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ROLE OF MONETARY POLICY IN THE TRANSITION TO AN ENVIRONMENTALLY SOUND ECONOMY? A TIME-SERIES ANALYSIS OF PAKISTAN

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Abstract. This study seeks to investigate how the dynamics of monetary policy, particularly in the context of financial development can address the climate crisis and contribute to the pursuit of sustainable development and an environmentally sound economy in Pakistan. The study utilizes time series data spanning from 1990 to 2020 for Pakistan and employs Dynamic OLS (DOLS) and Generalized Method of Moments (GMM) estimation techniques to study the causal relationship between financial development and climate change to check whether enhanced financial development can facilitate and promote sustainable progress. Three measures are used as a proxy to gauge the effect of climate change. It includes carbon dioxide (CO2), methane emissions (CH4) and ecological footprints (EF). The empirical results of this investigation affirm that financial development may have an impact on climate change, leading to higher carbon dioxide, methane emissions and ecological footprints via the credit channel. In light of these empirical findings, the study suggests that role of the financial sector for environmental protection through their lending criteria should be carefully examined. In addition, the study recommends monitoring of credit availability towards green growth in order to achieve sustainable development goals.

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I. INTRODUCTION

Intergovernmental Panel on Climate Change (IPCC, 2014; 2018) has projected that average global temperature is likely to increase by 1.5°C between 2030 and 2050 and by 4°C up till 2100 which would have serious consequences for global production. In addition, the effect of climate change on food availability as well as on food security is noticeable through the extreme weather conditions and erratic rainfall (Kumara, 2023). Bank of England (2015) submits that adverse climate changes pose significant threats to financial stability and economic development of a country. Hence, European Central Bank (2022a) emphasizes that acting within its mandate, monetary policy should contribute to the fight against climate change and keenly support the transition to an environmentally sound economy.

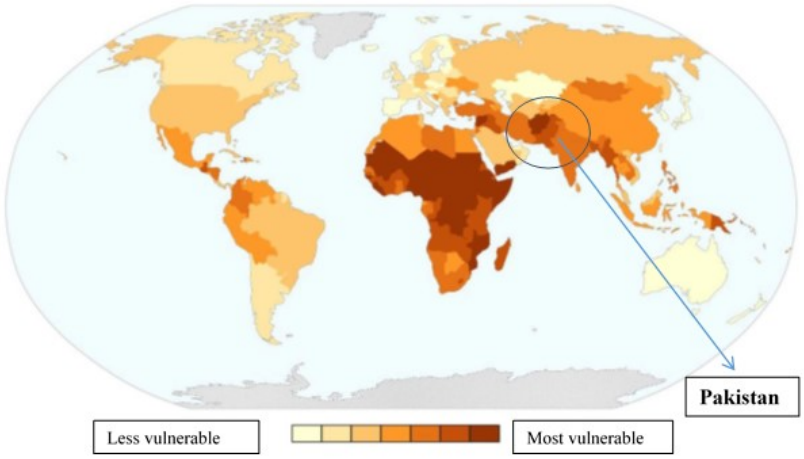
The climate change poses risks to financial stability; therefore, it falls under central banks' remit to ''ensure that the financial system is resilient to these risks'' (Roy, 2024). The central banks cannot ignore the financial risks posed by climate change and accordingly climate-related financial policymaking has been observed in East and South Asia countries (D'Orazio & Popoyan, 2022). Many European economies have introduced green bonds to finance green projects focusing low-carbon investments (European Central Bank, 2022b; Lichtenberger et al., 2022). However, in developing countries, financial markets are not well developed yet and there is a need to focus financial development. It is important to integrate sustainable developments goals into monetary policy frameworks for developing countries, endorsing Green Monetary Policy (GMP). The GMP Framework includes emissions reduction targets into conventional monetary policy instruments to confront the increasing concerns about environmental deterioration (Chen et al., 2021; European Central Bank, 2022a; Roy, 2024).

Pakistan is a country that is committed to fulfilling its SDG 13 responsibility.[1] It is a country highly threatened by climate change. The catastrophic floods in Pakistan of July 2022 constituted a climate disaster, wreaking havoc across the country. The aftermath included millions of displaced people, hundreds of causalities, destruction of villages and districts and billions of dollars in damages. Moreover, oil, gas and coal consumption has increased CO2 emissions two-fold in Pakistan during the last two decades which is also putting pressure on the country's ecological footprints and adding to its environmental concerns (Ullah & Lin, 2024). According to UNDP press release report on Aug 26, 2022, such calamities will continue to rise if prompt and appropriate action is not taken to mitigate the effects of climate change.

Figure 1 illustrates global map of human vulnerability. Here vulnerability refers to the climate extremes which adversely affect people, communities and nations.

FIGURE 1

Global Map of Vulnerability



[1] One of United Nation's Sustainable Development Goals (SDG) – Goal 13 is to take climate change policies to the national level and to promote mechanisms and strategies for effective climate-change planning.

