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Advancing Economic Research for a Resilient Pakistan

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As we conclude 2024, the Pakistan Journal of Economic Studies (PJES) remains steadfast in its mission to promote cutting-edge research and foster dialogue on our nation's pressing economic challenges. This year has underscored the importance of resilience and innovation as we navigate an ever-evolving global landscape.

In 2024, PJES published four issues, including the December 2024 issue. These issues bring together diverse contributions that reflect the dynamism of economic thought in Pakistan and beyond. The articles on these issues delve into critical areas such as sustainable development, fiscal and monetary policies, and the role of technology in economic transformation. With the economy recovering from external shocks and structural inefficiencies, these scholarly works offer actionable insights that can guide policymakers and practitioners alike.

The editorial board thanks the authors, reviewers, and readers who make PJES a beacon of scholarly excellence. Their dedication and intellectual rigour fuel the journal's continued success.

As we enter 2025, Pakistan's economy is at a pivotal juncture. After two years of navigating macroeconomic challenges and implementing stringent stabilization measures, the country is now positioned to transition from economic stability to sustained growth. This shift is a testament to the government's fiscal discipline, structural reforms, and improved global economic conditions.

Key sectors such as agriculture, information technology, manufacturing, and services are ready to witness dynamism, supported by targeted policy interventions and investments. Enhanced sustainable and affordable energy availability, infrastructure development under the China-Pakistan Economic Corridor (CPEC), and a resilient small and medium enterprise (SME) sector will drive economic activity. Additionally, the State Bank of Pakistan's proactive monetary policy must foster investor confidence and support private sector growth.

However, challenges such as inflationary pressures, ensuring equitable wealth distribution, and sustaining export competitiveness require continued vigilance and reform. Structural issues, including tax collection inefficiencies and governance deficits, must be tackled to ensure inclusive growth.

The Pakistan Journal of Economic Studies (PJES) remains committed to analyzing these developments, offering research-driven insights and fostering dialogue among policymakers, academics, and practitioners.

As Pakistan charts its course toward growth, collective efforts and informed decision-making will be key to unlocking its true economic potential.

Together, let us advance the frontiers of economic research and contribute to a more prosperous and resilient Pakistan. On behalf of the entire PJES team, I wish our readers a productive and insightful year ahead.

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Unveiling the Complexities: An ISM Approach to Understanding the Challenges in Biodiversity Finance Adoption

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ABSTRACT

Objective: Environmental damage is directly impacting the living creatures present all over the globe. Direct exploitation, deforestation, nuclear weapons, and carbon emissions are the leading factors in biodiversity loss. It enhances the need to adopt biodiversity finance, which lacks conceptualization. This study identifies and categorizes the impediments to the biodiversity finance adoption system.

Research Gap: The natural ecosystem and its reproduction system are declining due to climate change and environmental deregulation, adversely affecting biodiversity and creating global concerns for all. The adoption of biodiversity finance is significant in ensuring the sustainable management of biodiversity, but this emerging concept is hindered almost at every stage of its adoption. Still, no study has highlighted the challenges of the biodiversity finance implementation system.

Design/Methodology/Approach: The present research is conducted in two phases. Initially, an extensive literature review was done to enlist biodiversity finance challenges. It was presented to a panel of fifteen experts who shortlisted them to a final set of twenty-seven barriers. Later, these barriers were ranked in eight levels of a hierarchical model. ISM and MICMAC analysis was conducted to categorize the challenges according to their intensity levels.

The Main Findings: The results presented the knowledge gap as the critical factor causing limitations in biodiversity finance. The lack of standardized criteria and global pressures are not forcing economies to adopt biodiversity protection practices.

Theoretical / Practical Implications of the Findings: A proper regulatory framework is essential to ensure global and country-level sustainability. This study will assist financial institutions, regulatory and governing bodies, and researchers.

Originality/Value: It will add value to the existing body of knowledge of biodiversity finance by highlighting and categorizing the challenges in its implementation system.

