Digital Finance and Carbon Emission with Mediating Role of Consumption Structure: A Comparative Study Between Developed and Developing Countries

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Abstract

Digital finance has an advantage for promoting the reduction in cost, reduce the transaction cost and it also decreased the CO2 emission. The whole environment of the world change due to the global warming in the temperature of the world and this temperature is increased due to the carbon emission into the environment and the reduction of CO2 emission is done with the help of the digital finance. The main objective or purpose of the current study is to analyses the relationship between the digital finance and the carbon emission of the developing and underdeveloped countries. In current study the researcher also uses the mediating role of the consumption structure of the countries. They also point out that the future researchers should increase the time period of the data collection for better results and innovation effect on the carbon emission. The data has been collected from the developing and developed countries from 2013-2023. In developing countries Pakistan and India are taken and in developed countries Japan and Australia are selected. Descriptive statistics, Endogeneity tests, robustness tests, heterogeneity tests, correlation matrix and the regression analysis will be done by using the Stata. In regression analysis mediations steps are followed. Current study provides the policy implications to the top management of the companies as well as to the countries so that how can they control the emission of the carbon into the environment and how the consumption structure is control whether it's development-oriented consumption or enjoyment oriented consumption. The policy makers should encourage the people so that they can use the low carbon emission products which also improves the environmental condition of the countries.

Keywords: *Digital finance, Carbon emission, Consumption level, Regression analysis, Development oriented consumption and Enjoyment oriented consumption*

INTRODUCTION

The combination of the information technology and the traditional finance is known as the digital finance. Digital finance has also a same or the similar characteristics of the traditional finance. When the manufacturing and the financial development of the country becomes same then the industrial capital and the financial capital also becomes the same and it also needed by the real economy of the country (Chauvet & Jacolin, 2017). So that's why the upgrading and the optimization of the industrial structure also created. The potential problems also created due to the excessive financial development of the countries. The industrial hollowing out and the abnormal financial development would immoderate the speculation which also cause the excessive financial development (Webber, 2001).

The scope of traditional finance is improved with the help of the digital finance and it also help the delivery of the services to the general public of the countries (Liu et al., 2021). The relationship of the carbon emission efficiency on the digital finance in 283 cities are examined by Zhang and Liu (2022). The offline transactions are decreased due to the digital finance and the capital is directly flow to the low carbon emission industries. It ultimately improves the efficiency of the carbon emission because digital finance creates a low carbon impact. The financial development of the cities or country also plays a vital role in the carbon emission and it also examine the economy and the environment relationship (Wang et al. 2023). Due to the financial development influence

the carbon emission shows U shape of ICT and this is because when the financial development of the country is low it creates the U shape of the carbon emission (Wang et al., 2024).

The previous literature also supported the mechanism of the digital finance because it influences the carbon emission of the country and it is still infancy topic in the previous literature. The technological innovation also shows the significant influence on the digital finance of the countries and among the different potential mechanism of the countries. According to the Wu et al., (2023) the technological innovation and the upgrading industrial structure are considered as the essential mediation mechanism in between the digital finance and the carbon emission of the countries.

The result of the Hao et al. (2023) and Ma (2022) shows the positive relationship between the digital finance and the carbon emission reduction and it becomes possible when the countries invest mostly in the green technological innovation (GTI). The efficiency of the carbon emission also significantly related with the technological innovation of the countries (Wu et al., 2023). The disparities of the carbon emission reduction show the comprehensive impact on the digital finance due to the production technology innovation (PTI) and the green technological innovation (GTI) framework.

The financial services on demand for the small, medium and micro enterprises and farmers becomes so difficult because the companies not easily provide the financial services to the companies (Wang & Guo, 2022). The financial inclusion and financial discrimination also impact on the traditional finance which also becomes the main factor for the real economy of the country (Kling, 2021). The development of the digital finance becomes possible because the countries have not enough traditional financial services for the general public. It also improves or increase the scope of the financial services which ultimately increased the allocation of the financial resources of the countries which at the end improves the industrial structure upgradation and the economic development of the countries becomes possible (Wang & Wang, 2021).

There are some main research questions of current study i.e.

I. What is the relationship between the digital finance and the carbon emission?
II. What is the mediating role of consumption structure in between the digital finance and the carbon emission?

On the basis of the above mentioned research questions some of the research objectives of current study i.e.

I. To examine the direct relationship in between the digital finance and carbon emission.
II. To examine the mediating role of the consumption structure in relationship between the digital finance and carbon emission.

Ye et al., (2023) examined the relationship between the digital finance on the carbon emission. They also analyzed the relationship with the help of the mediators i.e. production technology, innovation technology and the green technology innovation. They analyzed that digital finance indirectly reduces the carbon emission of the country and they suggest that future studies should use this relationship with different context and also takes the consumption structure as a mediator in between the digital finance and carbon emission. So, current study used this gap and analyzed the relationship of the digital finance with the carbon emission with mediating role of the consumption structure in developing and the developed countries.

Literature Review

The concept of the artificial intelligence has been used for the utilization of the digital finance and with the help of the block chain the financial services are provided which at the end improve the qualitative efficiency of the services (Liu et al., 2022). There is a two direct impact of the digital finance on the carbon emission. Firstly, with the help of the online platforms the financial institutions provide the credit to the borrowers and ultimately it also reduced the offline resource and energy consumption which also reduced the carbon dioxide emissions into the environment (Zhang et al., 2023).