According to the global assessment, Pakistan is the one of the most vulnerable and climate-affected countries during the last twenty years (Birkmann et al., 2021). Therefore, reducing vulnerability is important for mitigation of climate change.

It is imperative that all sectors of the economy recognize their accountability towards their actions that have adverse repercussions on the environment. Economic agents in a developing country such as Pakistan lack a compelling incentive to invest in climate-efficient projects due to the multitude of other pressing economic problems demanding their attention. Though environmental authorities and governments acknowledge the challenges posed by climate change and have incorporated climate action goals into their development plans, their present attempts to do so are insufficient. The absence of drivers for a green economy is causing detrimental impacts.

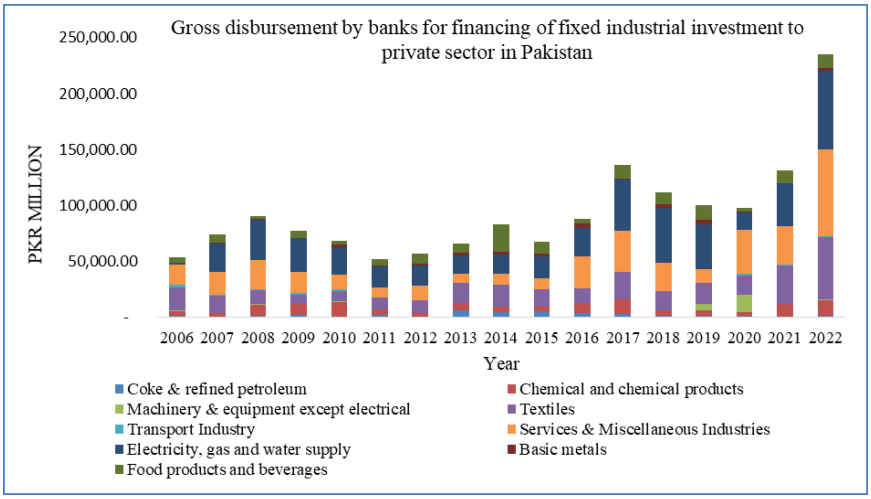
While in advanced countries green financing, green bonds, and green banking are now the most valuable instruments of monetary policy, yet it is a relatively new concept for low-income countries where the financial sector is not fully equipped with the new advancements and accordingly, they have not been able to take the advantages of the financing opportunities that might be available to them to attract green investments (Glemarec & Connelly, 2011; Chen et al., 2021).

In order to bring green economic revolution, huge investment is imperative and in this context, central banks, commercial banks and other financial institutions can contribute by exploring opportunities in green banking and by allocating funds and resources to support eco-friendly and energy efficient projects that would support the transition to an environmentally sound economy. With continuous financing of dirty industries over the last two to three decades, financial sector in Pakistan have indirectly contributed to environmental degradation. Since financial institutions have been providing finance to private businesses for fixed investment and working capital, with manufacturing sector being the major recipient, their involvement in environmental impairment cannot be overlooked.

Figure 2 below shows credit disbursement by banks for fixed industrial investment to some of the aggressively polluting industries in Pakistan from 2006-2022.

FIGURE 2

Gross Disbursement by Banks for Financing of Fixed Industrial Investment



The State Bank of Pakistan (SBP) issued green banking guidelines in 2017 for banks to fulfill their obligation in safeguarding the environment and to provide finance to enable the transition towards an economy characterized by resource efficiency and climate resilience (SBP, 2017). While some banks have taken minor initiatives as part of the Green Banking strategy of SBP, this is just the starting point. The wider role of the financial sector focusing financial development along with sustainability is yet to be explored in this context.

The main objective of this study is to investigate the dynamics of monetary policy, particularly in the context of financial development which can contribute to the pursuit of sustainable development in Pakistan. For this purpose, the study utilizes time series data spanning from 1990 to 2020 for Pakistan and employs Dynamic OLS (DOLS) and Generalized Method of Moments (GMM) estimation techniques to study the relationship between financial development and climate change. Credit availability is used as an indicator of financial development while carbon dioxide emissions (CO2), methane emissions (CH4) and ecological footprints (EF) are used as proxies of climate change. The empirical findings affirm that financial development leads to higher

carbon emissions, methane emissions and ecological footprints via the credit channel. Therefore, it is suggested that monetary policy should carefully focus financial development and support transition towards an environmentally sound economy.

Although, some studies are available for the role of monetary policy in sustainable development for developed countries however relatively limited studies are available for developing countries. Therefore, focus of the present study is Pakistan i.e. a less developed but highly vulnerable country. This study will furnish to the literature a study that outlines monetary policy actions and the involvement of the financial sector of Pakistan and essentially for developing countries, to lessen climate change effects and damages.

The study is presented as follows. Section II reviews the literature on the subject while Section III describes the theoretical framework, methodology and estimation techniques adopted in our analysis. Section IV discusses the data and variables. Section V provides the estimation results along with discussion of main findings. To end with, section VI concludes the study and offers some policy recommendations.