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1. Introduction

The world of the twenty-first century is experiencing a rapid evolution that is dragging people away from nature. The sustainable management of ecosystem processes is becoming significant, and the emphasis on adopting environment-friendly projects is increasing (Hussain et al., 2024). Almost every country is highlighting the need to endorse green practices (OECD, 2020). The natural reproduction process of nature is reducing and leading to significant biodiversity loss. It is causing the extinction of various animal and

plant species. Likewise, the natural reserves of resources are instantly depleted (Kedward et al., 2023). There is an urgent need to halt biodiversity loss and ensure natural environment restoration. The successful adoption of sustainable practices guaranteeing the preservation of biodiversity requires a considerable amount of investment. Unfortunately, emerging countries with economic instabilities are not strong enough to invest sufficient funds towards this practice individually (Shehzad & Khan, 2024a).

Biodiversity finance can be beneficial in reducing resource scarcity and achieving sustainability goals. This practice ensures the generation and management of funds and the utilization of economic incentives for sustainably managing biodiversity (Flammer et al., 2023). The emerging concept of biodiversity finance is in its conceptualization phase. There are gaps in the clarification and adoption of the idea. Though initial practices are done in developed economies, including Japan and China, developing economies are still behind in their adoption. The successful implementation of biodiversity finance is impeded by several challenges (Karolyi & Puente, 2023). Therefore, to cover this gap, the present study has presented the basic conceptualization of biodiversity finance and identified the factors challenging its implementation.

Harmful toxins in the natural environment gradually increase due to radioactive elements, pollution, burnings, and harmful agricultural means (Shehzad & Khan, 2024c). These circumstances directly impact the natural environment and its ability to regenerate and restore the damages. The deregulation of the natural environment is rapidly increasing and is creating global concerns for all. Therefore, adopting sustainable practices like biodiversity finance is essential to ensure the sustainable management of biodiversity and the natural environment (Shehzad & Khan, 2024b). Biodiversity finance faces challenges at different levels of its execution, including global, national, and individual. The implementation system is hindered due to the unavailability of various elements, including policy frameworks, rules and regulations, governing authorities, and political uncertainties, etc. (Cumming et al., 2021; Young & Castro, 2021). The lack of technological advancements and expertise is leading to the usage of harmful production means, which are directly causing environmental deregulation.

Similarly, the unavailability of eco-friendly projects and sustainable practices limits the adoption of green practices (Khan et al., 2022). The lack of involvement of financial institutions and the disinterests of international bodies also impede biodiversity finance (Shehzad & Khan, 2024b). Hence, the participation and collaboration of research institutions are crucial to adopting sustainable practices. No study has presented the challenges to biodiversity finance classified in different levels based on their challenging intensity. This research aims to unveil the complexities by identifying the challenges in adopting biodiversity finance and developing a hierarchical model of challenges. To successfully achieve the objectives, the study was initially identified through an extensive literature review, and the expert panel finalized the final list of challenges. Interpretive Structural Modeling (ISM) and Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) analysis were conducted to drive the study's results, presenting the multiple challenges to the biodiversity finance implementation system. The barriers' conceptualization and hierarchic classification will add to the existing literature on biodiversity finance. It will also assist in the formation of regulatory frameworks and policies accordingly.

The next sections of the study are constructed as follows: Section 2 presents the mechanism and existing literature on biodiversity finance and its impediments. Section 3 comprises the materials and methods used to conduct the analysis and drive the results presented in Section 4. Section 5 exhibits the essential findings and discussions, and the final section 6 is composed of the concluding remarks of the present study.

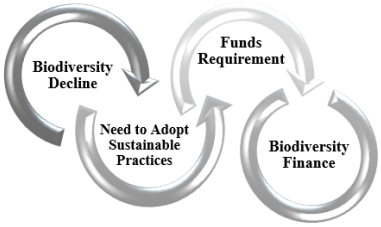
2. Literature Review

Natural processes of ecosystems and biodiversity are declining gradually. Biodiversity comprises all living creatures alive in the world. It includes the variety of life on land and below water, including animals, plants, fungi, micro-organisms, etc. (Tisdell, 1994). All the elements of biodiversity interact with each other to support life in the ecosystem. The natural environment and reproduction capacity of biodiversity are decreasing due to different natural, accidental circumstances and human actions (Saxena, 2023). Events like floods, earthquakes, droughts, and the outbreak of biological hazards can cause Natural hazards.

Harmful production means over-pollution, deforestation, excess usage of natural resources, explosions, blasts, etc., and unwanted human activities directly harming biodiversity (Kedward et al., 2023). This situation is raising concerns for the protection of biodiversity for all. The sustainable management of the processes created by nature is possible by the inward flow of capital towards this activity.