The green development requirements are fulfilling with the help of the resource allocation efficiency of the digital finance (Lee et al., 2023). Secondly, the technological benefits can also help the information asymmetry and within the lenders and the borrowers (Demertzis et al., 2018). The digital finance leverage and the financial

institutions would accurately and efficiently would provide the enterprises which are the environmentally friendly and provide the loans to the low consumption and the low-emission businesses which also contribute to the alleviating the pressure of environment.

With the help of the three potential mechanisms the digital finance indirectly affects the CEI. The production process improves and the usage of the energy efficiency with the help of the technological innovation would increase the CEI with the help of the digital finance capital. The carbon emission would rebound the technology innovation and the environmental innovation because digital finance facilities the technological innovation in the production process (Wang & Wei, 2020). The technological innovation would also stimulate the potential of innovation in the digital finance (Wang et al., 2022). The technological innovation also increased the carbon dioxide emissions it would ultimately decreased the efficiency of the carbon emission. The production efficiency improves with the help of the technological innovation and it also decreased the production costs.

The energy consumptions are indirectly increased with the help of the technological innovation and it at the end increased the carbon emissions. Secondly, PTI and GTI are essential to possess the distinct attributes for the digital finance. The environmentally friendly innovation domains can emphasize the advancements of the GTI (Du et al., 2021). Digital finance would directly support the green innovation and research and development and also decreased the carbon emissions, it also guides the government about the financial capital for the green innovations. According to the study of the Feng et al. (2022) and Li et al. (2022) the financial constraints and the financial barriers are increased when the companies used more of the digital finance for the financial development; but the financial support of the companies are increased with the help of the technological innovation which is done with the help of the digital finance. Green technologies are considered as the best or the most common factors which enhance the financial development of the companies. The direct environmental benefits are occurring with the help of the financial development and the use of the green technologies by the companies.

The previous researchers focus on the theoretical discussion and the empirical studies with the relationship of the digital finance and the inclusive development of the companies with the carbon emissions and both the local and the international researchers focus on these main factors (Ding et al., 2022; Wang et al., 2023a). There are two main points which should be considered after the results of the previous researchers. Firstly, the carbon emission is reduced with the help of the digital inclusive finance because it decreased the offline transactions of the companies. By facilitating the trade openness of the companies the financial development decreased the enegery related emission so it ultimately decreased the carbon emissions and it is studied by Shahbaz et al. (2013) Boutabba (2014). According to the study of the Dong et al. (2022) the carbon emission efficiency of the companies are increased with the help of the digital inclusive finance because it increased the regional innovation level as well as the entrepreneurial activities and this point is also supported by the Zhang et al. (2022).

The offline enterprises are digitalized with the help of the digital finance and it is done due to the digital inclusive finance of the companies. The high transaction cost is reduced due to the online financial services and it is supported by the transaction cost theory of finance. The transaction uncertainty and the high transaction frequency are becoming possible with the help of the resource consumption costs of the companies and it ultimately increased the carbon emission reduction of the companies (Yang et al., 2022). The “Ant Forest” platform which is one of the main or important service platform of the environmental services and it also increased the public engagement in the environmental activities which also motivate the individuals to follow the low carbon emission into the environment (Sun et al., 2021).

The number of transactions or the search costs by the consumers are also reduced with the help of the digital inclusive finance because it transfers the information to the enterprises when they need loans with the help of the digital platforms. The financing costs of the companies are decreased and it also improves the resource consumption which are considered as unnecessary (Li et al., 2023). The advanced digital technologies are attached with the digital inclusive finance i.e. it handles the large set of data and the block chain for the company-specific information so it also strengthens the transparency of the information. The financing failure which are caused due to the information asymmetry are also reduced and it ultimately achieved the carbon emission reduction goals.

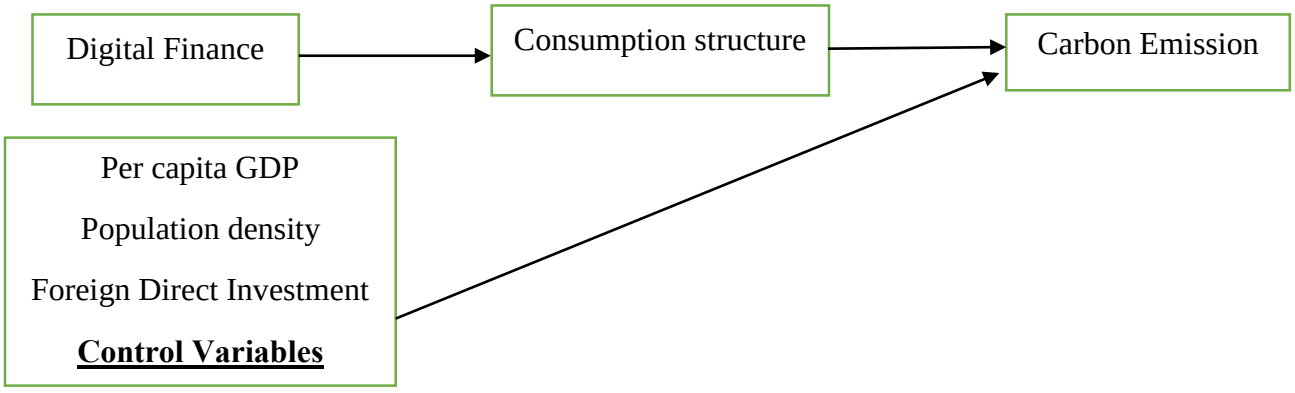
From an emerging sector services, the digital inclusive finance provides the attributes which are provide the minimal energy consumption, decrease in the pollution level and the efficiency improved and it is for the industrial level. The carbon emission is reduced due to the comparison of the conventional industries and it also becomes more favorable for the progression concept (Qin et al., 2022). The purview of the financial services is broadening and it becomes possible for the digital inclusive finance and it shatter the financing barriers which are encountered by the small and the medium size enterprises. The green transformation is supported with the help of the industrial upgrading which also facilities the optimal resource allocation which results in the high efficiency of the resources (Zhang et al., 2023).