II. LITERATURE REVIEW

The recent empirical research on sustainability and climate change impacts examines the role of monetary policy in the transition to an environmentally sound economy. It is now argued that central banks should play role in the convergence to green economy through green financing.

Climate change influences the effectiveness of traditional monetary policy by creating inflation, uncertainty and volatility which thereby reduces output growth. Therefore, it is argued that climate change management should also be a part of monetary policy as it shapes the mandate of central bank to deliver price stability, financial soundness and economic growth over time (Chen et al., 2021; Roy, 2024).

Apparently, monetary policy and climate issues are unrelated, however, the existing research maintains that climate factors and policies influence the growth of the economy, which is exactly what monetary policy cares about. Pioneering studies, investigating the role of central

banks and monetary policy under climate change include Haavio (2010) and Pachauri and Meyer (2014). These studies explain the transmission mechanisms between monetary policy and climate change. Pachauri and Meyer (2014) submit that climatic changes not only deepen existing risks but also create new risks for financial and economic systems. In addition, climate changes destroy physical capital and infrastructure and cause the loss of life which badly impacts the balance- sheets of house-holds and companies. Likewise, Economides and Xepapadeas (2018) examined two different versions of monetary policy i.e with and without incorporating climate changes in the models. The study established that the monetary policy's reaction to economic shocks is influenced by the climate change (Chen et al., 2021). In the same vein, Volz (2017) highlights that monetary policy may bring a fundamental change into economy by allocating resources towards environmentally sustainable projects. Moreover, the incorporation of sustainability into the goals of monetary policy may assist in the attainment of price stability target.

The serious financial threats caused by climate change suggest that all stakeholders' public as well as private along with policymakers should contribute towards the fight against climate change. While governments are the key players, a consensus is building that central banks cannot stand on the sidelines. An integrated policy framework is required to address the challenge of adverse climate change. It is argued that failure to engage central banks in the pursuit of sustainable development could result in increased levels of carbon emissions. It will further complicate already existing problem of climate change. The Paris Agreement and the United Nations 2030 Agenda for Sustainable Development (UN, 2015) also highlight the importance of monetary policy towards the mitigation of climate change and transition to an environmentally sound economy.

Monetary policy (MP) shows arrangements made by the monetary authority to influence money supply in the economy with the intention to focus some pre-determined macro-economic goals. In general, the main objective of the MP in most of the countries is low inflation, minimum unemployment and maximum growth along with stable interest rate. The MP chases these goals by utilizing three alternative tools, i.e open market operation, required reserve ratio in addition to discount window (Whitesell, 2011). However, qualitative tools are also offered by

monetary policy and termed as selective tools of MP (STMP). Though, quantitative tools consider the cost and volume of the credit, selective credit controls focus on the distribution of credit (Roy, 2024). The STMP discriminate between alternative uses of credit and influence the borrower and the lender of the credit. The technique of STMP essentially include different interest rates for certain types of credits and ceiling or upper-limit on the supply of loans for specific usages. Sustainable development or green economy necessitates the substitution of loans and investments from high-carbon emitters to low-carbon industries without confronting the goal of price stability (European Central Bank, 2022b). It is argued that it can be achieved with GMP focusing green financial development.

Green financial development makes it easier for firms to attract capital and lending from financial institutions specifically for new and energy efficient technologies. A study by Lee et al. (2015) on a panel data of 25 OECD countries to determine the relationship between carbon emissions and financial development reported a negative and statistically significant impact for eight developed countries, most of them European Union countries. These countries are strictly committed to implementation of renewable energy to combat the negative impacts of carbon dioxide emissions.

Likewise, Shahbaz et al. (2013b) have conducted an empirical study of the impact of financial development on environmental quality in South Africa in parallel with economic growth, coal consumption and trade. Their results show a statistically significant negative impact of financial development on carbon dioxide emissions which is explained by the authors in terms of maturity of the financial sector of South Africa. The authors believe that since the financial sector of the country is strong enough, it can allocate resources and funds for environment friendly projects. As a policy recommendation, the authors are of the view that financial development may be used as an instrument for improving environmental quality. Accordingly, an efficient capital market may be a good policy option, which if adopted will ensure that firms have enough liquidity through diverse portfolios to support them in the transition to be less-carbon intensive in the long-run.

In a similar study, Shahbaz et al. (2013a) have studied the impact of financial development on carbon dioxide emissions in Malaysia from 1971 to 2011. Other variables included in their model are foreign direct investment, trade and GDP per capita. The results reveal a decrease in CO2 emissions due to an increase in financial development. As a policy recommendation, the authors are of the view that financial institutions can use direct as well as indirect methods to combat environmental degradation. As a direct action, they can invest in research and development on cleaner technologies. As an indirect approach, the banking system may give preference loans to businesses that are engaged in environment friendly projects or they may incorporate carbon emissions terms into their existing financial products suggesting some role for green monetary policy.

