cointegrated (have long-run equilibrium relationship) with asymmetric adjustment process towards long-run equilibrium. Moreover, budgetary deviations below long-run equilibrium are corrected faster than deviations above it.

Keywords: *Fiscal Policy, Political Economy, Tax-spend, Cointegration*

JEL Classification: C10, E62, E63

1. Introduction

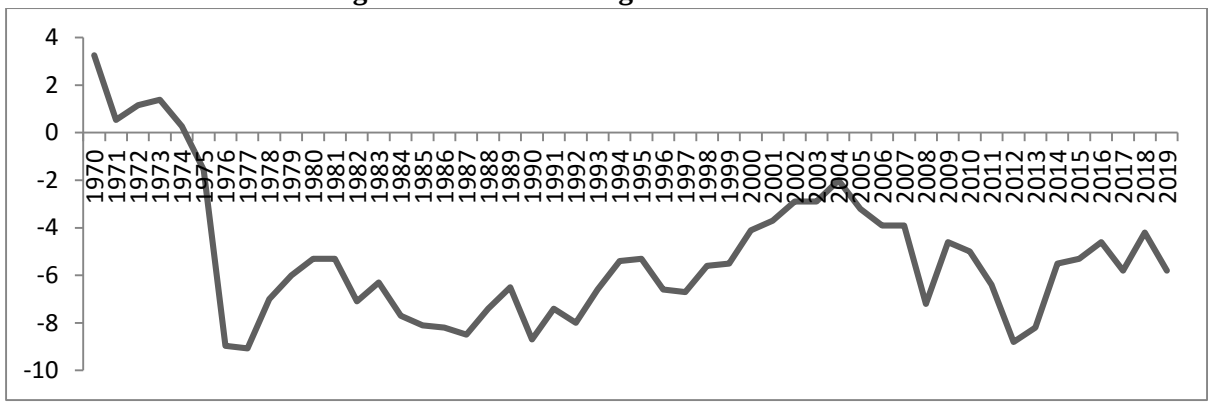
Fiscal policy is considered to be a fundamental part of economic policy. It is designed to achieve the major macroeconomic targets of an economy, which include mobilization of resources in order to finance government spending, stimulation of price stability, and sustaining growth in the long run. Additionally, it is also used to lessen the short term and medium term variations in investment, production and output. However, persistent budget deficits have distressing effects on macroeconomic targets. For instance, it reduces saving which consequently effects growth of the economy (Batrancea, 2021). Furthermore, it also has negative outcome on private investment, net exports and foreign direct investment (Tung, 2018). The worsening fiscal position due to economic crisis in developing countries has increased serious threats regarding long run fiscal sustainability of several economies. The direction and nature of the association among government taxes and spending help to define the pathway for fiscal consolidation to generate public finances. Therefore, it is important to understand the tax-spend nexus in the wake of fiscal complications (Narayan and Narayan, 2006). The issue of government revenues and expenditures remains very much essential in formulating any public policy due to its implications on fiscal deficits.

Most of the developing countries are facing a problem of large and growing fiscal deficit, including Pakistan. Large budget deficit is associated with adverse effect on GDP growth and investment (Chaudhary and Abe, 1999). Moreover, it also has disturbing effect on financial stability due to over borrowing (Reinhart and Rogoff, 2010). Fiscal adjustments are required to correct the budget deficit

through cuts in government expenditures or increase in the revenue sources. Huge quantities of resources should be collected and spend in the most efficient manner. However, it is critical to observe the financing channels and its implication in terms of sustainability. In addition, the fiscal deficit must be manageable in terms of debt to GDP ratio. Therefore, several measures have been proposed and implemented in Pakistan to ensure the sustainability of deficit. It includes broad-based tax reforms, restructuring of a tax system and administration, elimination of tax exemptions and tax shelters along with decrease in unproductive expenditures. However, it is unfortunate, that tax reform polices to target deficit turned out to be unsuccessful (Ahmed, 2018).

The trend of budget deficit in Pakistan is shown in Figure 1 over the period of 1970 to 2019. Pakistan is among one of the developing countries which has to face lot of financial constraints. Expansionary fiscal policies, short term and long term developmental plans and necessary imports play significant role in reducing national saving. The graph shows that Pakistan has been experiencing the problem of deficit since 1975. However, it is important to note that the intensity of the deficit has remained high in most of the years, particularly in recent years. The inability of government to cater revenues and restrict expenditures is clearly visible from the trend of budget deficit. If timely policies are not formulated to lessen the intensity of deficit then it may create severe problems that can lead to government failure. Hence, this study is an attempt to show the existing trend of the association between revenue and expenditure which may further guide to determine the direction of public policy.

Figure 1: Trend of Budget deficit in Pakistan



Source: Author's construction

The association of government taxes and expenditure is essential in assessing the role of government in resource distribution. However, the revenue-spending nexus is still an unsettled issue, despite of various theoretical and empirical developments in the literature. Hence, it is essential to recognize the causal connection between spending and revenue to define the appropriate policy for reduction in budget deficit. The issue of causation; spend-tax, tax-spend, bidirectional (fiscal synchronization) or nonexistent (fiscal independence or institutional separation) is important for the formulation of effective fiscal policy that targets to achieve reduction in deficit along with other short-term and long-term targets.

The empirical research on the relationship of tax-spend hypothesis has raised several observations which suggest the directions for new research. First, limited literature is available for transition and less developed economies. However, recent literature has taken into account these economies but still there is need to expand the research for transition and less developed economies as the available literature is too old or limited in scope. Secondly, there should be more empirical investigation on national and sub-national level for developing countries in order to take into consideration regime shifts, institutional setting and the macroeconomic situation. Thirdly, more recent, non-linear approaches are used that allow changes in fiscal behavior and budget sustainability below or above some particular threshold estimate.

These non-linear methodologies provide certain additional understanding related to fiscal behavior; therefore, it should be applied more extensively. Hence, in this study, focus is given to the issue of tax-spend nexus by applying the nonlinear approach. Although, there is intensified concerns among economists and politicians on the growing and large deficits but the literature seems to be silent in explaining the recent tax-spend or spend-tax causation in case of Pakistan with asymmetric behavior. Therefore, looking at the trend of budget deficit in Figure 1 for the economy of Pakistan, this study specifically try to comprehend the following questions keeping in view the tax-spend nexus. First, the study determines the long-run association concerning government spending and revenues. Second, it investigates that whether the budgetary adjustment follows symmetric or asymmetries process. Third, it explains the influence of government spending and revenues on short-run and long-run adjustment of the budget deficit.

2. Review of Literature

Rich empirical and theoretical literature is available on the association between spending and revenues in view of fiscal balance. Furthermore, it is observed that most of the frequent studies are found in developed economics, while fewer studies are available for less developed and emerging economics due to non-availability of reliable data. However, in the recent time focus has shifted to developing and emerging economies. It is important to note that the policy intervention in view of fiscal balance has regained the attention particular in economic crises, as has been experienced by all the economies during COVID-19. The debate on tax-spend association has generated four types of hypotheses. First, the hypothesis of tax-spend (revenues-expenditures) is validated if one way causation exists from taxes to spending. Whenever, there is raise in taxes to reduce budget deficit, it increases government expenditure, resulting more increase in deficit (Friedman, 1978). Therefore, it is desirable that fiscal adjustment should be via spending rather than tax (Panagiotis, 2004). Among others, the findings of Mounts and Sowell (1997), Husain (2004), Obeng (2015), Mutascu (2016), Khan et al. (2021), Nzimande and Ngalawa (2022) and Karakas and Turan (2019) endorsed this hypothesis.

The second hypothesis i.e. spend-tax (expenditures-revenue) is validated if causality is found from expenditure to taxes. In this case, government first defines its total expenses and later modifies the sources of revenue to finance expenditures. Barro (1979) also proposed this type of hypothesis in view of deficit financing expenditures. The hypothesis of spend-tax type is generally proposed and justified in the situation of crisis (Peacock and Wiseman, 1961; Roberts, 1978 and Konukcu-Onal and Tosun, 2008). Empirical support of this hypothesis is found in the studies of Ross and Payne (1998), Richter and Paparas (2013), Al-Zeaud (2015) and Karakas and Turan (2019).

The third one is fiscal synchronization hypothesis which maintained if there exists feedback or bidirectional causation among taxes and expenditures (Meltzer and Richard, 1981). In this case, government takes simultaneous decisions regarding taxes and consumption. In this context, Mehrara et al. (2011), Vamvoukas (2012), Raza et al. (2019), Akram and Rath (2019) and Soomro (2020) are few studies which are providing support for simultaneous intervention. The fourth hypothesis of institutional separation or fiscal independence indicates that revenues and spending are not dependent of each other (Baghestani and McNown, 1994; Payne, 2003). In this instance, the decision of taxes and spending are taken separately by the government. Hence, the empirical studies of Hoover and Sheffrin (1992), Iqbal and Wasim (2010) and Athanasenas et al. (2014) confirmed this hypothesis and provide support pertaining to independent decisions. The empirical validation of four types of hypotheses is due to country specific characteristics. Moreover, difference in period of analysis, lag length, model specifications and methodology are also important in generating inconsistent results across economies.

It is further noted that empirical literature is mostly dominated by applying the methodology of Granger (1969) causality. Therefore, earlier studies performed bivariate causation technique to analyze the association between taxes and expenditures. Hence, utilizing this technique, Blackley (1986), Ram (1988), Bohn (1991), Hakkio and Rush (1991) and Mounts and Sowell (1997) validated tax-spend hypothesis in USA, Payne (1997) in Canadian economy and Husain (2004) provided evidence in case of Pakistan. Later on, Engle and Granger (1987) presented the technique of cointegration, therefore, a different set of studies appeared based on error correction modeling which provides both short run and long run outcomes. Moreover, bivariate cointegration analysis extended as to a multivariate analysis (Johansen and Juselius, 1990). Hence, larger number of studies is available based on VAR and VECM (Richter and Paparas, 2013; Takumah, 2014; Afonso and Jalles, 2015). In this context, tax-spend hypothesis is supported in the studies of Park (1998) for Korea; Panagiotis (2004) for Greece; Al-Khulaifi (2012) for Qatar; Obeng (2015) for Ghana; Khan et al., (2021) for Malaysia; Nzimande and Ngalawa (2022) for Bostwana. However, utilizing same technique, spend-tax hypothesis is established in the study of Takumah (2014) for the low income economy of Ghana and Al-Zeaud (2014) confirmed this hypothesis for Malaysia.

The newest noteworthy development regarding the relationship of revenue and expenditure is the application of non-linear modeling approaches. This nonlinear modeling allows studies to investigate the sustainability of budget variations below or above some particular threshold estimate. Therefore, in recent times the studies are focusing on the threshold autoregressive (TAR) and MTAR to examine the relationship of taxes and expenditures. Hence, some asymmetric behavior on the tax-spend relationship is found in the US economy in the study of Young (2011). Moreover, similar results are obtained in the studies of Paleologou (2013) for Greece; Aworinde and Ogundipe (2015) for Nigeria and Tiwari and Mutascu (2016) for Romania. Whereas, no asymmetric behavior is found in the studies of Zapf and Payne (2009) for the USA, Paleologou (2013) for Germany and Sweden and Phiri (2019) for the South Africa.

In case of Pakistan the hypothesis of tax-spend is confirmed in the study of Husain (2004). While, spend-tax hypothesis is validated in Husain et al. (2010) and Aisha and Khatoon (2010). The results of Sadiq (2010) and Iqbal and Malik (2010) show no evidence of causation in any direction, hence; provide validation for fiscal independence hypothesis. The case of fiscal synchronization is also validated in the study of Baffes and Shah (1994) and Soomro (2020). Limited and inconclusive literature in case of Pakistan provides a rationale to determine the relationship between government revenues and expenditures. Moreover, the empirical results are not available using the recent dataset with asymmetric budgetary adjustments.

3. Methodology

The study includes annual data for Pakistan over the 43 years during 1976 to 2019. In order to explore the association between tax-spend hypothesis, the data on federal government tax receipts and current expenditures are collected from the Statistical Year Book of FBR and Economic Survey of different years. The series of tax receipt and expenditures are converted into log and then it is scaled by taking log of GDP. Data transformation technique is similar to the one provided in Ewing et al. (2006) and Young (2009).

3.1. Unit Root Test

ADF test is employed to look at the stationarity of the selected data. If unit root exists in both series i.e. revenues and expenditure then it is suggested to test the long-run association among revenues and spending by applying the technique of Engle-Granger (1987).

3.2. Cointegration

For cointegration analysis, Engle-Granger (1987) technique is applied among the series of revenues and expenditure. The existence of cointergation in the revenue and expenditures allow to estimate the long-run association given in specification (1) through OLS.

$$\mathrm{Re}\, v_t = \phi_0 + \phi_1 Exp_t + \varepsilon_t \qquad (1)$$

Where, Rev_t shows tax revenues and Exp_t is representing the current government expenditures. Error term is shown by ε_t. Cointegration among the variables of revenues and expenditures indicates the presence of long-run association among the given series and therefore, it is recommended to use the error-correction procedure. This error-correction mechanism offers the short-run adjustment process to its long run equilibrium value in case of any short run disequilibrium.

$$\Delta Exp_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta Exp_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta \mathrm{Re}\, v_{t-i} + \delta \hat{\varepsilon}_{t-1} + \mu_t \qquad (2)$$

$$\Delta \mathrm{Re}\, v_t = \tilde{\alpha}_0 + \sum_{i=1}^{p} \tilde{\alpha}_i \Delta Exp_{t-i} + \sum_{i=1}^{p} \tilde{\gamma}_i \Delta \mathrm{Re}\, v_{t-i} + \tilde{\delta} \hat{\varepsilon}_{t-1} + \tilde{\mu}_t \qquad (3)$$

The traditional tax-spend hypothesis is given in equation (2) and spend-tax hypothesis is presented in equation (3). These equations show that changes in expenditure (revenue) have symmetric effect on revenue (expenditure). Akaike information criterion is applied for the selection of lag length and $\hat{\varepsilon}_t$ is estimated residual from the cointegrating relationship using equation (1). The equations (2) and (3) are estimated by ordinary least square (OLS).

$$\Delta Exp_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta Exp_{t-i} + \sum_{i=1}^{p} \gamma_i^{NEG} D^{NEG} \Delta \mathrm{Re}\, v_{t-i} + \sum_{i=1}^{p} \gamma_i^{POS} D^{POS} \Delta \mathrm{Re}\, v_{t-i} + \delta \hat{\varepsilon}_{t-1} + \mu_t \qquad (4)$$

Where D^{POS} = 1 if Δ Rev> 0
= 0 otherwise

D^{NEG} =1 if Δ Rev<0
= 0 otherwise

Specification (4) permits variations in tax revenues for having asymmetric effects on spending depending whether the tax revenue changes are negative or positive.

$$\Delta \mathrm{Re}\, v_t = \tilde{\alpha}_0 + \sum_{i=1}^{p} \tilde{\gamma}_i \Delta \mathrm{Re}\, v_{t-i} + \sum_{i=1}^{p} \tilde{\alpha}_i^{NEG} D^{NEG} \Delta Exp_{t-i} + \sum_{i=1}^{p} \tilde{\alpha}_i^{POS} D^{POS} \Delta Exp_{t-i} + \tilde{\delta} \hat{\varepsilon}_{t-1} + \tilde{\mu}_t \qquad (5)$$

Where D^{POS} = 1 if Δ Exp> 0
= 0 otherwise

D^{NEG} =1 if Δ Exp<0
= 0 otherwise

Similarly, specification (5) in view of spend-tax, permits variation in expenditure for having asymmetric effects on tax revenues depending on whether the expenditure changes are negative or positive. The models of TAR and M-TAR are used to check the symmetry assumption of the ECM. Estimates of TAR and M-TAR models are based on the residuals $\hat{\varepsilon}_t$ of specification (1).

$$\Delta \hat{\varepsilon}_t = I_t \rho_1 \hat{\varepsilon}_{t-1} + (1 - I_t) \rho_2 \hat{\varepsilon}_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta \hat{\varepsilon}_{t-i} + \upsilon_t \qquad (6)$$

Where, for TAR

$I_t = 1$ if $\hat{\varepsilon}_{t-1} \geq \tau$

$= 0$ if $\hat{\varepsilon}_{t-1} < \tau$

For M-TAR

$I_t = 1$ if $\Delta\hat{\varepsilon}_{t-1} \geq \tau$

$= 0$ if $\Delta\hat{\varepsilon}_{t-1} < \tau$

The threshold level, τ, is obtained by following Chan (1993) procedure. This will enable to test the null hypothesis of no cointegration ($\rho_1 = \rho_2 = 0$) using the Φ-stat (F-statistic) from Enders and Granger (1998). If null hypothesis of no cointegration is rejected, then the assumption of symmetric vs. asymmetric with the related null hypothesis (H_0: $\rho_1 = \rho_2$, symmetric adjustment) is tested using Wald test. These threshold values are used for the estimation of ECM with short-run asymmetric effects.

$$\Delta Exp_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta Exp_{t-i} + \sum_{i=1}^{p} \gamma_i^{NEG} D^{NEG} \Delta \mathrm{Re}v_{t-i} + \sum_{i=1}^{p} \gamma_i^{POS} D^{POS} \Delta \mathrm{Re}v_{t-i} + I_t \rho_1 \hat{\varepsilon}_{t-1} + (1 - I_{t-1}) \rho_2 \hat{\varepsilon}_{t-1} + \mu_t \quad (7)$$

$$\Delta \mathrm{Re}v_t = \tilde{\alpha}_0 + \sum_{i=1}^{p} \tilde{\gamma}_i \Delta \mathrm{Re}v_{t-i} + \sum_{i=1}^{p} \tilde{\alpha}_i^{NEG} D^{NEG} \Delta Exp_{t-i} + \sum_{i=1}^{p} \tilde{\alpha}_i^{POS} D^{pOS} \Delta Exp_{t-i} + I_t \tilde{\rho}_1 \hat{\varepsilon}_{t-1} + (1 - I_{t-1}) \tilde{\rho}_2 \hat{\varepsilon}_{t-1} + \tilde{\mu}_t \quad (8)$$

In the above equations ρ_1, ρ_2 and $\tilde{\rho}_1, \tilde{\rho}_2$ are interpreted as speed of adjustment parameters. ρ_1, ρ_2 show the responsiveness of expenditures to above and below threshold budgetary disequilibria, respectively. Similarly $\tilde{\rho}_1, \tilde{\rho}_2$ represent the responsiveness of tax revenues to above and below threshold budgetary disequilibria. For cointegration to exist, at least one of the adjustment parameters must be non-zero. The traditional literature on tax-spend or spend-tax hypotheses consist of applying the Granger causality test on the lag coefficients of expenditure (Exp_t) in revenue equation (Rev_t) and vice-versa. In simple words using equations (2) and (3), there will be tax-spend hypothesis only if we'll be able to reject the following null hypothesis,

$H_0 : \gamma_1 = \gamma_2 = \ldots\ldots\ldots = \gamma_P = 0$

and accept the following given null hypothesis,

$H_0 : \tilde{\alpha}_1 = \tilde{\alpha}_2 = \ldots\ldots\ldots = \tilde{\alpha}_P = 0$

Furthermore, more recently the inclusion of asymmetries into the tax-spend or spend-tax hypotheses allow us to consider the effect of changes in revenues on expenditures depends on whether those changes in revenues are negative or positive, in a similar way. However, there is widely held believe in time series literature that granger causality test does not capture all aspects of causality. So, one need to proceed cautiously for testing tax-spend or spend-tax hypotheses using granger causality test.

On the other hand, an important insight regarding the causation relationship among government spending (Exp_t) and its revenues (Rev_t) can be gained by interpreting the speed of adjustment parameters ρ_1, ρ_2 and $\tilde{\rho}_1, \tilde{\rho}_2$. If only ρ_1 and/or ρ_2 are non-zero, it means that only government expenditures respond to the deviations from long run equilibrium relationship among government revenues and taxes, proving the spend-tax hypothesis and vice-versa.

4. Results and Discussions

The unit root test of ADF is offered in Table 1. The series of revenue and expenditure are found to be non-stationary at level, whereas, the series are stationary at first level. Therefore, it is suggested to check the coitegration relation between the variables under consideration. The series of revenue and expenditure is considered to have a cointegration relationship if the error term of equation (1) is turns out to be stationary. In this regard, computed ADF statistic (-3.27) is larger than the critical value at 10% level of significance, therefore, ADF test rejects the null hypothesis of unit root in error series which indicates that the series of revenues and expenditures are simply co-integrated.

Table 1: Results of Unit

Variables	ADF Test	Conclusion
Rev	-2.27	
ΔRev	-7.82***	I(1)
Exp	-2.56	
ΔExp	-7.52***	I(1)

Note: The symbols *** show significant at 1% level

Recent development in time series literature is the non-linear relationship among macroeconomic variables over business cycle. Furthermore, Enders and Granger (1998) show that model with symmetric adjustment will be misspecified if actual relationship among given variables is asymmetric. We next estimate equation (6) using TAR & M-TAR tests for asymmetric adjustment. Chan (1993) procedure is used to determine the consistent value of threshold. Following this technique, the values of $\widehat{\varepsilon_t}$, and $\Delta\widehat{\varepsilon_t}$ are arranged for TAR and M-TAR models in ascending order then 15% below and above (largest and smallest) values are discarded. Hence, the threshold value "τ" is the consistent estimate yields the smallest residual sum of squares is found to be laying in the middle of remaining 70% values. In this study, the resulted threshold value for TAR is τ = 0.000787 and for M-TAR is τ =0.000703

Table 2: Estimate for the Budgetary Disequilibrium

Model	Lags	T	ρ_1	ρ_2	$\rho_1 = \rho_2 = 0$	$\rho_1 = \rho_2$	D-W
TAR	1	0.000787	-0.71	0.066	4.32	5.11	2.05
			(-2.89)	(0.37)			
M-TAR	0	0.000703	0.27	-0.38*	5.34***	5.39**	2.02
			(1.08)	(-3.08)			

Note: t-statistic is given in brackets, ***, **,* shows the level of significance at 1%, 5% and 10%

TAR and M-TAR tests are used for the estimation of equation (6). The actual value of threshold parameter "τ" is used to examine whether the adjustment process is ideally captured as a TAR or M-TAR. The null hypothesis $\{H_0 = \rho_1 = \rho_2 = 0\}$ is tested for both TAR and M-TAR models. The test doesn't follow the standard distribution and the reported F- statistics is compared with the critical values provided by Enders and Siklos (2001). For symmetric adjustment the null hypothesis is $\{H_0 = \rho_1 = \rho_2\}$

and the F- statistics is compared to the standard F-distribution. Table 2 shows the outcome of the threshold cointegration by using the consistent estimate of the threshold.

Table 3: Results of M-TAR ECM Versions of Expenditure and Revenues Equations

Revenues ECM equation			**Expenditure ECM Equation**		
Variables	M-TAR		Variables	M-TAR	
$\tilde{\alpha}_0$	-.001	(-0.96)	α_0	-0.002	(-0.61)
$\tilde{\alpha}_1^{NEG}$	-0.14	(-1.01)	γ_1^{NEG}	-0.98	(-1.15)
$\tilde{\alpha}_1^{pos}$	0.078	(0.52)	γ_1^{POS}	0.32	(0.39)
$\tilde{\rho}_1$	0.28	(1.01)	ρ_1	-0.10	(-0.14)
$\tilde{\rho}_2$	-0.40***	(-2.90)	ρ_2	-0.31	(-0.92)
R^2	0.30		R^2	0.15	
AIC	-7.65		AIC	-5.82	
D-W stat	2.03		D-W stat	2.05	
F –stat ($\gamma_1^{NEG}=0$)	1.03		F-stat ($\gamma_1^{NEG}=0$)	1.34	
F-stat ($\gamma_1^{POS}=0$)	0.27		F-stat ($\gamma_1^{pos}=0$)	0.15	
F-stat $\rho_1=\rho_2$	5.06**		F-stat	0.075	

Note: t-statistic is given in brackets, ***, **,* shows the level of significance at 1%, 5% and 10%

ρ_1 represents the adjustment process above the threshold budgetary disequilibrium while ρ_2 shows the adjustment process below the threshold budgetary disequilibrium. For TAR test, point estimates of ρ_1, ρ_2 suggest that there will be convergence with rapid speed for positive discrepancies than for negative ones from τ=0.000787. An important hypothesis is to test the existence or nonexistence of cointegration where $H_{o:}\ \rho_1 = \rho_2 = 0$, rejecting null hypothesis (H_O) means that there is cointegration among given variables once both TAR and M-TAR values are obtained. Since this test follows non-standard F or Φ distribution, critical values for comparison are used from Enders and Siklos (2001). For TAR, critical values of 90%, 95%, and 99% for 50 observations with one-lag change are 5.55, 6.62, and 9.10, respectively. Since our computed value (4.32) does not exceed any of these critical values, therefore, we fail to reject the null hypothesis of no cointegration using TAR model. On the other hand, in case of M-TAR model, critical values of 90%, 95%, and 99% for 50 observations with no lag change are 5.02, 6.02, and 7.09, respectively. In comparison, our computed value in M-TAR model (5.34) exceeds one of the given critical values, therefore, we reject the null hypothesis of no cointegration. The next step is to test null hypothesis of cointegration with symmetric adjustment $H_o : \rho_{1=} \rho_2$ contrary to the alternative of cointegration with asymmetric adjustment using standard F-test or Wald test. The results are demonstrated in the second last column of Table 2. The computed F-stat of 5.39 (with *p-value*=0.02)

exceeds the critical value, we reject the null hypothesis of symmetric adjustment in favour of asymmetric adjustment. Therefore, estimation results reveal that in case of TAR model, cointegration with asymmetric adjustment of budgetary disequilibrium is rejected, however for M-TAR, asymmetric adjustment process is accepted at 5% significance level.

Finally, using the values of momentum threshold, expenditure as well as tax revenues ECM equations (7) and (8) are estimated with short-run asymmetric effects and results are presented in Table 3. We estimate equations (7) and (8) for different lag lengths and find one lag to be optimal for both equations using AIC criteria. The value of Durbin-Watson statistic also indicates that the errors are not autocorrelated, which further reinforces the choice of optimal lag length. We also include the lagged values of dependent variables in an asymmetric way. However, all of these values from both equations (7) and (8) are found insignificant, given by very low t-stat of these coefficients provided in Table 3. The speed of adjustment coefficients provides an interesting story of adjustment towards long run equilibrium relationship of government tax revenues and expenditure after short-run disequilibrium. The t-statistic of error correction terms indicate that government spending is weakly exogenous but government revenues adjusts only to the deviations from long run equilibrium if $\hat{\varepsilon}_{t-1} < 0.000703$. In other words, revenues responds to the below threshold deviations from long run relationship, whereas in case of positive deviations it shows persistence. We can also infer an important insight regarding the causation relationship among government tax revenues and its spending. Since only tax revenues responds to the deviations from long-run relationship, it means causality is running from taxes to spending and not the other way around. On this reasoning, a point can be made in support of tax-spend hypothesis. The implication of this type of hypothesis suggests that increase in the taxes induces more spending. This actually increases more fiscal deficit through higher spending. Hence, the appropriate policy is to decrease the taxes in order to curtail the budget deficits. Another, policy option is to do adjustments from spending side through efficient management of spending allocation.

5. Conclusions and Policy Implications

This study reconsiders the important issue of fiscal imbalance in order to define the direction of relationship among the series of revenues and expenditure. The understanding of this relationship is critical to achieve sustainable development. The risks linked to increasing or high levels of debt and deficits are extensively recognized in the literature. Hence, it is important to comprehend the relationship between revenues and spending for addressing fiscal imbalances in developing economies, keeping in view their ongoing budgetary position. However, the available reported literature regarding the revenue-expenditure nexus for Pakistan is inconclusive. Some studies are providing support in view of both types of spend-tax and tax-spend hypothesis, while some other have shown no causation in either direction. Furthermore, most of the previous empirical literature is too old and relies on Granger causality test.

The present study aims to empirically investigate the tax-spend or spend-tax nexus for Pakistan using the models of asymmetrical TAR and M-TAR cointegration. These techniques are applied to examine whether the government revenues and spending respond asymmetrically to the level as well as changes in budgetary disequilibrium in Pakistan by using annual data from 1976 to 2019. The TAR and M-TAR tests provide some evidence of the long run association among government revenues and expenditures characterize by asymmetric adjustment, whereby deviations below long-run equilibrium are corrected faster than deviations above it. The results also show some evidence in favor of tax-spend hypothesis during the time period of analysis. It concludes that revenue drives expenditures; therefore, fiscal balance can be achieved through raising taxes. The implication of this result indicates that taxes are raised in order to reduce budget deficit but it induces more spending and therefore, increases more gap between revenues and expenditures. In this scenario, it is more appropriate to adjust expenditures rather than bringing increase in taxes. Public expenditure management is crucial for fiscal discipline which needs effective and efficient allocation of resources. However, broadening the tax base can bring improvement in revenue

collection. A more transparent and flexible tax system can increase the government revenue, which consequently finances its expenditures. In addition, policies in view of curtailing tax evasion and avoidance can also serve as an important instrument in enhancing government collections of revenues.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure statement

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Climate Change Adaptation, Food Security and Livelihood: A Case Study of Multan Division

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Abstract

The study examines the relationship between climate change adaptation, food security, and livelihoods in the Multan division. Data was collected from four districts, including Multan, Vehari, Khanewal, and Lodhran, for the year 2023. The study employed the Ordinary Least Squares (OLS) method to estimate the results, utilizing five regression models with five dependent variables: on-farm adaptation strategy, storage adaptation strategy, diversification adaptation strategy, common pooling adaptation strategy, and mobility adaptation strategy. The independent variables considered in the analysis encompassed age, male-headed households, joint family structure, dependency burden, farming experience, years of schooling, land size, land ownership, land quality index, non-land assets index, income, access to services index, climate change index, and food security index. This research contributes to understanding the interplay between climate change adaptation, food security, and livelihoods in the Multan division, offering valuable insights for policymakers and stakeholders in designing effective strategies for sustainable development.

Keywords: *Climate Change, Adaptation, South Punjab, Livelihood, Food Security*

JEL Classification: *D64, Q22, Q120*

1. Introduction

The process of adapting to the effects of climate change is of the utmost significance in view of the growing danger posed by this phenomenon. It is necessary to provide top priority to adaptation techniques that can aid society and ecosystems in coping with the impacts of climate change as global temperatures continue to rise and extreme weather events become more frequent and severe. This is because it is imperative to give top priority to adaptation techniques that can assist society and ecosystems in coping with the consequences of climate change. Adaptation techniques encompass a diverse array of activities, such as the development of resilient infrastructure, the improvement of emergency readiness, the development of environmentally friendly farming practices, and the protection of biological variety.

One of the most important aspects that contribute to the significance of climate change adaptation is the capacity to lessen the impact that climate change will have on vulnerable groups. The effects of climate change are felt most acutely in developing countries, particularly those that have little resources and a deficient level of infrastructure. These implications could include a decrease in agricultural production, an increase in the danger of natural disasters, and an increased scarcity of water. Developing effective adaptation measures, such as early warning systems, climate-resilient infrastructure, and social safety nets, will help to mitigate the negative consequences that climate change will have on communities that are particularly susceptible (UNFCCC, 2015).

Furthermore, protecting ecosystems and biodiversity requires adapting to climate change. Ecosystems offer a variety of services, such as carbon sequestration, water filtering, and habitat creation. Ecosystems are significantly disrupted as a result of temperature and precipitation changes brought on by climate change, which can result in habitat loss, species extinction, and ecosystem degradation. We may increase ecosystem resilience and foster their capacity to adjust to changing conditions by putting into practice adaptation techniques that concentrate on protecting and repairing ecosystems, such as reforestation and protected area management (IPCC, 2014).