With the help of the knowledge spillover, influencing market size and factor combinations the digital finance can increased the more entrepreneurial opportunities (Baker, 2021). The urban innovation and the entrepreneurship are improved because of the expansion of the digital finance which also creates the more fluid financing environment for the technology intensive and innovative industries (Nambisan et al., 2019). The industrial structure adjustment would stimulate the level of urban innovation and entrepreneurship. In creation the job the entrepreneurial activity creates an endogenous driver for the economic growth, structural transformation and the industrial upgrading (Thurik, 2003). The innovative-intensive industries and the technology-intensive industries are become the source of market resource allocation and it also promotes the innovation method and the entrepreneurship of the market industries.

The household consumption and the individual consumption are affected due to the digital finance and it also impact on the innovative behavior of the firms. The digital finance significantly increased the household consumption of the people. The consumption on the health care, education and the recreation which also improves the services of the goods are also influences due to the digital finance of the industries. The product market would impact due to the consumer purchasing power and it is supported by the microeconomic theories which also impact the industry structure.

The time and the distance in time are saved with the help of the digital finance and it also provide the efficient information transmission which also reduced the access cost of the financial services for the public and in depth the inter regional economic activity relationship. The spillover effect of the digital finance is also studied by the previous researchers. The relationship of the digital finance and the carbon emissions are studied by the Wang and Guo (2022). The digital finance on the economic growth and the urban ecological efficiency are analyzed with the help of the digital finance spillover. The local industrial structure also influenced due to the peripheral area of the digital finance. The spatial autocorrelation effect of the industrial structure also supports this evidence.

On the basis of the above mentioned literature following research framework has been created. Digital finance is taken as independent variable; carbon emission is taken as independent variable; consumption structure is taken as mediator in between digital finance and carbon emission; per capita GDP, industrial structure, population density and the foreign direct investment are taken as the control variables.



This portion of current research paper shows that how the data has been collected and how the analysis of the study has been done. The data of the current study has been collected from World Development Indicators official websites. Data of the control variables are also collected from the International Monetary Fund website. In current

study the researchers take developing and the developed countries for the analysis. For the developing countries Pakistan and India has been selected and for the developed countries Japan and Australia has been selected. Following formulas are used to measure the impact of the digital finance on the carbon emission with mediating role of the consumption structure. For the data analysis the researcher selected 2013-2023-time period because for the panel data analysis usually researchers take 10 years of data. It also helps the researcher to generalize the results according to the 10 years of data.

Independent Variable

The ratio or the proxy of the degree of digitalization of the countries is considered as a proxy for the measurement of the digital finance. Secure internet servers (per 1 million person) used as a proxy to measure the digital finance of the countries (Ye et al., 2023). The data has been collected from the World Development Indicators website.

Dependent Variable

The calculation of the Zhang and Zhang (2015) and the Dong et al. (2022) for the calculation of the carbon emission are used in this study. They used the eight fossil energy sources i.e. raw coal, coke, crude oil, fuel oil, gasoline, kerosene, diesel and the natural gas.

Mediator

Consumption structure is taken as a mediator in this study. According to the method given by the Xing and Ye (2022) the consumption structure is calculated by using the relative proportion of the non-material consumption to the total household consumption as a proxy for measuring the consumption structure of the countries.

Control Variables

Per Capita GDP: each country level of the economic development is taken as a per capita GDP of the country.

Density of Population: The logarithm of the ratio of the total resident of the population to the required regional area is used.

Foreign Direct Investment: The logarithm of the amount of the total foreign direct investment are used for the FDI calculation.

Econometric Equations

$$CO2E_{i,t} = \beta_0 + \beta_1 DF_{i,t} + \beta_2 GDP_{i,t} + \beta_3 Pop\ den_{i,t} + \beta_4 FDI_{i,t} + \in_{i,t} \quad (1)$$

$$CS_{i,t} = \beta_0 + \beta_1 DF_{i,t} + \beta_2 GDP_{i,t} + \beta_3 Pop\ den_{i,t} + \beta_4 FDI_{i,t} + \in_{i,t} \quad (2)$$

$$CO2E_{i,t} = \beta_0 + \beta_1 CS_{i,t} + \beta_2 GDP_{i,t} + \beta_3 Pop\ den_{i,t} + \beta_4 FDI_{i,t} + \in_{i,t} \quad (3)$$

First equation shows the direct relationship between the independent variable and the dependent variable along with the control variables. Second equation shows the relationship of independent variable and mediator along with the control variables. Third equation shows the relationship of the mediator and the dependent variable along with the control variables. CO2E shows the carbon emission of the countries; DF shows the digital finance of the countries; GDP shows the per capita gross domestic product of the countries; Pop den shows the population density of the countries; FDI shows the foreign direct investment of the countries; CS shows the consumption structure of the countries; β shows the constant terms; $\in$ shows the error term; i for the number of the countries and t for the time period.

Results and Analysis

The current study is analyzed with the help of the Stata software. Panel data analysis has been done because the nature of data is panel. The researcher has been done some basic tests for the analysis i.e. descriptive statistics, correlation matrix, panel unit root test and the regression analysis.