Likewise, Dikau and Volz (2021) discussed a specific green monetary policy tool used by People's Bank of China which is termed as 'window guidance'. This instrument is an informal policy instrument and it promotes sustainable lending by facilitating credit towards sustainable projects. Similarly, many European economies have introduced green bonds to finance green projects focusing low-carbon investments (Lichtenberger et al., 2022).

Conversely, in developing countries, financial markets are not well equipped up till now (Flaherty et al., 2017). It is important to mention that quantitative instruments usually available in developing countries are not instruments of green monetary policy as discussed by Whitesell (2011). Instead, financial development focusing qualitative tools of monetary policy such as selective credit control instruments may be the ideal approach for the mitigation of climate change and to achieve sustainable development goals. Here, the selective credit control tool refers to the reallocation of funds from dirtier industries to cleaner industries through the banking channels.

This review of literature suggests that climate events have unfavorable effects on the prices of financial assets which in turn influence the financial position of the banks and firms. Generally, adverse climatic changes lower liquidity and profitability, causing a higher rate of default of the firms that damage the financial sector of the economy. In this scenario and especially after the endorsement of the

Paris Agreement, central banks are engaged in the climate change concerns. Likewise, the existing literature outlines the necessity of integrating sustainable developments goals into monetary policy frameworks, recommending green monetary policy framework that includes emissions reduction targets into conventional monetary instruments to confront the increasing concerns about climate change.

III. METHODOLOGY AND THEORETICAL FRAMEWORK

Pakistan is facing serious climate and sustainable development challenges and it is important to investigate in detail the nexus between financial development introduced by monetary policy and environmental degradation in the presence of economic growth for Pakistan to provide useful insights for the future course of action.

THEORETICAL FRAMEWORK

The theoretical discussion in this sub-section is based on the studies of Chen et al., (2021), European Central Bank (2022b) and Roy (2024). The theoretical foundation for our model can be expressed as follows:

$$E = f(FD)$$

here E refers to environmental degradation and FD stands for financial development. Environmental degradation is the response variable in this study and carbon dioxide emissions (CO_2), methane emissions (CH_4) and ecological footprints (EF) characterize the prime measures of climate change or environment degradation in Pakistan (Ullah & Lin, 2024). The focused variable is financial development representing the monetary mechanism in the model. It is measured through domestic credit (CR) provided to the private sector by banks and other financial corporations in the country and is referred to as financial development in the literature (Shahbaz et al., 2013b).

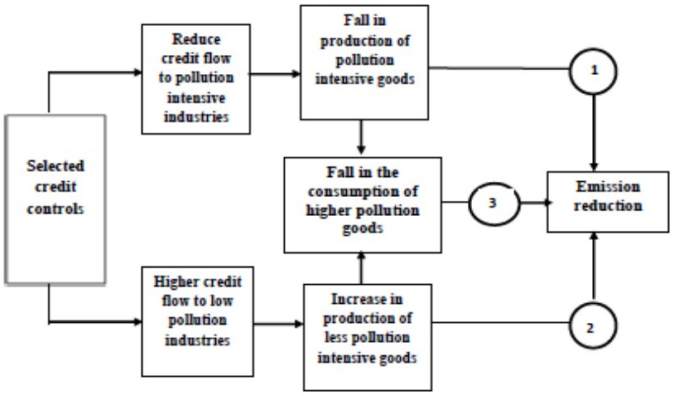
How the mechanism works is that a revision of the key interest rate by the central bank has an effect on the credit and loans provided by commercial banks to businesses and individuals. The refinancing position of banks changes accordingly too. An increase in credit availability in the economy due to an expansionary monetary policy leads to greater spending and a higher consumption level, the impact of which on environmental emissions needs to be analyzed.

Levine (2005) explains financial development as processes that are involved to improve the functions performed by financial institutions. This includes savings, capital allocation for productive investments, risk management and improved goods and services exchange. Several studies have related domestic credit to financial development of a country. Shahbaz et al. (2013a) and Lee et al. (2015) have reported a negative impact of financial development on environmental emissions. Accordingly, when the financial sector of a country is advanced, robust and mature, it functions as a conduit for directing investments into environmentally friendly projects (Birdsall & Wheeler, 1993; Frankel & Rose, 2002; Roy, 2024).

Figure 3 illustrates the transmission mechanism of the green monetary policy. The GMP works through production and consumption channels and utilizes selective credit controls tools (STMP). As discussed earlier qualitative tools of monetary policy are more effective as compared to quantitative tools when concern is mitigation of climate change. The channels shown in Figure 3 suggest that with an increase in the green advances, the credit flows to the less polluting industries. On the other hand, the credit rationing mechanism reduces the credit flow to carbon intensive industries (Roy, 2024).

FIGURE 3

Transmission Mechanism of Green Monetary Policy and Climate Change



Source: Authors build up based on European Central Bank (2022b) and Roy (2024).