Eco-friendly practices are becoming moderately common in developed economies with abundant resources and capital. Sustainable practices are still neglected in underdeveloped and developing economies with resource scarcity (Shehzad & Khan, 2024a). Although developing economies have natural resources like land and cheap labor, they have limited flow to required capital (Akram et al., 2023). Therefore, sustainable practices generating low financial returns on investments are neglected by developing economy investors. Moreover, these practices are usually riskier and generate long-term returns for investors (Adeel et al., 2022). The low-risk appetite of investors majorly limits the flow of funds towards sustainability projects. Biodiversity finance is the best solution in this situation, ensuring the conservation and preservation of biodiversity (see Figure 1). The concept of biodiversity finance is still in its emerging phase and lacks basic conceptualization. Prior researchers have highlighted the idea with its basic conceptualization and measures.

Figure 1: Biodiversity Finance Mechanism



Source: Authors' Estimation

Karolyi & Puente (2023) called attention to biodiversity finance and described it as raising and managing capital and using financial tools and incentives to ensure sustainable biodiversity management. The emerging concept of biodiversity finance is still in its development phase. People are still not aware of the basic conceptualization and significance of biodiversity finance. Rachel et al. (2021) have presented biodiversity expenditure as a significant element for reducing pressure on biodiversity. The lack of conceptual development and consensus creates fundamental misconceptions about biodiversity finance. Practitioners relate it with green finance, CSR, and sustainable investment practices (Ansari et al., 2023).

The successful implementation of biodiversity finance is facing problems at various levels of its adoption. Many impediments to biodiversity finance are discussed in the literature. The lack of awareness and knowledge gap are the foremost challenges to adopting biodiversity finance systems. Once the stakeholders know the basic concept and its significance, they will adopt this practice quickly (Rubino, 2000). Knowledge gaps create misperceptions in investors, certain perceptions, and psychological barriers from the viewpoints of international and domestic investors of biodiversity finance (Khan et al., 2024). The obstacles to biodiversity finance are not limited to the lack of global pressures, which is also a significant challenge for the initial adoption phase of biodiversity finance (Ziolo et al., 2021). Global pressures can compel countries to launch sustainable and eco-friendly projects. It will force regulatory bodies and governments to make strict laws and regulations to protect biodiversity and natural resources (Ali & Khan, 2022). The unavailability of the regulatory framework is a crucial challenge to the adoption system of biodiversity finance (Desalegn & Tangl, 2022).

Investors still avoid SRI practices due to the conflicts of interest in social investments. They consider SRI a purposeless investment decision, giving them minimal financial returns (Shehzad & Khan, 2024a). Similarly, financial institutions are also not interested in stainability projects and schemes. The lack of interest in financial institutions creates problems in raising funds for sustainability projects (Khan et al., 2022). Furthermore, assessment is also a significant concern for investors when making sustainable

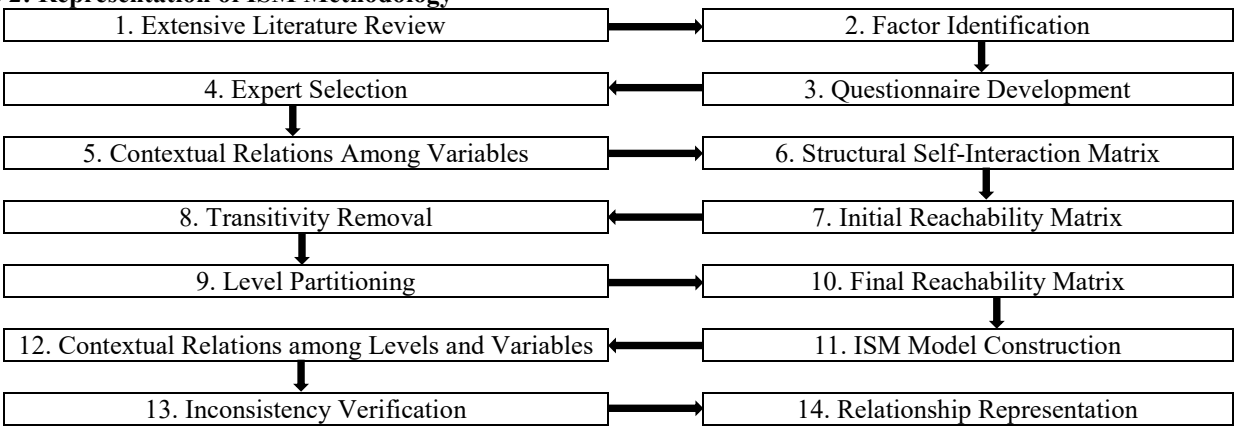
investment decisions. The financial return is the essential requirement of every investor, and a lack of proper risk management directly hinders the biodiversity finance adoption system (Darus et al., 2014). Individual investors in emerging economies usually have a limited risk appetite and avoid investing in social return-generating investment opportunities (Desalegn & Tangl, 2022). Similarly, the emerging states have limited monetary resources and provide minimal or no support to non-financial return-generating businesses. Lack of state support impedes the adoption of biodiversity finance systems (Du et al., 2018). In brief, the successful implementation of a system of biodiversity finance is limited by global, country-level, and individual challenges. These challenges directly affect sustainable biodiversity management. Controlling these impediments will help create a better place for all to live.