Table 4.1 shows the descriptive statistics of developing countries i.e. Pakistan and India. The result of the descriptive statistics of Pakistan shows that the mean or the average value of the CO2E is 5.225 which means on average the CO2E is 5.225 but the result of India shows 2.1155 which means that the CO2E of Pakistan is higher as compared to the India and it also shows that the pollution is maximum in Pakistan as compared to India. DF

shows that the mean or the average value of digital finance of Pakistan shows $38.28 billion but the DF of India shows $112.58 billion. The result shows that the digitalization of the India is higher as compared to Pakistan. CS shows that the Pakistan consumption is $5.003 billion but the consumption of India shows $0.703 billion on the non-material and the household expenses. The result shows that the Pakistani consumption is higher as compared to the Indian consumption. GDP shows that the earning of the country into the country as domestic product.

The result of the developing countries shows that the GDP of Pakistan is $1451.89 billion while the GDP of India shows $1843.63 billion. The result shows that the GDP of India is higher as compared to the Pakistani GDP. Popden shows the population density of the country that how much dense the population of the country in the particular time period. The result shows that the mean or the average value of Popden is 278 while the result of Indian population shows 415 which means that the total population of the India is higher than the total population of Pakistan. FDI shows that the mean or the average value of Pakistan shows $1.9 billion but the Indian result shows $42.44 billion which is quite higher ratio as compared to Pakistan so that it shows that the Indian FDI is much higher than the Pakistani FDI.

Table 4.1
Descriptive Statistics of Developing countries

	Pakistan				India			
Name of the Variables	**Mean**	**Std. Dev**	**Min**	**Max**	**Mean**	**Std. Dev**	**Min**	**Max**
CO2E	5.225	2.1155	5.042	5.375	1.7636	0.1433	1.5	2
DF	38.285	19.039	0.5451	110.56	112.58	58.61	1.6612	474.27
CS	5.003	2.2883	4.6651	5.545	0.7035	0.0561	0.6211	0.782
GDP	1451.89	718.892	1259.7	1620.7	1843.63	921.85	1434	2411
Popden	278	136.23	258	300	415.26	214.03	392.77	434.6
FDI	1.9	0.447	1.33	2.58	42.44	21.07	24	64.36

Note: CO2E shows the carbon dioxide emission of the countries; DF shows the digital finance of the countries; CS shows the consumption structure of the countries; GDP shows the per capita gross domestic product of the countries; Popden shows the population density of the countries and FDI shows the foreign direct investment of the countries.

Table 4.2 shows the descriptive statistics of developed countries and for the developed countries the researcher selected Japan and Australia. The result shows that the CO2E of the Japan shows 9.2 mean value while the Australia shows 14.5 mean value which means that the Australia emission of CO2 is higher than the Japan. DF shows 6118.01 mean value of Japan while the Australia shows 22848.84 which means the digitalization of Australia is much higher than Japan. CS shows that the mean value of the Japan shows 7.03 and the Australia shows that 8.25 which means that the household consumption of the Australia is much higher than the consumption of Japan. GDP of Japan shows $ 9633.91 billion and the Australia shows $ 39243.63 billion which is much higher than the Japan GDP. Popden shows 333.17 of Japan while the Australia population density shows 337.8 which means that the Japan population is higher than the Australian population. FDI shows 28.02 mean value of Japan while the Australia shows 234.85 mean value which means that the Australian FDI is much higher than the Japan FDI.

Table 4.2
Descriptive Statistics of Developed countries

	Japan				Australia			
Name of the Variables	**Mean**	**Std. Dev**	**Min**	**Max**	**Mean**	**Std. Dev**	**Min**	**Max**
CO2E	9.2	4.7912	8	10.3	14.5	7.3435	7.1	8
DF	6118.01	3059.04	552.90	2848.72	22219.84	108.09	1.199	948.45
CS	7.029	3.7509	5.2918	8.257	0.7261	0.0384	0.6556	0.7909
GDP	9633.91	19816.16	34017	49145	39243.63	4127.87	6301	12720
Popden	333.17	166.929	326.2	337.8	147.43	73.888	143.9	149.11
FDI	28.02	14.347	0.55	62.58	234.85	114.96	166.08	334.07

Note: CO2E shows the carbon dioxide emission of the countries; DF shows the digital finance of the countries; CS shows the consumption structure of the countries; GDP shows the per capita gross domestic product of the countries; Popden shows the population density of the countries and FDI shows the foreign direct investment of the countries.

The graph shows overall result of the variables used in the study. In creation of this graph mean or the average values of the variables are used. The result shows that the GDP of the countries on average is higher as compared to the other variables used in the study. DF shows that most of the population of the country used the modern technology which is digital finance used for the daily operations.