A vital worldwide issue, food security includes the availability, use, and stability of food to guarantee that everyone has access to enough, safe, and nourishing food to lead healthy lives. It is crucial for several reasons. First off, public health and nutrition are directly related to food security. For human growth and development, especially in vulnerable groups like children, pregnant women, and the elderly (FAO, 2020), adequate access to nourishing food is essential. Malnutrition, stunted growth, impaired immune systems, and increased susceptibility to diseases are all consequences of inadequate food access (FAO, 2020; WHO, 2020). In order to improve global health outcomes and lessen the burden of diseases linked to malnutrition, food security must be promoted.

Second, socioeconomic development is significantly influenced by food security. People who have access to enough food can be useful members of society, which promotes economic growth and lowers poverty (FAO, 2020). People may concentrate on their education, skill development, and work prospects when they are not concerned about where their next meal will come from. This increases productivity and income levels. Food shortages and hunger can cause social discontent, conflicts, and migration, which makes food security important for social stability and peace (FAO, 2020).

Individuals' well-being and the growth of societies as a whole are reliant on their ability to earn a living. It includes how individuals earn a living and meet their fundamental needs, such as food, shelter, and healthcare. Economic security, social integration, and a sense of purpose are provided by a person's means of subsistence, which demonstrates the significance of this factor. According to Sen (1999), a means of subsistence enables individuals to escape poverty and enhance their standard of living, thereby fostering human capabilities and enhancing the quality of life as a whole. If a person or family has access to a consistent and sufficient income, they are in a better position to meet their fundamental requirements, make investments in education, and improve their health. According to Chambers and Conway (1992), this, in turn, contributes to the economic prosperity and social stability of the community.

In addition, having a means of subsistence is essential for promoting social cohesiveness and inclusion. People who do not fear for their financial futures are better able to contribute meaningfully to society, maintain meaningful relationships with others, and build social networks (DFID, 1999). It does this by building a sense of belonging and communal participation among individuals, which in turn helps to the general health and resilience of communities and individuals. In addition, sustainable professions give power to underprivileged groups such as women and young people by giving them access to economic opportunities and lowering their risk of being exploited and excluded (Ashley & Carney, 1999). According to the United Nations Development Programme (UNDP), 2015, livelihoods contribute to the elimination of inequities and the promotion of social justice, both of which are vital for sustainable development.

According to the Intergovernmental Panel on Climate Change (IPCC), climate change has the potential to affect food security by reducing the availability of water resources for irrigation, reducing crop yields, and increasing the frequency of parasites and diseases. Small-scale farmers, whose means of subsistence, including income and food supply, are directly threatened by these developments because agriculture is their primary source of income and sustenance. In addition, climate change can cause an increase in the

volatility of food prices, which can have an effect on both the ability of vulnerable populations to buy food and the availability of food (FAO, 2016).

To overcome these challenges, adaptation solutions to climate change are absolutely necessary to implement. According to the Intergovernmental Panel on Climate Change (IPCC), an adaptation strategy may include the implementation of climate-resilient agricultural techniques such as conservation agriculture and agroforestry. These activities increase soil fertility, water management, and crop variety. These approaches assist farmers in adjusting to the shifting weather conditions, which in turn helps them boost their income and their overall output. In addition, diversification of livelihoods beyond agriculture, such as through the development of non-farm enterprises or alternative income-generating activities, can increase resilience to the effects of climate change and reduce reliance on climate-sensitive sectors (FAO, 2016).

In a nutshell, the relationship between food security, livelihood, and climate change adaptation emphasizes the need for integrated approaches that address both agricultural productivity and the socioeconomic well-being of communities. Individuals and societies can increase their resilience, ensure food security, and sustain livelihoods in the face of climate change challenges by implementing adaptive strategies.

2. Review of Literature

Climate change poses significant challenges to global food security, necessitating comprehensive adaptation strategies. Table 1 provides a summary of studies that explore the intricate relationship between climate change adaptation, food security and livelihood.

Table 1: Summary of Studies on Climate Change Adaptation and Food Security

Author(s)	Country	Time period/ observation	Methodology	Measurement	Main Results
Wesche and Chan (2010)	Canada	Multiple methods and survey : 1997 to 2000 Food frequency interview, harvest calendars, 24-h recalls, social agricultural interviews	Comparative analysis technique	Consumption	Temperature, land, water, vegetation and wildlife (+)
Urama and Ozar (2011)	Central Africa	Questionnaire 1490 household participated in questionnaire Secondary data collected from 2005 to 2009	Mean, standard deviation, percentage scores.	Productive stage of life	Agricultural innovations, food security (+)
Sonag et al. (2011)	Kenya	Interviews and questionnaire	Indigenous knowledge strategies	Skill and Knowledge	Income, trade and knowledge (+) Price (-)
Hannah et al.(2013)	Mexico, west Africa, Himalayas, new Guinea, Sulawesi	The eco crop dataset, global biodiversity information facility	Multiple climate and emissions scenarios method	Investment priority	Poverty, agricultural production , ecosystem, international policy(+)

Rasul and sharma (2015)	South Asia	1990 to 2010	The development oriented approach Sectorial adaptation approach	-	Food security, water, energy (+)
Summary of Studies on Climate Change Adaptation and Livelihood					
Osbahr et al. (2008)	Mozambique	Qualitative data Data collected from 2003 to 2004 Quantitative data 1997-2001 in flooding 1983-1984, and 1994-2003 in drought	Mixed qualitative and quantitative technique	Investment	Drought, storm and flood, poverty, income and rural Livelihood (+)
Iwasaki et al, (2009)	India	Qualitative method 25 household in each community from November 2007 to December 2007	Sustainable livelihood approach (SLA)	Qualitative Analysis	Human capital, Natural capital, Financial capital, Social capital and physical capital (+)
Nuorteva et al.(2010)	Cambodia	Interviews held in2008 19 participants	Crosscut approach	Qualitative Analysis	Population , drought, flood, price (+)
Pouliotte et al. (2011)	Bangladesh	Interviews held in 2004 21 individual participated	Bottom-up approach	Qualitative Analysis	Income, Food, Safe Drinking water, Safety of property, Health (+)
Bryan et al.(2012)	Kenya	Interviews held July 2009 to February 2010 710 participants	Soil and water conservation techniques	Crop system simulation Model	Food security, profitability ,Greenhouse gas mitigation (+)
Summary of Studies on Climate Change Adaptation, Livelihood and Food Security					
Lambrou et al. (2013)	India	Questionnaire 190 individuals participated in survey	Chi- square method	Qualitative Analysis	Food security, livelihood (+) Gender inequality discrimination (-)
Boutin and Smit (2015)	Sub- Saharan Africa	Qualitative data	General circulation model	Qualitative Analysis	Food security and livelihood (+)
Funk et al. (2019)	India	Primary method 215 household participated in survey	Binary regression model	Qualitative Analysis	Education, HS, Livestock ownership, Poverty, Climate change awareness (+)
Shah et al. (2020)	Trinidad and Tobago	Primary method 138 household	OLS	Qualitative Analysis	Food security and Livelihood (+)

The study addresses several research gaps in the existing literature. Firstly, there is a lack of studies specifically focusing on the Multan Division, which limits our understanding of the unique challenges

and potential adaptation strategies in this region. By conducting a case study in Multan Division, this research contributes to filling this gap by providing valuable insights into the climate change adaptation, food security, and livelihood dynamics in the area. Secondly, while existing literature primarily focuses on on-farm adaptation strategies, this study aims to broaden the scope by examining a range of adaptation strategies including on-farm, storage, diversification, common pooling, and mobility. By considering multiple adaptation strategies, this research provides a more comprehensive understanding of the diverse approaches that individuals and communities employ to cope with climate change impacts and enhance their food security and livelihoods in Multan Division. Lastly, an additional research gap in the literature is the lack of studies that explicitly link climate change adaptation with food security and livelihood outcomes. This study seeks to bridge this gap by investigating the interrelationships between climate change adaptation measures and their impacts on food security and livelihoods in Multan Division. By examining these linkages, the study contributes to the broader understanding of how climate change adaptation strategies can enhance food security and livelihood resilience in the context of a specific region.

3. Data Source and Sampling Design

Data play a crucial part in the research process, acting as the basis on which every step are based. The goals of the research must be in line with data collecting as a deliberate task. Any research project must start with the crucial duty of gathering data, followed by careful data analysis and the subsequent interpretation of the findings. For the collection of data for this study, we have used primary sources. The data are collected from the small agricultural farmers of four districts of Multan division (Multan, Vehari, Khanewal and Lodhran).

An effective sample size determination method is needed because empirical research requires a representative statistical sample. Krejcie & Morgan (1970) created a sample size chart to fill the gap.

The formula for the determination of sample size is as follows:

$$s = X^2 NP(1-P) + d^2(N-1) + X^2 P(1-P) \tag{3.1}$$

where, X^2 is the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841), N is the population size, P is the population portion (Assumed to be 0.50 since this would provide the maximum sample size) and d is the degree of accuracy expressed as a proportion (0.05).

We have determined the sample size by utilizing Krejcie & Morgan (1970) formula which suggests that 384 is the sample size to determine the sample size for a finite population of 1000000 or more. We have used proportional sampling to determine the sample size based on rural population as our study is related to agriculture sector. Following formulas is applied to find the proportional sample size:

$$S = \frac{Rural\ Population\ in\ district_i}{Total\ Population\ in\ Mul\tan Division} \times 384 \tag{3.2}$$

Table 2 presents an overview of sample size determination.

Table 2: Sample Size Determination

District	Rural Population	Sample Size (based on rural Population)	Sample Taken in Actual
Multan	1802103	1802103/6263028x384=110	120
Vehari	1754984	1754984/6263028x384=108	120
Khanewal	1704229	1704229/6263028x384=104	120
Lodhran	1001712	1001712/6263028x384=61	80
Total Population in Multan Division	6263028	384	440

4. Model Specification and Methodology

After collecting the data, the subsequent step involves employing suitable techniques to derive results. In this study, the analysis would be organized into two stages. The initial stage entails conducting a descriptive or preliminary analysis of the data, while the second stage involves performing multivariate analysis to determine the factors that affect the on farm, storage, diversification, common pooling and mobility diversification.

4.1 An Elementary Data Analysis

An elementary analysis of the data consists of the frequency and percentages analysis of the variables under study.

4.2 Econometric Analysis of the Determinants of Climate Change Adaptation

To explore the factors of climate change adaptation in Multan division, we have used five types of climate change adaptation strategies i.e., on farm, storage, diversification, common pooling and mobility adaptations. The impact on on-farm, storage, diversification, common pooling, and mobility adaptations is investigated using the ordinary least square (OLS) regression analysis.

Model 1: Determinants of On-Farm Adaptation Strategy

This model aims to predict the on-farm adaptation strategy based on several socio-demographic and economic variables.

$$OFA = f\left(AGE, MH, JF, DB, FEXP, YOS, LSIZE, LOWNER, LQI, NLAI, INC, ASI, CCI, FSI\right) \quad \textbf{(4.1)}$$

The econometric form of the model is:

$$\begin{aligned} OFA = {} & \beta_0 + \beta_1 AGE + \beta_2 MH + \beta_3 JF + \beta_4 DB + \beta_5 FEXP + \beta_6 YOS \\ & + \beta_7 LSIZE + \beta_8 LOWNER + \beta_9 LQI + \beta_{10} NLAI + \beta_{11} INC \\ & + \beta_{12} ASI + \beta_{13} CCI + \beta_{14} FSI + \varepsilon \end{aligned} \quad \textbf{(4.2)}$$

Model 2: Determinants of Storage Adaptation Strategy

This model aims to predict the storage adaptation strategy based on several socio-demographic and economic variables.

$$SA = f\left(AGE, MH, JF, DB, FEXP, YOS, LSIZE, LOWNER, LQI, NLAI, INC, CCI, FSI\right) \quad \textbf{(4.3)}$$

The econometric form of the model is:

$$\begin{aligned} SA = {} & \beta_0 + \beta_1 AGE + \beta_2 MH + \beta_3 JF + \beta_4 DB + \beta_5 FEXP + \beta_6 YOS \\ & + \beta_7 LSIZE + \beta_8 LOWNER + \beta_9 LQI + \beta_{10} NLAI + \beta_{11} INC \\ & + \beta_{12} ASI + \beta_{13} CCI + \beta_{14} FSI + \varepsilon \end{aligned} \quad \textbf{(4.4)}$$

Model 3: Determinants of Diversification Adaptation Strategy

This model aims to predict the diversification adaptation strategy based on several socio-demographic and economic variables.

$$DA = f\left(AGE, MH, JF, DB, FEXP, YOS, LSIZE, LOWNER, LQI, NLAI, INC, CCI, FSI\right) \quad \textbf{(4.5)}$$

The econometric form of the model is:

$$\begin{aligned} DA = {} & \beta_0 + \beta_1 AGE + \beta_2 MH + \beta_3 JF + \beta_4 DB + \beta_5 FEXP + \beta_6 YOS \\ & + \beta_7 LSIZE + \beta_8 LOWNER + \beta_9 LQI + \beta_{10} NLAI + \beta_{11} INC \\ & + \beta_{12} ASI + \beta_{13} CCI + \beta_{14} FSI + \varepsilon \end{aligned} \quad \textbf{(4.6)}$$

Model 4: Determinants of Common Pooling Adaptation Strategy

This model aims to predict the common pooling adaptation strategy based on several socio-demographic and economic variables.

$$CPA = f\left(AGE, MH, JF, DB, FEXP, YOS, LSIZE, LOWNER, LQI, NLAI, INC, CCI, FSI\right)$$

(4.7)

The econometric form of the model is:

$$\begin{aligned} CPA = {} & \beta_0 + \beta_1 AGE + \beta_2 MH + \beta_3 JF + \beta_4 DB + \beta_5 FEXP + \beta_6 YOS \\ & + \beta_7 LSIZE + \beta_8 LOWNER + \beta_9 LQI + \beta_{10} NLAI + \beta_{11} INC \\ & + \beta_{12} ASI + \beta_{13} CCI + \beta_{14} FSI + \varepsilon \end{aligned} \quad \textbf{(4.8)}$$

Model 5: Determinants of Mobility Adaptation Strategy

This model aims to predict the mobility adaptation strategy based on several socio-demographic and economic variables.

$$MA = f\left(AGE, MH, JF, DB, FEXP, YOS, LSIZE, LOWNER, LQI, NLAI, INC, CCI, FSI\right) \quad \textbf{(4.9)}$$

The econometric form of the model is:

$$\begin{aligned} MA = {} & \beta_0 + \beta_1 AGE + \beta_2 MH + \beta_3 JF + \beta_4 DB + \beta_5 FEXP + \beta_6 YOS \\ & + \beta_7 LSIZE + \beta_8 LOWNER + \beta_9 LQI + \beta_{10} NLAI + \beta_{11} INC \\ & + \beta_{12} ASI + \beta_{13} CCI + \beta_{14} FSI + \varepsilon \end{aligned} \quad \textbf{(4.10)}$$

Table 3 provides an overview of the variables used in our study, including their abbreviations, descriptions, and measurement methods.

Table 3: Variables: Abbreviation, Description and Measurement

Variables	Abbreviation	Description of Variables	Measurement
Dependent Variables			
On-Farm Adaptation	OFA	It represents the mean of two factors, with values ranging between 0 and 1.	Continuous
Storage Adaptation	SA	It represents the mean of two factors, with values ranging between 0 and 1.	Continuous
Diversification Adaptation	DA	It represents the mean of two factors, with values ranging between 0 and 1.	Continuous

Common Pooling Adaptation	CPA	It represents the mean of two factors, with values ranging between 0 and 1	Continuous
Mobility Adaptation	MA	It represents the mean of two factors, with values ranging between 0 and 1	Continuous
Independent Variables			
Age	AGE	Age of farmer (in years)	Continuous
Male Headed	MH	Either the farmer is the head of the family or not.	0 for No, 1 for yes
Joint Family	JF	Either the farmer live in a joint family or not.	0 for No, 1 for yes
Dependency Burden	DB	It is calculated by dividing the total numbers of non-earner to the total members of the household.	Continuous
Farming Experience	FEXP	How long a famer has been involved in farming activities.	Continuous
Years of Schooling	YOS	Number of years of schooling.	Continuous
Land Size	LSIZE	The physical size or area of land that is owned by farmer.	Continuous
Land Owner	LOWNER	Either the farmer is the owner of the land or not.	0 for No, 1 for yes
Land Quality Index	LQI	It represents the mean of four factors, with values ranging between 0 and 1.	Continuous
Non-Land Assets Index	NLAI	It represents the mean of four factors, with values ranging between 0 and 1.	Continuous
Income	INC	Monthly income of household measured in rupees	Continuous
Access to Service Index	ASI	It represents the mean of four factors, with values ranging between 0 and 1.	Continuous
Climate Change Index	CCI	It represents the mean of four factors, with values ranging between 0 and 1.	Continuous
Food Security Index	FSI	It represents the mean of four factors, with values ranging between 0 and 1.	Continuous

5. Results and Discussion

In this section, we present the comprehensive analysis and insightful discussions on the results obtained from our study. We delve into the key findings and their implications, shedding light on the significant patterns, trends, and relationships that emerged during our research.

Table 4 shows the factors that effect on-farm adaptation in Multan division and its four districts (Multan, Vehari, Khanewal, and Lodhran). The first variable is age that is positively associated with on-farm adaptation in all places except Multan district which is statistically significant in all areas expect Lodhran district, it means that if the age increases, the farmers adopt the climate tolerant varieties and shift to new crops or new method of cultivation. But in the Multan district, the farmer age is increase and they are not shifting for new crops and climate tolerant varieties because they adopted the old method of cultivation. The reason of positive association is that the old farmers are more experiences so that they are able to take the strong decisions about improving the cultivation methods so they shift their crops for the better growth of production. Old farmers have better access to financial resources and supportive labor, which can facilitate the adoption of climate- tolerant varieties and crop shifting practices. They are capable of investing in new seeds and modifying infrastructure or seeking advice from agricultural extension service (Enete and Anyekuru, 2011). While the reasons behind negative influences are, the older farmers have followed the old family traditions and have less believed on the latest techniques so

that avoid the method of shifting the crops (Brown et al., 2018).The old farmers have not aware about the recent techniques and innovations in agricultural methods so they are not adopting the high quality of seeds in the farm growth (Ali and Erenstein, 2017). The old age farmers are also risk- averse because they followed smooth and traditional methods (Funk et al., 2019). The other studies by (Ali and Erenstein, 2017; Brown et al., 2018; Funk et al., 2019) also found positive and negative relationship.

Table 4: Determinants of On-Farm Adaptation in Multan Division, Multan, Vehari, Khanewal and Lodhran Districts

Variables	Multan Division	Multan District	Vehari District	Khanewal District	Lodhran District
Constant	-.181 (.525)	-.283 (.000)	1.059 (.151)	-1.290 (.032)	-1.517 (.075)
Age	.003 (.003)	-.042 (.030)	.160 (.029)	.016 (.000)	.106 (.246)
Male Headed	.082 (.448)	-.089 (.528)	.071 (.096)	.455 (.067)	.109 (.252)
Joint Family	.169 (.000)	-.010 (.042)	.121 (.108)	.061 (.347)	.118 (.032)
Dependency Burden	.619 (.000)	-.009 (.041)	.122 (.042)	.045 (.762)	.117 (.083)
Farming Experience	.010 (.000)	.024 (.005)	.012 (.025)	.020 (.000)	.245 (.018)
Years of Schooling	.708 (.000)	.023 (.045)	.004 (.058)	.007 (.022)	.516 (.001)
Land Size	-.292 (.006)	-.037 (.085)	.017 (.007)	.019 (.044)	.242 (.097)
Land Owner	.101 (.069)	.050 (.055)	.283 (.067)	.173 (.007)	.465 (.040)
Land Quality Index	.166 (.032)	.148 (.087)	.317 (.064)	.128 (.089)	.353 (.039)
Non-Land Asset Index	.244 (.059)	.058 (.008)	.323 (.053)	.165 (.028)	.281 (.000)
Log of Income	.047 (.042)	.045 (.007)	.029 (.030)	.118 (.025)	.455 (.041)
Access to service Index	.064 (.088)	.057 (.006)	.058 (.009)	.362 (.023)	.657 (.025)
Climate Change Index	1.395 (.020)	.463 (.017)	.088 (.076)	.264 (.028)	.449 (.044)
Food Security Index	.313 (.000)	.179 (.058)	.051 (.085)	.284 (.042)	.239 (.000)
Model Summary					
R-Squared	.285	**.**208	.217	.234	.281

The male headed indicate that being in a male-headed household has a positive impact on on-farm adaptation excluding in Multan district. However, the coefficient is statistically insignificant in all areas expect Vehari and Khanewal district, it means that farmer is the male head in the family, farmer adopt the climate change tolerant varieties and shift to new crops strategies. In the Multan district, the farmer is the head of the family but they are not using the climate tolerant varieties and new method of cultivation because they have followed the culture and traditional method of cultivations. The reasons that provide incentive for positive association of the male head of the house hold have increased to adopt the adaptive strategies for climate shock so famers understand to shift their crops in adverse situation

(Abid et al., 2019). While the reasons that encourage negative association is that the famers as the male head, they use the traditional farming method and have been growing the same crop for generations may resist changing their practices. They may view crop shifting as unnecessary or risky (Brown et al., 2018). Our results are in line with the following studies (Brown et al., 2018; Abid et al., 2019).

The joint family defines that it has a positive impact on on- farm adaptation excluding in Multan district. The coefficient is statistically insignificant in Vehari and Khanewal district while in all area of Multan and Lodhran district, it means that if the family lives in the joint family system, the farmers adopt the climate tolerant varieties and shift to the new cultivation method. In the Multan district, the famer lives in joint family and they are not shifting the crops and climate tolerant varieties because they are not risk taker and also follow the smooth method for cultivation. The reasons that provide incentive for positive association are, in the joint family system, knowledge and experience about agricultural are often passed down through generations. Old family members who have experience with farming, they share their wisdom with younger farmers. So they share the information about crop shifting and the benefits of climate- tolerant varieties (Adzawla and Kane, 2019). In joint family system, there is often a larger labor available within the family. By adopting climate- tolerant varieties and practicing crop shifting, farmers are using new method of cultivation (Enete and Anyekuru, 2011). Farmer in a joint family system may be the more risk- averse as compared the individual farmers. They may prefer to stick to familiar crops and varieties that they have use to be successful in the past, rather than taking risk with new crops or adopting new varieties of crops. They have fear to losses the past benefit (Enete and Anyekuru, 2011). Our result is line with the following study (Enete and Anyekuru, 2011; Adzawla and Kane, 2019).

The next variable is dependency burden. The dependency burden has a positive impact on on- farm adaptation excluding in Multan district. However, the coefficient is statistically insignificant in Khanewal district expect all areas are significant. The dependence burden increases, the farmers adopt the climate tolerant varieties and shifting to the crops because they meet the family expense and achieves the better standard of living. But in the Multan district, they are not shifting the new crop and climate tolerant verities because they followed the cultural and traditional methods. The reasons that provide incentives for positive association is that farmers with high dependence burden, such as those who rely heavily on agriculture as their primary source of income or those with larger household to support, they feel stronger economic pressure to adopt strategies that can help ensure a stable crop production. Crop shifting and tolerant varieties are contributing to reduce the risk that is associated with climate change (Mardy et al., 2018). While the reason that encourages the negative association is, may be the farmers have limited resources and information and they are not financially strong to adopt the climate tolerant varieties and shifting the new crop strategy. Our result is line with the following study (Adzawla and Kane, 2019). Our result is line with the following study (Mardy et al., 2018; Adzawla and Kane, 2019).

The farming experience is the important variable. The farming experience has a positive impact on on-farm adaptation in all the areas. The coefficients are statistically significant in all the areas. The farmer experience increases, the farmers adopt the climate tolerant varieties and shift to new crops method for cultivation. The reasons that provide incentive for positive association are, experience farmers have spent many years in agricultural field so framers have great knowledge and skills in agricultural sector. This knowledge helps them to understand the benefits and risks associated with crop shifting and the use of climate tolerant varieties, making them more likely to adopt these practice (Kom et al., 2020). Framer with experience are more likely to have established relations and access to resources such as research and challenges related to crop shifting and climate tolerant varieties. These resources provide them with information, access to improve seeds related to crop shifting and climate- tolerant varieties. These resources help to enhance their adaptation of these practices (Savari and Zhoolideh, 2020). Our results are line with the following studies (Kom et al., 2020; Savari and Zhoolideh, 2020).

The year of schooling is relates to farmer education. The year of schooling has a positive impact on on-farm adaptation in all the areas. The coefficients are statistically significant in all the areas. In the family

year of schooling increases, so the farmers adopt the climate tolerant varieties and shift to the new crops. The reasons that provide incentive for positive association are, education provides farmers with access to information and knowledge about sustainable agricultural practices, climate change, and the benefits of crop shifting and climate- tolerant varieties. Farmers with higher levels of education, to be aware of the challenges about the climate change and understand the importance of adopting their farmer practices accordingly (Enete and Anyekuru, 2011). Our results are line with the following studies (Enete and Anyekuru, 2011).

The land size is important variable on on-farm adaptation. The land size has a positive impact on on-farm adaptation in all the areas except Multan division and Multan district. The coefficients are statistically significant in all the areas. It means that if the land size increases, the farmers adopt the climate change tolerant varieties and shift to the new crops or new method of cultivation. But in the Multan division and Multan district, the year of schooling increase but they are not adopting the old and traditional method of cultivation. The reasons that provide incentive for positive association is, the size of land increases, so the farmer has more space for the experiments. The farmer is using crop shifting activity and reduces the vulnerability of their agricultural system. Large land size provides the more portions of their land to various crops. And farmer is using the climate tolerant varieties such as high quality seed, water management system so it increases the crop productivity (Savari and Zhoolideh, 2021).While the reason that encourages the negative association is, the land size is larger so the farmer have not adopt the crop shifting activity due to less farming experience and they are not take risk to change the cultivation method (Bro, 2020). Our results are line with the following studies (Bro, 2020; Savari and Zhoolideh, 2021).

The land owner play important role in managing the land resources under the ownership. The land owner has positive impact on on-farm adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the land owner increases the farmers adopt the climate tolerant varieties and shift to the new crops. The reason is that landowners typically have great financial stability and investment capacity compared to farmers who do not own land. This financially stability and investment in new seeds, technologies for implementing crop shifting and adopting climate tolerant varieties (Tran et al., 2020). The land owners, who have a significant investment in their land, they manage the risk that is associated with climate change. The crop shifting and the use of climate tolerant varieties can help landowners the potential impacts of climate vulnerability on their agricultural production and protect the long-term productivity and also value their land (Bro, 2020).Our results are line with following studies (Tran et al., 2020; Bro, 2020).

The variable of land quality index is a comprehensive measure used to assess the quality of the land. The land quality index has positive impact on on- farm adaptation in all areas. The coefficients are statistically significant in all the areas. The land quality index increases that the farmer shifts to new crops for cultivation method and adopt climate tolerant varieties. The reason that provides incentive for positive association is that a higher land quality index better soil fertility, which is useful for successful crop cultivation. Fertile soils provide the necessary nutrients and organic matter that support healthy plant growth. When the farmers have access to high-quality land with fertile soils, they are more likely to have successful crop production and can consider shifting crop maximize productivity and adapt to changing climatic conditions (Ali and Erenstein, 2017).Our results are line with following study (Ali and Erenstein, 2017).

The tenth variable is non- land asset index. The non- land assets index has positive impact in the all the areas. The coefficients are statistically significant in all the areas. It means that if the non- land assets index increases that they are adopting the climate tolerant varieties and shift to the new crops for cultivation. The reasons that provide incentive for positive associations are, the non- land assets index means famer have own car, tube well, tractor and livestock that these facilities provide farmers financial capacity to invest in new agricultural practices. The Crop shifting and the adoption of climate tolerant varieties may initial investment in seeds, infrastructure and equipment's. Having a higher non-land assets

index allows farmers to allocate the resources that they make it easier for them to adopt these practices (Ali and Erenstein, 2017). The non- land assets can contribute to farmers overall risk management capabilities. Having a diverse set of assets can provide a safety during the periods of crop failure due to the climate change. The Farmers have with higher non-land assets to absorb shocks and enabling them to adopt the crop shifting and climate tolerant varieties that contribute the long term benefits (Abid et al., 2019). Our results are line with following studies (Ali and Erenstein, 2017; Abid et al., 2019).

The variable log of income is a fundamental aspect of financial well-being and refers to the earnings received by individuals. The log of income has positive impact in all areas. The coefficients are statistically significant in all the areas. It means that if the log of income increases that they are adopting the climate tolerant varieties and shift to the new crops. The reason is that higher income levels provide farmers with the financial capacity to invest in new crops and varieties. Shifting to different crops or adopting climate tolerant varieties often involves additional costs, such as purchasing seeds, new equipment's or implementing improved farming practices. With increased income, farmers can afford these investments and make the necessary changes in their farming systems (Ali and Erenstein, 2017).Our results are line with following studies (Ali and Erenstein, 2017).

The access to service index is used to access the availability and equality of essential services. The access to service index has positive impact in all areas. The coefficients are statistically significant in all the areas. It means that access of service index increases that farmers are shifting to new crops and adopt the climate tolerant varieties. The reasons that provide incentive for positive associations are that having access to well –maintain surfaced roads allows farmers to transport their products to markets more efficiently and at a lower cost. It reduces the transportation time, minimizes the product damage and expands the reach of their produce. This increased market access enables farmers to sell their products to a wider customer base, potentially leading to higher sale and profitability (Abid et al., 2019). Availability of information plays a important role in empowering farmers with knowledge about best practices market trends, weather patterns and government policies. This leads to improved farm management, pricing and market opportunities (Sujakhu et al., 2019).

The thirteenth variable is climate change index. The climate change index has positive impact in all areas. The coefficients are statistically significant in all the areas. The reason is that provide incentive for positive association is that the climate change index provides farmers with valuable information about the risks and impacts of climate change on their farming systems. It helps raise awareness about the need for adaptation and encourages farmers to understand the importance of crop shifting and ado[ting climate- tolerant varieties to reduce these risk (Kom et al., 2020).Our result is line with following study (Kom et al., 2020).

The last variable is food security index. The food security index has positive impact in all areas. The coefficients are statistically significant in all the areas. It means if the food security index increases that farmers are adopting climate tolerant varieties and shift to new crops for cultivation method. The reasons that provide incentive for positive association is that food security fulfill the basic necessities of poor people. The house hold encouraged the activities that reduced the level of poverty (Ndiritu and Muricho, 2021). In the barter activity system, farmers fulfill their need in the small scale level (Kom et al., 2020). Our results are line with following studies (Kom et al., 2020; Ndiritu and Muricho, 2021).

The value of R- square in Multan division model is 0.28 which means that about 28 percent variation in on-farm adaptation is explained by independent variables. In the Multan district model is 0.20 which means that about 20 percent variations in on-farm adaptation. In the Vehari district model is 0.21 which means that about 21 percent variations in on farm adaptation. In the Khanewal district model is 0.23 which means that about 23 percent variations in on-farm adaptation. In the Lodhran district model is 28 which means that about 23 percent in on farm adaptation.

Table 5 shows the factors that affect storage adaptation in Multan division and its four districts (Multan, Vehari, Khanewal, and Lodhran). The first variable is age that is positively associated with storage adaptation in all the areas. The coefficients are statistically significant in all the areas. It's meant that if the age increases that the farmers adopt the home-saved seeds and store their crops. The possible reasons of positive association are that older farmers often possess a wealth of traditional knowledge and experience accumulated over years of farming. They may have learned traditional practices of seed saving and crop storage from previous generations. This knowledge can be passed down and utilized to adopt home-saved seeds and effective crop storage techniques (Ali and Erenstein, 2107). Older farmers may have developed skills and technique for preserving seeds over time. They understand the importance of selecting, collecting and storing seeds from healthy and productive crops for future planting. Their experience and expertise in seed preservation can positively influence the adoption of home-saved seeds among younger generations of farmers (Funk et al., 2019). Our results are lines with following studies (Ali and Erenstein, 2107; Funk et al., 2019).