3. Materials and Methods

3.1 Interpretive Structural Modelling

ISM is a significant research methodology with various advantages. It is considered an essential technique for establishing and transforming complex phenomena. It also helps construct frameworks for understanding and resolving complex problems. Similarly, it can be used to identify the relationship among different items. ISM methodology includes multiple steps that present the relations among factors. Initially, it starts with an extensive literature review to identify the barriers already highlighted by prior researchers. Later, a comprehensive list of factors presenting the impediments to the biodiversity finance implementation system is made through an in-depth literature review. A questionnaire protocol was developed to get expert opinion, including the fundamental question for each identified factor and their proper consent. The study seeks expert opinion in two phases and makes sure to avoid repetition of the panel to avoid biasedness in the opinion. In phase I, 59 identified barriers are presented to the three experts to seek their opinion in finalizing the barriers list for the phase II study.

Figure 2: Representation of ISM Methodology



Source: Authors' Estimation

After this, the relevant experts were requested to participate in the research process, selected based on their expertise and availability. The complete study objective and answering procedures are explained to the experts to get the best output from them. The contextual relationship of each variable is made with the other variable; the same process is continuous for all variables. Structural Self Interaction Matrix (SSIM) is developed to present the relations existing in all variables. This step is considered one of the most critical steps based on relationship identification. This identification is based on the classifications made after discussing with the panel of three experts in Phase I who are not part of the research process of Phase II. The relationships are presented through 'V,' 'A', 'X,' and 'O'. The steps of ISM remain continuous until the Initial Reachability Matrix (IRM) is changed to a conical matrix after transitivity removal and level partition. The formation of the ISM model is the next step, and lastly, the relationships among variables are presented. The complete steps of the ISM methodology are presented in Figure 2, including ISM steps specifically in 2, 6, 7, 9.10, and 11.

3.2 Research Design

The present study has adopted the ISM approach to develop and investigate the relationships among the different factors to identify the barriers to adopting biodiversity finance (Khan et al., 2022). An in-depth literature review was conducted to determine the challenges to biodiversity finance, which were later used to develop a questionnaire protocol. A panel of fifteen experts was finalized through purposive sampling to obtain assistance from their skills, knowledge, and expertise. The key reason for involving experts was to verify the barriers and their categorization to form a multi-layered structural model. Experts were selected based on their direct linkage with biodiversity protection projects, experiences, and awareness about the environmental and other factors causing biodiversity decline. Moreover, experts working on the financial mechanisms for the conservation and restoration of biodiversity were also part of the selected panel. The demographic details of the expert cluster are below in Table 1.