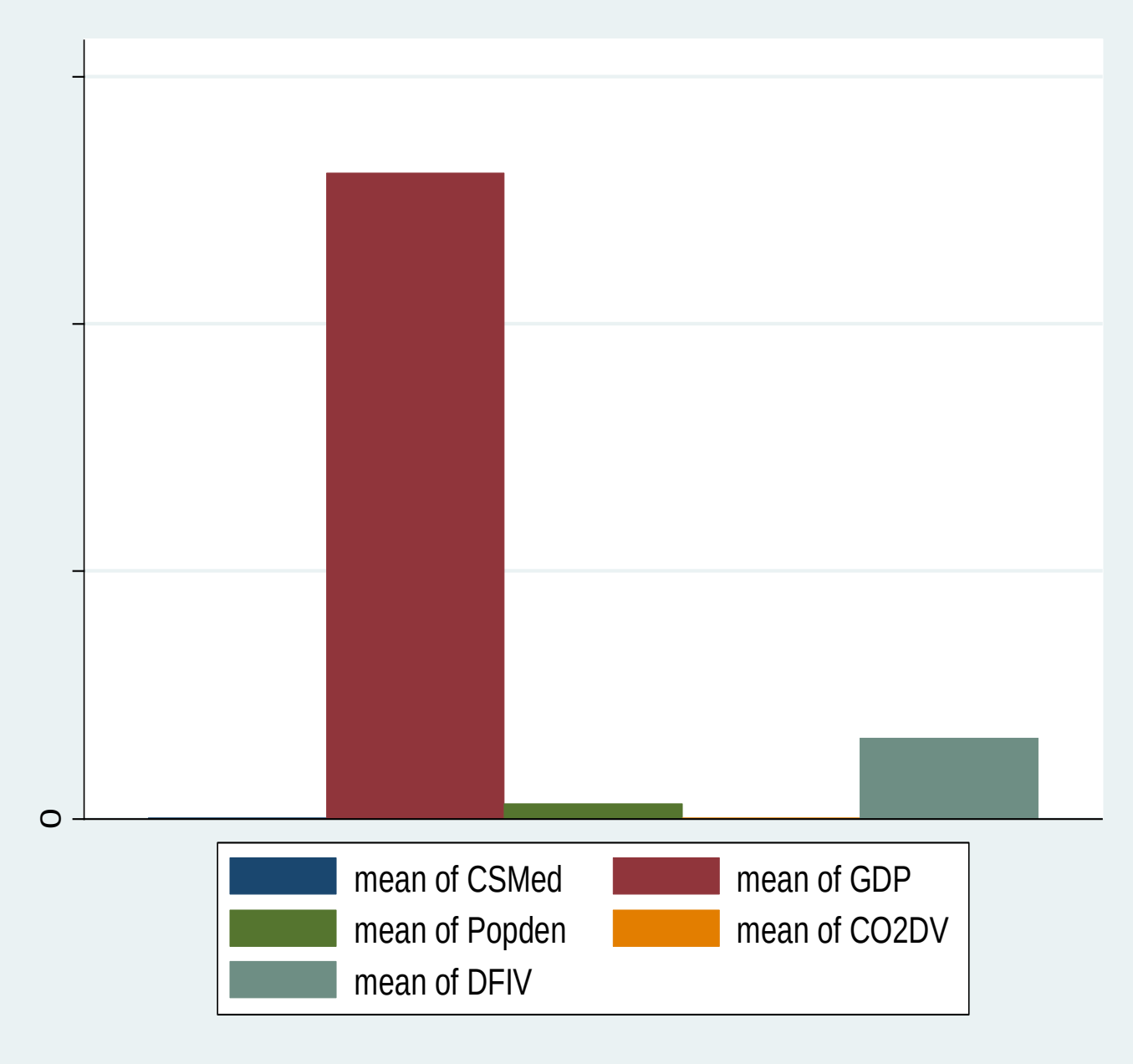


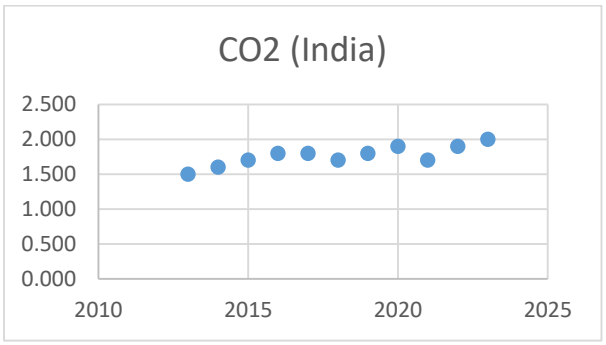
Table 4.3 shows the correlation matrix of the developing as well as the developed countries as an overall result but the individual results of the countries are also mentioned in appendix. The result of correlation matrix shows that DF and CO2E are positively related with each other's; CS and CO2E is positively related because when the CS increased then the CO2E of the countries are also increased; CS and DF are also positively related; GDP and CO2E shows positive relationship which means if the GDP of the country increased it would also increase the CO2E of the countries; Popden and CO2E are negatively related because when the population of the country increased it would decreased the CO2E of the countries and if the popden decreased then the CO2E also decreased; FDI shows positive relationship with the CO2E; DF and FDI are negatively related; FDI and CS are negatively related; FDI and GDP are negatively related and last but not the least FDI and Popden are also negatively related.

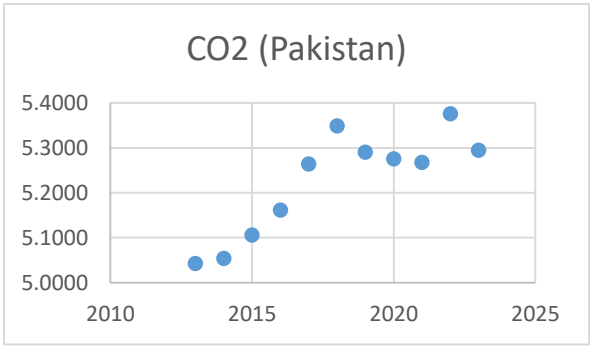
Table 4.3
Correlation Matrix

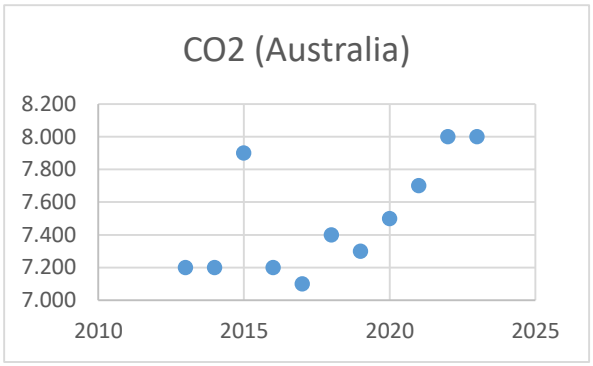
	CO2E	DF	CS	GDP	Popden	FDI
CO2E	1					
DF	0.3076	1				
CS	0.5604	0.4696	1			
GDP	0.4712	0.5158	0.6100	1		
Popden	-0.5355	0.1104	0.1648	0.0710	1	
FDI	0.2564	-0.0970	-0.5810	-0.1083	-0.4399	1