The male head in the important pillar of family refers to a situation where a male individuals assumes the primary leadership role within the family. The male head is positively associated with on storage adaptation in all the areas. The coefficients are statistically significant in all the areas except the Lodhran district. Its mean that if male as the head of the family that they are using home-saves seeds and storing their crops. The possible reason of positive association is that male head farmers may have greater access to information and training programs related to seed saving and crop storage. They can share this knowledge to implement improved techniques and share best practices within their farming community. By actively seeking and disseminating information, male head farmers can positively impact the adoption of these practices (Kom et al., 2020).

Table 5: Determinants of Storage Adaptation in Multan Division, Multan, Vehari, Khanewal and Lodhran Districts

Variables	Multan Division	Multan District	Vehari District	Khanewal District	Lodhran District
Constant	.600 (.036)	.599 (.091)	.487 (.050)	.271 (.063)	.932 (.091)
Age	.003 (.094)	.001 (.006)	.109 (.052)	.001 (.724)	.538 (.204)
Male Headed	.263 (.015)	.473 (.030)	.038 (.011)	.376 (.055)	.502 (.181)
Joint Family	.079 (.035)	.068 (.360)	.079 (.231)	.151 (.004)	.776 (.078)
Dependency Burden	1.395 (.020)	.076 (.008)	.044 (.004)	.133 (.255)	.960 (.000)
Farming Experience	.007 (.000)	.003 (.002)	.011 (.019)	.007 (.029)	.520 (.009)
Years of Schooling	.003 (.459)	.008 (.074)	.009 (.074)	.002 (.087)	.588 (.008)
Land Size	.012 (.017)	.021 (.040)	.004 (.043)	.003 (.089)	.647 (.108)
Land Owner	8.103 (.002)	.042 (.027)	.082 (.047)	.021 (.011)	.767 (.084)
Land Quality Index	.252 (.001)	.082 (.027)	.301 (.046)	.047 (.089)	.008 (.087)
Non-Land Asset Index	.380 (.000)	.500 (.000)	.038 (.093)	.048 (.056)	.434 (.071)
Log of Income	.065 (.000)	.030 (.017)	.067 (.005)	.120 (.005)	.400 (.001)

Access to service Index	.029 (.004)	.184 (.018)	.082 (.043)	.191 (.027)	.214 (.003)
Climate Change Index	-.034 (.007)	-.397 (.076)	-.100 (.088)	-.190 (.076)	-.555 (.004)
Food Security Index	.917 (.000)	.134 (.028)	.441 (.009)	.082 (.063)	.034 (.000)
Model Summary					
R-Squared	0.348	0.346	0.358	0.363	0.366

The joint family is essential variable because family members live together and share resources. The joint family is positively associated with storage adaptation in all the areas. The coefficients are statistically significant in all areas excluded Multan and Vehari district. It means that if the farmer's family lives in the joint family system that they are using home-saves seeds and storing their crops. The possible reasons of positive association are that in joint family system, different family members often bring diverse knowledge and skills to farming activities. Older generations may possess traditional knowledge of crops storage techniques, while younger members may have exposure to modern farming practices. The exchange of knowledge and skills within the family can enhance the understanding and implementation of effective crops storage and home- saving seeds methods (Tran et al, 2020)

The fourth variable is dependency burden. The dependency burden is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in the entire areas excluded Lodhran district. It means that if the dependency burden increases that they are storing their crops and use their home-saved seeds. The possible reasons of positive association are that when farmers depend heavily on their own crops for income, they have a strong incentive to maximize the value of their harvested crops. This encourages them to invest time and effort in proper storage techniques to prevent spoilage, pest and quality degradation. By effectively storing their crops, farmers can ensure a steady supply of food for their households and maintain the availability of seeds for future planting (Tran et al., 2020). When farmers are heavily dependent on storing crops and using home- saved seeds, they are more likely to possess knowledge and skills related to proper storage techniques and seed selection. This knowledge can be passed down through generation, ensuring the continuity of traditional practices within farming household and community (Ali and Erenstein, 2017). The other studies by (Ali and Erenstein, 2017; Tran et al., 2020) also found positive relationship.

The farming experience encompasses the knowledge, skills and practical how-know gained through hands- on involvement in agricultural activities. The farming experience is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in the entire areas. It's means that if the farming experience increases that they are storing their crops and use their home-saved seeds. The possible reasons of positive association are that with experience, farmers become better equipped to make informed decisions regarding crop storage, like weather pattern and pest prevalence. So they allocate resources effectively and make informed choices regarding when and how to store their crops and save seeds for future use (Kom et al., 2020). Experienced farmers often have a wider network of fellow farmers, agricultural experts or agricultural extension service. Through these networks, they can exchange information, share experiences and learn about new and innovative techniques for crop storage and seed saving (Emran et al., 2014). Our results are lines with following studies (Emran et al., 2014; Kom et al., 2020).

The years of schooling are essential variable. The year of schooling is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in the entire areas except Multan division. Its mean that the year of schooling increases that farmer is storing their crops and using home-saved seeds. The possible reasons of positive association is that education enhances critical thinking and skills, enabling farmers to make informed decisions about seed selection, storage

techniques and post- harvest management. Farmers with higher level of education can evaluate different options, assess the benefits and risk of various practices and choose the most suitable method of storing their crops and utilizing home-saved seeds (Bro, 2020).

The land size plays a crucial role in determining the potential for various activities such as farming and land development. The land size is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in all areas. The coefficients are statistically significant in the all areas except Multan division. It shows that if the land size increases that farmers are using their home-saved seeds and storing their crops. The possible reason of positive association is that farmers with larger land sizes often have access to more resource, including storage facilities and land for seed production. They can allocate a space for crop storage, such as ware houses, soils which helps ensure proper conditions for storing crops. Moreover, with more land size, farmers can allocate specific areas for seed production, allowing them to save and select high- quality seeds for future planting (Abid et al, 2019).

The variable of land owner plays crucial role in storage adaptation. The land owner is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in all areas. The coefficients are statistically significant in all areas. It shows that if the land owner increases in the area so that farmer are using their home-saved seeds and storing their crops. The possible reasons of positive associations are that landowners typically have a long-term perspective on farming. Owning the land provides stability and security, allowing farmers to plan and invest infrastructure and storage facilities. With ownership, farmers are more likely to make long term commitments to their farming operations, including the adoption of practices that support proper crop storage and seed saving (Abid et al., 2019). Landowners have a direct stake in the profitability and sustainability of their land. They are motivated to implement practices that maximize the productivity and value their land. They are motivated to implement practices that maximize the productivity and value of their land over the long term. Storing crops properly and utilizing home-saved seeds aligns with this goal, as it reduce costs, maintains the availability of quality seeds and ensures a consistent supply of produce(Akinnagbe and Irohibe, 2014).Our results are lines with the following studies (Akinnagbe and Irohibe, 2014;Abid et al., 2019).

The land quality index is essential for storage adaptation. The land quality index is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in all areas. It shows that if the land quality index increases so that farmer is storing their crops and using home-saved seeds for cultivation. The possible reason of positive association is that land quality directly affects are crop productivity. The high- quality land with fertile soil and adequate nutrients have support the better crop growth. When farmers have access to such type of land, they are more likely to have successful harvests, producing abundant crops for seed- saving purpose (Abid et al., 2019). The high- quality land often encourages the adoption of sustainable agriculture practices, such as organic farming. These practices promote of soil health and fertility. Farmers on land with good quality may be more inclined to implement sustainable practices, which align with the principles seeds- saving and proper crop storage (Akinnagbe and Irohibe, 2014). Our results are lines with the following studies (Akinnagbe and Irohibe, 2014; Abid et al., 2019).

The non- land assets index is a measure used to evaluate the assets possessed by individuals. The non-land assets index is positively associated with on storage adaptation in all the areas. The coefficients are statistically significant in all areas. It shows that if the non-land assets index increases so the farmers are storing their crops and use the home- saved seeds. The possible reason of positive associations is that the non- land assets index means farmer have own car, tube well, tractor and livestock that the ownership of tube well or other irrigation infrastructure enables farmers to have better control over water availability for their crops. Reliable irrigation systems contribute to consistent crop growth and yield, adequate water supply supports crop health and quality, making the stored crops and home-saved seeds more resilient (Ali and Erenstein, 2017).

The log of income is essential for the storage adaptation. The log of income is positively associated with on storage adaptation in all the areas. The coefficients are statistically significant in all areas. It means that log of income increases that the farmers are using their home-saved seeds and storing their crops. The possible reason of positive associations is that the higher income allows farmers to invest in infrastructure and facilities for crop storage. They can afford to build or purchase storage structures such as warehouses and cold storage facilities. Income enables farmers to maintain and improve these storage facilities over time, supporting effective crop storage practices. (Abid et al, 2019).

The access to service index is used to assess the availability, availability, quality and affordability of essential services. The access of service index is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the service index increases so that farmers are storing their crops and using home-saved seeds because they are adopting the climate change strategies. The possible reason of positive associations is that a higher service index shows better access to knowledge and information related to seed saving and crop storage practices. Farmers have benefits from the organizations that gives the workshops and advice that provide them valuable information on effective seed- saving techniques and proper crop storage method (Abid et al, 2019).

The climate change index plays crucial role in storage adapttaion. The climate change index is negatively associated with on storage adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the climate change index increases so that farmers are not storing their crops and not using home-saved seeds because they are not adopting the climate change strategies. The possible reasons of negative associations is that that climate change can lead to increased temperatures and altered humidity pattern, which can negatively affect crop storage. The weather changes can create conditions to the growth of mold and fungi that is leading to spoilage and loss of seed viability (Kom et al., 2020).

The food security index is important variable in the storage adapttaion. The food security index is positively associated with on storage adaptation in all areas. The coefficients are statistically significant in all the areas. It shows that if the food security index increases so the farmers are using their home-saved seeds and storing their crops. The possible reason of positive associations is that home saved seeds play a vital role in maintaining seeds play a vital role in maintaining seeds security, which is essential for sustainable agriculture. A higher food security index shows that farmers have the resources and capacity to store and utilize home-saved seed security and reducing dependency on external seed sources (Ndiritu and Muricho, 2021).

The value of R-square in the Multan division model is 0.34 which means that about 34 percent variations in storage adaptation. In the Multan district model is 0.34 which means that about 34 percent variations in storage adaptation. In the Khanewal district model is 0.35 which means that about 35 percent variations in the storage adaptation. In the Lodhran district model is 0.36 which means that about 36 percent variations in the storage adaptation.

Table 6 shows the factors that affect diversification adaptation in Multan division and its four districts (Multan, Vehari, Khanewal, and Lodhran). The variable of age that is negatively associated with diversification adaptation in all the areas. The coefficients are statistically significant in all the areas except Khanewal and Lodhran district. It means that if the age increases, the farmers are not adopting the non-farm activities and they are not engaging in multiple income- generating activities. The possible reasons of negative association are that older farmer may experience reduced physical ability and energy compared to younger farmers. This can limit their capacity to engage in non-farm activities or income generating activities that require physical strength (Brown et al., 2018). Non – farm activities and certain income – generating activities often require the adoption and use of modern technologies. Old farmer may face challenges in adapting to new technologies due to limited familiarity (Funk et al., 2019). The other studies by (Brown et al., 2018; Funk et al., 2019) also found negative relations.

The male head can vary in different cultures and it increases the decision power. The male head is positively associated with on diversification except Multan division adaptation in all the areas. The coefficients are statistically significant in all the areas except the Multan district, Khanewal district and Lodhran district. Its mean that if the male is the head of the family so that they are engaging in non-farm activities. Farmers are also starting multiple income generating activities. The possible reason of positive association is that the male head farmer typically holds decision making authority within the household and farming operations. This authority allows him to allocate resources to income- generating activities and non- farm activities (Adzawla and Kane, 2019). Our result is line with the following study (Adzawla and Kane, 2019).

The third variable is joint family. The joint family is positively associated with diversification adaptation in all the areas. The coefficients are statistically significant in all areas excluded Multan and Vehari district. Its mean that if the farmer is living in joint family system so that they are engaging the non-farm activities and farmer engages in multiple income-generating activities. The possible reasons of positive association is that farmer in a joint family ensure that there is expertise and knowledge available to effectively manage agricultural activities. The farmer can employ modern farming techniques, crop selection and resources utilization to maximize agricultural productivity. So the family allocates their resources to other income generating activities (Adzawla and Kane,2019).

The dependency burden is decisive variable in the diversification adaptation. The dependency burden is positively associated with on diversification adaptation in all areas. The coefficients are statistically significant in the entire areas excluded Multan district. It means that if the dependency burden increases so that the farmers are engaging non-farm activities and farmers engages in multiple-generating activities to spread the risk across different products. The possible reason of positive association is that dependency burden means there is available labor force that can be utilized for both farming and non-farming activities. This labor availability enables the family to engage in diverse income- generating activities without the need to hire external workers. The farmer and other family members can contribute the skills and efforts to various sectors, expanding the scope of income generation (Mardy et al., 2018).Our result is line with the following study (Mardy et al., 2018).

Table 6: Determinants of Diversification Adaptation in Multan Division, Multan, Vehari, Khanewal and Lodhran Districts

Variables	Multan Division	Multan District	Vehari District	Khanewal District	Lodhran District
Constant	1.298 (.000)	-.283 (.071)	3.130 (.001)	.815 (.004)	-.294 (.056)
Age	-.004 (.084)	-.004 (.004)	-.206 (.006)	-.001 (.760)	-.001 (.842)
Male Headed	.161 (.191)	.133 (.017)	.226 (.000)	.256 (.334)	.023 (.271)
Joint Family	.331 (.084)	.010 (.893)	.112 (.216)	.033 (.033)	.118 (.000)
Dependency Burden	.066 (.186)	.177 (.003**)**	.101 (.063)	.015 (.023)	.088 (.018)
Farming Experience	-.085 (.017)	-.231 (.008)	-.005 (.081)	-.001 (.036)	-.003 (.092)
Years of Schooling	.129 (.092)	.002 (.004)	.007 (.023)	.763 (.002)	.025 (.046)
Land Size	-.236 (.028)	-.142 (.005)	-.002 (.075)	-.872 (.002)	-.005 (.011)
Land Owner	-.168 (.069)	-0.36 (.000)	-.124 (.013)	-.153 (.093)	-.122 (.062)

Land Quality Index	-.097 (.002)	-.123 (.042)	-.519 (.012)	-.401 (.014)	-.181 (.071)
Non-Land Asset Index	.050 (.000)	.020 (.005)	.290 (.049)	.462 (.002)	.102 (.090)
Log of Income	.124 (.041)	-.016 (.022)	.175 (.017)	.085 (.034)	.083 (.098)
Access to service Index	-.005 (.026)	-.084 (.053)	-.082 (.061)	-.068 (.087)	-.035 (.009)
Climate Change Index	.437 (.000)	.325 (.045)	.829 (.001)	-.575 (.003)	.796 (.016)
Food Security Index	-.319 (.000)	-.346 (.009)	-.142 (.030)	-.449 (.004)	-.589 (.020)
Model Summary					
R-Squared	0.247	0.265	0.286	0.266	0.278

The farming experience is essential for the diversification adaptation. The farming experience is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in the entire areas. The possible reasons of associations are that farming requires significant time and effort, particularly during crucial seasons or when unexpected situations arise. The demands of farming can limit the time and resources available for pursuing non-farms activities. This could potentially hinder the family's ability to fully engage in or expand their non-farm activities (Kom et al., 2020). While farming experience with specialized knowledge and skills in agriculture, it may not directly translate to expertise in non-farm activities. Engaging and other income generating activities often requires skills set, market knowledge and management approach. The lack of expertise in non-farm sectors may create the challenges (Savari and Zhoolideh, 2020). Our results are line with the following studies (Kom et al., 2020; Savari and Zhoolideh, 2020).

The years of schooling plays important role in diversification adaptation. The year of schooling is positively associated with on diversification adaptation in all areas except Multan division. The coefficients are statistically significant in the entire areas. Its show that if the year of schooling increases so that the farmers adopts the non- farming activities and farmers engages in multiple income-generating activities to spread the risk across different products. The possible reason of positive association is that farmer education enhances the farmer's basic business and management skills. This includes skills related to budgeting, record-keeping and risk assessment. With these skills, farmers can better manage their finances, allocate resources effectively, and market strategic decision to maximize profitability in both farm and non- farm activities (Savari and Zhoolideh, 2020).

The land size is important role in determining land use and development potential. The land size is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in all areas. Its mean that if the land size increases so that the farmers are not increasing to adopt the non-farming activities, farmers are not engaging in multiple income- generating activities. The possible reason of negative association is that farmer managing a larger land size requires more time, effort and resources. Farmers with larger landholding may need to prioritize their focus and allocate a significant portion of their resources to farming activities alone. This may limit their ability to diversify their income sources or invest in non-farmer activities due to resource constraints (Bro, 2020).

The land owner is a unique position of ownership and responsibility for a specific piece of land. The land owner is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in all areas. Its mean that if the land ownership increases so that the farmers are not increasing to adopt the non-farming activities, farmers are not engaging in multiple income-generating activities. The possible reason of negative association is that farmers who own land may have specialization may benefit their farming activities; it may limit their expertise in non-farm sectors.

Engaging in diverse income generating activities often requires sill set, market knowledge, and management approaches. The lack of expertise in non-farm sectors may create challenges of such activities (Ali and Erenstein, 2017). Our results are lines with the following study (Ali and Erenstein, 2017).

The land quality index is a comprehensive tool that evaluates the quality of a piece of land for specific purpose. The land quality index is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in all areas. It shows that the land quality index increases that the farmers are not increasing to adopt the non-farming activities; they are not engaging in multiple income- generating activities. The possible reasons of negatively associations is that land that is not suitable for farming, this can directly affect the income generated from farming activities, which in turn can impact the economic condition of the farming community. It reduced the agricultural income can then directly impact non- farming activities, as farmers may have less disposable income to spend on goods and services provided by non- farming sector (Ndiritu and Muricho, 2021).

The non- land assets index plays crucial role in diversification adaptation. The non- land assets index is positively associated with on diversification adaptation in all the areas. The coefficients are statistically significant in all areas. It means that if the non-land assets increases so that farmers are engaging the non- farm activities, they also engaging in multiple income generating activities. The possible reasons of positive associations are the non- land assets index means famer have own car, tube well, tractor and livestock that the non-land assets often involves gaining specialized knowledge and skills. Farmers with more education and training related to the non-farming activities such as machinery operation. This knowledge can be shared with other farmers, contributing to the overall agricultural development and facilitating the adoption of innovation practices (Ali and Erenstein, 2017).

The log of income plays essential role in the diversification adaptation. The log of income is positively associated with on diversification adaptation in all the areas except Multan division. The coefficients are statistically significant in all areas. It means that if the log of income increases so that the farmers are adopting the non-farm activities and they are also engaging multiple income- garneting activities. The possible reason of positive association is that higher farmer income can lead to increased demand for labor in non-farming sectors. As farmers spend more on goods and services, business in those sectors experience higher sale and growth. So it leads to the creation of new job opportunities reducing unemployment rates and providing additional income sources for the local community (Mardy et al., 2018).

The access to service index is provides the objective to measure to access the services that are vital for their well-being and quality of life. The access of service index is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in all the areas. Its means that if the access the service index increases so that they are not adopting the income- garneting activities and they are also not engaging the non- farming activities. The possible reasons of negatively associations is that farmer take loan form the banks but that they high level of interest rate and other side farmers have less knowledge to get the loan opportunity. The different organizations are giving the advice about agricultural sectors. So, the farmers have no accessed to get this type of knowledge because these types of organization stats up their set up in the urban areas (Iwasaki et al., 2009).

The climate change index is a powerful tool for assessing the impacts of climate change on various aspects of the economy. The climate change index is negatively associated with on diversification adaptation in all areas except Khanewal district. The coefficients are statistically significant in all the areas. It means that if the climate change index increases so that farmers are adopting the non-farms activities and they are also engaging multiple income- garneting activities. But in Multan they are not adopting the income- garneting and non- farming activities. The reason is that farmers use the old and traditional methods of cultivation. The possible reasons of positive associations is that climate change can negatively affect agricultural productivity by altering temperature and patterns, causing shifts I pests

and diseases and impacting soil fertility. It reduces the crops yields and livestock productivity can directly impact farmer income, leading to decreases spending in non- farming sector (Kom et al., 2020).Our result are line with following study (Kom et al., 2020).

The food security index is a vital tool for measuring the availability, accessibility and affordability of food. The food security index is negatively associated with on diversification adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the food security index increases so that the farmers are not engaging the non-farms activities and not engaging the income- garneting activities. The possible reason of negative association is that in the situations where farmers struggle to attain food security, they may need to dedicate a significant amount of time and labor to agricultural activities. This leaves them with limited time and resources to engage in no- farming activities. The focus on food production and subsistence can reduce their ability to explore additional economic activity (Zurovec and Vedeld, 2019).

The value of R-square in the Multan division model is 0.24 which means that about 24 percent variations in diversification adaptation. Whereas in the Multan, Vehari, Khanewal, Lodhran districts it is 0.26, 0.28, 0.24, 0.26 percent variations in diversification adaptation.

Table 7 shows the factors that affect common pooling adaptation in Multan division and its four districts (Multan, Vehari, Khanewal, and Lodhran). The variable of age that is positively associated with common pooling adaptation in all the areas except Multan division and Multan district. The coefficients are statistically significant in all the areas. Its means that if the age increases so that the farmers use common resources such as forests, water or labor. The possible reason of positive association is that the older farmers often uses valuable traditional knowledge and practices that have been passed down through generations this knowledge can include sustainable land management techniques, water conservation methods or traditional forest management practice. Their experience and wisdom can contribute to sustainable utilization and preservation of common resources (Mardy et al., 2018).Our results are lines with following study (Mardy et al., 2018).

The variable of male head is essential in common pulling adaptation. The male head is positively associated with on common pooling adaptation in all the areas. The coefficients are statistically significant in all the areas except the Khanewal district and Lodhran district. It shows that if the male is the head of the family so that they are using common resources such as water, forest and labor. The possible reason of positive association is that the male head is valuable knowledge and skills related to resource management. It recognizing and valuing this diversity can contribute to more comprehensive and effective approaches to utilizing common resources sustainability (Ali and Erenstein, 2017). Our results are lines with following study (Ali and Erenstein, 2017).

Table 7: Determinants of Common Pooling Adaptation in Multan Division, Multan, Vehari, Khanewal and Lodhran Districts

Variables	Multan Division	Multan District	Vehari District	Khanewal District	Lodhran District
Constant	-.722 (.018)	-.847 (.054)	1.640 (.057)	.818 (.038)	.576 (.084)
Age	.004 (.040)	.006 (.007)	.103 (.060)	.002 (.337)	.021 (.595)
Male Headed	.283 (.015)	.059 (.095)	.702 (.001)	.064 (.689)	.012 (.076)
Joint Family	.007 (.192)	.013 (.068)	.275 (.002)	.027 (.029)	.035 (.343)
Dependency Burden	.099 (.036)	-.024 (.006)	.126 (.071)	.166 (.088)	.055 (.020)

Farming Experience	.004 (.055)	.008 (.082)	.102 (.034)	.104 (.010)	.021 (.085)
Years of Schooling	.010 (.073)	-.001 (.256)	.016 (.016)	.202 (.090)	.011 (.072)
Land Size	.088 (.000)	.013 (.041)	.005 (.063)	.405 (.035)	.023 (.048)
Land Owner	.062 (.048)	.022 (.037)	.283 (.235)	.460 (.002)	.046 (.035)
Land Quality Index	.002 (.066)	.210 (.044)	.292 (.042)	.031 (.052)	.013 (.077)
Non-Land Asset Index	.008 (.029)	.068 (.041)	.259 (.082)	.572 (.021)	.012 (.055)
Log of Income	-.044 (.071)	-.029 (.053)	-.098 (.060)	-.011 (.000)	-.017 (.036)
Access to service Index	-.257 (.001)	-.454 (.005)	-.236 (.091)	-.118 (.000)	-.010 (.027)
Climate Change Index	.368 (.001)	.517 (.007)	.046 (.052)	.084 (.008)	.407 (.001)
Food Security Index	.418 (.000)	.354 (.021)	1.111 (.000)	.021 (.008**)**	.125 (.046)
Model Summary					
R-Squared	.246	.245	.255	.265	.296

The joint family is essential variable. The joint family is positively associated with common pooling adaptation in all the areas. The coefficients are statistically significant in all areas excluded Multan division and Lodhran district. It shows that if the farmer is living in the joint family system so that they are using common resources such as water, forest and labor. The possible reason of positive associations is that in a joint family system, family members can share the labor and workload linked with resources management. This can transfer the burden on individual farmers and ensure that task related to water management, forest conservation, and labor- intensive activities are distributed among family members the collective effort can lead to more efficient resources utilization and conservation (Kom et al., 2020).

The dependency burden provides the quantitative measures of the non-working person in a family. The dependency burden is positively associated with on common pooling adaptation in all areas except Multan district. The coefficients are statistically significant in the entire areas excluded Lodhran district. Its mean that if the dependency burden increases so that the farmers are using the common resources such as water, forest and labor. The possible reason of positive association is that a non-working person in a farmer family can contribute to labor- intensive activities related to resources management. They can help with task such as maintain water infrastructure, implementing forest conservation measures and engaging in agricultural activities. The workload on other family members and enhance the overall efficiency of resources utilization (Abid et al., 2019).

The farming experience is essential for common pooling adaptation. The farming experience is positively associated with on common pooling adaptation in all areas except Multan division. The coefficients are statistically significant in the entire areas. Its means that if the farming experiences increases so that the farmers are using the common resources such as water, forest and labor. But in the Multan division, farmers are not using common resources because they moves from the technological filed. They are adopting the new technologies and strategies. The possible reasons of positive association is that farmers with experience have a deep understanding of local conditions, including water availability, soil type and climate patterns. This knowledge allows them to make informed decisions regarding water usage, forest conservation practices and labor management that are used to the specific

needs of the area. They can apply their knowledge to optimize resources utilization while minimizing negative impact (Wilson, 2013).

The next variable is years of schooling. The year of schooling is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in the entire areas except Multan district. It means that farmers are using the common resources such as water, forest and labor. The possible reason of positive association is that a year of schooling provides individuals with knowledge about the important of resources conservation, environmental sustainability and impacts of human activities on natural system. With a higher level of education, farmers are more likely to be aware of sustainable practices and the potential consequences of sustainable resources use. They can apply this knowledge to make informed decisions regarding water management, forest and labor practices (Abid et al., 2019).

The land size plays crucial role in the common pooling adaptation. The land size is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all areas. It means that if the land size increases so that the farmers are using the common resources such as water, forest and labor. The possible reason of positive association is that farmers with larger land sizes may have more control over resources allocation and management decision. They may have the ability to strategically plan water usage, implement forest conservation measures and organize labor more effectively. However, the positive impact depends on how these resources are managed and sustainable practices are organized (Mubaya and Mafongoya, 2016).

The eighth variable is land owner. The land owner is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all areas except Vehari district. It means that if the land ownership increases so that farmers are using the common resources the water, forest and labor. The possible reason of positive associations is that farmers as the landownership to take a long term perspective and engaging in sustainable resources management. When farmer own land they cultivate, they are more invest in adopt sustainable water management techniques, wellbeing of the land for future generation (Abid et al., 2019).

The land quality index is essential because it is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all areas. It shows that if the land quality index increases so the famers are adopting the water, forest and labor. The possible reason of positive associations is that land ownership provides farmers with security of tenure, which can encourages them to make long term investments in resource management. When farmers have secure rights over their land, they are more likely to invest in soil conservation measures, protect water sources and implement sustainable labor practices. This sense of ownership can foster deeper commitment to responsible resources use (Wichern et al., 2019).

The non- land assets index is necessary because it is positively associated with on common pooling adaptation in all the areas. The coefficients are statistically significant in all areas. It shows that if the non-land assets index increases so that farmers are adopting the water, forest and labor. The possible reason of positive associations is that non- land assets index means famer have own car, tube well, tractor and livestock. So, non- land assets often enhance the farmer knowledge and develop new skills. This process of acquiring technical know-how can enhance farmers understanding of sustainable resources management practices. For using advanced equipment may necessary for training on proper maintains and operation, which can translate into better water and labor management practices (Mubaya and Mafongoya, 2016).

The next variable is log of income. The log of income is negatively associated with on common pooling adaptation in all the areas. The coefficients are statistically significant in all areas. It means that log of income increases so that farmers are not adopting the water, forest and labor. The possible reasons of negatively associations is that higher income farmers have the financial capacity to engage in more

intensive agricultural practices, which can have negative impact on common resources. If increased in water using for irrigation and extensive labor practices without adequate consideration for sustainable resources management can lead to environmental degradation and depletion of resources (Wilson, 2013).

The variable that is access to service index plays important role in the common pooling adaptation. The access of service index is negative associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all the areas. It means that access to service index so that farmers are not adopting the common resources such as water, forest and labor. The possible reasons of negative associations is that farmers have the service capacity to engage in more intensive agricultural practices, which can have negative impact on common resources. If increased in water using for irrigation and extensive labor practices without adequate consideration for sustainable resources management can lead to environmental degradation and depletion of resources (Abid et al., 2019).

The variable climate change index is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all the areas. It shows that if the climate changes index increases so that farmers are using the common resources such as water, forest and labor. The possible reason of positive associations is that the farmer climate change index reflects farmer's ability to adapt to climate change and implement strategies to mitigate its negative effects. Farmers who are more aware of climate change risked and have higher adaptive capacities may more likely to adopt sustainable resource management practices. This can include efficient water usage, reforestation efforts and adopting climate- smart agricultural techniques (Mubaya and Mafongoya, 2016).

The last variable is food security index. The food security index is positively associated with on common pooling adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the food security index increases so that farmers are using common resources such as water, forest and labor. The possible reasons of positive associations is that farmers who focus on food security are often more connected to their local environment and possess valuable traditional knowledge about resource management. This knowledge can contribute to sustainable practices that promote the efficient use of water, responsible forest utilization and effective labor management (Wichern et al., 2019). The R-square values indicate the percentage of variation in common pooling adaptation explained by the models: 24% for Multan division and district, 25% for Vehari district, 26% for Khanewal district, and 29% for Lodhran district.

Table 8 shows the factors that affect mobility adaptation in Multan division and its four districts (Multan, Vehari, Khanewal, and Lodhran). The variable age is negatively associated with mobility adaptation in all the areas. The coefficients are statistically significant in all the areas except Khanewal district and Lodhran district. It means that if the age increases so that farmers are not resident in the local area. The possible reasons of positive association is that older farmers who are not local residents may have limited knowledge of the specific farming practices, local climate, soil conditions that influence agricultural production in the area. The lack of familiarity can reduce their farming techniques to suit the local context (Abid et al., 2019).

The variable male head is essential because it is positively associated with on mobility adaptation in all the areas. The coefficients are statistically significant in all the areas except the Lodhran district. If the farmer is head of the family so that farmer is local resident. The possible reasons of positive association is that being a local resident often means having a deep understanding of the local environment, climate, soil condition and farming practices. The local knowledge and experience can provide the farmer with valuable insights to the specific needs and challenges of the area, allowing them to make informed practices accordingly (Wilson, 2013).