Table 1. Demographic Details of the Sample Respondents

Sr. No.	Title	Gender	Designation	Qualification	Experience (Years)	Nature of Expert
1	A***	Female	Lecturer	M.S	5	Subject Expert
2	B***	Male	Assistant Director	MBA	10	Environmentalist
3	C***	Male	Environmental Officer	MBA	12	Banker
4	D***	Male	Senior Lecturer	M.S.	11	Subject Expert
5	E***	Male	Environment Officer	Ph.D	15	Environmentalist
6	F***	Female	Data Analyst	M.S	12	Economist
7	G***	Male	Corporate Manager	CFA	10	Other
8	H***	Female	Senior researcher	M.S	9	Biodiversity Researcher
9	I***	Male	Lecturer	MBA	8	Subject Expert
10	J***	Male	Social Activist	MBA	15	Other
11	K***	Female	Credit Manager	M.S	11	Banker
12	L***	Female	Professor	M.S	9	Biodiversity Researcher
13	M***	Male	Environmental Officer	M.S	10	Environmentalist
14	N***	Male	Operations Manager	MBA	11	Banker
15	O***	Male	Social Activist	MBA	10	Other

Source: Authors' Estimation

3.3 Data Collection

Initially, 59 barriers to the adoption of biodiversity finance systems were identified through an extensive literature review. The comprehensive list of these barriers was presented to the panel of three experts in Phase I, who removed and added them according to their expertise. Finally, an ISM questionnaire was formulated for 30 barriers and provided to the 15 experts who were requested to rank them first based on their expertise. They also identified overlapping barriers and suggested excluding them (see Table 2). We removed three barriers, "pressure to attain SDGs," "inadequate recycling process," and "massive industrialization," based on their advice that they suggested did not directly impede biodiversity adoption. Finally, they end up with 27 barriers that have the highest score. After assigning them individual codes, the final list of barriers was presented in Appendix A. They were further asked to confirm and rank the barriers through the ISM approach and highlight their contextual relations. The respondents were asked about the effect of every individual barrier on the other barriers and their relationship directions. The exact process was followed continuously till the final extraction of the different clusters of challenges.

4. Analysis and Results

The present study has selected the ISM approach to analyze the significant challenges of the biodiversity finance adoption system. An in-depth literature review and a panel of experts have helped identify and shortlist the barriers. The inter-relations present among the challenges of biodiversity finance are determined through SSIM. The finalized 27 challenges and their relation are presented through SSIM, which was constructed through aggregating (w,z) data in the form of VAXO.

Table 2. Barrier Verification by the Panel of Experts

Sr. No.	Barriers	Experts															Total		Included/ Neglected
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	✓	✗	
1	Lack of Global Pressure	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✗	✗	11	4	Included
2	Difficulties in International Fundraising	✓	✗	✓	✓	✗	✗	✓	✓	✓	✓	✗	✗	✗	✓	✗	8	7	Included
3	Perception-Related Barriers	✗	✓	✓	✗	✓	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓	9	6	Included
4	Inadequate Recycling Process	✗	✓	✓	✗	✗	✓	✗	✗	✗	✓	✓	✗	✗	✗	✓	6	9	Neglected
5	Political Conflicts	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	14	1	Included
6	Unavailability of Regulatory Framework	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗	✓	✓	12	3	Included
7	Lack of futuristic approach	✓	✓	✗	✗	✗	✓	✓	✓	✓	✗	✗	✓	✓	✓	✗	9	6	Included
8	Social and Cultural Practices	✓	✓	✗	✗	✓	✓	✗	✓	✗	✓	✓	✗	✗	✗	✓	8	7	Included
9	Lack of Subsidies and Alternatives	✗	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✗	✗	✓	10	5	Included
10	Knowledge Gap	✗	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	11	4	Included
11	Massive Industrialization	✗	✗	✓	✗	✗	✓	✗	✓	✓	✓	✗	✗	✗	✗	✗	5	10	Neglected
12	Insufficient Budget Allocation	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	14	1	Included
13	Psychological Barriers	✗	✗	✓	✓	✓	✓	✗	✓	✗	✓	✗	✓	✓	✓	✗	10	5	Included
14	Lack of Standardized Criteria	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	14	1	Included
15	Less Interest in Financial Institutions	✓	✗	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	12	3	Included
16	SRI Practice	✗	✗	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✗	✗	✓	9	6	Included
17	Eco-Friendly Projects	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓	✓	✓	12	3	Included
18	Economic Instability	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	13	2	Included
19	Technical Expertise and Skilled Personnel	✗	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	12	3	Included
20	Institutional and Research Collaboration	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗	✓	✓	✓	✗	12	3	Included
21	Lack of Private Finance Flows	✓	✗	✗	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	10	5	Included
22	Role of NGOs	✗	✓	✓	✓	✗	✓	✓	✓	✗	✓	✓	✗	✗	✓	✓	10	5	Included
23	Risk Management	✓	✓	✗	✓	✗	✗	✓	✓	✓	✗	✗		✗	✓	✓	9	6	Included
24	No Mechanism for Tracking Biodiversity Loss	✓	✗	✗	✓	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓	✗	10	5	Included
25	Low Financial Returns	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	13	2	Included
26	Absence of Sustainable Practices	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10	5	Included
27	Inflationary Pressure	✓	✓	✓	✗	✗	✗	✓	✓	✓	✓	✓	✗	✗	✓	✓	10	5	Included
28	Absence of Governance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	14	1	Included
29	Conflicts of Interest within Social Investments	✓	✗	✓	✗	✓	✓	✓	✗	✗	✗	✓	✗	✗	✓	✓	8	7	Included
30	Pressure to Attain SDGs	✓	✗	✗	✗	✓	✗	✗	✓	✓	✗	✓	✗	✗	✗	✗	5	10	Neglected