Note: CO2E shows the carbon dioxide emission of the countries; DF shows the digital finance of the countries; CS shows the consumption structure of the countries; GDP shows the per capita gross domestic product of the countries; Popden shows the population density of the countries and FDI shows the foreign direct investment of the countries.

The below graphs show the CO2 emission of developed and developing countries. The result shows that the emission of CO2 is increased in Pakistan because the digitalization increased which also increased the consumption of the energy resources. As compared to the result of India the CO2 emission is much higher as compared to Pakistan. The CO2 emission of Pakistan is higher but it increased gradually. The graph of Japan shows that CO2 emission fluctuates with time period and the result of Australia shows that CO2 emission is increased with time because of the ozone effect.







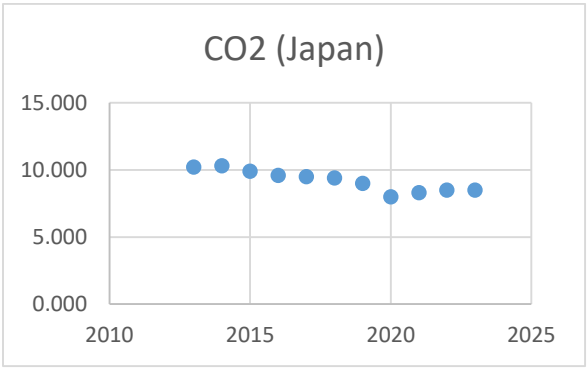


Table 4.4 shows the generalized methods of moments regression analysis. The result of model 1 shows the direct relationship of DF and CO2 emission. The result of model 1 with the help of GMM model shows that the result of DF and CO2 are not significant because the p-value is higher than 0.05. Digital finance become the source of

reducing the transaction cost, improve the speed of the transaction and also decreased the CO2 emission because the new source of technology is used by the companies which also results in decreasing the CO2 emission (Nambisan et al., 2019). Model 2 shows the relationship of DF and CS because it's the mediation paths and the researcher takes CS as dependent variable with DF. The result of model 2 shows that DF is positively and significantly with the CS of the developed and developing countries because with the increase in the consumption structure the digital financial inclusion is also increased. Model 3 shows the relationship of the CS and CO2 emission. The result of model 3 shows the relationship of consumption structure and the carbon emission of the countries. The result shows that CS has 0.002 p-value and the coefficient sign shows positive value which means that CS is positively and significantly related with CO2 emission. Overall the result of the GMM model shows that with the addition of the consumption structure in between the DF and CO2 the results become more significant and more clear results are shows.

Table 4.4

The impact of digital finance inclusion on the CO2 emission with mediating role of consumption structure

	Generalized Methods of Moments		
Name of Variables	**Model 1**	**Model 2**	**Model 3**
DF	(-0.00035) 0.077	(0.0010) 0.000***	
CS	-	-	(0.2161) 0.002**
GDP	(0.00148) 0.000***	(0.0008) 0.007	(0.0012) 0.000***
Popden	(-0.0213) 0.000***	(-0.0167) 0.000***	(-0.018) 0.000***
FDI	(-0.0061) 0.000***	(-0.0271) 0.000***	(-0.0029) 0.894
C	(10.7801) 0.000***	(9.0290) 0.000***	(8.934) 0.000***

Note: DF stands for digital finance; CS stands for consumption structure; GDP stands for gross domestic products; popden shows the population density of the countries and FDI shows the foreign direct investment of the countries.

Table 4.5 shows the direct relationship of dependent variable and independent variable of developing countries i.e. Pakistan and India. The result of the developing countries shows that the digitalization in Pakistan negatively related with the carbon emission because when the digital finance increased it would increase the emission of carbon dioxide into the environment. The result of India shows that DF is positively and significantly related with CO2E because when the digitalization increased it would also increase the emission of the carbon dioxide into the environment which also cause the global warming. In Pakistani result GDP shows negative and insignificant relationship with CO2E and in India it shows positive and significant relationship. Popden shows positive and significant relationship with CO2E but in India it shows positive and insignificant relationship. FDI shows positive and significant relationship with CO2E in Pakistan and in India it shows negative and significant relationship with CO2E. R-square of Pakistan shows 93.31% which means overall 93.31% of the CO2E relationship is explained with the help of DF. In India DF explains 86.23% of the relationship with CO2E. Overall the direct relationship model of Pakistan is better as compared to India.

Table 4.5

Relationship of Digital finance and Carbon emission of developing countries

	Pakistan		India	
Variables	**t-stats**	**p-values**	**t-stats**	**p-values**
DF	1.36	0.003**	0.57	0.002**
GDP	-0.49	0.640	2.35	0.05*
Popden	2.99	0.024**	1.70	0.987
FDI	2.58	0.042**	-0.02	0.001**
C	4.68	0.003**	0.54	0.000***
R-square	0.9331		0.8623	

Note: DF shows digital finance; GDP shows gross domestic product; Popden shows the population density of the countries; FDI shows the foreign direct investment.