Table 8: Determinants of Mobility Adaptation in Multan Division, Multan, Vehari, Khanewal and Lodhran Districts

Variables	Multan Division	Multan District	Vehari District	Khanewal District	Lodhran District
Constant	.802 (.011)	.352 (.055)	.914 (.094)	1.191 (.050)	2.691 (.006)
Age	.141 (.010)	-.003 (.002)	-.101 (.027)	-.324 (.331)	-.004 (.529)
Male Headed	.103 (.031)	.343 (.061)	.155 (.069)	.227 (.014)	.023 (.000)
Joint Family	.089 (.031)	.085 (.018)	.034 (.039)	.085 (.196)	.196 (.072)
Dependency Burden	.043 (.075)	.361 (.004)	.074 (.097)	.342 (.024)	.256 (.299)
Farming Experience	-.004 (.098)	-.005 (.003)	-.102 (.063)	-.105 (.013)	-.004 (.013)
Years of Schooling	.120 (.000)	.004 (.118)	.005 (.025)	.005 (.092)	.004 (.019)
Land Size	-.507 (.000)	-.011 (.016)	-.201 (.000)	-.487 (.000)	-.011 (.009)
Land Owner	-.010 (.035)	-.062 (.090)	-.213 (.274)	-.212 (.058)	-.149 (.078)
Land Quality Index	-.510 (.000)	-.428 (.027)	-.009 (.057)	-.612 (.000)	-.878 (.001)
Non-Land Asset Index	.180 (.028)	.197 (.005)	.128 (.019)	.126 (.003)	.005 (.079)
Log of Income	.064 (.012)	.043 (.011)	.015 (.091)	.034 (.003)	.227 (.006)
Access to service Index	-.159 (.020)	-.154 (.061)	-.013 (.032)	-.161 (.005)	-.036 (.006)
Climate Change Index	.300 (.006)	.495 (.046)	.619 (.003)	.296 (.002)	.209 (.017)
Food Security Index	-.054 (.050)	-.079 (.026)	-.757 (.000)	-.248 (.004)	-.130 (.098)
Model Summary					
R-Squared	.253	.251	.269	.245	.240

The next variable is joint family. The male head is positively associated with mobility adaptation in all the areas. The coefficients are statistically significant in all areas excluded Khanewal district. If the farmer is living in the joint family system so that farmer is the local resident. The possible reason of positive association is that in a joint family setup in the local resident have enhance the efficiency of the farmer. Because joint families often share resources such as land, tools and providing access to a boarder rage of agricultural resources (Budhathoki et al., 2020).

The dependency burden is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in the entire areas excluded Lodhran district. If the dependence burden increases so that farmer is the local resident. The possible reason of positive association is that non-working family members, such as elderly parents or young children, contribute to the emotional and social wellbeing of the family. Their presence provides a support system for the working members, which can positive impact their mental health and satisfaction (Pradhan et al, 2017).

The farming experience is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in the entire areas. If the farming experience so that farmer is local resident. The possible reason of positive association is that farmers with experience in farming have developed a deep understanding of the local environment, climate and soil conditions. This local expertise allows them to make informed decisions and adapt their farming practices to maximize productivity and sustainability (Abid et al., 2019).

The variable years of schooling plays a important role. The year of schooling is positively associated with on mobility adaptation in all areas except Multan district. The coefficients are statistically significant in the entire areas except Multan division. It means that if the year of school increases so that farmer is the local resident. The possible reasons of positive association is that year of education enhance the farmer skills and practices. If the farmer lives in the local area so the knowledge empowers them to make informed decision and adopt innovative activities (Budhathoki et al., 2020).

The next variable is land size. The land size is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all areas. It means that if the land size increases so that the farmer is the local resident. The possible reasons of positive association is that the farmer live in the local area so the land size provides the farmer with increased the opportunities for agricultural production (Wilson, 2013).

The variable land owner is important because it is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all areas except Vehari district. It means that if the land ownership increases so that farmer is the local resident. The possible reasons of positive associations is that farmer is the landowner in the local area so the farmers allow them in engage in long-term planning, making investment in their farming operations and access credit or financing (Pradhan et al, 2017).

The land quality index is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all areas. It means that if the land quality index increases so that farmer is the local resident. The possible reason of positive associations is that land quality plays important role in enhancing the agricultural productivity. The high- quality land with fertile soil and water availability enhance the agricultural production (Abid et al., 2019).

The non- land assets index is positively associated with on mobility adaptation in all the areas. The coefficients are statistically significant in all areas. It means that if the non- land assets index increases so that farmer is the local resident. The possible reasons of positive associations is that non- land assets index means famer have own car, tube well, tractor and livestock. The farmer is living as a local resident in the area so the non- land assets can generate income through various means. The livestock can provide a regular source of income through sale of milk and related products. Increased the income from non- land assets enhances the farmers livelihood and overall well-being as a local resident (Wichern et al., 2019).

The log of income is positively associated with on mobility adaptation in all the areas. It shows that if the log of income increases so that farmer is the local resident. The coefficients are statistically significant in all areas. The possible reason of positive associations is that higher farmer income allows for increased purchasing power, enabling framers to spend more on goods and services within the local economy (Wilson, 2013).

The access of service index is negatively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all the areas. It means that if the access of service index increases so that farmer is the not local residents. The possible reason of negative associations is that services such as agricultural programs and getting the advice from the organizations and loan facilities

are not access because the farmer is not living in the local area so the impact on farmer activities, income and overall living conditions (Pradhan et al, 2017).

The variable is climate change index is essential because it is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all the areas. It shows that if the climate change index increases that farmer is the local resident. The possible reason of positive associations is that farmer who is living in the local area, so the farmer aware the climate change conditions. The farmer is using sustainable farming techniques, adopting water management strategies (Mardy et al., 2018).

The food security index is positively associated with on mobility adaptation in all areas. The coefficients are statistically significant in all the areas. It means that food security index increases so that farmer is the local resident. The possible reason of positive associations is that when farmers have food security, so it shows that farmer produces enough food to meet their own needs. So, the farmer selling their product to generates income. Food security can contribute to increased financial stability and livelihood opportunities for farmer (Abid et al., 2019).

The value of R-square in the Multan division model is 0.25 which means that about 25 percent variations in mobility adaptation. In the Multan district model is 0.25 which means that about 25% variations in the mobility adaptation. In the Vehari District model is 0.26 which means that about 26% variations in the mobility adaptation. In the Khanewal district model is 0.24 which means that about 24% variations in the mobility adaptation. In the Lodhran district model is 0.24 which means that about 24% variations in the mobility adaptation.

6. Conclusions and Policy Implications

6.1. Conclusions

The study aimed to examine the relationship between climate change adaptation, food security, and livelihoods in the context of the Multan division. The study collected the data from the small agricultural farmers of the four district of Multan division namely Multan, Vehari, Khanewal and Lodhran, and used the Ordinary Least Squares (OLS) method to estimate the results. The following five regression models are used, each with the unique dependent variables: on-farm adaptation strategy, storage adaptation strategy, diversification adaptation strategy, common pooling adaption strategy and mobility adaptation strategy. The dependent variables included a wide variety of variables, such as socio-demographic variables (age, male headed, joint family), farmer-related factors (farmer experience, farmer education), land-related determinants (land size, land owner, land quality index), non-land assets index, income, access to services index, climate change index, and food security index.

The findings of this study provide a substantial contribution to our understanding of the dynamics and nature determinants of agricultural adaptation to climate change. This study offers a thorough analysis that highlights the complex nature of farmer's reactions to climate change impacts by taking into account the five different adaptation techniques and their accompanying independent factors.

The results of the study provide several insights. First, the socio-demographic determinants of farmers are playing important role in determining the climate change adaptation strategies. Such as age, male headed and joint family all are the important factors for determining the adaptation techniques. The findings of the study suggest that the decisions of selecting the efficient adaptation methods are influenced by intra-household, age and headed of the household.

Secondly, the framer's related variables like experience of the farmers, and education of the farmers (measured by the years of schooling) are found the significant factors for determining the adaptation strategies. The farmer who has experience and highly educated are more likely to adopt the different adaptation strategies as compared to the uneducated and less experience farmers. It highlights the

importance of education and experience in the agriculture sector that enhances the farmers and empowered them to adopt the climate change adaptation strategies.

Thirdly, the study also used land related variables (such as size of the land, land owner, and land quality index) that play a significant role while deciding the climate change adaptation technique. The farmers who are the owner of the large land and have higher quality of land are more likely to engage in adaptation strategies as compared to those famers who are the owner of small land size and have lower quality land. Similarly, if the farmers are owner of the land then they are more likely to use the climate change adaptation strategies.

Furthermore, the study also indicates that the non-land assets index, income level of the farmers, and access to services index, are important determinants of farmer's climate change adaptation behavior. The farmers with greater non-land assets and higher income are more likely to adopt the diversification, common pooling and mobility adaptation strategies. And the farmers who easily access to services such as financial resources are more likely to adopt the on-farm and storage adaption strategies.

Moreover, the study also shows the role climate change index and food security in deciding the appropriate adaptation strategies. The selection and efficacy of various adaptation techniques is influenced by the climate change index, which quantifies the severity and frequency of climate-related difficulties, similarly, the food security index also plays a significant role for adopting the climate change strategy. The farmers who secure food are more likely to adopt the storage adaptation.

6.2 Policy Implications

The results of the study provide valuable insights for the government, policy makers and researchers to promote agriculture adaptation.

Policies to Promote the Climate Change Adaptation Strategies

The policy makers may have to focus on providing a specialized training and capacity building programs to the various age groups of the farmers.

- The government may implement gender-responsive policies and programs to encourage adaptation strategies by addressing the difficulties and possibilities encountered by faring households with males as the head of the family.
- The policy makers may have to implement the policies to promote the joint family system because on-farm adaptation, common pooling and storage adaptation is more likely to adopt by farmers living in the joint family system.
- In order to encourage farmers with high dependency burdens to embrace adaptation techniques, the government should establish and execute inclusive policies and programs that offer financial and technical support.
- In order to capitalize on farmer experience, the government should set up mentoring programs and knowledge-sharing networks. So that famers can get knowledge and experience to adopt adaptation strategies.
- The government should create and implement thorough education and training programs that improve farmer's expertise in climate-smart agricultural practices, promoting resilience and adaptability on the farm.
- To encourage and facilitate adaptation strategies, the government should create policies that offer incentives and support systems suited to farmers with small land size.
- The policymaker may establish the land quality improvement initiatives to the farmers to improve the quality of the land because famers with high quality land are more likely to adopt the adaptation strategies.
- The government should develop the financial incentives and policy to enhance the farmer's income, access to non-land assets and access to services to promote the adaptation strategies.

- The government should create and implement comprehensive agricultural policies that incorporate adaptation measures with an emphasis on raising food security by promoting sustainable farming methods, expanding market connections, and improving access to resource.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Impact of China Pakistan Economic Corridor on Economic Development of Balochistan: A Descriptive Study

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Abstract
The China-Pakistan Economic Corridor study aims to connect Gwadar's deep seaport in Balochistan province with Kashgar in northwest China. It serves as a gateway linking Europe to Africa when fully operational. The project seeks to provide a comprehensive financial overview of the corridor project and examine investment flows, especially on Gwadar's development potential. The research aims to assess the corridor's impact on the province's economic conditions using quantitative methods involving primary and secondary data analysis for descriptive purposes. The study concludes that while indicators such as HDI, FDI, and FPI have shown improvement over recent years, there is still limited awareness among the general public about CPEC's current impact on provincial economic development, leading to dissatisfaction amongst native people.

Keywords: *CPEC, Balochistan, Quantitative, FDI, HDI*

JEL Classification: *O11, O15*

1. Introduction
The China-Pakistan Economic Corridor involves the development of infrastructure, including roads, railways, and ports, as well as investments in various sectors such as energy, agriculture, and industrial development (Asif et al., 2021). These investments and infrastructure development are expected to increase economic growth, create jobs, and improve connectivity between the two countries. Moreover, the China-Pakistan Economic Corridor has the potential to benefit not only China and Pakistan but also the entire region (Asif et al., 2021). The China-Pakistan Economic Corridor is a crucial initiative to strengthen economic cooperation between China and Pakistan. It has the potential to bring significant economic benefits to both countries and contribute to regional development and integration. The China-Pakistan Economic Corridor aims to strengthen economic cooperation between China and Pakistan through infrastructure development, investment, and job creation (CECP Significance, 2021).

The China-Pakistan Economic Corridor is a multi-billion dollar project that aims to enhance connectivity and promote economic cooperation between China and Pakistan. The China-Pakistan Economic Corridor has been a significant point of discussion not only for China and Pakistan but also for the entire region. The project involves infrastructure development, energy projects, and economic initiatives that are expected to substantially change the region's trade and development dynamics. The corridor, which spans from Gwadar in Pakistan to Xinjiang in China, is a colossal undertaking that has the potential to reshape the region's economic landscape. The collaboration between China and Pakistan in the CPEC project symbolizes a deepening of their strategic partnership. It is not only an economic venture but also a testament to the growing political and diplomatic ties between the two countries (Rank et al., 2022)

Additionally, the project is expected to bring economic prosperity to Pakistan's underdeveloped and marginalized regions, providing new employment and growth opportunities. Given the ambitious scope of the CPEC, some concerns and challenges need to be addressed. These include environmental impact

assessments, security considerations, and the socio-economic implications of the project on local communities. However, with careful planning and transparent governance, CPEC has the potential to serve as a model for regional corridors. The economic corridor is a monumental project that aims to revolutionize the connectivity and economic cooperation between China and Pakistan (Sheikh et al., 2019).

The Economic Corridor of China-Pakistan is the first collection of projects in the world. Western China is linked to Baluchistan; this massive effort in Pakistan is worth about $46 billion. CPEC is one of Pakistan's megaprojects, "One Belt, One Road." Pakistan sees this as a sign of China's long-term friendship (Wolf, 2016). The presidents of China and Pakistan have put forth a long-term strategy for the China-Pakistan Economic Corridor. By the end of 2018, the $28 trillion early harvest plan will be finished. In Pakistan, Gwadar is another main component of the CPEC. It belongs to China Overseas Port Holding at the end of the corridor, while it belongs to Pakistan's government. The Chinese media have tried to concentrate instead on Pakistan's advantages. However, the port is also familiar with the geopolitical challenges of the US and India (Naz, 2018)

The two countries have banned Chinese energy imports, which could intensify China and China's tension. Though plans are delayed, economic growth in Pakistan has shifted to port. The project is expected to be fully extended by 2030. CPEC appears to have significantly impacted Pakistan's regions, especially Baluchistan. The project should have greatly affected the city because it was a significant European oil export route. This article analyses the financial benefits Baluchistan could gain from the project. It also discusses capital inflows and their effects on Gwadar Harbor (Baloch, Shahzad & Ahmed, 2024).

The project is expected to benefit both countries and increase development efforts. However, criticisms have highlighted several aspects that should be excluded. This study is in Baluchistan, a project to identify the benefits of CPEC and Gwadar's Port's role in economic development. The China-Pakistan Economic Corridor (Chin-Pakistan Economic Corridor) is a megaproject aimed at developing the port of Gwadar to link the three main corridors leading to the Silk Road. Baluchistan, a poor province, needs a high degree of development from this project. A significant amount of evidence is required for the project to be practical; this project indicates the CPEC project's vision in Pakistan. CPEC development must be measured in the sense of this project after many years of initialization. This research includes three key assumptions that can serve the study goals: a financial overview of the advantages of CPEC (Wolf, 2016).

2. Review of Literature

Pakistan and China have entered into new ties through joint participation in the China-Pakistan Economic Corridor project. Thanks to China's many benefits, the project was a "moral incentive" for Pakistan. Critics say that CPEC was China's key strategy for the Indian Ocean to take over. Many condemned the Gilgit-Baltistan project in Pakistan. Like India, other countries are raising whether the project would facilitate the Chinese military to Pakistan. The official agreement on port repair between China and Pakistan was concluded on February 18, 2013. The Chinese president plans to visit Pakistan for the formal beginning of the CPEC in 2014 (Ramay, 2016).

China Pakistan has embarked upon a novel relationship by participating in the China-Pakistan Economic Corridor initiative. After the 1950s, the relationship between the two countries took off. Due to China's various benefits, the project has proven to be a "morale booster" for Pakistan. The primary reason for this is that Pakistan's economy lags behind other Asian nations, and it is a country that seeks asylum from different nations like China (Ashraf, Shafiq & Batool, 2017).

Opponents claim that China's ultimate goal in controlling the Indian Ocean is to seize control of the region through the CPEC. According to a Pakistani official, Gwadar's construction was explicitly done as a favor to make financing and operations in Islamabad easier. In actuality, the Gwadar naval base was intended to be constructed by 1958—before China even attained the status of a significant world power (Ashraf et al., 2017). For this reason, Pakistan has appealed to the US and the USSR for assistance. Instead of endorsing the location's potential strategic importance, Musharraf claimed that China initiated the building as a favor. Officials in Pakistan, however, do not support the critiques. They claim the port's purpose was to serve as a gateway to Asia and the nation's economy (Ashraf et al, 2017).

2.1. CPEC project

The key objective of the economic corridor China-Pakistan was to establish trade ties between the two countries. China has access to blue water from the Baluchistan-Xinjiang project. Pakistan also has the objective of launching this initiative. The Pakistani newspaper has released a long-term plan for 2017. It spoke of the interest in agriculture, which promotes rapid plant growth. Thanks to China's many advantages, the project has become a "moral stimulus" for Pakistan. Relations between the two nations started in the 1950s and have grown. Most CPEC projects in the country are built to produce and provide electricity. As a country, China invests at a rate of two percent in public lending infrastructure projects. Chinese grants have funded all Gwadar-related ventures (Hali, Shukui, & Iqbal, 2015).

2.2. Specifics of the project

Around 64% of all investments are to be invested in Pakistan's electricity production. Approximately $686 million is spent expanding Gwadar's port and related ventures. The Orange Line Metro project was the only CPEC transport program. It is not a short-term CPEC deal; it is a long-term plan which will be dissolved from 2014 to 2030. However, short-term CPEC ventures are expected to be completed by 2017. CPEC begins in northwest China and ends in Gwadar Port. Gwadar Port is now under Chinese influence in Pakistan (Shah, 2015).

Pakistan suffered from decades of power shortages, particularly in the manufacturing sector. CPEC plays a significant role in the electricity and fuel supply to Pakistan as a whole. China uses coal as an essential fuel and electricity resource; Pakistan is vulnerable because of the high resource cost (Raziq et al., 2021). By 2020, China intends to complete the project. It will increase the country's GDP, create jobs, and eventually raise living standards for people. CPEC impacts the country's economy and considerably affects the individual level (Baloch et al., 2024).

It is expected to invest approximately $34 billion in energy by 2020. Gadani in Baluchistan is one of the biggest failures of this initiative. Several related projects have been canceled for many factors, which could lead to a shift in investment. China aims to attract additional infrastructure projects to promote growth in Pakistan as well as agricultural and industrial projects. The latter concerns vegetation growth, which benefits both countries equally (Huang, Fischer, & Xu, 2017).

2.3. Effects of such projects

Pakistan will quickly see short-term project results. China's plans will be well-planned and prepared for the city's entire population. The project is also projected to increase the economy of Pakistan by 5 percent in the future. The World Bank anticipates GDP growth will rise by 5.8% in 2019. When done, Gwadar Harbor will be a central hub for many things, including gas and LNG. The country has export potential in many sectors, such as agriculture and industry (Huang et al., 2017).

Pakistan sees Gwadar port as a focal point for many nations, such as Uzbekistan and Tajikistan. According to Wang (2017), a Sino-Pak specialist, Karachi is the biggest competitor. Because of the road and other advanced features, Karachi is in danger of being more attractive than Gwadar by 2020. The

port of Karachi is experiencing congestion problems, which lead to payment. For many neighboring countries, Gwadar can be a cheap alternative. The government is rising as the population increases (Haq & Farooq, 2016).

2.4. Baluchistan

Baluchistan has become a Central Asian, Middle East, and South Asian corridor. Baluchistan's climate is mild all year round and is the right choice for many traders. In Pakistan and neighboring countries, the Gwadar port is significant. This expanding port attracts global infrastructure capacity; China is Pakistan's second-largest recipient of the port. Nevertheless, despite its rich mineral wealth, Baluchistan has yet to demonstrate its high economic contribution to Pakistan. Several factors include poverty and the map's ruggedness (Adnan & Fatima, 2016).

2.5. One Belt One Road

The Silk Road has been a 400-mile highway linking China, India, Egypt, Rome, Greece, and the African Subcontinent. Critics argue that the CPEC project would profoundly impact Baluchistan as a whole. The harbor of Gwadar will become a center for business and trade. This project would increase Pakistan's economy by 5% in the future. The economic motives for the whole project are short routes up to 6,000 kilometers. The question is whether this project will help the public in the end (Huang et al., 2017).

The area still has the banner of Pakistan's least famous and most impoverished province. Its literacy rate is the lowest, and its industrialization level is low (Jinchen, 2016).

3. Conceptual Framework

Information regarding CPEC investments in the province of Baluchistan may be included in this financial report. The sum of money spent on construction is essential to be mentioned here; It also describes citizens' buying power due to the lack of jobs and development in the CPEC project in Figure 1.

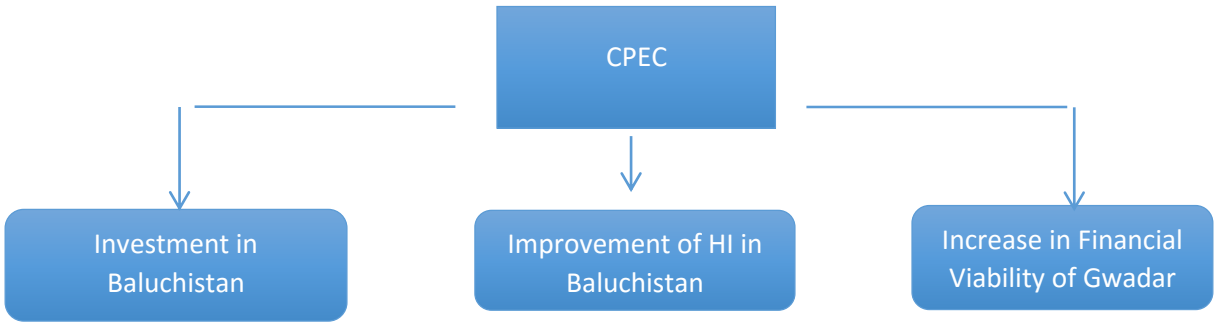

Figure 1. Conceptual Model

The first part of the framework contains detailed information on Baluchistan investment. It analyses the growth or decline of investment-related development factors. The CPEC project was a success factor in providing the planned development with the growth of an investment (Wolf, 2016). However, if the statistics are negative, then it is clear that the rejection rate favors critics and adversaries. The analysis of China's proper use of resources was also part of the structure. The study also provides statistical information based on official websites. Furthermore, the success of the CPEC project also reflected changes in the physical infrastructure (Jinchen, 2016).

For China and Pakistan, the elements of FDI and FDI are essential. Despite China's comparatively low level of foreign investment, Pakistan's FDI is thriving, according to recent data from the World Bank. This hypothesis holds water since it demonstrates China's investment in Pakistan.

H1: Baluchistan receives Chinese FDI and FPI support.

Another tool for evaluating a nation's growth is the Human Development Index, which can offer criteria based on outcomes. For instance, a nation's development status will decline if its index is low in two years.

H2: CPEC investment increases the Baluchistan Human Development Index (HDI).

Gwadar and the Chabahar Harbour compete with one another in the fields of economy and commerce. Another source of controversy was that financial incentives would dictate the port's commercial use; some claimed that Chabahar Port would benefit China.

H3: Gwadar's port is much more financially viable than Chabahar's port (Iran)

The financial position might resolve whether the Chinese government is sincere about Pakistan's growth. The conceptual framework is used, and these hypotheses are for research purposes.

4. Methodology

Research methods focus on perfection-oriented research. It is based either on human philosophy or on authentic sources. In the 19th century, when science was associated with research, the word "paradigm" appeared. The initial term positivism, Auguste, says the approach is objective and does not affect people's emotions and feelings. Using this method, the researcher can achieve high accuracy using a hypothesis or research experiment. This way, unscientific or superstitious beliefs are eliminated. The main objective of this paper is to examine the financial benefits of the Baluchistan CPEC project. A thorough analysis of the accounts and financial statements was mandatory; a survey by several economic officials and residents were also critical.

The study required a scientific approach to analyzing CPEC and Baluchistan's financial aspects. Two different methods for quantitative research were identified when choosing a technique: measurable and working with numbers. The result of a particular study ends with confirmation or confirmation using a quantitative approach. The financial facts reflecting CPEC projects taken from websites like the World Data Bank and the Human Development Index were analyzed to determine the economic facts. A detailed analysis was carried out to measure the hypothesis and fill the literature gap and the available data.

The main focus of this project is to evaluate funding for the Baluchistan CPEC project. There were approximately 150 respondents who received recent surveys. After carefully studying the literature and the subject, the people were selected. The respondents set included several officials on the financial aspects of CPEC; businesses (commerce chambers), 30; online (social media) surveys, 70; news channel TV reporters, anchors, and research analysts, 30; the Ministries, 20.

The study aims to obtain accurate information to analyze the benefits of the Baluchistan CPEC project. The question of the research was the starting point for the entire study. Essential topics for in-depth assessment have been selected. An analysis was carried out using all possible quantitative methods.

The study required information on both sides: basic and additional methods. The first way of collecting data is significant since it can affect the results' accuracy and reliability. This technique aims to better understand the CPEC benefits for Baluchistan and analyze China's financial aspects. Further information was needed to analyze and evaluate the survey data.

The data collected were analyzed with SPSS software. The information had to be entered into an SPSS sheet. Different tests were also conducted, such as a paired T-test sample and variance analysis.

Validity is an important research topic because it represents the researcher's credibility. The validity of the report also depends on its accuracy. This paper carried out a t-test analysis to confirm the accuracy of the data. It has been used to check the accuracy of the obtained data. Validity is an important research topic because it expresses the researcher's trust. The validity of the report also depends on its accuracy. The FDI, FPI, and HDI data were taken from the central bank's official website.

Quantitative research has been carried out to measure the results and ensure accuracy. The papers mainly discussed contradicting factors that increased the desire to take on the project. Furthermore, the selected respondents involved many Baluchistan officials in CPEC financial aspects, especially Gwadar. About 80 respondents were provided with a close-ended survey questionnaire. At first, the finance-related people were selected from various sources such as newspapers, the Internet, and others. These sources also provided information about the involvement of each respondent in the financial sector. After that, the invitation email was sent to the selected respondents. There are a total of 26 departments in Baluchistan and 47 ministers.

Moreover, the chosen respondents involved these ministers and all the laborers and staff members in the financial sector. Of about 80 possible participants, 50 replied that they had ten ministers and Ex Ministers in the Baluchistan province. Furthermore, they were given the questionnaire in the correct format through emails. The data was collected from July 2018 to December 2018.

	Number of respondents
Businessmen (Chambers of Commerce)	18
Online Survey (Using Social Media)	15
TV reporters, Anchors, and Research Analyst from news channels through email	7
Ministers & Ex Ministers	10
Total	50

4.1 Instruments used

For the survey, SPSS or Software Package for the Social Science was used to get accuracy. Secondary information was also needed to analyze and evaluate the survey's information. The secondary data was gathered from the World Data Bank and the Human Development Index and verified through the State Bank of Pakistan and Ministry of Finance Government of Pakistan data. Ultimately, combining both sources of resources can ensure that the particular research is correctly formulated.

5. Results and Discussions

Every question about the various economic sectors impacted by the Baluchistan CPEC project was included in the survey. Transportation, healthcare, education, the economy, industry, human development, equitable prospects for developing the Gwadar port, and mass incomes were among them.

Particulars	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	50	100.0	100.0	100.0

The frequencies and percentages of the survey and the questions asked from the respondents are shown in Table 1.

Table 1

Particular	Frequency	%	Valid %	Cumulative %
Gwadar Port gets benefits from highways and railways.				
Yes	50	100.00	100.00	100.00
No	0	0.00	0.00	
CPEC project brings better health				
Yes	47	94	94	94
No	3	6	94	100
Balochistan government is interested in education projects.				
Yes	34	68	68	68
No	16	32	32	100
The province's financial stability will improve from CPEC.				
Yes	34	68	68	68
No	16	32	32	100
Can Industrial Development increase job creation under CPEC?				
Yes	20	40	40	40
No	30	60	60	100
Has the CPEC project affected the common man's life positively?				
Yes	44	88	88	88
No	6	12	12	100
Do the people of Balochistan benefit more than those of the other three provinces from CPEC?				
Yes	9	18	18	18
No	41	82	82	100
Economy development started after CPEC.				
Yes	40	80	80	80
No	10	20	20	100
Total	50	100.00	100.0	

All the respondents think the Gwadar port will benefit from the network of roads and railways under the CEPC project. Infrastructure development boosts the performance and utilization of the Port. The health issues of the people of Balochistan will improve under the CPEC projects. According to the descriptive survey, 94% of the respondents believe that the health conditions of the public in Balochistan will improve; only 6% think otherwise. A 50-bed hospital is under construction at Gwadar; some other health projects are designed and approved for the people of Balochistan but have not yet been completed and operational.

Facilities such as the girl's college, water purifying facility, and Gwadar cleaning project for cross-border trade and fish export are meant to improve the region. The federal government has also arranged customs, business, and immigration in the Mand, Gwadar, Mashkel, and Panjgur regions.

About 57% of the population attended school by 2016, considerably less in Baluchistan. About 56% of literature persons are literature, while matric enrollment students represent approximately 44% of the country.

32 % of respondents think that the Balochistan government is not interested in education projects, whereas 68% believe that the Balochistan government is working to improve education through the CPEC projects. A similar percentage of respondents replied to the next question related to the financial stability of the province. 32 % of respondents think Balochistan province will not have financial stability, whereas 68% of respondents believe that the province will be financially stable.

As asked by the respondents, industrial development under the CPEC will create job opportunities for the people of Balochistan. 60 % of the respondents think Balochistan people will not get job creation and opportunities, but 40% believe that CPEC will create job opportunities in Balochistan. About 88% of the respondents replied that the project CPEC positively affects the lives of the people of Balochistan. In contrast, only 12 % do not agree with the statement that CPEC will not positively impact the lives of people in Balochistan. Most respondents think that the people of other provinces will get more benefits than those of Balochistan. Only a few respondents believe that Balochistan will benefit more than other provinces. 80% of the respondents think economic development started in Balochistan, whereas 20 % think otherwise.

Hypotheses testing

"H1: Due to FDI and FPI of China, Baluchistan will gain the funds through investment.

The main goal of the CPEC project is to link the port of Gwadar with Xinjiang to create a shorter route for trade. For developmental packages such as highway and road development, 62 billion has been provided to the country.

Figure 2: FDI rate of Pakistan

The rate of increase in FDI since China decided to invest in the nation is seen in figure 2. Around $27 billion worth of CPEC projects are expected to be completed for Pakistan's future growth (Bechtel, 2018). The evidence supports the hypothesis that Baluchistan Province will gain additional funds through CPEC.

H2: Due to CPEC investment, the human development index (HDI) will improve in Baluchistan.

The results in figure 3 demonstrate an additional facet of progress in Baluchistan through human development. It was noted that both locals and visitors will gain equally from the project. Furthermore, it was observed that Baloch's development was given precedence in particular sectors, such as industry.

The responses from the respondents were compared to Pakistan's human development index (Bechtel, 2018).

Figure 3: Human Development Index of Pakistan

Source: **http://hdr.undp.org/en/countries/profiles/PAK**

Pakistan is now ranked 147th in the world in terms of the Human Development Index. It demonstrates how the Human Development Index's cost has steadily increased during 2013–2014. The world's average price was found to be 0.710, although the human development index rate is 0.550. The evidence presented here supports the second hypothesis. The CPEC project is causing the nation to experience development in terms of human growth (Bechtel, 2018).

H3: Gwadar Port is financially more viable than Chabahar Port (Iran).

As part of the CPEC project, Pakistan and China recently inked six additional agreements to enhance the port of Gwadar. On the other hand, the port of Chabahar has been delayed several times in developing the plan. Iran may look to China to advance quickly (Yunling, 2015). Compared to other ports, these figures demonstrate the financial viability of the port of Gwadar.

Pakistan's foreign minister also said the government sought ways to use proper communications across the country. He added that the CPEC project is vital to the country's development (Yunling, 2015). This revolutionary change will lead to prosperity and economic stability. It was a universal statement from all Pakistani news. The financial development and accessibility of Gwadar's port compared to the port of Chabahar is obvious".