Green monetary policy suggests that an increase in the credit flows to the low carbon emission industries leads to an increase in the capital formation as well as productivity of these industries while a fall in the credit flows to the high carbon emission industries decreases their capital formation. Accordingly, the production of low-carbon intensive goods and hence their consequent consumption increases. While, production of carbon intensive industries decline and consequently consumption also goes down. As a result, emission levels shrinks through the multiplier mechanism. Altogether, green monetary policy reduces overall carbon emissions

This discussion suggests that green monetary policy ensures that credit supply is discouraged to dirty or pollution intensive industries while credit supply is encouraged to cleaner industries. Therefore, GMP should be focused in developing countries which includes selective credit tools of monetary policy (STMP) for the mitigation of climate change.

METHODOLOGY

The baseline model for our analysis is given as follows:

$$E = f(FD)$$

where E refers to environmental degradation and FD stands for financial development which is measured with credit availability (CR). Consistent with previous studies, gross domestic product per capita (GDP), energy consumption (EN), trade openness (TR) and agriculture (AG) have been included in the model as control variables. The baseline model after including control variables can be expressed as follows:

$$E = f(CR, GDP, EN, TR, AG)$$

The interconnectedness of economic activity, presented by GDP per capita in our study, with industrial progress, results in heightened environmental emissions and the premise here is that a rise in GDP correlates with an elevation in carbon emissions and environmental degradation. Explaining the Environment Kuznet Curve (EKC) hypothesis, Grossman and Krueger (1995) observed that while in the initial phase, with growing per capita income, environmental quality deteriorates but as an economy progresses, environmental quality is

expected to improve with a tendency of economic agents to invest into environment-friendly and sustainable projects (Sana et al., 2021).

Energy consumption stands out as a significant catalyst for environmental degradation, with carbon emissions emerging as a direct fallout of energy production. The repercussions of this process manifest in air and water pollution, ultimately contributing to climate change. Studies conducted by Chishti et al. (2021), and Khattak et al. (2020) have delved into the intricate relationship between energy use and CO2 emissions, revealing the detrimental effects of heightened carbon emissions resulting from energy combustion on the environment.

Trade openness in our model is the total value of exports and imports of goods and services. While some studies reveal a positive impact of trade openness on environmental degradation, others show a negative impact (Shahbaz et al., 2013; Sana et al., 2021). Suri and Chapman (1998) elaborate on the relationship between manufactured goods imports by industrialized nations and their energy demands. As the imports of energy intensive goods rise, there is a corresponding decrease in energy requirements of the developed countries, resulting in a reduction in environmental emissions and contributing to the descending slope of the Environmental Kuznets Curve (EKC). Conversely, an uptick in the exports of energy intensive manufactured goods leads to heightened energy needs and subsequently increased emissions, aligning with the ascending slope of the EKC. Therefore, the influence of trade on carbon emissions varies based on the specific segment of the EKC that a country occupies. This study incorporates trade as a control variable to examine its potential impact on environmental degradation.

Agriculture is included in the model as a control variable too. Since agricultural activities like agricultural waste burning, animal waste and rice production lead to CH_4 and CO_2 emissions, it is added to the model to see the results of agricultural productivity with the environment (Mar et al., 2022). The functional form of the model is as follows:

$$E_t = \alpha_0 + \alpha_1 CR_t + \alpha_2\, GDP_t + \alpha_3 EN_t + \alpha_4 TR_t + \alpha_5 AG_t + \varepsilon_t \quad (1)$$

The logarithmic version of the model is as follows:

$$lnE_t = \alpha_0 + \alpha_1 lnCR_t + \alpha_2 lnGDP_t + \alpha_3 lnEN_t + \alpha_4 lnTR_t + \alpha_5 lnAG_t + \varepsilon_t \quad (2)$$

The following three empirical models are estimated with CO_2 in the first model, CH_4 in the second model and EF in the third model as the target variables representing environmental quality:

$$lnCO_{2t} = \alpha_0 + \alpha_1 lnCR_t + \alpha_2 lnGDP_t + \alpha_3 lnEN_t + \alpha_4 lnTR_t + \alpha_5 lnAG_t + \varepsilon_t \quad (3)$$

$$lnCH_{4t} = \alpha_0 + \alpha_1 lnCR_t + \alpha_2 lnGDP_t + \alpha_3 lnEN_t + \alpha_4 lnTR_t + \alpha_5 lnAG_t + \varepsilon_t \quad (4)$$

$$lnEF_t = \alpha_0 + \alpha_1 lnCR_t + \alpha_2 lnGDP_t + \alpha_3 lnEN_t + \alpha_4 lnTR_t + \alpha_5 lnAG_t + \varepsilon_t \quad (5)$$

ESTIMATION TECHNIQUE

The two estimation techniques applied to the model are Dynamic Ordinary Least Square (DOLS) and Generalized Method of Moments (GMM).

DOLS estimation is employed to evaluate the long-run impact of the independent variables on the outcome variable as it addresses endogeneity that is usually found in time-series data. Johansen co-integration test confirms the presence of co-integrating link and a long-run association of the variables in our data (Ahmad & Khan, 2002). DOLS is an alternative approach to Ordinary Least Square regression in which leads and lags are introduced to address the problem of serial correlation in a time-series data. Newey West standard errors are estimated to adjust for serial correlation.