Table 4.6 shows the direct relationship of digital finance and carbon emission of developed countries i.e. Japan and Australia. The result of the developed countries shows that the digitalization in Japan positively related with the carbon emission. The result of Australia shows that DF is positively and significantly related with CO2E. In Japan result GDP shows negative and significant relationship with CO2E and in Australia it shows positive and insignificant relationship. Popden shows positive and highly significant relationship with CO2E but in Australia it shows negative and significant relationship. FDI shows positive and insignificant relationship with CO2E in Japan and in Australia it shows positive and significant relationship with CO2E. R-square of Japan shows 91.24% and in Australia R-square shows 65.80%. The result of R-square means that the result of Japan explained more results as compared to the results of Australia.

Table 4.6

Relationship of Digital finance and Carbon emission of developed countries

	Japan		Australia	
Variables	**t-stats**	**p-values**	**t-stats**	**p-values**
DF	2.60	0.040**	0.47	0.002**
GDP	-0.67	0.027**	0.25	0.809
Popden	3.80	0.000***	-0.15	0.004**
FDI	0.64	0.547	0.54	0.005**
C	3.64	0.013**	0.42	0.002**
R-square	0.9124		0.6580	

Note: DF shows digital finance; GDP shows gross domestic product; Popden shows the population density of the countries; FDI shows the foreign direct investment.

Table 4.7 shows the relationship of independent variable and mediator of developing countries i.e. Pakistan and India. The result of the developing countries shows that the digitalization in Pakistan positively and significantly related with the consumption structure because when the digitalization of the country increased it would also increase the consumption of the people of the country. The result of India shows that DF is positively and significantly related with CS. In Pakistani result GDP shows positive and highly significant relationship with CS and in India it shows positive and insignificant relationship. Popden shows negative and highly significant relationship with CS but in India it shows negative and insignificant relationship. FDI shows negative and significant relationship with CS in Pakistan and in India it shows positive and significant relationship with CS. R-square of Pakistan shows 87.15% and in India it shows 95.39%. Overall the result of India is better than the result of Pakistan because the R-square value is higher in Indian result.

Table 4.7

Relationship of Digital finance and Consumption structure of developing countries

	Pakistan		India	
Variables	**t-stats**	**p-values**	**t-stats**	**p-values**
DF	2.71	0.010**	0.58	0.001**
GDP	7.52	0.000***	1.10	0.353
Popden	-6.91	0.000***	-0.28	0.792
FDI	-11.05	0.000***	0.04	0.000***
C	10.15	0.000***	1.10	0.000***
R-square	0.8715		0.9539	

Note: DF shows digital finance; GDP shows gross domestic product; Popden shows the population density of the countries; FDI shows the foreign direct investment.

The result of table 4.8 shows the result of the relationship of digital finance with the CS of the developed countries i.e. Japan and Australia. The result of the developed countries shows that the digitalization in Japan is positively and significantly related with the consumption structure because Japan is considered as the most developed or the most digitalized country according to the use of the technology. According to the Hao et al., (2023) the consumption of the energy resources and the industrial adjustments should be analyzed and have impact on the CO2 emission. The result of Australia shows that DF is positively and significantly related with CS because Australia is also considered as one of the most developed country of the world and on the technology basis the people of Australia used most of the digital technology for the daily use. In Japan result GDP shows negative and highly significant relationship with CS and in Australia it shows negative and insignificant relationship.

Popden shows negative and significant relationship with CS because the population of the Japan is not very dense and it does not directly impact on the digitalization of the country; but in Australia it shows positive and significant relationship because Australia is considered as one of the most population dense country in the world according to the population so it also impacts on the CS of the country. FDI shows negative and insignificant relationship with CS in Japan because in Japan the technology is very high quality and the country not in need of having the foreign investment across the world but in Australia it shows negative and significant relationship.

Table 4.8

Relationship of Digital finance and Consumption structure of developed countries

	Japan		Australia	
Variables	**t-stats**	**p-values**	**t-stats**	**p-values**
DF	1.90	0.010**	0.080	0.040**
GDP	-14.60	0.000***	-1.14	0.297
Popden	-2.88	0.028**	0.11	0.005*
FDI	-1.67	0.147	-1.72	0.003*
C	3.98	0.002**	0.53	0.000***
R-square	0.9820		0.9147	

Note: DF shows digital finance; GDP shows gross domestic product; Popden shows the population density of the countries; FDI shows the foreign direct investment.

Table 4.9 shows the relationship of mediator to the dependent variable i.e. the relationship of the consumption structure on the carbon emission of the developing countries. The result of the below table shows that CS is

positively and significantly related with the CO2E in Pakistan as well as in India. GDP shows positive and highly significant relationship with CO2E and in India it also shows positive and significant relationship. Popden shows negative and highly significant relationship in Pakistan and positive and insignificant relationship with India. FDI shows negative and insignificant relationship in Pakistan while in India it shows positive and insignificant relationship.

Table 4.9
Relationship of Consumption structure and Carbon emission of developing countries

	Pakistan		India	
Variables	**t-stats**	**p-values**	**t-stats**	**p-values**
CS	3.08	0.004**	2.42	0.05*
GDP	13.64	0.000***	1.82	0.001**
Popden	-11.11	0.000***	0.03	0.978
FDI	-0.13	0.895	0.48	0.652
C	11.92	0.000***	0.05	0.000***
R-square	0.9717		0.8533	

Note: DF shows digital finance; GDP shows gross domestic product; Popden shows the population density of the countries; FDI shows the foreign direct investment.