Pakistan was facing a high energy crisis before the start of the CPEC project. The energy sector needs to improve in a developed country. Baluchistan has a high level of natural resources, and energy security can be provided to Pakistan. The energy source is a lifeline for a country that strives for industrial development. China needs the energy to boost the development of the port to shorten the Silk Road. Under the CPEC project, a share of around 33 billion dollars is planned, increasing its energy efficiency (Economic Division, 2023).

The development of the railway is one of the most critical CPEC projects. Economic returns and rail network development go hand in hand. The railway network in Baluchistan is not in good condition to make trade easier without any problems. China offers a rail network development strategy to improve

trade in Pakistan's economic corridor. The project will upgrade several highways highlighted in Figure 4, including Karachi-Lahore-Peshawar (ML-1) (1736 km) (Idress et al., 2018).

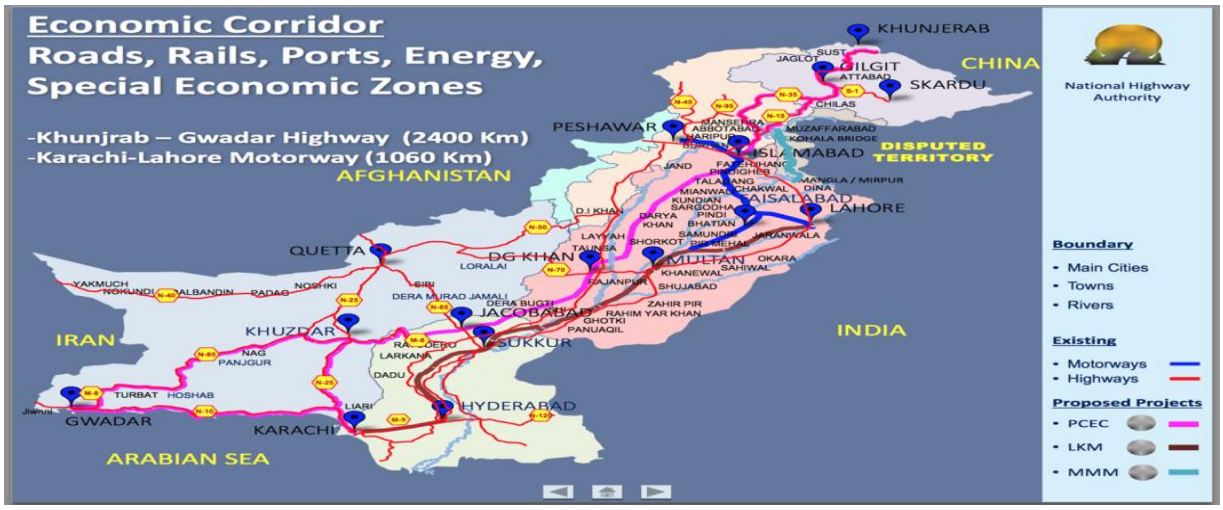

Figure 4: proposed projects (source: Haq's Musings)

The project will supply cargo and container equipment by connecting various cities to Balochistan. Farmers are not losing because they have no vehicle. Baluchistan will benefit primarily from the new railways, connecting to remote areas like Havelian, Turbat, Huzdar, Besima, Khoshab, and Gilgit. President Hussein said the economic corridor between China and Pakistan would help the country as quickly as possible. Only if they know and speak Chinese can young people benefit directly from the project. The corridor has already brought numerous changes, such as an abundance of energy that requires future energy—this CPEC project intended to turn Gwadar Port into a second Dubai. The development of the port of Gwadar can bring stability and peace to the country. The economic hub offers the nation good opportunities. The project changed many Baluch people's lives (Bakhtiyar, 2023).

6. Conclusions and Policy Implications

For the two countries, the China-Pakistan corridor was an equal substitute. Baluchistan has been viewed as one of the country's most significant regions, encouraging several traders and countries to use the gateway to economic growth through its strategic position. The study provides a detailed analysis of the economic factors linked to Balochistan's CPEC project. The China-Pakistan Economic Corridor was one of Pakistan's best substitutes. The project will also help the underdeveloped province of Baluchistan in Pakistan grow. Due to inadequate roads and railroads, farmers find traveling and selling fruit challenging. The province still lacks abundant natural resources, while others are trying to use them (Khan & Liu, 2019).

The economic corridor between China and Pakistan has only raised many people's expectations if they understand their life advantages. The investment will be aimed at developing the Gwadar port. Road and rail development could benefit local farmers and fishers, equalize prosperity, and boost the local Sardinian economies. Both countries will benefit from this project equally. The real benefit to the people of Baluchistan is that they will be given proper employment opportunities. China can be sure it spends much money persuading the local people. Most of the investment money should be spent on infrastructure, education, and health, which can benefit society considerably. The importance of the project and its cost-benefit must be presented to the local native people. The province's economy is primarily informal; positive steps are needed to record the economy, which will lead the province to economic growth and development (Shahzad, Ahmed, & Fatima, 2023).

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Trade Globalization and Human Welfare: An Analytical Study of Pakistan

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Abstract

There is widespread consensus that international trade drives economic growth. There is a bunch of literature that confirms this consensus, while economic growth is concerned with the means to human welfare which is the intended end outcome of all economic activities. Thus, this study is concerned with whether global trade directly influences human welfare. We have conducted the time series analysis by taking the data from 1990 to 2021. We measured human welfare through the Human Development Index (HDI) and Global Trade through the KOF Trade Globalization Index. We chose the ARDL strategy for cointegration based on the characteristics of the time series data, and we presented both short- and long-term results. We concluded from data analysis that global trade and human development have a long-term, positive, and significant link. Moreover, Human development is also significantly and positively associated with population growth, public development spending, and economic growth. Hence, these findings suggest that, for Pakistan to pursue its human development goals, policymakers should adopt policies that promote free trade, complemented by measures to encourage economic growth, public development expenditure, and population.

Keywords: *Trade, Globalization, Human Development, Cointegration*

JEL Classification: *F1, F6, O15*

1. Introduction

Since the time of Adam Smith, International Trade and Economic Growth were considered to be interconnected. Adam Smith highlighted the beneficial effects of global trade on the growth of the economy. It was regarded as driving force for economic growth. But these both variables became independent during the neoclassical period, as in their framework, international trade was seen to offer static gain but did not fully explain the growth process, hence leading to the neglect of global trade's importance in fostering the growth of the economy until 1960s. The emergence of endogenous growth models brought these theories back together. A more precise understanding of the relationship between economic expansion and global trade was made possible by the incorporation of knowledge accumulation and innovation into the endogenous growth theory. According to empirical data, trade openness generally had a positive impact on growth, particularly for developed countries (DCs) because of higher rates of innovation at home and for less developed countries (LDCs) because of dynamic effects, catch-up convergence, importation of capital goods, and innovation adaptation. (Afonso, 2001).

Over the last thirty years, trade liberalization has gained significant traction, especially in developing and transition economies. Growing awareness of the shortcomings of import substitution development methods and the influence of global financial institutions such as the World Bank and the International Monetary Fund has contributed to this change. These organizations frequently condition their support on trade liberalization policies. The persistent

conviction that liberalization is necessary for the shift from closed to open economies is the primary motivating factor for the broad adoption of trade reform (Zahonogo, 2016).

1.1. Situational Analysis of Pakistan

During the last 32 years (1990 to 2021), Pakistan average economic growth is around 4 percent. In the latest UN Human Development Report, Pakistan's Human Development Index (HDI) ranking for 2021-2022 has deteriorated, dropping seven places compared to the previous year. Pakistan's Human Development Index (HDI) fell two spots in 2020, putting the country in the poor human development category. This decline was mostly caused by low income, health, and education indices. In the current HDI rating, Pakistan is ranked 161st out of 192 countries. In Pakistan, the average life expectancy at birth is just over 66 years. Pakistan's gross per capita national income is slightly over $4,600, yet the average person barely completes eight years of education.

Pakistan has shown consistent improvement in its Human Development Index (HDI) since the early 1990s. The significant drop in Pakistan's HDI ranking for 2021-22 can be attributed to both methodological changes in the ranking process and Pakistan's relatively modest progress compared to other countries. Although Pakistan managed the Covid-19 pandemic well, the aftermath of the summer flooding will likely continue to affect the HDI ranking for some time (the behavior of HDI is shown by figure 1). Additionally, the country grapples with issues like inflation, unemployment, and security concerns. Additionally, the government's focus on internal power struggles may divert attention from pressing economic and social issues, despite economic hardships and the impact of natural disasters.

In the context of Trade Globalization, Pakistan has steadily pursued trade liberalization policies, with notable advancements occurring in the 1950s, 1960s, and 1980s. Trade policies were implemented in the 1950s to increase access to reasonably priced agricultural products and raw materials, thereby aiding small businesses. The late 1960s saw the introduction of export promotion programs, which included import subsidies, export bonuses, and currency devaluation. Pakistan has likewise embraced liberal policies regarding financial inflows, especially during the 1990s. Pakistan started trade reforms by lowering its tariff rate from 17% to 10% in the late 1980s. Trade restrictions were lifted from the Pakistani market by subsequent changes in 2005 and 2007, which established the tariff rate at 25% and 14.7%, respectively. Due to these liberalization initiatives, commerce significantly increased. In 2007–2008, it increased from 25% to 37% of GDP, and in 2010–2011, exports reached $20 billion. Nevertheless, Pakistan's exports fell by 3.06% in 2017. To enhance international trade, the Pakistani government signed free trade agreements with various countries, including China, Sri Lanka, and members of the South Asian Free Trade Area (SAFTA). The connectivity infrastructure under the China-Pakistan Economic Corridor (CPEC) and initiatives in Central Asia aimed to improve trade connectivity further. These efforts aimed to create a more open and competitive trade environment, enhancing economic growth and development in the country (Luqman & Soytas, 2023).

Despite these efforts, there is still room for improvement in Pakistan's trade liberalization policies. Additionally, the influence of the IMF and the impact of the war on terror have constrained trade policies and affected investment opportunities, leading to challenges in sustaining export growth. Pakistan needs to continue working on improving its trade policies to strengthen its position in the global market. Figure 1 shows the behavior of series of Trade globalization in Pakistan. By observing the graph of trade globalization we can conclude that from 2014 to 2019, the trade globalization index experienced a decline, dropping from 35 to 34, because of the economic challenges and geopolitical factors that impacted Pakistan's trade relations. In 2020 and 2021, the index slightly decreased to 33, indicating a plateau in trade globalization, which can be attributed to the global economic slowdown and pandemic-related disruptions affecting international trade.

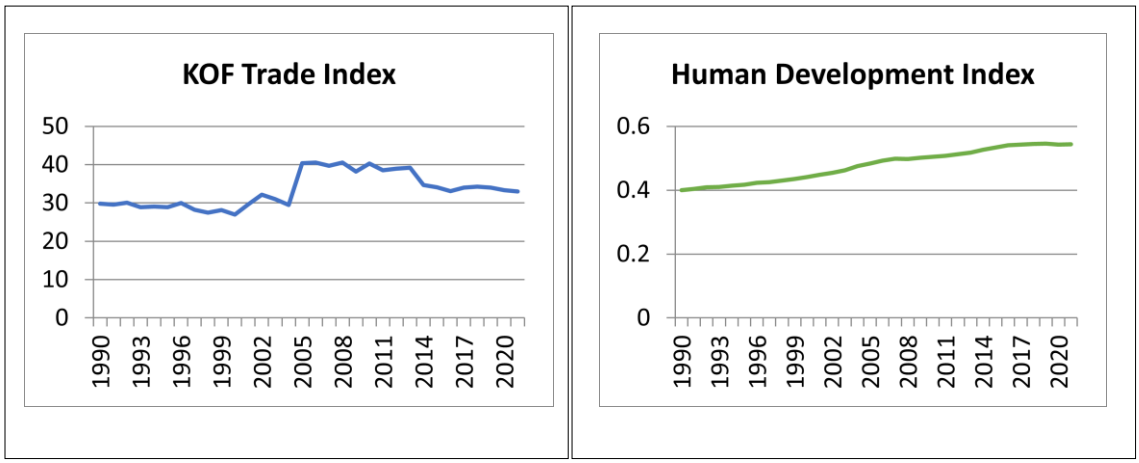

Figure 1: Trade Globalization and Human Development in Pakistan
(**Source:** Author's Construction by using data)

It is widespread consensus that trade is very much important for the economic expansion, hence a significant source of human development. Therefore, there is need to put serious attention on these issues like trade globalization and human development. However, it is difficult to extract the relationship between trade globalization and economic development from the figure 1. There is need of proper data analysis on this study. Previous studies just focused on the economic return of trade globalization while there is lack of examination of social return (in the form of human development) of trade globalization. This study explores the complex relationship between the dependent variable of human welfare, as determined by the Human Development Index (HDI), and independent variables such trade liberalization, economic growth, government development expenditure, inflation, and demographic data.

Our goal is to identify the complex relationships and pathways by which these factors affect human welfare through analysis. It is anticipated that trade liberalization will promote economic expansion and increase accessibility to necessities, ultimately improving human welfare. The GDP Growth Rate, which measures economic growth, is essential for raising living conditions and promoting social progress. Moreover, government development expenditures have a significant direct impact on human welfare. Furthermore, human welfare depends on maintaining stable economic conditions through the management of inflation. Finally, tackling socioeconomic issues and improving general human welfare require an understanding of demographic dynamics, particularly population changes. Thus this study is going to explore the relationship between trade globalization and human development for the 32 years from 1990 to 2021.

The paper had been set up as fellows. Following the introduction, section 2 offers a thorough analysis of earlier research as well as a theoretical framework derived from the literature. Prerequisites for data analysis are given in Section 3, along with a review of research methodology and the selection of variables and data. The outcomes of the data analysis are discussed in Section 4. The study's conclusion and recommendations are given in Section 5.

2. Review of Literature

The connection between international trade and economic well-being has been the subject of several theoretical, descriptive, and empirical investigations. The researchers continued to disagree on the direction of the link. While some researchers found a negative correlation between these two variables, others found a positive correlation. However, the data type, duration of analysis, selection

of variables and econometric method varied across these studies. Most of the studies measured the economic well-being through GDP growth rate, and poverty (head count ratio), while only few studies used human development index to measure the economic well-being. Similarly, different proxies for trade liberalization are used by these studies.

The positive and significant association between international trade and economic well-being has been confirmed by a multitude of empirical investigations (Makki & Somwaru, 2004; Narayan & Smyth, 2005; Akmal et al. 2007; Wacziarg & Welch, 2008; Chaudhry et al. 2010; Hussain et al. 2010; Klasra, 2011; Ahmad et al. 2012; Busse & Königer, 2012; Shahbaz, 2012; Simplice, 2013; Chaudhry & Imran, 2013; Jawaid, 2014; Ali & Panhwar, 2017; Jawaid & waheed, 2017; Onakoya, Johnson & Ogundajo, 2019, Abbasi et al. 2022). Using the Cobb Douglas production function, Narayan & Smyth (2005) discovered that trade agreements has a long-term positive correlation with economic activity, but a short-term correlation that is negligible. In a similar vein, Akmal et al. (2007) claimed that trade liberalization contributes to Pakistan's poverty reduction over time but not immediately.

Chaudhry et al. (2010), in contrast, confirm the beneficial effects of trade on growth of economy over the long and short terms. Furthermore, Busse & Königer (2012) made a significant contribution to the trade liberalization literature by establishing the more precise measure of trade openness, which is the volume of import and export as a percentage of the total GDP that is lagged. They thought that by taking this metric into account, biases that can arise from simultaneous changes in GDP and trade volume are avoided. Shahbaz (2012) furthered this conversation by highlighting the ways in which trade is positively connected with economic growth. A number of factors, such as the effective use of resources from export-oriented policies, the draw of foreign direct investment, the accessibility of cutting-edge technology for domestic production, and the encouragement of financial and economic integration, are some of the ways that trade liberalization promotes the growth of the economy.

Simplice (2013) contributed to the debate by analyzing a rich panel data set, used instrumental variable methodology with the new indicator of human development adjusted for inequality and found that trade globalization positively affects human development, particularly in terms of life expectancy. Jawaid (2014) made contribution by comparing the three different measures of trade openness. He applied rigorous econometric techniques and found that it is export which is positively associated with economic growth while import has negative influence on economic growth. Similarly, Jawaid & waheed (2017) confirmed these findings that export-oriented policies are important for economic expansion in the context of Pakistan. However, Abbasi et al. (2022) reveals that while globalization initially has a negative short-term impact on economic growth, it eventually becomes a positive driver. Globalization has had an influence, although not as much as was once thought, even though it has helped the economy.

The significance and advantages of economic liberalization in developing economies like Pakistan cannot be denied. However, it is crucial to avoid focusing solely on economic aspects while neglecting other dimensions of human and social development, as this can have detrimental consequences (Noshab, 2002). Globalization is essential for economic growth, yet it brings risks like increased poverty. Studies show a weaker link between trade openness and economic growth over time. Pakistan's experience with globalization has been inconsistent, leading to poor trade performance despite liberalization efforts. Foreign direct investment hasn't boosted exports. This period saw decreased GDP growth, rising unemployment, increased indebtedness, and higher poverty rates due to swift trade liberalization and other factors. (Anwar, 2002). Some of empirical research support the notion that trade and economic well-being are negatively correlated (Siddiqui

& Iqbal, 2005; Yasmin et al. 2006; Hye, 2012; Ali & Abdullah, 2015; Hasan & Waheed, 2021; Luqman & Soytas, 2023).

Yasmin et al. (2006) added to the debate by presenting the unexpected finding that trade liberalization and poverty do not significantly correlate, contradicting the idea that trade leads to economic progress. Hye (2012) also offered a contribution, stating that while trade is clearly adversely correlated with economic growth, it can really promote it when linked with human capital. Additionally, Ali & Abdullah (2015) argued that, in the context of Pakistan, trade has a negative long-term impact on economic growth that can be attributed to an emphasis on raw material exports rather than finished goods and weak conflict management institutions. Hasan & Waheed (2021) similarly claimed that domestic variables, such as a high dependent population ratio, infant and maternal mortality rates, and a lack of basic amenities like sanitary services, might be blamed for the detrimental effects of trade.

Overall, there is ongoing debate at the national and international levels on the connection between trade liberalization and economic prosperity. Our research revealed conflicting findings about how trade globalization affects economic prosperity. The majority of research revealed a correlation between economic growth and trade, indicating that the social benefits of trade—namely, human development—were mostly disregarded in favor of the social benefits of trade. Few researches have examined how trade globalization affects human development. Furthermore, there is a dearth of work discussing the social effects of trade globalization in the context of Pakistan. Therefore, by examining the connection between trade globalization and human development, this study aims to close this gap.

3. Methodology

This section focuses on providing a comprehensive understanding of theoretical framework, model specification, selection of variables, and data behavior. Additionally, it discusses the calculations necessary for selecting an appropriate technique to estimate the proposed model (stationarity test of time series data)

3.1. Theoretical Framework

We have extracted a structured perspective on the theoretical correlation between Global Trade and Human Development from (Ali & Panhwar, 2017) which is based on a comprehensive analysis of international sources and a thorough review of prior literature. An upsurge in global trade is anticipated to create avenues for importing essential equipment linked to Education, Health, Transportation, and Infrastructure, along with an augmentation in the arrival of capital goods. This, in turn, is projected to stimulate efficiency, productivity, investment, and exports, thereby fostering a chain reaction towards economic growth, increased employment opportunities, elevated per capita income, and improved healthcare and education provisions, ultimately culminating in enhanced human development. This conceptual framework is represented in Figure 2.

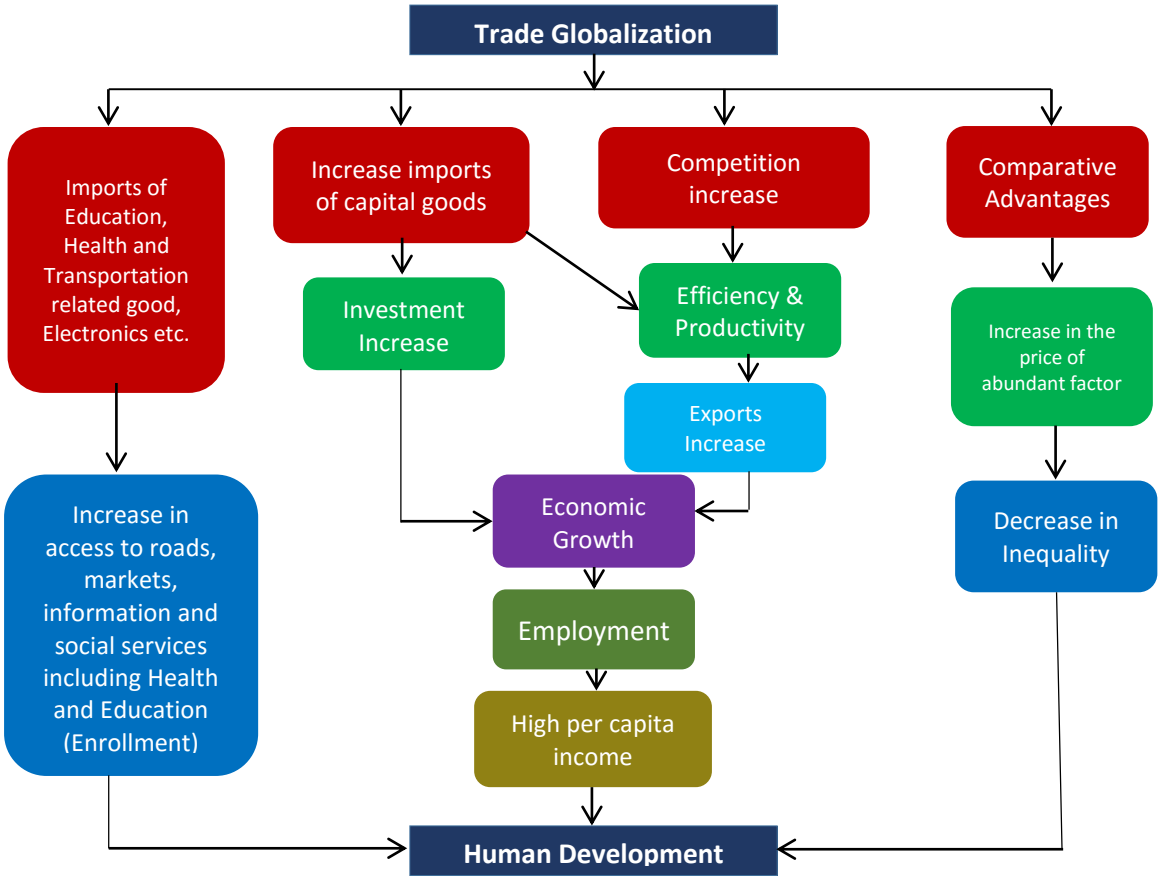

Figure 2: Theoretical Framework (Source: Author's Construction)

3.2. Model Specification

This primary goal of this paper is to determine how trade globalization affects human welfare. Generally this relationship can be defined as

$$Human\ welfare_t = f(trade\ Globalization_t\ , Z_t) \quad (1)$$

Here the human welfare at the time *t* is defined as a function of trade globalization at the time *t*, where Z includes other control variables at the time *t* that might have influence on human welfare. As far as the measurement of these variables are concerned, the best measurement of human welfare is human development index which is a composite index including the dimensions of health (long and healthy life), Education (expected and average years of schooling) and better living standard (per capita income), constructed by UNDP. On the other hand, the best measure of trade globalization is the Trade Globalization (*de facto, de jure)* indicator of Economic Globalization Dimension of Globalization Index initially constructed by Axel Dreher (Dreher, 2006). We have used the latest version of this index (Gygli et al. 2019). Trade Globalization Index includes trade in goods, trade in services, trade partner diversity, trade regulations, trade taxes, tariffs, and trade agreements. Hence the equation (1) could be written in econometrics terms as equation (2)

$$HDI_t = \beta_0 + \beta_1 Trade\ Globalization\ Index_t + \beta_i Z_t + \varepsilon_t \quad (2)$$

Where β_0 shows the intercept term and β_1 is the slope coefficient which shows the sensitivity of HDI due to one unit change in trade globalization index, while β_i shows the slope coefficients of

control variables and ε_t is the error term which captures the effects of all those variables that are not included in model.

3.3. Data and Variables

Data has been collected from authentic sources and selection of variables is done based on the literature review. The following Table 1 shows the description about the variables:

Table 1: Description of Variables

Type of Variable	*Variable Names*	*Proxy*	*Unit of measurement*	*Source of Data*
Dependent variable	Human Welfare	Human Development Index	Scale (between 0 to 1)	UNDP
Independent variables (explanatory)	Trade Liberalization	KOF Trade Globalization Index	Scale (between 1 to 100)	KOF Swiss Economic Institute
Controlled variables	Economic Growth	GDP Growth Rate	Annual percentage	WDI
	Public sector Development programme	Govt. Development Expenditure	Million Rupees	Economic Survey of Pakistan
	Inflation	GDP Deflator	Annual Percentage	WDI
	Demographic information	Population	Annual Total	WDI

Data for these variables have been collected from 1990 to 2021.

Table 2: Summary Statistics

Summary Statistics	**Variables**					
	HDI	**KOF trade index**	**GDP Growth**	**Development Expend.**	**Inflation**	**Population Total**
Mean	0.477813	33.32037	4.083490	509833.8	10.03697	1.75E+08
Median	0.488500	33.04623	4.414541	296409.0	8.606082	1.76E+08
Maximum	0.546000	40.58247	7.705898	1693474.	38.51199	2.31E+08
Minimum	0.400000	26.97735	-1.274087	56050.00	3.258605	1.15E+08
Std. Dev.	0.050614	4.517870	1.970196	511689.0	6.696291	35710132
Normality test of data						
Jarque-Bera	2.884496	2.918284	0.997869	4.739668	129.9379	2.170739
Probability	0.236396	0.232436	0.607177	0.093496	0.000000	0.337777

The variables' summary statistics, including the mean, median, maximum and lowest values, standard deviation, and Jarque-Bera test of normality, are displayed in Table 2. The HDI in Pakistan has varied between 0.40 and 0.54 between 1990 and 2021, according to the above table, whilst the trade globalization index has fluctuated between 26.97 and 40.58. The Jarqu-Bera test is used to determine whether or not data is normally distributed while assessing data normality. A series is

said to be normally distributed if the probability of the Jarqu-Bera statistics is higher than 0.05. With the exception of inflation, every data series is regularly distributed, as the accompanying table demonstrates.

3.3. Properties of time series data (Stationarity of Data, Pre-Estimation Test)

Testing the attributes of time series data is essential prior to performing any analysis on a time series. Most time series analysis estimators rely on having (weakly) stationary data in order to be valid. A process that exhibits constant mean, variance, and auto-covariance throughout time is said to as weakly stationary.. Ensuring stationarity allows us to confidently apply various time series analysis techniques, as they assume a stable and consistent behavior of the data over its entire duration. On the other hand, non-stationary time series may have varying statistical characteristics, making conventional analysis methods unreliable. Before moving on to more analysis if a time series is determined to be non-stationary, suitable transformations or differencing can be used to bring the series into stationarity.

3.3.1. Augmented Dickey Fuller Test (ADF)

Data stationarity is tested using the ADF test. It examined whether or not the variable adheres to a unit root process. The alternative is that the variable was formed by a stationary process; whereas the null hypothesis of this test is that the variable includes a unit root or was not generated by a stationary process. The following table 3 demonstrates the results of ADF test:

Table 3: Unit Root Test (Stationarity Test)

Variable Names	*Level*			*First Difference*			*Stationarity*	*Order of integration*
	Drift and Trend	*Drift only*	*None*	*Drift and Trend*	*Drift only*	*None*		
HDI	-1.674 (0.737)	-1.110 (0.698)	-1.839 (0.981)	-2.758 (0.222)	-2.654 (0.093)	-1.557 (0.110)	Stationary at 1st difference	I(1)
KOF Trade Index	-1.616 (0.762)	-1612 (0.465)	0.015 (0.680)	-6.057 (0.000)	-6.095 (0.000)	-6.187 (0.000)	Stationary at 1st difference	I(1)
GDP Growth	-4.276 (0.012)	-4.359 (0.001)	-1.403 (0.146)	-	-	-	Stationary at level	I(0)
Development Expend.	-1.961 (0.598)	-0.278 (0.917)	0.893 (0.893)	-4.314 (0.011)	-4.689 (0.000)	-4.441 (0.000)	Stationary at 1st difference	I(1)
Inflation	-5.986 (0.000)	-5.897 (0.000)	-1.435 (0.137)	-	-	-	Stationary at level	I(0)
Population	-0.779 (0.955)	-1.697 (0.421)	1.147 (0.931)	-3.314 (0.085)	-2.821 (0.068)	-0.170 (0.615)	Stationary at 1st difference	I(1)

Note: *Values in column shows the tau-statistics and the value in parenthesis shows the respective probability of tau-statistics*.

Since the p-value in every model under level is more than 0.10, we are unable to reject the null hypothesis of a non-stationary series, which makes it clear from Table 3 above that HDI is not stationary at level. Nevertheless, under the model with drift, HDI is found to be stationary at first difference; hence, we can conclude that HDI has an order of integration of one. In a similar vein, it is discovered that the population, government development spending, and the KOF trade index are all stationary at first difference, while the GDP growth rate and inflation are integrated of order zero.

3.4. ARDL approach to cointegration (Estimation)

When the variables have mix integration orders of zero and one, the Auto Regressive Distributed Lag (ARDL) model is applied. Regression models that include both lagged values of the independent variables and lagged values of the dependent variable are known as ARDL models. Through the use of autoregressive terms, it enables us to investigate the relationship between the lagged values of independent variables and the present value of the dependent variable. Regarding the creation and use of ARDL models in time series analysis and econometrics, Pesaran and Shin (1999) and Pesaran, Shin, and Smith (2001) have made important contributions.

To apply the ARDL model, the dependent variable needs to be integrated of order one. We estimate our model using the ARDL approach to cointegration as Table 3 shows that the HDI is integrated of order one, meaning that it is also affected by its own prior values. The estimation of the Error Correction Mechanism, or the short-term relationship between the variables, is the first step in the ARDL technique of cointegration. Next, the long-term relationship between the variables is tested. If there is a statistically significant negative Error Correction Term (less than one) in the cointegration equation, adjustment always attempts to "error correct". This suggests that the variables have sustained associations with one another.

Short Run Equation

$$\Delta HDI_t = \alpha + \sum_{i=1}^{q} \rho_i \Delta HDI_{t-i} + \sum_{i=0}^{p} \beta_{1i} \Delta Trade\ GI_{t-i} + \sum_{i=0}^{p} \beta_{2i} \Delta GDP\ Growth_{t-i} + \sum_{i=0}^{p} \beta_{3i} \Delta Development\ Expend_{t-i} + \sum_{i=0}^{p} \beta_{4i} \Delta Inflation_{t-i} + \sum_{i=0}^{p} \beta_{5i} \Delta Population_{t-i} + \delta_1 HDI_{t-1} + \delta_2 Trade\ GI_{t-1} + \delta_3 GDP\ Growth_{t-1} + \delta_4 Devel.Expend_{t-1} + \delta_5 inflation_{t-1} + \delta_6 Population_{t-1} + \varepsilon_t \quad (3)$$

Long Run Equation

$$HDI_t = \alpha + \sum_{i=1}^{q} \rho_i HDI_{t-i} + \sum_{i=0}^{p} \beta_{1i} Trade\ GI_{t-i} + \sum_{i=0}^{p} \beta_{2i} GDP\ Growth_{t-i} + \sum_{i=0}^{p} \beta_{3i} Development\ Expend_{t-i} + \sum_{i=0}^{p} \beta_{4i} Inflation_{t-i} + \sum_{i=0}^{p} \beta_{5i} Population_{t-i} + \varepsilon_t \quad (4)$$

The Error Correction Model (ECM) of ARDL is represented by equation (3) above. If the coefficients $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 \neq 0$, then we can draw the conclusion that the variables have a long-term relationship. The coefficient in the long run based on the ideal lag duration at level is represented by equation (4).