GMM serves as the second estimation method utilized, incorporating both internal and external instruments. Two external instrumental variables chosen based on their validity are savings (as a percentage of GDP) and debt (as a percentage of GDP) and lagged values of control variables have been employed within the GMM model as internal instruments. The instrumental variables are found to be relevant and exogenous with F statistics confirming the relevance of the instruments and Hansen's J Chi square test the exogeneity of the instruments (Khan & Ahmad, 2022).

IV. DATA AND VARIABLES DESCRIPTION

The study includes environmental degradation as the dependent variable and it is proxied by three different indicators namely carbon dioxide (CO_2), methane (CH_4) and ecological footprints (EF). Financial development has been added as the main focused variable which is measured by domestic credit (CR). Annual data for the period 1990 to 2020 has been retrieved from the World Development Indicators (WDI) of the World Bank and Global Footprint Network (GFN). Table 1 provides the details of the variables.

TABLE 1

Variables and Definitions

Variable	Proxy	Unit of measurement
Carbon dioxide emissions (CO_2)	Environmental degradation	Metric tons per capita
Methane Emissions (CH_4)	Environmental degradation	kt of CO2 equivalent
Ecological footprints (EF)	Environmental degradation	EFP of consumption Global Hectares per capita
Domestic credit to private sector (CR)	Financial development	% of GDP
GDP per capita (GDP)	Economic activity	constant 2015 US$
Energy use (EN)	Energy consumption	kg of oil equivalent per capita
Trade openness (TR)	Trade	(import + export) % of GDP
Agriculture, forestry & fishing (AG)	Agriculture	% of GDP

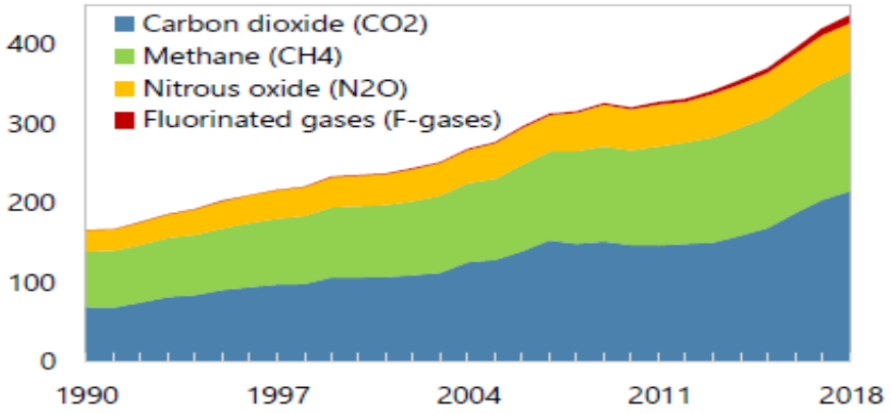
Our study includes alternative indicators for environmental degradation. It includes CO_2, CH_4 and EF. Carbon dioxide, considered to be the most appropriate indicator of climate change, is emitted significantly due to human-induced activities which include economic growth (Shahbaz et al, 2013a), energy consumption (Shobande, 2021;), trade openness (Shahbaz et al., 2013b; Pradeep, 2021), foreign direct investment (Pradeep, 2021) and urbanization (Liddle, 2013) among others. Methane (CH4) is another indicator of greenhouse gas emissions (GHG) that traps heat in the atmosphere and rises the Earth's temperature. Agricultural activities, coal production, industrial processes and landfills are the main sources of methane emission (Mar et al., 2022). Although, CH_4 remains in the atmosphere for a considerably brief duration as compared to CO_2, yet it has much stronger influence than

CO_2 in trapping heat in the atmosphere. Since Pakistan is an agricultural economy, it is notable to include methane into the model as an indicator of climate change. The third proxy used for environmental degradation is ecological footprints. The EF is considered a broader and comprehensive measure of quality of environment; therefore, our study includes EF (Ullah & Lin, 2024). The ecological footprints measures how fast we consume resources and generate waste as compared to how fast nature can absorb our waste and generate resources. According to Global Footprint Network (2017), most of the countries face ecological deficits as their use of resources is higher than their ecosystem's ability to recover.

Figure 4 represents the constitution of greenhouse gases over the last three decades in Pakistan and the rising volume of CO_2 and CH_4 can be observed.

FIGURE 4

Composition of Greenhouse Gas Emissions in Pakistan (MtCo2e)



Source: IMF Staff Country Reports (2022)
Note: This figure shows the evolution and composition of greenhouse gas emissions, all converted to metric tons of CO2 equivalent (MtCO2e), for Pakistan from 1990 to 2018.

Descriptive statistics for variables included in our analysis are given in Table 2.