Table 4.10 shows consumption structure and carbon emission of developed countries i.e. Japan and Australia. The result of below table shows that CS is positively and significantly related in both countries with the CO2E because when the consumption of the people on the daily use increased it would also increase the CO2E into the environment. GDP shows positive and significant relationship in both countries Japan and Australia. Overall the result of the Japan shows most effective results as compared to the result of Australia result.

Table 4.10
Relationship of Consumption structure and Carbon emission of developed countries

	Japan		Australia	
Variables	**t-stats**	**p-values**	**t-stats**	**p-values**
CS	1.12	0.003**	0.86	0.025*
GDP	1.15	0.010***	0.65	0.004**
Popden	-1.15	0.000***	0.98	0.03**
FDI	0.13	0.005	0.22	0.012
C	0.05	0.000***	1.64	0.000***
R-square	0.8455		0.6841	

Note: DF shows digital finance; GDP shows gross domestic product; Popden shows the population density of the countries; FDI shows the foreign direct investment.

Discussion and Conclusion

The current study analyses the relationship between the digital finance and the carbon emission of the developing as well as the developed countries. The study also takes the consumption structure as a mediator. The study takes Pakistan and India as a developing countries; while Japan and Australia as a developed countries. The data has been collected from the World Development Indicators website. From 2013-2023 the data has been collected for the analysis of the study. The result of the study shows that the DF is positively and significantly related with the developing countries while in the developed countries it also shows positive and significant relationship. CS shows positive and significant relationship with the CO2E because when the household consumption of the country increased it would also increase the CO2E automatically. The increased consumption structure intricately mediates the impact of digital inclusive finance on carbon emissions. Within this framework, digital inclusive finance acts as a catalyst for upgrading consumption. According to the results of Shahbaz et al. (2013) digital finance is the main or the most important factor which reduces the CO2 emission. They studied digital finance and CO2 emission in China and according to the Shahbaz et al. (2013) results the reduction in the CO2 emission is done with the help of the digital finance.

The current study shows some recommendations for the policy makers i.e. digital finance directly related with the consumption structure of the developing as well as the developed countries so that the local authorities would also improves the policy standards because it also directly related with the CO2E of the developed and developing

countries. The policy makers should encourage the people so that they can use the low carbon emission products which also improves the environmental condition of the countries. Different policy for the strategies should create which also improves the consumption structure of the people.

The current study has some limitations; firstly, the current study only takes two developing countries and two developed countries. So, in future the researchers take some extra countries so that the results should be improved with the help of the more data on the countries. Secondly, the current study only takes the macroeconomic data for the analysis. In future the researchers should take the microeconomic data for the analysis.

Appendix

Table 1
Correlation Matrix of Pakistan

	CO2E	DF	CS	GDP	Popden	FDI
CO2E	1					
DF	0.5109	1				
CS	-0.3252	0.4768	1			
GDP	0.3665	0.0280	-0.4442	1		
Popden	0.2380	0.4794	-0.0683	0.5151	1	
FDI	0.6511	0.1616	-0.0815	0.6152	0.2740	1

Note: CO2E shows the carbon dioxide emission of the countries; DF shows the digital finance of the countries; CS shows the consumption structure of the countries; GDP shows the per capita gross domestic product of the countries; Popden shows the population density of the countries and FDI shows the foreign direct investment of the countries.

Table 2
Correlation Matrix of India

	CO2E	DF	CS	GDP	Popden	FDI
CO2E	1					
DF	0.4009	1				
CS	-0.3351	-0.2415	1			
GDP	0.2349	0.4414	-0.5422	1		
Popden	0.4223	0.5955	-0.6152	0.6592	1	
FDI	0.6159	0.5019	-0.6299	0.6399	0.2866	1

Note: CO2E shows the carbon dioxide emission of the countries; DF shows the digital finance of the countries; CS shows the consumption structure of the countries; GDP shows the per capita gross domestic product of the countries; Popden shows the population density of the countries and FDI shows the foreign direct investment of the countries.

Table 3
Correlation Matrix of Japan

	CO2E	DF	CS	GDP	Popden	FDI
CO2E	1					
DF	-0.6155	1				
CS	-0.4661	0.4511	1			
GDP	0.3375	-0.3637	-0.4932	1		
Popden	0.2810	-0.3933	-0.5484	0.4282	1	
FDI	-0.6118	0.6199	0.4012	-0.3441	-0.5792	1

Note: CO2E shows the carbon dioxide emission of the countries; DF shows the digital finance of the countries; CS shows the consumption structure of the countries; GDP shows the per capita gross domestic product of the countries; Popden shows the population density of the countries and FDI shows the foreign direct investment of the countries.

Table 4
Correlation Matrix of Australia

	CO2E	DF	CS	GDP	Popden	FDI
CO2E	1					
DF	0.2848	1				
CS	-0.4949	-0.5843	1			
GDP	0.3256	0.2865	-0.4913	1		
Popden	0.4722	0.6134	-0.5211	0.3386	1	
FDI	0.2865	0.1312	-0.3187	0.0422	-0.2258	1

Note: CO2E shows the carbon dioxide emission of the countries; DF shows the digital finance of the countries; CS shows the consumption structure of the countries; GDP shows the per capita gross domestic product of the countries; Popden shows the population density of the countries and FDI shows the foreign direct investment of the countries.

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