4. Results and Discussions

The result presentation commences with descriptive statistics and correlation matrix. The outcome of the descriptive statistics is offered in Table 1. The result deliberates on the statistics that check normality of data distribution. The dependent variables considered in this study are financial development, while the independent variables are ICT variable measured by mobile phone subscription and internet, economic growth, FDI and human capital. In the descriptive statistics, foreign direct investment has lowest average and middle values; ICT variable has highest average and median values while other dependent and explanatory variables' mean and median values fall with these two extreme values.

By using the ARDL approach to estimate the aforementioned model, results are produced. These findings include cointegration results, which show the long-term relationship between the variables, and short-term outcomes in the form of error correction model. The following tables display the findings:

Table 4: Short Run Results

Variables (Short run form)	***Coefficients and Standard Errors***
ΔHDI_{t-1}	0.333*** (0.108)
$\Delta KOF\ Trade\ GI_t$	-2.22E-05 (9.10E-05)
$\Delta GDP\ Grwoth_t$	0.001*** (0.000)
$\Delta GDP\ Grwoth_{t-1}$	-0.0003** (0.0001)
$\Delta Development\ Expenditure_t$	0.0006 (0.0014)
$\Delta Development\ Expenditure_{t-1}$	-0.0072*** (0.0014)
$\Delta Population_t$	-0.013 (0.109)
$\Delta Population_{t-1}$	-0.202* (0.108)
Cointegration Term	-0.516*** (0.064)
Selected Model	ARDL (2, 1, 2, 0, 2, 2)
Included Observation (Sample)	30 years after adjustment (1990-2021)

Note: *Standard Errors are in parenthesis*
**** p<0.01, ** p<0.05, * p<0.1*

The findings of an error correction model are shown in the table 4 above. The calculated short-run coefficients mentioned above are either difficult to interpret or cannot be understood simply. The error correction or cointegration term is the most important component of this model since it is critical to determining how well the variables are convergent. The error correction term must be statistically significant, negative, and consistent with accepted econometric theory in order for convergence to take place. The model's error correction term in this instance complies with these predictions. Furthermore, according to the coefficient of the error correction term (ECM), each period will see an adjustment of roughly 52% which shows how quickly the model's variables converge to their long-term equilibrium connection.

The next step will be to perform a bound test to see if there is a long-term relationship between Trade Globalization and the HDI. The results of this test will produce a Wald or F-statistic, which we will use to determine whether or not the variables have a stable, long-term relationship.

Null Hypothesis: H0: $\delta_1=\delta_2=\delta_3=\delta_4=\delta_5=\delta_6 = 0$

Alternative Hypothesis: H1: $(\delta_1=\delta_2=\delta_3=\delta_4=\delta_5=\delta_6) \neq 0$

Table 5: Bound Testing

Test Statistics	***Value***	***K (Degree of Freedom)***
F- Statistics	6.57***	5
Critical Bound Values		
Significance	***Lower Bound***	***Upper Bound***
10% (*)	2.407	3.517
5% (**)	2.910	4.193
1% (***)	4.134	5.761

The bound test findings, including the F-statistic and the accompanying lower and upper critical bounds, are shown in Table 5. We compare the F-statistic with the upper critical bound in order to ascertain whether cointegration is present. We reject the null hypothesis of no cointegration, if the F-statistic is greater than the upper critical bounds. In the present case, the table's F-stat exceeds the upper bound, suggesting a long-term relationship between trade globalization and the HDI. Having established the long-run association between the variables, we can now proceed to interpret the long-run results presented in Table 6. These results will provide insights into the equilibrium relationship between the HDI and Trade Globalization along with other controlled variables and their long-term behavior, allowing us to understand the underlying dynamics and implications of their interactions over an extended period.

Table 6: Long Run Results

Independent Variables (Long run form)	***Human Development Index (dependent) Coefficients and Standard Errors***
$KOF\ Trade\ Globaliztion\ Index$	0.0062*** (0.0002)
$GDP\ Growth\ rate$	0.0036*** (0.0007)
$Development\ Expenditures$	0.0078** (0.0036)
$Inflation$	-9.30E-05 (8.87E-05)
$Population\ (Total)$	0.1768*** (0.0131)
$Constant$	-2.9907*** (0.2116)
Log Likelihood	168.8812
F-Statistics	3175.403***

Note: *Standard Errors are in parenthesis,*
**** p<0.01, ** p<0.05, * p<0.1*

The long-term association between the variables is seen in Table 6. The significance of the F-statistic suggests that all explanatory variables and the Human Development Index (HDI) have a

substantial long-run relationship. This indicates that the model as a whole has significance in explaining the long-term connection between these variables. We find that there is a significant and positive relationship between the HDI and the KOF Trade Globalization Index when we look at the individual importance. To be precise, a rise of one unit on the Trade Globalization Index scale translates into a corresponding increase of 0.006 units on the HDI. This result supports our premise that trade globalization and human welfare do really has relationship. The rationale behind this positive relationship lies in the widely accepted notion that trade acts as an engine of economic growth, leading to higher per capita income. Moreover, global trade facilitates the exchange of ideas, knowledge, and technology among countries, which, in turn, improves infrastructure, healthcare services, and education systems. Consequently, the HDI ranking of a country improves. Considering the context of Pakistan, we can conclude that trade globalization contributes to the long-term enhancement of human development. The positive association between trade globalization and the HDI suggests that as Pakistan engages more with global trade, its human welfare indicators are likely to improve over time.

As far as the relationship of control variables with HDI are concerned, we found that all the variables except inflation, are significantly explaining the HDI. We find that Economic growth has direct influence on HDI, as increase in the economic growth would bring the increase in the overall income leading to the better living standard. Similarly, we find that increase in the govt. development expenditure which includes the expenditure on infrastructure, health services, education system, and employment generation helps to improve the ranking of Pakistan in HDI. Moreover, we also reached to very surprising results that increase in population of Pakistan is also positively associated with Pakistan's HDI. The rationale behind this relationship would be increase in population would generate more labor force or human capital that would generate more economic activities and would bring innovation, hence more economic growth leading to human development.

4.1. Statistic Diagnostic (Post-Estimation)

Statistic Diagnostic is residuals (estimated values of error term by model) based test which are used to test for assumptions of model to insure the stability of estimated coefficient attached with independent variables. The assumptions of model are, there should be no serial correlation in residuals, variance of residuals should be constant, and residual should be normally distributed. The following list of tests are applied to insure the stability of estimated results.

1. Serial correlation LM-Test
2. Heteroskedasticity Test
3. Histogram Normality Test
4. CUSUM and CUSUM sum of square Test

The null hypothesis of these entire tests is that there is no serial correlation in the residual series, variance of residuals remained constant over the time, and generated series of residual is normally distributed.

4.1.1. Serial correlation LM-Test:

Table 7: Breusch-Godfrey Serial Correlation LM Test

F-statistic	1.0905	*Prob. F(2,13)*	0.3649
*Obs *R-squared*	4.3102	*Prob. Chi-Square(2)*	0.1159

Based on the chi-square distribution, the observed R-squared has a p-value larger than 0.05, as shown in the above table. As a result, it is not possible to rule out the null hypothesis that there is no

serial association. This finding suggests that the model's assumption is satisfied because there is no serial correlation in the residuals.

4.1.2. Heteroscedasticity test

Table 8: Heteroskedasticity test: Brausch-Pegan-Godfray

F-statistic	0.6533	*Prob. F (14,15)*	0.7838
*Obs*R-squared*	11.3638	*Prob. Chi-Square(14)*	0.6572
Scaled explained SS	3.6672	*Prob. Chi-Square(14)*	0.9972

The above table is showing the results of heteroskedasticity test of whether the variance of residual remained constant or not. If we look at the probability value of observed R-squared then we can say variance of residual remained constant over the time, as the p-value is greater than 0.05 so we are unable to reject the null hypothesis of constant variance of residuals over the time, hence meeting the assumption of model.

4.1.3. Normality test

The Figure 3 displays the distribution of series of residuals which confirms that residual are normally distributed. Similarly, the probability of Jarque-Bera test is more than 0.05 so we are unable to reject the null hypothesis that residuals are normally distributed, meeting the assumption of model.

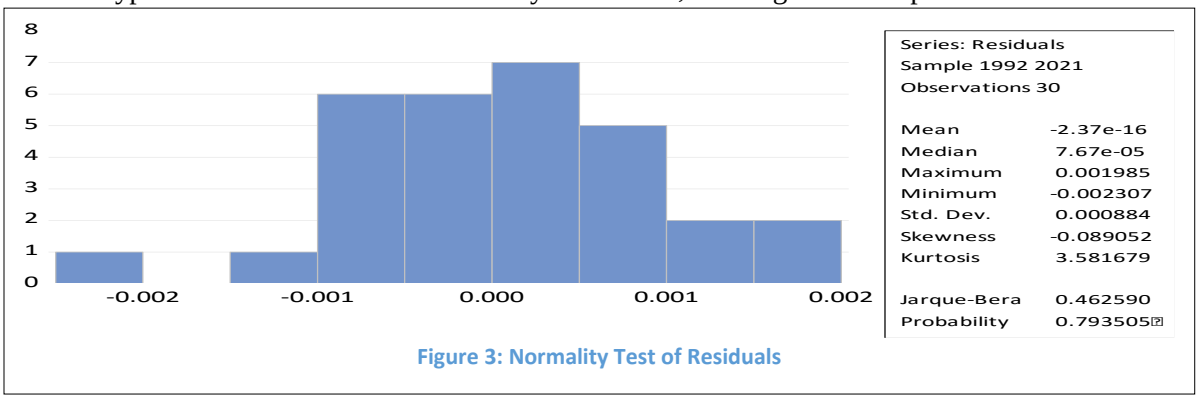

Figure 3: Normality Test of Residuals

4.1.4. CUSUM and CUSUM sum of square

The Cumulative Sum of Recursive Residuals test, or CUSUM test for short, is a model's parameter constancy test. The upper and lower boundaries for the 5% significance threshold in this test are shown by red lines. The parameters are considered unstable when there is a break in the data, as indicated by the blue line crossing either of the red lines. The parameters, on the other hand, are said to be steady and constant over time if the blue line stays in between the red lines.

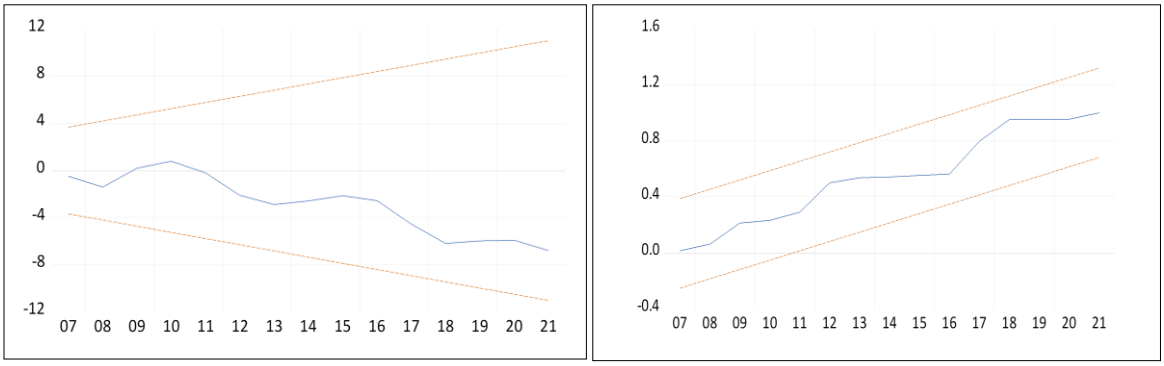

Figure 4: Stability Test of Estimated Parameters

Cusum and Cusum sum of square are used to show the changing behavior of parameters that whether they remain stable or going to change over time. In above figure 2 it is obvious that blue lines are between the red lines so we can conclude that parameters estimated by ARDL bound testing approach are stable, hence there is stable relationship between HDI and Trade Globalization in Pakistan.

5. Conclusions and Policy Implications

International trade has been recognized as a catalyst for the growth of economy since the era of Adam Smith. A large amount of research backs up the widely held belief that trade opens up access to more expensive domestically produced items, which in turn promotes economic growth. Global trade also makes it easier to import infrastructure, capital goods, and supplies for the healthcare and educational sectors, which eventually boosts production and efficiency. This in turn fuels economic expansion, job creation, rising per capita income, and ensuing advancements in human welfare. Despite the wealth of research confirming the positive relationship between global trade and economic growth, relatively limited attention has been devoted to exploring the direct link between global trade and human welfare – the ultimate goal of economic activities. Consequently, this paper delves into the connection between trade globalization and human welfare. Initially, a straightforward functional relationship between these variables is proposed. To measure these variables, the Human Development Index (HDI) stands in for human welfare, while the KOF Trade Globalization Index serves as a proxy for trade globalization.

Subsequently, a model is formulated, with HDI as the dependent variable, trade globalization as the independent variable, and several control variables (comprising GDP growth rate, population, inflation, and public development expenditures) that could impact HDI. Time series analysis is undertaken using data spanning from 1990 to 2021, sourced from reputable entities such as the World Bank, Economic Survey of Pakistan, UNDP, and KOF Swiss Economic Institutes. The ADF test is used to account for time series qualities because the data are time series. Findings show that the variables' orders of integration (I(0) and I(1)) are mixed, which prompts the use of the ARDL approach to cointegration and reveals both short- and long-term relationships between the variables. A strong and favorable long-term correlation between trade globalization and human development is revealed by ARDL estimation. In particular, a rise of one unit in the Trade Globalization Index is correlated with a 0.006-unit increase in the HDI; the small coefficient is explained by the dispersion and data range. Among the control regressors, all variables – except inflation – significantly predict HDI behavior, consistently aligning with theoretical expectations. To fortify the results, post-estimation techniques such as serial LM correlation tests, heteroskedasticity tests, normality tests, and cumulative sum of square assessments are employed. These confirm the stability and consistency of coefficients estimated through the ARDL approach.

Based on these findings, the following policy recommendations are proposed:

Given the established favorable and significant link between the KOF Trade Globalization Index and HDI, policymakers are advised to concentrate on further integrating Pakistan into the global economy. Strategies encompass trade liberalization, reduction of trade barriers, and promotion of export-focused industries. Encouraging foreign direct investment and strengthening trade ties with other nations can also enhance human welfare indicators. Economic growth directly impacts HDI through elevated per capita income and improved living standards. Therefore, policymakers should prioritize policies fostering sustainable and inclusive economic growth. This might entail investing in infrastructure, supporting small and medium-sized enterprises, and nurturing an environment conducive to business growth.

The study underscores the importance of government development expenditure in enhancing HDI. To bolster human development, policymakers should allocate adequate resources to sectors like healthcare, education, infrastructure, and job creation. Investing in human capital development can yield a skilled and productive workforce, contributing to overall societal and economic advancement. Surprisingly, a positive relationship between population growth and Pakistan's HDI is identified. However, policymakers must ensure that population growth is accompanied by strategies to harness the demographic dividend. This involves investing in education and healthcare to empower the expanding labor force and ensure it contributes to economic productivity and innovation. Finally, these policy recommendations aim to leverage the favorable relationship between trade globalization, economic growth, government development spending, and population growth with Pakistan's HDI. By implementing well-designed policies in these areas, Pakistan can enhance its human development indicators and improve the overall well-being of its citizens. However, it's essential to tailor these policies to the specific context and challenges faced by the country to achieve sustainable and inclusive human development.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Tourism Nexus with Economic Growth and Factors Derives Tourism in Pakistan: Insights from ARDL

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Abstract

Tourism plays a central role in the economic growth of numerous countries. It encourages foreign exchange, investment, and employment opportunities in the host country. Numerous studies have been published on factors driving the tourism industry in Pakistan. However, they left the research gap and made unexplored the effect of the crime index and military regime and technology on the tourism industry in Pakistan. Therefore, this study utilized two models, multiple and simple regressions from the period of 1996 to 2021 and 1995 to 2020, to fill gape this study employed autoregressive and distributive lags model (ARDL) and other statistical tools, such as augmented Dickey fuller test (ADF), White and autoregressive conditional heteroscedasticity (ARCH) tests, Serial LM test, principal components analysis (PCA). The findings of the study reveal that there is a positive and statistically significant association between tourism and economic growth in the short run as well as in the long run. In addition to this, the results of the tourism determinants model outlined that, terrorism, crime, and military regime, adversely affect tourism in Pakistan in the long run. While fixed telephone subscription (FTS) proxy for technology, hard infrastructure (HI), inflation positively determines tourism in Pakistan both in the short run and long run. Thus, this study recommends that government needs to design sustainable and effective policies to boost tourism in Pakistan.

Keywords: *Tourism, Terrorism, military regime, Crime, Economic Growth, ICT infrastructure*

JEL Classification: Z32, F43, H54, O1

1. Introduction

The tourism industry is a vital industry for the economic prosperity of numerous countries in the world Naseem (2021), which they strive to develop. It helps and improves economies in several ways such as foreign exchange, employment opportunities, and increases income level (Nguyen, 2021, Nadeem et al., 2020, Bayar and Yener, 2019, Khan and Rasheed, 2016). Thus, the improvement in the tourism industry has been very crucial for developed and underdeveloped countries; along with this, it has become the most important agenda for policymakers, because of its major contribution to the economies. At the world level, governments are trying to make better policies to reduce macroeconomic hitches concerning their economies, such as low growth, unemployment, poverty, and current account deficits, but the tourism industry can reduce these problems. Moreover, by developing the tourism industry, the "income inequality" in the world can be tackled, because it can facilitate the movement of income from developed countries to non-developed countries. Furthermore, its development can enhance the livelihoods of the rural areas. According to the "World Tourism Organization (UNWTO)", the tourism sector is the lifeline for rural communities in under-developed nations.

The spillover effect of the tourism industry in the world is undeniable because it provides abundant nourishment to the economies through different links, first and foremost, its development reduces poverty, encourages investment in infrastructure, improves sustainable development, and enhances household income (Badulescu et al., 2020, Brida et al., 2020). Furthermore, it is the source of foreign exchange that facilitates the procurement of capital goods and technology to help expand production in the economy. Therefore, many governments pay much importance to supporting and making advanced tourism a credible source of employment generation and economic growth (Brida et al., 2020).

In previous years, the Corona pandemic became a major obstacle for global industries, including the tourism industry (Abbas et al., 2021). Due to this alarming pandemic, the contribution of tourism to world economies declined. According to the World Travel and Tourism Council (Economic Impact, 2022) in 2020, 62 (million) jobs vanished, and its contribution to world GDP declined by 50.4% year in one year. However, after Corona pandemic, the world was back to normal in 2021, the tourism contribution to world GDP rose from 5.3% in 2020 to 6.3% in 2021, and 18.2 (million) jobs were recovered.

Pakistan is an underdeveloped country but rich with immense tourist destinations due to its history, culture, biological and geographical diversity. these tourist destinations include Neelum Valley, Gilgit Baltistan, Hunza Valley, Ayubia, Kaghan, Naran, Muree, Malam Jabba, Chitral, Shandor festival, camel and jeep safari in the Cholistan Desert, gorgeous glaciers, k2 world second highest mountain (Arshad et al., 2018). However, despite such great potential, the tourism sector has not been able to bear its fruits. many factors have been responsible for mainstreaming tourism; notably, the poor infrastructure and lack of necessities in the tourist destinations, lack of marketing for tourism, high inflation, and due to security issues, since 2000, international tourist arrivals declined in Pakistan (Arif and Shikirullah, 2019).

Furthermore, after 9/11 Pakistan has faced a drastic decline in tourism and has shifted its focus from tourism to terrorism which has resulted in spending millions of dollars in its fight against terrorism. (Rauf et al., 2020). Although, in recent years terrorism has been curtailed. Antonio Guterres head of UNO (2020) has addressed at a summit in Islamabad, that transformation of Pakistan from terrorism to tourism is unambiguously remarkable. Furthermore, to enrich the tourism industry, Pakistan has taken the following steps, (1) establishment National Tourism Coordination Board (NTCB) in 2018, to help the provincial governments in tourism development. Moreover, to make strategic planning for tourism development nationally. (2) Launching of a web portal to provide information and accessibility to international tourists, (3) allocation of Rs.1 billion to the Pakistan Tourism Development Endowment Fund (PTDEF) to advertise the historical spots and cultural beauty of Pakistan. Moreover, Pakistan held a tourism summit in 2019 in Islamabad, and great facilities were offered to international tourists by eliminating administrative problems. The announcement "E-Visa to 175 countries" would enhance the inflow of international tourists to Pakistan (Azam et al., 2022).

Along with this, the Tourism industry has emerged as a new industry in Pakistan. The World Travel and Tourism Council (WTTC), annual research report (2022) highlighted that international visitor spending has contributed 2.9% to total exports and 5.1% of jobs have been created, which became 3.34 million in 2021. The contribution of the tourism industry to Pakistan's economy is not satisfactory. However, it can be attributed to political instability, poor infrastructure, and inflation. Many studies were conducted on Pakistan's economy (Azam et al., 2022, Khan et al., 2022, Rehman et al., 2020), proposed in their policy recommendations, that Pakistan needs to eliminate high inflation, political instability and spend on infrastructure to attract foreign tourists to increase the contribution of the tourism industry to Pakistan GDP.

This research is based on the introduction section which covered tourism and economic growth nexus. Second, it contains a literature review on all variables that are examined in this study and adds research contribution to the existing literature. Third, it includes the theoretical framework, methodology, results, conclusion, and policy recommendation.

2. Review of Literature

The association between tourism and economic growth has been extensively studied in the last two decades at the world level. For example, Selimi et al. (2017), Mishra et al. (2011), Fayissa et al. (2008), Kostakis and Theodoropoulou (2017), Brida et al. (2020), Badulescu et al. (2020), Garidzirai and Pasara (2020), Naseem (2021), Huseynli (2022), Destek and Aydın (2022), and these studies have concluded that tourism has substantial positive impact on the economic growth. However, the effects were different in magnitude.

Moreover, many researchers have tested the tourism-led economic growth hypothesis in their studies, and they accepted that this hypothesis is true. For example, Lean and Tang (2010), Tang and Tan (2018), Jalil et al. (2013), Tang et al. (2016), these studies used advanced econometrics techniques and models and revealed that economic growth has strong links with tourism. Further, he argues that a rise in tourism will lead to an upsurge in economic growth. Therefore, Fayissa et al. (2008) and Brida et al. (2020) proposed policy guidelines, that governments need to develop and promote tourism to flourish the economic growth.

In addition to this, the existing literature was not free of contradictory results, but however, it may be due to different methodologies, the geographical differentiation of the study areas, and the business cycle condition of each country or region. For example, Lin et al. (2019) found in their empirical study both tourism-led growth hypothesis and economy-driven tourism-led growth hypothesis. This study reveals that 9 regions have experienced economy-driven tourism growth, while 10 regions have experienced tourism-led growth hypothesis in China. Moreover, it has been disclosed that tourism development can be an effective way of reducing the income gap among regions. Similarly, Işik et al. (2017) found both hypotheses for different countries.

The tourism-led growth hypothesis was presented in China, the USA, Germany, and Turkey, and the growth-led tourism exists in Spain and the UK. However, the bi-directional causality emerges for Germany between tourism and economic growth. This study further argues that tourism and economic growth are dependent on each other and recommends two guidelines for policymakers to promote tourism for sustainable economic growth or vice versa. Whereas, the tourism-led growth hypothesis was rejected by Katircioglu (2009) in the context of Turkey and also did not find any co-integration between tourism and economic growth.

Furthermore, the bidirectional causality was found in many studies (Badulescu et al., 2020, Dogru and Bulut, 2018, Katircioglu, 2009). On the other hand, the negative impact of tourism also emerges in the literature regarding the environment. Anser et al. (2020) used different variables to assess its link with different hypotheses but they found that international tourism receipt increases Co2 emission and verified the pollution haven hypothesis (PPHH) in G7 countries.

In the context of Pakistan, Jalil et al. (2013), Aleemi (2015), Manzoor et al. (2019), Rehman et al. (2020), and Azam et al. (2022) revealed that tourism has a positive relationship with economic growth. An increase in tourism activities will aggrandize economic growth. Moreover, being a divergent sector tourism not only contributes to the internal sector of the economy but also flourishes the external sector as well, but attention is needed. Currently, Pakistan is facing a severe Balance of Payment deficit and the lowest foreign exchange reserves in history ever. However, with inbound tourism development, the

deficit (BOP) can be tackled. A study conducted by Rasheed et al. (2019) found long run and statistically significant negative relationship between BOP deficit and tourism. Further, recommended that the government formulate the best policies for tourism development it will help in reducing the balance of payment deficit and will increase the foreign exchange reserves.

2.1. Tourism and Inflation

Inflation is one factor from which tourists judge the economic stability of any country. An increase in inflation decreases the purchasing power of tourists which ultimately has an impact t on the tourism industry because goods and services prices become expensive to afford. Khan et al. (2022) and Achyar and Hakim (2021) argue that inflation is a vulnerable factor, which discourages investment in tourism infrastructure and tourists visits. Hence, it has a negative influence on the tourism industry.

Furthermore, Pektas and Unluonen (2020) reveal that an increase in inflation exerts an effect on per-person spending which may cause a reduction in tourism demand. Similarly, Athari et al. (2021) used panel data for 76 countries from the period of 1995-2017 and concluded that inflation has a significant negative impact on tourism in the sample countries. An increase in prices obstructs tourism. More interestingly, the marvelous hypothesis tourism led to inflation was found in the existing literature. Shaari et al. (2018) highlight that expansion in the tourism industry triggered inflation in Malaysia. Therefore, they concluded that the government needs to take proactive measures to impede the over-expansion of the tourism industry to maintain a stable inflation rate.

2.2. Physical Infrastructure and Tourism

Well-developed infrastructure is not only crucial for manufacturing industries but for the tourism industry to grow as well. A country with having quality infrastructure will enjoy more fruits from the tourism industry, the best example is the United Arab Emirates. Khan and Rasheed (2016) demonstrated that tourism and infrastructure positively correlated with each other's. Further, their results revealed that a 1 percent increase in infrastructure encourages tourism by 1.76 percent. The same conclusions were given by Seetanah et al. (2011) and Fareed et al. (2016) regarding the bond between infrastructure and tourist arrivals but the magnitudes were different. Improved infrastructure attracts the inflow of tourists because they feel comfortable if the best infrastructure services are available.

Nguyen (2021) argues that investing in tourism infrastructure such as hoteling and restaurant industry, recreational facilities, transport, and communication, has a major and positive impact on the inflow of international tourists. In addition to this, the results indicated that in the long run, a 1 percent increase in the tourism infrastructure boosted the inflow of international tourists by 0.7503%, 0.4026%, and 0.7836% to Vietnam. Moreover, Mandić et al. (2018) gathered data through a questionnaire from 312 respondents, and for most of the respondents, recreational facilities and tourism infrastructure are influential factors in improving the tourism industry. Furthermore, the short-run and long-run positive impact of infrastructure on tourism was confirmed by (Ahmed and Anwar, 2016).

2.3. ICT Infrastructure and Tourism

In the 20th century, Technology has got much attention due to its revolutionary role in the digitalization of world economies and the advancement of Global industries including the tourism industry as well. Many studies have used different proxies for ICT infrastructure to analyze its impact on tourism development. For example, Lee et al. (2021) used proxies for ICT infrastructure such as mobile cellular subscription, fixed broadband subscription; and secure internet servers and revealed that an increase in these variables has a positive impact on tourism. Similarly, Sharma et al. (2022) constructed an index through principle component analysis and pointed out that ICT infrastructure has a positive impact on tourism in the short and long run in India. Furthermore, Adeleye (2023) gathered data for 33 countries and created an index by using principle component analysis and applied the GMM technique. They

found that the effect of ICT is positive, and it moderated the tourism-led growth hypothesis (TLGH) in East Asia and the Pacific.

Adeola and Evans (2020) used data from the period of 1996 to 2016 for Africa and applied the dynamic panel gravity model and found that ICT infrastructure has a statistically significant and positive nexus with the advancement of tourism. Further, revealed if ICT infrastructure increases it leads to an increase in the arrival of tourists. Moreover, software applications and the fastest speed of ICT infrastructure are very important for tourism development. In addition to this, the theoretical study of Khan and Hossain (2018) indicated that it is very crucial for the development of the tourism and hospitality industries. Further, highlighted, that it has a significant impact on organizations if they can use ICT for processing and dispersing information, managing distribution, internal efficiencies, and creating new directions for future commercial growth with a worldwide audience. However, a negative impact of ICT infrastructure on tourism also emerged in the study of Nadeem et al. (2020) in the case of Pakistan.

2.4. Terrorism and Tourism

Terrorism has serious consequences in terms of creating fear in the minds of tourists. Due to terrorism, tourists fear traveling to tourist spots. Further, their results indicated that there is a negative relationship between tourist arrival and terrorism. If a 1% increase occurs in terrorism tourism will decline by – 0.61 percent (Khan and Rasheed, 2016). Furthermore, the negative impact of terrorism has emerged in various studies (Nadeem et al., 2020, PK and Sanjeev, 2020, Santana-Gallego et al., 2016, Raza and Jawaid, 2013, Drakos and Kutan, 2003).

Moreover, an increase in terrorism slows down globalization, rise in military spending, endangers the lives of people and prosperity, and increases the risk for international investors (Fareed et al., 2018). Terrorism created uncertainty and safety problems and imposed limitations on the tourism industry's growth. The study by Manrique-de-Lara-Peñate et al. (2022) showed that the expansion in the tourism industry is associated with insecurity and uncertainty, if insecurity and uncertainty come down to their minimum level in the countries; the value added, which is generated by tourism would rise by 14.3%. Whereas in case of increasing to the maximum level, the value added would decline by 17.5%.

Göktuğ Kaya et al. (2022) explored the connection between tourism and terrorism in the context of Turkey from the period of 2012- 2018 on a monthly basis by using (ARDL). Further, they found that there was no short-run effect of terrorism on tourism revenue but indicated that in the long run, terrorism negatively affects tourism. However, Zeman and Urban (2019) that the impact of terrorism is not significant on international tourism in the developed countries having strong political regimes as compared to politically unstable and under-developed countries. Further, argued that in a similar way developed countries may be affected, if terrorist attacks prevail.

2.5. Crime and Tourism

Since 2000, crime and tourism relationships have become one of the omnipresent topics of tourism literature. A theoretical study by Mataković and Cunjak Mataković (2019) demonstrates that the impact of crime can be on two levels, micro-level and macro-level. At the micro level, it adversely affects the image of tourists' destinations and the decision power of individuals to go or not, to the tourist's destination, where, criminal incidents take place, while on the macro level, it has a general effect on social community. Further, revealed, that for tourism development a safe environment is necessary. An empirical study conducted by Santana-Gallego et al. (2016) from the period of 1995 to 2013 for 171 countries confirmed that crime negatively affects tourism.

Similarly, Altindag (2014) used a panel data set for European countries and revealed that tourism and crime are negatively associated with each other. Further, explained that international tourists are more

responsive to crime. In the case of Pakistan Rauf et al. (2022) used time series data and indicated that there is an asymmetric and significant association between crime and tourism. Further, argued if the crime rate increases, tourism will decline in the country. Moyo and Ziramba (2013) used Monthly data from the period 2003 to 2011 to analyze the impact of various types of crimes on tourism in South Africa. They found that sexual crimes, kidnapping and murder, and car hijacking hurt tourism in South Africa, both in the short run and long run. However, Shchokin et al. (2023) disclosed that the impact of crime on tourism is a multi-dimensional problem that needs the development of appropriate preventive policies.

2.6. Contribution to the literature

A bulk of theoretical and empirical studies have been published in developed nations and under-developed nations to examine the factors that influence the tourism industry. For example KILIÇ and Ünzüle (2018) in Turkey, Khan and Rasheed (2016) in Pakistan, Mazrekaj (2020) in Kosovo, (Hamilton and Tol, 2007) for Germany, UK, Ireland, Nuseira and Aljumahb (2020) in UAE, Khan et al. (2022) in Pakistan and in many more countries.