TABLE 2

Variables and Definitions

Variable	CO_2	CH_4	CR	GDP	EN	TR	AG
Mean	0.6938	11.6126	21.7332	1172.4930	449.8913	32.0378	23.3356
Standard Deviation	0.1019	0.2611	3.9591	177.3968	24.1226	3.9812	0.9984
Minimum	0.5059	11.2054	15.3860	924.6347	397.0965	25.3062	21.6080
Maximum	0.9184	12.0401	28.7337	1502.8910	500.4320	38.4993	25.6172

V. EMPIRICAL RESULTS

We start the estimation process by checking the data for stationarity and co-integration. The Augmented Dickey Fuller (ADF) unit root test is applied to check whether the variables are non-stationary with the null hypothesis of non-stationary time series (Khan & Khan, 2020). The results are presented in Table 3 below:

TABLE 3

Summary of Augmented Dickey Fuller (ADF) Unit Root Test

	ADF Test statistics		
Variable	Level Form	First differenced Form	Result
CO_2	-1.7336	-3.3667**	Stationary at first difference
	(0.405)	(0.023)	
CH_4	-3.0598	-4.4192*	Stationary at first difference
	(1.000)	(0.002)	
EF	-2.5532	-5.419*	Stationary at first difference
	(0.501)	(0.000)	
CR	-1.0743	-4.1297*	Stationary at first difference
	(0.713)	(0.003)	
GDP	-0.5912	-3.1483**	Stationary at first difference
	(0.858)	(0.034)	
EN	-2.3677	-3.7852*	Stationary at first difference
	(0.159)	(0.008)	
TR	-1.7288	-5.3734*	Stationary at first difference
	(0.407)	(0.000)	
AG	(2.193)	-5.4632*	Stationary at first difference
	(0.213)	(0.000)	

Note: Probabilities in parentheses
t-statistics significance at 1%, 5% and 10% are given by * , ** and *** respectively

The ADF test results confirm that all variables in the model are non-stationary in their level forms but stationary at first difference indicating

that all variables are integrated of order 1 I(1). The results of Trace statistics and Eigenvalue statistics from Johansen co-integration test confirm the presence of a long run relationship in the time-series data (Khan & Ahmad, 2022).

Since the model is observed to have co-integrating equations, DOLS estimation technique has been selected for the study and GMM estimation is employed to cross-check the results that are given in Table 4.

The results indicate a significant positive impact of domestic credit on carbon emissions, methane emissions and ecological footprints. The parameter estimate shows that a unit percentage increase in domestic credit leads to a 0.6198% increase in CO_2 emissions and 0.3272% increase in CH_4 emissions using DOLS estimation techniques respectively. The parameter estimates from DOLS and GMM estimations show that domestic credit has a significant positive effect on all climate change proxies.

With an enhanced availability of financial resources from banks, the economy experiences heightened borrowing and lending, fostering economic growth. Nevertheless, if this investment is directed towards increased production but environmentally unsustainable technology, the anticipated result is a rise in economic growth accompanied by a surge in carbon emissions and environmental degradation.

Concerning Pakistan, the significance of domestic credit extended to the private sector appears to be influential in carbon emissions and contributes to environmental degradation. Providing loans and credit for agricultural and industrial development with substantial carbon footprints allows businesses to access funds for expanding production facilities and plants. However, this leads to increased environmental damage in the form of higher levels of CO_2, CH_4 emissions and EF. Similarly, as individuals have access to more credit, they tend to elevate spending on consumer goods, resulting in an increased use of fuel and electricity and higher emissions. Consequently, a rise in CO_2 concentrations and environmental degradation due to intensified consumption becomes inevitable (Lee et al., 2015; European Central Bank, 2022b; Roy, 2024).

Our empirical findings confirm that augmented credit availability leads to an increase in environmental degradation as the increased credit provision by the banking sector prompts a rise in the request for consumer financing products including motor vehicles, new appliances, mortgages and leveraged loans which place pressure on environmental resources. Likewise, increased credit supply leads to environmentally un-sustainable production which causes damage to the environment in Pakistan.

TABLE 4

Estimation Results for Environmental Degradation and Financial Development in Pakistan

Variables	CO_2		CH_4		EF	
	DOLS	GMM	DOLS	GMM	DOLS	GMM
CR	0.6198***	0.3637**	0.3272***	0.0527	0.7125***	0.632***
	(0.0966)	(0.1724)	(0.0602)	(0.1293)	(0.1033)	(0.2145)
GDP	1.17780***	1.1998***	1.2616***	1.6338***	1.8108***	1.9214***
	(0.1170)	(0.2280)	(0.0730)	(0.2024)	(0.4013)	(0.5316)
EN	1.1186***	1.0580*	1.3656***	0.5072*	1.441***	1.732***
	(0.2924)	(0.3799)	(0.1824)	(0.2972)	(0.3244)	(0.6341)
TR	-0.0815*	-0.1678**	-0.1152*	-0.0678	-0.0271	-0.0534*
	(0.0792)	(0.0808)	(0.0494)	(0.1091)	(0.0194)	(0.0287)
AG	0.7287**	0.9246*	0.1175**	0.6787	1.0371***	1.0827***
	(0.2308)	(0.5269)	(0.1440)	(0.0436)	(0.1314)	(0.3577)
Constant	-5.7966**	-11.9315***	-4.5794***	-4.7559**	-3.1591***	-6.3241***
	(1.6991)	(1.9644)	(1.0599)	(2.0499)	(1.1432)	(1.4478)
R-squared	0.9917	0.9161	0.9991	0.9829	0.9121	0.8931