However, in the case of Pakistan, this study is diverse from the existing studies in many ways. First, we have constructed the tourism and crime index by using principal components analysis. Secondly, we estimated the impact of the military regime and crime index on tourism for the first time in this study. Third, the impact of technological advancement was only studied by Nadeem et al. (2020) using quarterly data and found, that technological improvement negatively affects the tourism industry in Pakistan. Thus, we have used a proxy for technology and utilized annual data that really its impact is negative.

3. Methodology

The link between tourism and economic growth has been explored through various theories and paradigms by previous studies.

3.1. Theoretical Framework

Modernization theory (MT) is the most important theory in this regard, which received a prominent status in the 19th century and the mid-20th century. It was used by Khan et al. (2022). This theory sheds light on the fact that progress toward the development of a region depends on the efficient use of inner sources. Tourism is reflected as a key internal source that holds the potential to enlarge the economic growth of a country (Khan et al., 2022).

Furthermore, Sharpley (2000) revealed that it continues to support the rationale for the inducement of tourism development. Further, argued, foreign exchange earnings, backward linkages, and multiplier concepts in the whole economy are soundly embedded in it. Similarly, this theory was linked with Rostow's steps of economic growth. They stated that this theory is also called the 'Rostow theory of growth' which follows various sequential stages that help in emerging tourism projects. Thus, this theory has principal applications in public policy and the economic field.

3.2. Data Sources

To empirically analyze the nexus between tourism and economic growth, we have gathered time series data from the period of 1995 to 2021 from WDI. While, for determinants of tourism, we have gathered time series data from the period of 1996 to 2020. The data on GDP per capita and tourism was collected from World Development Indicators (WDI) crime data was gathered from Pakistan Social Indicators (PSI) and terrorism data was collected manually from Wikipedia.

3.3. Tourism Economic Growth Model

$PCI_t = \beta_1 + \beta_2 Tindex_t + \varepsilon_t$ (1)

β_1 *is* Constant

PCI is the per capita proxy for economic growth, and $Tindex$ is the tourism index.

$\varepsilon_t = error\ term$

We have constructed the 'tourism index' by using principal component analysis from the variables, international tourism recipe in dollars, international tourism recipe for passenger transport items in current US dollars, international tourism recipes for travel items in current USD, International tourism expenditures for passenger items in USD, International tourism expenditures for travel items in USD, total expenditures for international tourism in USD. Many studies (Khan et al., 2022, Naseem, 2021, Brida et al., 2020, Nadeem et al., 2020, Rehman et al., 2020, KILIÇ and Ünzüle, 2018) have used proxies for tourism from the above variables. However, instead of taking, 1 or 2 variables as proxies for tourism from the above variables like the existing studies. We have constructed an index by using principal components analysis (PCA) from all these variables because all variables are measured in USD. It may be a contribution to the existing literature.

3.4. ARDL Specification for Tourism Economic Growth Model

$\Delta(PCI)_t = \alpha_0 + \alpha_1(TINDEX)_{t-1} + \alpha_2(PCI)_{t-1} + \sum_{i=1}^{n} \delta_i \Delta(TINDEX)_{t-i} + \sum_{i=1}^{n} \gamma_i \Delta(PCI)_{t-i} + \varepsilon_t$ (2)

In eq (1) α_0 drift parameter and α_i are the long run coefficients i= 1, 2 and γ_i, δ_i are the short run coefficients and ε_t is the error term.

If cointegration exists in eq (2) then the following model will be estimated

$$(PCI)_t = \alpha_0 + \sum_{i=1}^{n} \beta_i CPI_{t-i} + \sum_{i=0}^{n} \theta_i TINDEX_{t-i} + \varepsilon_t \quad (3)$$

For the long-run adjustment and short-run dynamics, the following model will be estimated.

$$\Delta(PCI)_t = \sum_{i=1}^{n} \beta_i \Delta(PCI)_{t-i} + \sum_{i=0}^{n} \sigma_i \Delta(TINDEX)_{t-i} + \theta(ECM)_{t-1} + \varepsilon_t \quad (4)$$

Eq (4) estimates the short-run relationship and the speed of adjustment toward the long run. If $\theta(ECM)_{t-1}$ is negative and statistically significant then the dependent variable will converge to its equilibrium in the long run by the speed of $\theta(ECM)_{t-1}$.

3.5. Basic Model for Tourism and its Determinants

$Tindex_t = \beta_1 + \beta_2 FTS_t + \beta_3 TERR_t + \beta_4 CI_t + \beta_5 MR_t + \beta_6 HI_t + \beta_7 CPI_T + U_t$ (5)

Where in equation (5), $Tindex$ is the tourism index, FTS represents fixed telephone subscription proxy for ICT infrastructure, $TERR$ represents numbers of terrorism incidents, CI is the crime index, MR is the military regime, HI is the transport and storage communication proxy for hard infrastructure, CPI represents inflation.

$\beta_1\ is\ constant$

MR = Dummy variable. For military regime periods, we assign 1, and for democratic government, we assign 0.

CI = crime index, this index has been made from, murders, kidnapping, and robberies through principal components analysis (PCA)

U_t is the error term.

For ICT infrastructure we have used a proxy fixed telephone subscription. This variable was part of PCA indexes constructed by many other studies (Adeleye, 2023, Sharma et al., 2022). Moreover, different variables and PCA indexes constructed from different variables were used by the existing studies as a

proxy for ICT infrastructure (Lee et al., 2022, Lee et al., 2021). However, due to data limitations on other variables, this study has used only FTS as a proxy for ICT infrastructure.

3.6. ARDL Specification for Tourism Determinants Model

In the model below, α_0 is the drift term and α_i are the long-run coefficients where i= 1, ……, 7, the σ_i, $\delta_i, \gamma_i, \phi i, \theta i, ¥i$, representing short-run coefficients of the model and ε_t is the error term.MR is a dummy variable used for military regimes. Therefore, there are no lags, and no differences form of the MR.

$$\Delta(Tindex)_{t=}\ \alpha_0 + \alpha_1(FTS)_{t-1} + \alpha_2(TINDEX)_{t-1} + \alpha_3(HI)_{t-1} + \alpha_4(MR)_t + \alpha_5(CINDEX)_{t-1} + \alpha_6(CPI)_{t-1} + \alpha_7(TERR)_{t-1} + \sum_{i=0}^{n} \beta_i \Delta(FTS)_{t-i} + \sum_{i=1}^{n} \sigma_i \Delta(TINDEX)_{t-i} + \sum_{i=0}^{n} \delta_i \Delta(HI)_{t-i} + \sum_{i=0}^{n} \phi i \Delta(CINDEX)_{t-i} + \sum_{i=0}^{n} \theta i \Delta(CPI)_{t-i} + \sum_{i=0}^{n} ¥i \Delta(TERR)_{t-i} + \varepsilon_t \quad (6)$$

The existence and absence of long-run relationships through testing hypothesis will be formulated as. The null hypothesis of (no long-run relationship):

$$H_o: \sum_{i-1}^{N} \alpha_i = 0$$

Alternative hypothesis of (long-run relationship)

$$H_1: \sum_{i-1}^{N} \alpha_i \neq 0$$

For checking the evidence of long-run relationship F-test is used. In case of evidence of finding co-integration among the variables in the model (7) the next long-run model (8) will be estimated

$$(Tindex)_t = \alpha_0 + \sum_{i=0}^{n} \beta_i FTS_{t-i} + \sum_{i=1}^{n} \theta_i TINDEX_{t-i} + \sum_{i=0}^{n} \delta_i (TERR)_{t-i} + \sum_{i=0}^{n} \gamma_i (HI)_{t-i} + \lambda_i(MR)_t + \sum_{i=0}^{n} \phi_i (CI)_{t-i} + \varepsilon_t \quad (7)$$

If equation 7 is satisfied, then we will use the following one.

$$\Delta(Tindex)_t = \sum_{i=0}^{n} \beta_i \Delta(FTS)_{t-i} + \sum_{i=1}^{n} \sigma_i \Delta(TINDEX)_{t-i} + \sum_{i=0}^{n} \delta_i \Delta(HINF)_{t-i} + \sum_{i=0}^{n} \gamma_i \Delta(CINDEX)_{t-i} + \sum_{i=0}^{n} \phi i \Delta(CINDEX)_{t-i} + \sum_{i=0}^{n} \theta i \Delta(CPI)_{t-i} + \sum_{i=0}^{n} ¥i \Delta(TERR)_{t-i} + \alpha_4(MSTABILITY)_t + \theta(ECM)_{t-1} + \varepsilon_t \quad (8)$$

Equation (8) estimates the short-run results and the error correction term ($\theta(ECM)_{t-1}$) shows conversion to equilibrium in the long run, where the value of θ is theoretically said to be negative.

4. Results and Discussions

Table 1 represents the descriptive statistics of all variables. The mean value of the dependent variables per capita income is 1131.687 and the tourism index (Tindex) is 652.141. Moreover, RERR terrorism incidents have the smallest value which is 2 and it is also not normally distributed the p-value of Jarq-Bera is 0. However, of these all variables, TERR is the most uncertain variable.

Table 1. Descriptive statistics

	PCI	**TINDEX**	**HI**	**FTS**	**CINDEX**	**CPI**	**RERR**
Mean	1131.687	652.141	248913.5	4034908	13033.18	7.942	35
Median	1144.664	577.378	230184	3596537	13262.55	7.645	16.5
Minimum	931.701	274.719	13259	2376786	7217.41	2.529	2
Maximum	1452.852	1061.375	690140	6370860	24131.01	20.286	213

S-Deviation	171.680	134.943	205822.7	1300313	4399.188	4.153	49.489
Jarq-Bera	1.873	2.143	1.975	2.622	0.749	4.708	53.246
J-P Value	0.392	0.396	0.372	0.270	0.688	0.095	0
Skewness	0.446	-0.219	0.494	0.457	0.356	0.904	0.219
Kurtosis	2.034	1.661	2.080	1.740	2.570	0.378	8.208

Source: Authors' Calculation

Table 2. Augmented Dickey-Fuller Test Results

	At level		At first difference		
Variables	**t-statistics**	**p-value**	**t-statistics**	**p-value**	**Conclusion**
PCI	-4.360821	0.0107	…	…	I(0)
TINDEX	-1.739541	0.703	-3.959798	0.0004	I(1)
FTS	-0.224426	0.5953	-3.761894	0.0006	I(1)
HI	-0.86804	0.9407	-4.853715	0.0007	I(1)
CINDEX	-4.926239	0.0043	…	…	I(0)
TR	-2.856817	0.1926	-7.78542	0	I(1)
CPI	-2.369967	0.1598	-7.795726	0.0001	I(1)

Source: Authors' Calculation

Table 2 shows the result of the unit root test that reveals that GDP per capita and crime index are stationary at a level. While other variables are stationary at first difference.

Table 3. ARDL Bound Test for Economic Growth and Tourism

Lower Bound	**Upper Bound**	**Significance**
3.02	3.51	10%
3.62	4.16	5%
4.18	4.79	2.5%
4.94	5.58	1%
F-statistics = 4.15 (10%)		

Source: Authors' Calculation

Table 3 represents the results of the bound test for the long-run relationship between tourism and per capita income, which is a proxy for economic growth. Based on the F statistics which exceed the upper bound limit at a 10% level of significance. Hence, we reject the null hypothesis of no co-integration and accept the alternative hypothesis of co-integration between economic growth and tourism.

Table 4. Long Run Coefficient of ARDL

Variable	**Coefficient**	**Std-Error**	**T-Statistics**	**P-Value**
Tindex	0.75404	0.187417	4.023325	0.007
C	706.3955	99.1174	7.126857	0.000

Source: Authors' Calculation

Table 4 indicates that there is a positive and statistically significant long-term association between economic growth and tourism. If 1 unit increase occurs in tourism the economic growth will grow by 0.75 percent. Moreover, our results are steady with the results of many other existing studies in terms of

sign For example, Fareed et al. (2018), Rehman et al. (2020), Naseem (2021), Azam et al. (2022) and Khan et al. (2022), these studies confirmed the long-run link between economic growth and tourism.

Table 5. ECM Results between Tourism and Economic Growth

Variables	coefficient	std-error	t-statistics	p-value
D(PCI(-1))	0.394567	0.15404	2.56146	0.0186
cointEq(-1)	-0.122671	0.033122	-3.173644	0.0014
R-Squared = 0.57 Adjusted-R = 0.55				

Source: Authors' Calculation

Table 5 shows that there is a positive short-run relationship between economic growth and tourism based on statistical evidence. Further, the ECM value is negative and statistically significant, meaning that the dependent variable will move from disequilibrium to equilibrium with a 12 percent speed of adjustment after one year.

Figure 1. CUSUM Test

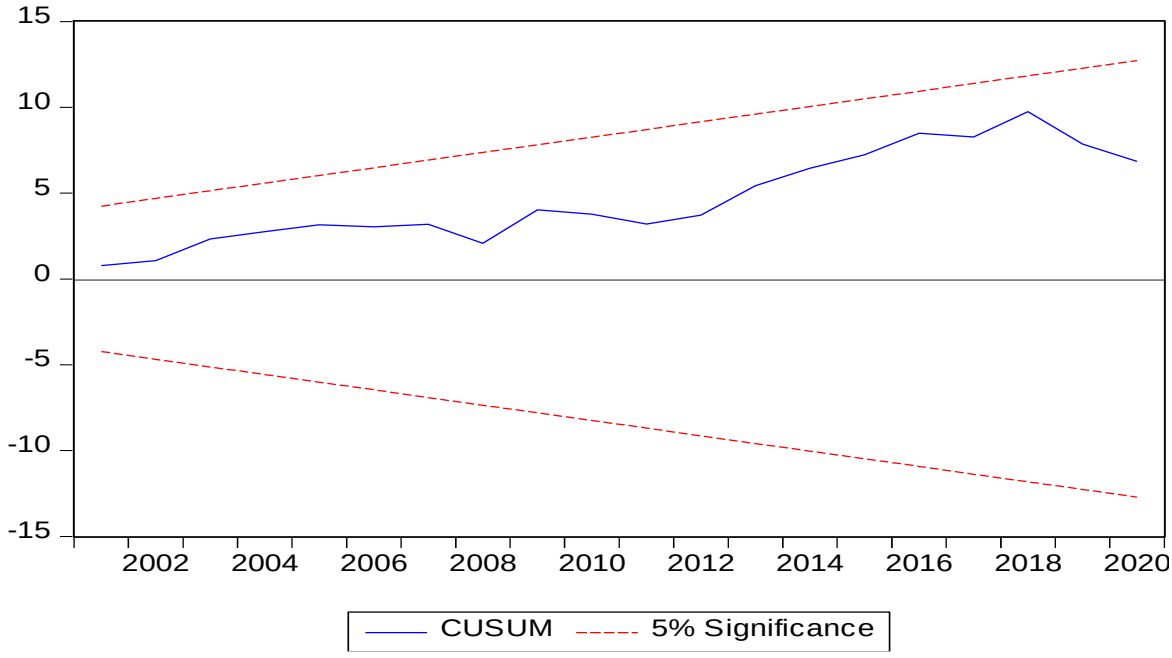


Figure 1 CUSSUM test confirms the stability of coefficients over a period of time. Whenever the coefficients are stable, we accept that the model is stable.

Table 6. Other diagnostic test results

Test	f-statistics	p-value
White heteroscedasticity	0.791945	0.6292
Ramsey specification	0.510793	0.2474
Serial LM test	0.49387	0.6183

Source: Authors' Calculation

Table 6 indicates that there is no heteroscedasticity and nor there is a miss specification of the model. In the white test, we accept the null hypothesis of homoscedasticity. While in Ramsey reset, we accept the null hypothesis of no miss specification and in the serial LM test we accept the null hypothesis of no autocorrelation at all levels of significance.

Table 7. Correlation Matrix

	CPI	**FTS**	**HI**	**CI**	**TERR**
CPI	1				
FTS	0.370254	1			
HINFRAS	0.099938	-0.079597	1		
CINDEX	0.443453	0.403575	0.7537445	1	
TERR	0.462526	0.568373	0.086893	0.4477411	1

Source: Authors' Calculation

Table 8. ARDL Bound Test for Tourism and Its Determinants

Lower Bound	**Upper Bound**	**Significance**
2.12	3.23	10%
2.45	3.61	5%
2.75	3.99	2.50%
3.15	4.43	1%
F-statistics = 7.806297		

Source: Authors' Calculation

Table 7 represents the correlation coefficients between explanatory variables. Further, it indicates that there is no severe multicollinearity, and all the coefficients are desirable.

Table 8 shows us the results of the bound test for tourism and its determinants model. Based on F-statistics which exceed the upper bound values at all levels of significance. Hence, we reject the null hypothesis of no cointegration and accept the alternative of cointegration among the variables.

Table 9. Long Run ARDL Results

Variable	**Coefficient**	**std-error**	**t-statistics**	**p-value**
FTS	0.00024	5.03859	4.7685	0.005
HI	0.0002348	0.000294	7.985401	0.0005
CPI	15.13381	7.00622	2.160053	0.0832
MR	-159.269	66.87544	-2.381577	0.063
CINDEX	-0.08284	0.025358	-3.266783	0.0223
TERR	-1.804773	0.446377	-4.043157	0.0099
C	242.3032	102.8352	2-356229	0.0651

Source: Authors' Calculation

Table 9 represents the long-run relationship between tourism and its determinants. Further, we obtained that FTS, which is a proxy for technology has a positive and statistically significant slender impact on tourism. Moreover, this result is consistent in terms of signs with other foreign studies such as Lee et al. (2021), Sharma et al. (2022), Adeleye (2023), and differs from Nadeem et al. (2020), results in terms of sign in case of Pakistan. Similarly, hard infrastructure has a positive and statistically significant weak impact on tourism in Pakistan.

However, the weak impact of FTS and HI may be due to two reasons. The first one is, that the government of Pakistan has not been able to fully concentrate on the long run-on soft infrastructure and hard infrastructure. Another, the weak impact of FTS and HI can be linked with terrorism. Khan and Rasheed (2016) revealed in their study that whatever, efforts made by the government for tourism development will be meaningless until terrorism is eliminated. I is found that terrorism has a strong statistically significant negative impact on tourism. If the number of incidents increases, it will create threats and uncertainty and will lead to a decrease in tourism by -1.80.

The results of terrorism are uniform in sign with many other studies, including Khan and Rasheed (2016), Raza and Jawaid (2013), Santana-Gallego et al. (2016), and Nadeem et al. (2020). Moreover, the relationship between tourism and CPI is positive and statistically significant in the long run and it differs from other study's findings. The logical reason behind this relationship may be the exchange rate depreciation in recent years. Researchers claimed that in Pakistan exchange rate depreciation has a major role in inflation in Pakistan (Khan and Gill, 2010). Maybe it's due to the indirect link of exchange rate depreciation with tourism. Thus, tourists may be replaced by exchange rate depreciation over inflation. Because, if changes in exchange rate depreciation are greater than changes in inflation rate, it will provide economic benefits for international tourists in the form of purchasing power.

The crime index has a statistically significant long-run negative relationship with tourism in Pakistan. Countries where crime activities prevail will destroy the soft image of those countries and will lead to a fall in the inflow of international tourists. Hence, in the case of Pakistan, if there is a unit increase in crimes, it will decline the tourism by -0.08. Moreover, this result aligns with other studies' findings in terms of sign (Rauf et al., 2022, Santana-Gallego et al., 2016, Moyo and Ziramba, 2013). Furthermore, it is found that MR, which is a proxy for military regimes, has a statistically significant negative impact on tourism in Pakistan.

The dictatorship comes into power by force, which deviates from democracy and foreign tourists are more sensitive towards the democratic system. The coefficient value of dictatorship is -159.2690. It means due to military regimes the tourism industry suffered a lot from dictatorship and is still suffering due to the poor decisions of the past. Further, it shows us, that if dictatorship gets control in Pakistan, it will have serious negative consequences on tourism and will decline tourism by -159.2690, in Pakistan.

Table 10. ECM Results of Tourism and Its Determinants

Variables	coefficient	std-error	t-statistics	p-value
D(fts)	8.743201	3.660015	2.384669	0.0298
d(HI)	0.001001	0.000454	2.206446	0.0423
d(CPI)	15.79089	7.309389	2.160358	0.0463
d(TERR)	0.208736	0.356798	0.585025	0.5667
MS	-18.58214	39.45617	-0.470956	0.644
d(CINDEX)	-0.040952	0.023486	-1.743702	0.1004
Ect(-1)	-0.941732	0.298124	-3.158855	0.0061
C	27.90695	26.82736	1.040242	0.3137

Source: Authors' Calculation

Table 10 represents the short-run relationship between tourism and its determinants. Further, the results revealed that FTS, HI, and CPI have a positive and statistically significant short-term impact on tourism. While military regime, cindex has a statistically insignificant negative impact on tourism in the short run. It is found that terrorism has a positive impact on tourism, but statistically insignificant. The value of the ect(-1) is -0.941732 and statistically significant. It means, that the dependent variable will move to its equilibrium by the speed of adjustment -0.941732 after one year. The overall model is significant at a 10 percent level of significance.

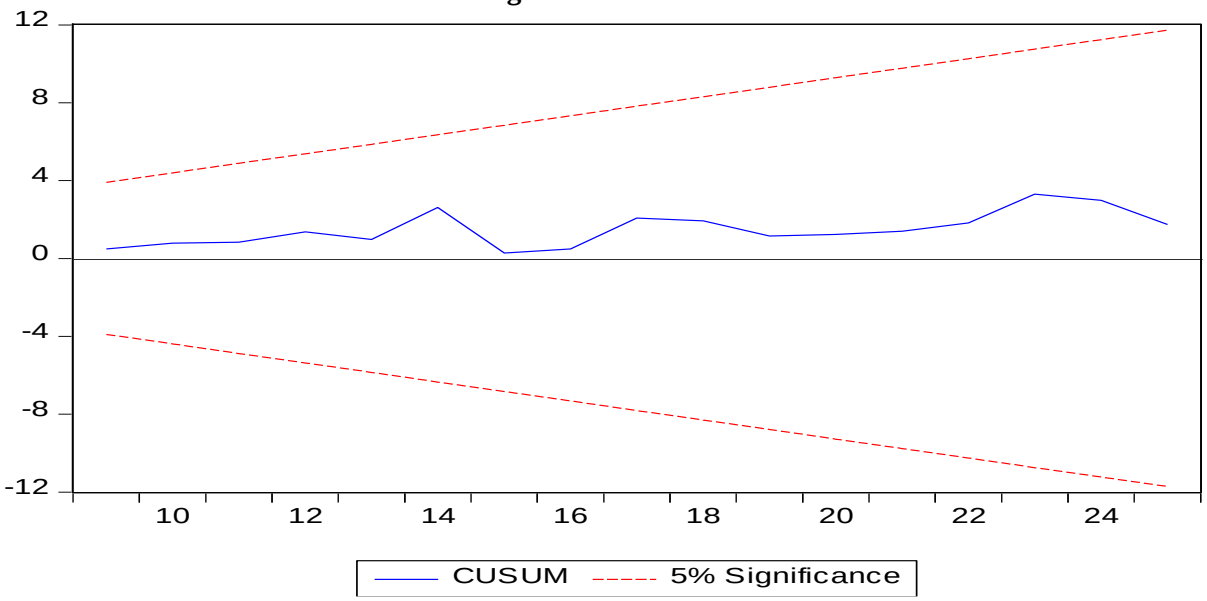
Table11. Diagnostic tests results

Test	f-statistics	p-value
ARCH	0.969660	0.3360
Ramsey specification	0.799561	0.4357

Source: Authors' Calculation

Based on table 11 we accept the null hypothesis of no heteroskedasticity and as well accept the null hypothesis of no miss specification of the model.

Figure 2. Cusum Test



The cusum test shows that a green line occurs between upper and lower red lines, and it confirms the stability of the model.

5. Conclusions and Policy Implications

Tourism plays a crucial role in the economic growth of the countries. It encourages foreign exchange reserve and income generation; and creates employment directly and indirectly, in the domestic economy. Therefore, this study has used two models to analyze the impact of tourism on economic growth and tourism determinants. For this purpose, we gathered time series data from the period 1995 to 2021 and estimated short-run and long-run results using ARDL. For obtaining valid results this study employed different statistical tools, such as the augmented Dickey-Fuller test (ADF) for unit root, White and ARCH for the detection of heteroscedasticity, Correlation Matrix for multicollinearity detection, CUSSUM Test for checking the stability of the models. Moreover, this study has constructed tourism and crime indexes for the first time.

In the first model, it is found that tourism has a statistically significant relationship with economic growth in the short run as well as in the long run. If a positive shock occurs in tourism, it will boost the economic growth of Pakistan While, in the second model, terrorism, crime index, and military regime, are influential factors, which adversely affect tourism in Pakistan in the long run. Furthermore, the nexus of tourism was positive with fixed telephone subscription (FTS) which is a proxy for technology infrastructure and transport and storage communication (HI) in the long run. However, its impact was negligible. In the short run the consumer price index (CPI), FTS, and HI have a positive effect on tourism. In addition, the model diagnostic tests show that there were no problems of autocorrelation and heteroscedasticity, Ramsey reset test and Serial LM test results were also satisfactory.

In light of the empirical findings the study suggests the following policy options: To increase the contribution of tourism to the economy, the government needs to explore the natural beauty,

archeological spots, and cultural beauty, in the world through different advertisements. Moreover, the government must overhaul the organization, which has been authorized for the development of the tourism industry in Pakistan. Furthermore, the government needs to pay more attention to the hard infrastructure and soft infrastructure which are necessary for boosting tourism in the economy. Soft infrastructure means that different artificial things with highly equipped technology should be developed in tourist destinations to attract tourists.

Secondly, the ICT infrastructure needs to be developed to provide accessibility to foreign tourists through different software applications- visa service should be advanced so that foreign tourists may not face any difficulty in getting visas. Tourism organizations need to provide all information regarding the different tourist destinations on software so that foreign tourists get information easily. However, before spending a significant amount on ICT infrastructure and hard infrastructure, the government should design an effective policy and plan to tackle terrorism in Pakistan. If the terrorism issue is resolved completely, then spending on both infrastructure for tourism, and advertisement for tourism will bring fruitful output.

Moreover, to provide a clean environment without criminal activities, the government must advance the police system to reduce criminal activities in tourist destinations. It will not only play an important role in the reduction of criminal activities but also will reduce terrorism in Pakistan.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure statement

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Impact of Income Inequality and Population Density on Carbon Emissions in Pakistan

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Abstract

This research inspects the consequence of the contribution of income inequality towards CO_2 and the role of the urban population in the case study of Pakistan. The purpose of this study is to assess the influence of the high population density of Pakistan and income inequality on carbon emanations. The current study employed statistics of time series of the years from 1985 to 2020 by applying the approach of ARDL bounds testing to achieve this goal. Empirical results for the carbon emissions confirm the occurrence of a long-run co-integration relationship between population density and income inequality. The results of the error-correction visualization of the ARDL model indicate that all predictors and their lagged values influenced the dynamics of CO2 emissions in Pakistan from 1985 to 2020. The outcomes of the current study specify that there is a direct relationship between carbon emission and inequality of income, population density, GDP, GDP square, and urban population. The estimated results specify that as the contribution of low-income groups rises in Pakistan the emission of carbon also rises. This study also confirms that increasing population density will increase carbon emissions. The observed outcomes of this research offer policy implications that should focus on providing subsidies for clean energy to diverse groups, especially in urban areas.

Keywords: *Environmental Degradation, Population Density, Income inequality, Carbon Emission, Sustainable Development*

JEL Classification: Q53, Q23, E24, O1, Q52

1. Introduction

The world has been facing severe environmental as well as social disasters. In the previous few decades, carbon dioxide emissions have rapidly increased. During the previous years, Pakistan contributed continuously to post substantial expansion in carbon emissions and has seemingly postulated certain severe doubts about the atmosphere (Baloch et al. 2017). For different socio-economic classes, the contribution of carbon emissions is different. The poor and underprivileged societies can be a serious threat to contributing towards CO_2 due to the lack of resources in urban areas (Zhu et al., 2018). Essentially, the affiliation between income disparity and environmental degradation has been ignored in the mainstream of emerging countries. Greater income disparity can deteriorate the degradation of the atmosphere for the reason that when a greater disparity in income, it is claimed that natural resources are spoiled by needy people. According to Grunewald et al. (2017), Superior income disparity is associated with higher carbon emissions in high-income and upper-middle-class economies, while larger income disparity is associated with lower carbon emissions in middle-class and low-income economies (Yasmeen et al., 2024).

In developing nations like Pakistan, the source of CO_2 emanations can be due to the higher density of the population, in especially urban areas. Because poor or low-income people exploit more fossil fuels for heating or cooking purposes and owing to this, they emanate additional carbon dioxide into society.

Even in the urban areas of emerging nations like Pakistan, the posh urban area adores additional resources instead of the group of lower income who survive in kachi abadi. Furthermore, these classes of lower income are restricted to living in an area of heavily populated and they cannot have the funds for greenhouses and further resources.

In countries like Pakistan, environmental degradation increases because of rapid urbanization too. This is urbanization at a rapid pace because of a shifting of residents to urban areas from rural areas as well as an urban population increase. Leading to the upsurge in pollution, all main cities of Pakistan face random and unplanned development. In the cities, the wide practice of fuel that is of low-quality and mutually intense extension in the number of vehicles on highways has produced substantial difficulties of pollution of air because of which in most populous cities of Pakistan the level of air pollution is rising and producing serious problems relating health.

In Pakistan, the mainstream of the population uses outmoded automobiles, and folks do not pay enough devotion to their maintenance, which results in contamination in the metropolises. As weighty automobiles consume great diesel, they emanate enough carbon dioxide. Industries and companies trust old, heavy vehicles that are not maintained properly, which results in the emanations of carbon. Furthermore, industries are focused on cities, so all heavy vehicles are liable for the deterioration of the environment. Not every vehicle has the same effect on the atmosphere. The exhaust of electric vehicles does not produce any noticeable pollution. On the other hand, when they are powered by energy produced from non-renewable resources like coal, oil, and natural gas, they release pollutants inadvertently. Outdated diesel vehicles emanate straight contaminants, albeit not all vehicles emanate the same volume. Folks from the well-off can buy electric or newer model vehicles, at the same time as those folks from poor families can only afford old model cars. Thus, the primary source of carbon emanations is the poor circle. Poor quality of air can be created by the removal of toxic areas, public transportation, and traffic mobbing. In Pakistan, poor quality of air and smog are triggered by the smoke from brick kilns, industrial pollutants, and cars, burning of grain crops by residual, and overall solid waste, which has an impact on the whole city. It is destructive to the health of the inhabitants.

According to the widely regarded BP Energy (2021) statistics evaluation of World Energy, countries with a high population density were responsible for 52% of worldwide carbon dioxide emissions in the past year 2020. The main cause of high GHG emissions is the increasing energy demand in transportation brought on by a large population. About 24% of the world's CO_2 emanations are attributable to the transportation industry, with road transportation contributing the most.

There is conflicting data about the connection between income inequality and CO_2 emissions in the body of the current study. Higher-income disparity has been linked to decreased CO_2 emissions, according to certain research (Ravallion et al., 2000; Heerink et al., 2001; Boyce, 2007; Qu and Zhang, 2011; Guo, 2014). Nonetheless, alternative research indicates either that there is no effect (Borghesi, 2006; Wolde-Rufael and Idowu, 2017) or that income inequality is positively correlated with carbon emissions (Gassebner et al., 2008; Baloch et al. 2020; Drabo, 2011; Golley and Meng, 2012; Baek and Gweisah, 2013; Zhang and Zhao, 2014; Hao et al., 2016; Kasuga and Takaya, 2017; Knight et al., 2017; Zhu et al., 2018). In a similar vein, Sager (2019) estimates the number of Environmental Angle curves for the US from 1996 to 2009 and concludes that household carbon is significantly influenced by wealth. Regarding methodology, the majority of studies employ either panel data (Ravallion et al., 2000; Borghesi, 2006; Gassebner et al., 2008; Drabo, 2011; Hübler, 2017; Ahmed, 2024) or cross-sectional data (Heerink et al., 2001; Golley and Meng, 2012; Jorgenson et al., 2017; Kasuga and Takaya, 2017; Knight et al., 2017) for a large sample of nations covering various income levels and time periods. The rest are country-specific and based on time series data (Baek and Gweisah, 2013; Knight et al., 2017) or panel data (Hao et al., 2016).

Most of the research that has already been done usually shows that the results vary depending on the sample nations selected, the econometric methods used, and the income inequality measure. Grunewald et al. (2017) discovered, for instance, that greater disparities in earnings are interrelated to lower CO_2 emissions in low- and middle-income nations and higher CO_2 emissions in upper-middle- and high-income economies. When measuring income inequality in terms of the wealthiest 10% of the population, Jorgenson et al. (2017) found a positive correlation between income inequality and CO_2 emissions; however, when measuring disparities of earnings using the Gini coefficient, the correlation was null. Using quantile regression (QR), Hübler (2017) discovered a negative correlation between emanations of carbon along with disparity of earning; however, fixed effects (FE) regression revealed no such correlation.

There are several reasons why the relationship between CO_2 emissions and income inequality might vary over time. Changes in the rate of urbanization, awareness of and attitudes toward climate change, improvements in environmentally friendly technologies, adjustments to government policies regarding environmental protection, and structural changes are some possible sources of complexity. We make multiple contributions to the body of current literature. This is the first study to calculate the link between CO_2 emissions and income disparity across time for various life stages. To do so, we included the top 10% of income holders, the middle 40%, and lower-income groups separately so that we can see the impact of income inequality on environmental degradation.

A second contribution is that this research included urbanization and transport energy consumption. The contribution of developing countries in CO_2 emissions is surpassing that of developed countries (Batool et al. 2023). In developing countries like Pakistan, there is not much industry and there is enhanced CO_2 emissions. What is the source of this environmental degradation? The answer is simply the contribution of other factors like urbanization, and transport energy consumption. The functions that are specific to a country are especially crucial because different countries have different rates of urbanization, energy, investment, and environmental policies, which lead to varying CO_2 emission levels. As a result, the relationship between income inequality and CO_2 emissions is probably going to exhibit inconsistent trending patterns. The effects of population density, transportation energy, and income inequality on carbon emissions in Pakistan were examined in this study.

This research contributes to the literature by highlighting that poor and low-income groups contribute more to carbon emissions due to high population growth and urbanization. Therefore, this is an important study in Pakistan that examines the relation amongst disparity of income, the density of population along per capita the gross domestic product, population density in cities, and emissions of carbon.

2. Review of Literature

The present study empirically evaluates the connotation amongst income disparity and density of population, sideways with the per capita GDP and the urban population on the emissions of carbon in Pakistan. the examination of the disparity of income sideways with degrading the environment has not been recognized with adequate deliberation and consequently, it arrives as an incipient and warm research occurrence in the experiential literature. Current portions deliberate previously theoretical literature, in addition to detailed literature from preceding research and the research gap.

A study by Ahmed and Luqman (2024) focused on the climate change adaptation tactics embraced by the urban population of Pakistan. The research investigated 450 urbanites in Rawalpindi, using the model Heckman's Treatment effect the results show that education and income positively correlate with

urbanites' adoption of suitable adoption methods. The urbanites if they have a strong knowledge about patterns of temperature and rainfall are inclined to apply at hand adoption techniques.

Choi et al. (2010), examine the presence of the Environmental Kuznets curve (EKC) for the emanations of carbon and its causal relation with openness and the growth of the economy. The current study uses the data of time series from the period 1971-2006 of China. China shows an N-shaped curve of the Environmental Kuznets Curve (EKC) while Japan shows a U-shaped Environmental Kuznets Curve (EKC). The current study shows the dynamic relation among the variables by implementing a model of vector autoregression or a Vector Error Correction Model (VECM). The consequences of this study show that there is an indication of large heterogeneity among the impacts of variables and the countries.

Guo (2013), investigates the interesting relationship between the Kuznets curve of income and carbon. The study used the estimated methods of random effects (RE), fixed effects (FE), and feasibly generalized least squares (FGLS). The results show that the disparity of income of a cross-country has an indirect consequence on the average level of emanations of carbon dioxide (CO_2) but a direct consequence on the aggregate elasticity of income of the releases of carbon dioxide (CO_2). Secondly, there is a presence of an inverted-U relation among the emissions of per capita carbon dioxide (CO_2) and income per capita in all samples of countries and the groups of higher income and lastly, the negative or indirect consequence of income discrepancy on the average level of the releases of carbon dioxide (CO_2) diminish alongside with the per capita growth of income.

Another study by Ota (2017), inspected the form of the Environmental Kuznets Curve (EKC) for a sample of 20 member countries of Asian ADB to evaluate the influence of growth of an economy on degrading the environment. This study shows that both Asian trends in the disparity of income and the degrading the environment appear, generally, to follow Kuznets' hypothesized curve up to the lesser level of great income as income increases, although divergent trends could be detected between economies that are in the range of great income. There are Irregularities in the curves that show changing relationships (i.e., the relation between income and the emissions of carbon, and the connection between income and the inequality of income) that seem to develop increasingly difficult.

A recent study in China about a new trend of inequality of carbon footprints in different provinces of China was conducted, and the quantity of additional CO_2 emissions linked with numerous poverty-lessening schemes was used to calculate the climate burden. The results show that eliminating poverty will not stop the nation from meeting its climate goals with an average increase of 0.1%-1.2% carbon footprints annually by the household (Sun, Mi, Du, & Coffman, 2024).

Zhang et al. (2017), evaluate the unequal impacts of consumption of household through different income households overall carbon emissions, by employing a method of hypothetical extraction and the model of semi-closed input-output. The outcomes of the current study show that the impact on the releases of carbon created by the consumption of the households of urban areas is 1.8 times approximately that of consumption of rural households. Secondly, the economy by excluding the consumption of the households of higher income would cause superior reductions in carbon emissions than lower-income households. Thirdly, from the food sector, the relative decline of families the emanation of carbon is the greatest, whereas least from the residential sectors. Another study by Yang, Ali, Hashmi, and Jahangir (2022) also worked on the relationship between income inequality, institutional quality, and CO_2 emissions where the results show that the increase in income inequality leads to an increase in CO_2 emissions.

Islam et al. (2017), analyzed the relationship between the degradation of the environment (carbon emission), total consumption of energy, growth of an economy, and the expansion of the industrial

production index in a case study in Bangladesh from period 1998 to 2013. Vector Auto Regression Model and variance decomposition of VAR (Vector Auto regression) were used to evaluate the outcome of such variables on the emissions of carbon. The outcomes of the VAR model suggest that GDP per capita and industrial production have a direct connection with the emission of carbon. Moreover, investigation through variance decomposition indicates over time, emissions of carbon have a reliable influence on industrial production, while industrial production has a greater effect on carbon emanation in the short period that disappears in the long term which is reliable with the hypothesis of Environmental Kuznets Curve (EKC).

Baloch et al. (2018), inspect the consequence of the growth of an economy and income inequality on the degradation of the environment in Pakistan by using the approach of ARDL bounds testing from 1966 to 2011. The estimated outcome of this study shows that emissions of carbon increase with the increase in the gap of income in Pakistan. The study confirms that the growth of an economy in Pakistan comes up with greater emanations of carbon and the hypothesis of the Environmental Kuznets Curve (EKC) is not effective for Pakistan throughout the research period. In another research, Khan & Yahong, (2021), applied the co-integration approach of an Autoregressive Distributive Lag (ARDL) along with Nonlinear Autoregressive Distributive Lag (NARDL) in the framework of Pakistan for the year 1971–2015, investigating the short and long-run influence of poverty, population, income disparity, and GDP per capita on carbon dioxide (CO_2) emissions. The symmetric results of this study reveal that the size of population, poverty, and GDP per capita all raise emanations of carbon in the long and short run, whereas income disparity has no effect. However, in the long run, wealth disparity reduces the degradation of the environment in terms of carbon emissions. The NARDL study backs up the ARDL findings, indicating that poverty, growth of an economy, and population have a direct influence on the emanations of carbon in Pakistan.

Ali et al. (2022), inspect the influence of the development of the economy, usage of fossil fuels, and the size of the population on the emanations of carbon in Bangladesh, Pakistan, and India from the year 1971 to 2014. A panel Autoregressive distributed lags model was in use, as well as a procedure of Vector error correction. The Granger causality examination is performed to evaluate the direction of causality. The results of auto-regressive distributed lags (ARDL) illustrate that the relation between emanations of carbon and the development of an economy is U-shaped, as predicted by the hypothesis of the environmental Kuznets curve. Consequently, in the long haul, the usage of fossil fuels and the size of the population have a favorable influence on carbon emanations. Secondly, CO_2 has a detrimental influence on the development of the economy. The long-term effects of fossil fuels, foreign direct investment, and total exports on the development of an economy have been overwhelmingly beneficial. CO_2, usage of fossil fuel, and FDI Granger cause economic progress in the near run. Last but not least, CO_2 emissions have a detrimental influence on population size whereas the development of an economy has a favorable influence in the long term.

In South Asia, Pakistan is urbanizing at the quickest rate. The research was conducted with the goal of knowing how Pakistan's urbanites are dealing with climate change. A survey was conducted which gathered the data using Heckman's Treatment effect model on social, economic, demographic, and physical aspects. The explanatory variables were age, education, income, and occupation. The outcome of this research shows that age and other explanatory variables are positively and significantly related to climate change adoption. To survive climate change households with major divergences in the yearly average temperature are more presumable to adopt any adoption strategy. There is lesser respondent adoption capacity because of the considerable amount of variables poverty composes which makes them more susceptible to climate change (Ahmed et al., 2023).

3. Methodology

3.1 Theoretical background

Inequality is a concept of multiple dimensions. From the mid-1990s onwards, many economists have produced numerous theoretical explanations to describe the link between economic disparity and degrading the environment such as Khan & Yohang (2021), Wang et al. (2021), Liu et al. (2020), and many more. Whereas some of the explanations imply a direct link, such as Boyce (1994), Torras and Boyce (1998), and Borghesi (2006)'s "equality hypothesis," others believe that more disparity could be indirectly linked with emanations (Heerink et al. 2001; Ravallion et al. 2000; Scruggs 1998).

The relationship between several measures of environmental deterioration and per capita income is theorized to exist, according to the environmental Kuznets curve (EKC). Pollution emissions rise and environmental quality fall during the early stages of economic expansion, but above a certain level of per capita income, the tendency turns around, and at high income levels, economic growth actually improves the environment. This suggests that the relationship between per capita income and environmental damage or emissions is inverted U-shaped.

The theoretical framework encompasses income inequality, which determines the relation between carbon emissions and the levels of income. According to the EKC hypothesis, environmental pressures increase as income level increases at the initial stage of economic development, but later these pressures diminish along with the income levels (Guo, 2015). Boyce (1994) stated that when the income gap between poor and rich widens then the poor are more likely to overexploit natural resources and increase carbon emissions, while the rich may not necessarily increase investment to improve the environment. Another study states that the underprivileged and poor societies are severely influenced by an unbalanced distribution of income subsequently they are mostly a susceptible portion of the society (Khan & Yohang, 2021).

3.2 Econometric Model

To conclude the association among variables of this study, the econometrics model or equation is as follows:

Were,

$$CO_{2t} = \alpha_0 + \alpha_1 IE_t + \alpha_2 PD_t + \alpha_3 GDP_t + \alpha_4 (GDP)^2_t + \alpha_5 URB_t + \mu_t$$

Where CO_2 denotes the carbon emanations that are measured in metric tons per capita. IE represents income inequality and the proxy for this variable is the top 10%, middle 50%, and bottom 50%. PD represents the population density per square kilometer. GDP represents Gross Domestic Product that is measured as constant 2015 US $. URB represents the urban population that is measured in annual percentage.

The source of variables CO_2 emissions, population density, GDP, GDP square, and urban population is the World Bank (WB). The source of income inequality data is obtained from WID (World Inequality Database).

3.3 Data

The impetus of this study is to investigate the inspiration of income disparity and the density of the population on emanations of carbon. The current research used time series statistics from 1985 to 2020 to attain the objective and assortment of this time period due to the readily available variable data from WID (World Inequality Database) and WB (World Bank). The dependent variable is carbon dioxide CO_2 emission while population density and income disparity for the bottom 50% are taken as independent variables alongside other independent variables such as urban populations, per capita GDP, and GDP square. To identify the objectives of this study, these explanatory variables will help.

The secondary data used to develop the current study came from government organizations. The data on carbon emissions, urban population, population density, and GDP (Gross Domestic Product) and GDP square were attained from the WB (World Bank). Whereas data for income inequality (bottom 50%) is collected from WID (World Inequality Database).

Other explanatory factors, such as GDP per capita, are employed in several research; for example, Kusumawardani & Dewi (2020), Hundle (2021), Mushtaq et al. (2020), Jorgenson et al. (2017), and Hailemariam et al. (2020). Asongu et al. (2020) and Jorgenson et al. (2017) used the urban population.

3.4 Explanation of Variables

3.4.1 Carbon dioxide (CO_2)

One of the greenhouse gases is carbon dioxide (CO_2) which exists naturally in the atmosphere. In this study, carbon dioxide equivalent data CO_2e greenhouse gasses. Data taken from the World Bank (WB) in metric tons per capita. This variable is used in previous research to quantify greenhouse gas emissions (Cui et al. 2021, S Khan & Yahong 2021, Islam et al. 2017 and Wang et al. 2021).

3.4.2 Income inequality

Income inequality is an uneven distribution of income throughout a population. This study has measured the impact of the top 10%, middle 40%, and bottom 50% of income distribution on carbon emissions. Data was collected from the World Inequality Database (WID). This variable is used in various research such as Grunewald et al. (2017), Hundle. (2021), Baloch et al. (2017), Khan et al. (2021), Knight et al, (2017) and Yang et al. (2020).

3.4.3 Population Density

It is the number of individuals per km^2. Data on population density was taken from the World Bank (WB) from the period 1985 to 2018. Population density used in various research e.g., Khan et al. (2021), Muhammad et al. (2020), Rahman et al. (2020), and Aye & Edoja (2017).

3.4.4 Gross Domestic Product (GDP)

GDP is the market value for all finished goods and services that are produced in a specific period and on a border of a country. In this study, the data for per capita GDP measured as constant 2015 US $ taken from the World Bank (WB) from the period 1985 to 2018. The variable per capita GDP used in much research is Khan et al. (2021), Kusumawardani & Dewi (2020), Osadume & University (2021) and Tanchangya & Zhou Ayoungman (2022).

3.4.5 Urban Population

The shifting of population from the countryside to the cities is urbanization. In Pakistan, there is a speedy urbanization because of a shifting of inhabitants to urban areas from rural areas. Data taken from the World Bank (WB) in annual percentage. This variable was used in previous research that is Alabi et al. (2021), Khoshnevis & Dariani (2019), and Khan et al. (2017) to quantify greenhouse gas emissions.

4. Results and Discussions

Table 1 presents a summary of statistics for five different measures (CO2, IE, PD, GDP, and URB) across 35 observations. On average, the CO2 emissions are 0.510 units. The highest observed CO2 emissions are 1.162 units and the lowest observed CO2 emissions are 0.045 units. Similarly, the maximum value of income inequality is 4.312 and the minimum value of IE is 0.045. Population density is also extremely high with an average number of 156 people. This summary provides an overview of the distribution and range of these variables.

Table 1: Descriptive statistics

Measures	CO_2	IE	PD	GDP	URB
Mean	0.510	3.326	156.98	6.321	44.23
Median	0.401	3.283	150.99	6.526	32.36
Maximum	1.162	4.312	252.87	6.440	57.26
Minimum	0.045	3.262	78.012	6.128	40.62
N	35	35	35	35	35

4.1 Unit Root Test Results

The current work used the traditional ADF test has been enhanced, and only the intercepts "at level" [I (0)] and "first difference" [I (1)] are included to assess the unit root problem. The outcome demonstrates that the variables GDP square, income inequality for the poorest 50% of the population, and carbon emissions had unit roots at the first difference mean at the level where they are not stable. The variables that are stationary at the level include income inequality in the top 10%, middle 40%, population density, gross domestic product, and urban population. The estimated findings are displayed in the following table.

Table 2: Unit root results of stationarity

Variables	Augmented Dicky Fuller (ADF) At Level (t-statistic)	Augmented Dicky Fuller (ADF) 1st Difference t-statistic	(P-Value)	Order of integration
Carbon Emission	----	-4.499915	0.0013	I(1)
Income Inequality				I(0)
Top 10% (IE)	-3.008936	----	0.0441	I(1)
Income Inequality Middle 40% (IE)	-2.677192	----	0.0884	
Income Inequality bottom 50% (IE)	----	-3.385672	0.0186	I(1)
Population Density (PD)	-3.686204	----	0.0363	I(0)
Gross Domestic Product (GDP)	-4.056750	----	0.0031	I(0)
				I(1)
Gross Domestic Product square (GDP^2)	----	-4.789942	0.0012	
Urban Population (URB)	-8.439992	----	0.0000	I(0)

After determining that all of the variables are stationary, the current study has opted to use the method known as ARDL, which stands for Autoregressive Distributed Lag to the co-integration technique in order to estimate the model.

4.2 The Long Run Coefficients

To assess the long-term relation amongst variables, the procedure of ARDL certifies the prospect.

Table 3: Long-run ARDL results

Variables	Coefficients	t-statistics	P-value
I.E Top 10%	3.970932	2.960721	0.0138
I.E Middle 40%	2.260352	3.015679	0.0080
I.E Bottom 50%	2.895955	2.606050	0.0165
P.D	0.013642	2.929674	0.0080
GDP	0.132937	3.044239	0.0062
GDP^2	-0.105233	-8.353006	0.0034
URB	0.307151	3.456691	0.0024

Table 4: Error Correction Representation for the Selected ARDL Model

Variables	Coefficient	t-statistics	P-value
$\Delta \ln (CO_2)_{t-1}$	1.4673267	12.269732	0.0001
$\Delta \ln$ GDP	-0.324423	-2.923765	0.0326
$\Delta \ln (GDP)_{t-1}$	-3.078632	-23.17624	0.0003
$\Delta \ln (GDP)_{t-2}$	-2.876342	-15.87354	0.0004
$\Delta \ln (GDP)^2$	0.017923	1.437652	0.1153
$\Delta \ln (GDP)^2_{t-1}$	0.261725	25.72564	0.0001
$\Delta \ln (GDP)^2_{t-2}$	0.167432	16.79873	0.0004
$\Delta \ln$ (I.E Top 10%)	-0.287621	-9.228721	0.0011
$\Delta \ln$ (I.E Top 10%)$_{t-1}$	-0.432661	-9.287381	0.0002
$\Delta \ln$ (I.E Top 10%)$_{t-2}$	0.176254	20.27652	0.0032
$\Delta \ln$ (I.E Middle 40%)	-0.336721	-6.263728	0.0001
$\Delta \ln$ (I.E Middle 40%)$_{t-1}$	-0.238624	-6.736464	0.0021
$\Delta \ln$ (I.E Middle 40%)$_{t-2}$	0.326511	22.78686	0.0062
$\Delta \ln$ (I.E Bottom 50%)	-0.116252	-8.786381	0.0037
$\Delta \ln$ (I.E Bottom 50%)$_{t-1}$	-0.167382	-7.987321	0.0001
$\Delta \ln$ (I.E Bottom 50%)$_{t-2}$	0.272635	21.78563	0.0072
$\Delta \ln$ (PD)	1.278934	24.28651	0.0001
$\Delta \ln$ (PD)$_{t-1}$	0.562966	6.046238	0.0002
$\Delta \ln$ (PD)$_{t-2}$	-2.834216	-4.107621	0.0059
$\Delta \ln$ (URB)	-0.523763	-2.991243	0.0022
$\Delta \ln (URB)_{t-1}$	4.062389	22.997832	0.0022
$\Delta \ln (URB)_{t-2}$	7.319251	22.043281	0.0022
ECT $_{t-1}$	-0.432170	-4.87656	0.0062

The assessed consequences illustrate that in the model, on all the variables CO_2 releases have a positive and strong influence. The consequences of the long run suggest that in Pakistan higher levels of carbon emanations are related to higher income disparity and higher density of population.

Most of the researchers have also verified the direct association between releases of carbon and population density and income disparity e.g., Abdullahi Baba et al. (2024), Wajid et al. (2023)

and Khan et al. (2021) in Pakistan propose a positive effect of poverty, economic progress, and inhabitants on the emanations of CO_2 nevertheless also a negative effect of income disparity on the CO_2 emissions. Baloch et al. (2020) assess that an expansion in disparities in earnings increases carbon releases. Baloch et al. (2017) inspect the indirect effect of the density of the population along with the percentage of industry on carbon emanations. Muhammad et al. (2020) in Pakistan show the usage of energy and the size of the population are contributing emanations of carbon.

The error-correction illustration of the model ARDL is given in the above table. The result shows that all predictors and their lagged values affect the dynamics of CO_2 emissions in Pakistan during 1985–2020.

4.3 Diagnostic Test

Following an analysis of the long-term relationships between the study's variables, additionally, an examination for diagnosis, such as the serial correlation to ensure that the results are robust, the LM test is run. The econometric model is at risk due to serial correlation. Consequently, to ascertain whether a serial correlation existed in the calculated model, the Breusch Godfrey LM Test was employed. As a given probability level rises beyond the allowed threshold of 5%, the "serial correlation" null hypothesis is considered rejected. The Breusch Godfrey LM Test is now being used in this investigation to verify the serial correlation.

Table 5: Estimated Results of Serial Correlation (Breusch-Godfrey Serial Correlation) LM Test

F-statistic	Prob. F(2,19)	Obs*R-squared	Prob. Chi-Square(2)
0.712875	0.5029	2.512858	0.2847

Source: Authors' estimations

From the above-mentioned estimations, the detected R-squared probability Chi-Square is 0.2847 which is higher than 0.05. So, accordingly, the null hypothesis was rejected, showing there is no serial correlation in the data.

4.4 Results of the Stability Test

The calculated model ARDL's constancy was verified using the CUSUM test, and the results supported the model's stability. The results of the stability test are shown in Figures 2 and 3. It indicates that throughout the research period, parameters are stable, and, at a 5% significance level, all coefficients are steady or there are no structural changes in the model. Within the space between the two essential lines, the CUSUM and CUSUMSQ graphs' directions continue.

Figure 1: CUSUM of Recursive Residuals

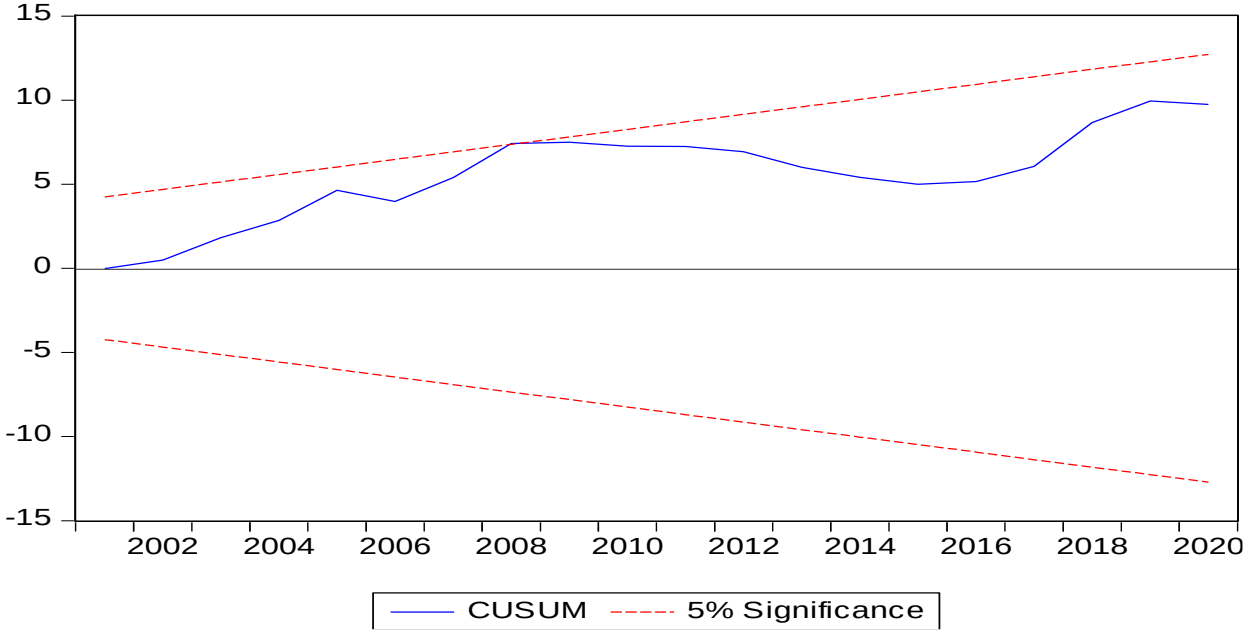
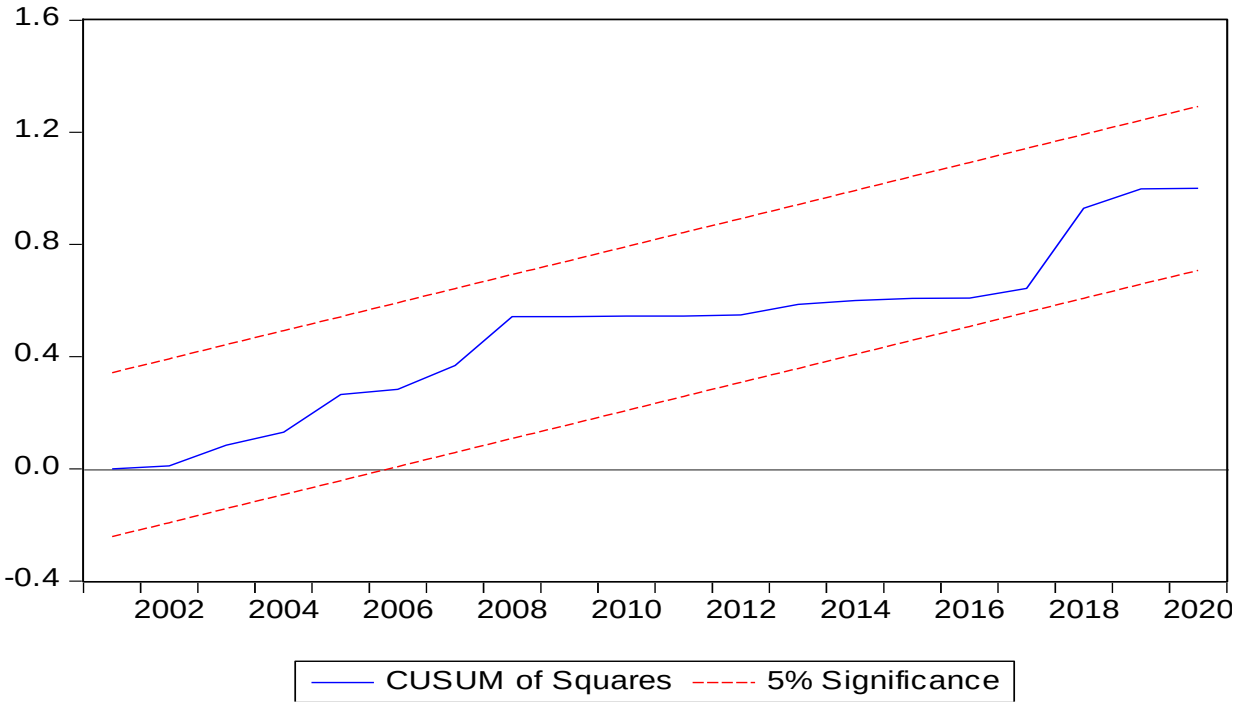


Figure 2: CUSUMQ of Recursive Residuals



5. Conclusions and Policy Implications

To accomplish the goals of this research, the consequences of this research convey a substantial insight by investigating the link between income disparity, population density, and carbon emanations, as well as with urban population and GDP in the model by using the time-series data

from 1985 to 2020 for country Pakistan. The purpose of the current research is to accomplish dependable regression consequences. The consequences of current research found that the disparity of income and density of population are crucial features in influencing the CO_2 emissions in Pakistan as the CO_2 emissions are the enormous involvement to the devastation of the atmosphere. Furthermore, due to enhancing the expansion of population and speedy urbanization, at an incredible rate, the climate of the world is growing, which is badly distressing the environment, which is against sustainable goals.

The consequences demonstrate that there is a strong or direct connotation between population density and CO_2 releases. Therefore, between population density and CO_2 releases, there exists a direct relation. From such results, it is inferred that environmental degradation in Pakistan, the population is the leading cause. Higher population density has absolutely enabled social as well as economic progress, but the higher population density is the reason for increasing the emissions of carbon. The outcomes of the present research also determine that there is a direct relationship that exists between carbon emissions and income disparity. Carbon emissions increase when there is an increase in income inequality. As income inequality increases it can drastically deteriorate the degradation of the atmosphere because due to inequality of high earning, asserted that those in poverty often overuse natural resources because they see it as their last chance to survive. Hence, a greater financial status is linked to greater CO_2 emissions. An increasing trend in income inequality has dreadfully distressed the society of different economic classes.

An increase in per capita GDP and urban population increases the emanations of carbon. Thus, there exists a relation that is positive amid carbon emanations with per capita GDP and urban population. More people are moving from rural areas to urban areas for the sake of getting better opportunities. This is the reason that the population of the cities is increasing gradually, which tends to raise the carbon emanations. The pattern of consumption for energy and fuel has transformed as urban lifestyles have enhanced. Due to urban sprawl and the growth of population, the necessity for automobiles for households is growing, which affects a rise in the traffic volume.

5.1 Policy Implications

To limit the degradation of the environment, the authorities or government of Pakistan should take numerous serious activities built on the consequences of their strategies including the deterioration of income inequality and the size of the population, in addition to a maintainable GDP and the strategy for the urban population.

The consequences of this study demonstrate that fair income distribution can minimize carbon emanations. Policies that assist the accumulation of assets that can narrow the gap in income and boost the minimum wage should be implemented for those who are employed. Moreover, it is recommended that lawmakers consider the necessity of rules pertaining to a friendly work environment so that workers with low salaries can help their struggle to proficiently get more when they can receive more, they can buy more sophisticated appliances and sustain their maintenance of cars that will have it running additional efficiently. That as a result lessens carbon releases. Subsidies are also provided to poor folks by government officials.

The organization of potential public transport should be a strategy to minimize the dependence on private conveyance such as vehicles, to lessen CO_2 emanations in cities. The administration

should diminish the charges for Metro buses so that deprived folks can effortlessly consume conveyance. Furthermore, for the upcoming extenuation of emanations of CO_2, conscious initiatives of the reasons and effects of altering the environment should be broadly encouraged.

The concerned establishments and the government of Pakistan must improve a thorough strategy to make sure that the profits of all the productive as well as economic activities reach the deprived and needy folks. The government should construct factories outside of the cities so that huge and weighty vehicles and trucks with extreme diesel consumption cannot arrive or travel through urban areas. Emissions of carbon can be diminished by accepting such plans. The government should tax those cars that emanate more carbon and contaminate the atmosphere. With the help of social media, the government of Pakistan should train individuals about the suitable maintenance of cars.

This research shows that poor folks or low-income groups discharge more carbon because of the greater density of population in urban areas and income inequality amid them; so, it concentrated on the poor folks of the bottom 50% of income disparity than this study did not based on the whole inequality of income for every sector of the society. There are negligible emissions from the rich class because they have enough money so they can buy electrical appliances and advanced and new models of vehicles, they can also pay high bills of electricity and adequately maintain their automobiles.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure statement

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