Note: Standard error in parentheses, *** shows significance level at 1%, ** shows significance level at 5%, * shows significance level at 10%

A positive impact of GDP per capita on CO_2, CH4 emissions and EF has been established in this study via both DOLS and GMM estimation. The relationship between economic growth and environmental harm has been extensively explored through the Environment Kuznet Curve (EKC) hypothesis. This framework is widely recognized for assessing whether economies would have a positive or negative impact on pollution levels as they grow. In countries like Pakistan that are initially progressing and positioned on the upward position of the EKC, the initial stages of economic progress brings with it escalated pollution levels. Due to the absence of a sustained commitment to environmentally friendly production practices in Pakistan, producers fail to factor in sustainability

and environmental impact and the increased industrial activity coupled with economic growth contributes to elevated levels of environmental emissions.

According to Grossman (1995), in the early phases of development in low and middle-income countries, growth tends to be resource-intensive and private entities do not perceive significant advantages in practicing conservation and sustainability. In a country with low to middle income, such as Pakistan, achieving growth and development involves creation of pollution which needs to be addressed by upgrading outdated equipment with newer technologically efficient alternatives (Grossman, 1995).

The ultimate outcome of increased level of economic activity and credit hinges on the relative strength of either the scale effect or the technique effect. Where the technique effect prevails, efficient allocation of resources and usage of better and efficient techniques of production with the enhanced credit availability results in a reduction in pollutants (Grossman and Krueger, 1991). On the contrary, in the presence of scale effect, a positive impact would be observed on environmental discharges. Pakistan lies on the ascending segment of the EKC where the scale effect predominates and thus, economic growth is complimented by increased levels of CO_2 emissions and environmental deterioration (Sana et al., 2021).

Significant positive results are observed for energy consumption in our study. Our findings indicate that energy use positively influences alternative indicators of environmental degradation. Carbon emissions are one of the direct consequences of energy production as well as energy consumption whereas methane emissions result from extraction of oil and natural gas as well as coal mining, transport and production. The detrimental consequences of energy combustion are also marked by a substantial rise in carbon emissions. While energy use directly intensifies carbon emissions, it also indirectly leads to environmental deterioration via higher economic growth which again leads to greater demand for energy. Our findings confirm that energy consumption is one of the most significant contributors to environmental degradation in Pakistan (Shahbaz et al., 2013a).

Trade shows a statistically significant negative impact on carbon emissions and ecological footprints but an insignificant impact on methane emissions. According to Shahbaz et al. (2013b) and Tayebi and Younespour (2012), the impact of trade on greenhouse gas emissions depends on the characteristics and comparative advantage a nation has in terms of its trade (Sana et al., 2021). The composition effect of trade in Pakistan implies lower emissions due to increase in trade. Lastly, the results for agriculture are positively significant. While increased agricultural activities, specifically burning of rice residue to prepare the land for other crops, leads to environmental disruption or degradation in case of Pakistan.

To summarize, our empirical findings suggests that financial development is positively linked with environmental degradation in Pakistan. Therefore, there is a necessity of integrating sustainable developments goals into monetary policy framework, recommending green monetary policy framework to confront the increasing concerns about climate change. The green monetary policy will ensure that credit supply is discouraged to dirty or pollution intensive industries while credit supply is encouraged to cleaner industries.

VI. CONCLUSION AND POLICY RECOMMENDATIONS

This study investigates the impact of monetary policy via the financial development on climate change in Pakistan. Carbon emissions, methane emissions and ecological footprints have been used a proxy for climate change and credit availability has been selected as a proxy for financial development. Time series data from 1990 to 2020 for Pakistan has been analyzed by applying DOLS and GMM estimation techniques. Our findings confirm a positive significant impact on carbon dioxide, methane emissions and ecological footprints through the credit channel in the case of Pakistan. The results of the credit channel mechanism of this study imply a financial sector of Pakistan that is not yet fully developed. Hence, a rise in the domestic credit deteriorates the environment as the enhanced availability of funds is directed towards irresponsible consumption and production activities that are accompanied by inefficient resource usage rather than being targeted towards

environmentally efficient projects. Ultimately, levels of environmental emissions escalate in Pakistan.

The convergence to an environmentally sound economy necessitates initial large capital intensive investments into alternative renewable energy resources. Incorporating environmental targets and designing policies for overall reducing credit availability to dirty firms and industries by banks and the financial sector is a viable option to combat climate change. The findings of this study propose further exploration into the consequences of increased credit and lending directed towards initiatives that harness green energy resources. In addition, the study recommends monitoring of credit availability towards green growth in order to achieve sustainable development goals.

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