Source: Authors' Estimation

The contextual relationship existing among the challenges of biodiversity finance is presented as; 'V': challenge w is influencing challenge z, 'A': challenge z is influencing challenge w, 'X': both w and z influence each other, and a relation is present among them, and 'O': w is not having any relation with z. The relationships existing among all variables were represented through the defined symbols. The contextual relations of the challenges to biodiversity finance are presented in Table 3.

Table 3. Structural Self-Interaction Matrix

Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1		V	V	A	V	X	X	V	A	V	V	X	V	V	V	O	X	V	V	X	O	V	O	V	V	O	O
2			O	A	A	V	O	V	A	V	O	A	X	V	O	A	O	X	X	X	A	A	A	V	A	A	O
3				O	A	X	X	O	X	O	X	A	O	X	V	O	A	X	O	A	V	O	A	V	A	O	X
4					V	V	O	V	O	V	O	A	V	O	O	V	O	O	V	V	O	O	V	O	V	X	O
5						X	O	V	A	V	V	A	V	V	V	A	O	A	V	V	V	V	O	V	V	A	V
6							A	A	A	A	X	X	A	A	V	O	O	X	O	O	O	A	O	O	O	O	V
7								O	A	O	X	A	O	V	V	O	O	O	O	V	O	O	O	O	O	O	X
8									A	X	O	A	V	V	V	A	O	V	X	V	O	A	X	V	O	A	O
9										V	X	A	V	V	V	O	V	X	V	A	V	V	O	V	O	O	V
10											O	A	V	V	V	A	O	V	V	V	O	A	O	V	A	A	O
11												X	O	X	V	A	O	X	X	A	O	O	A	V	A	O	X
12													V	V	V	O	O	V	V	V	O	A	O	V	O	O	O
13														V	V	A	O	A	V	V	O	A	O	A	O	A	O
14															X	A	O	A	A	A	A	A	A	A	A	A	X
15																A	O	A	A	A	A	A	A	A	A	A	X
16																	O	O	V	O	O	O	V	V	V	A	O
17																		V	O	O	V	O	O	O	O	O	O
18																			O	X	V	X	O	V	O	O	V
19																				A	O	O	A	V	O	A	A
20																					O	V	O	V	O	A	V
21																						O	O	V	A	O	X
22																							O	V	O	O	O
23																								V	A	A	V
24																									A	A	A
25																										A	V
26																											O
27																											

Source: Authors' Estimation

The relationship between the "absence of governance" and other barriers to the adoption of biodiversity finance systems is presented in the first row. The presence of 'V' presents that the "absence of governance" can influence "difficulties in international fundraising," which is supported by prior researchers as well (Anej et al., 2023). The absence of governance can lead to multiple factors, including "political conflicts" and further to "economic instability" (Nedopil et al., 2021). Likewise, row 26 presents the relation of "lack of global pressure" with the other barriers to biodiversity finance. Global pressure imposed by foreign regulatory bodies and countries can force domestic organizations to adopt biodiversity finance mechanisms, which are hindered by the "unavailability of the regulatory framework" (Xu et al., 2022). Similarly, the presence of 'A' in the next row presents that "political conflicts, lack of standardized criteria, economic instability (Mngumi et al., 2022), and absence of governance, etc." lead to "difficulties in international fundraising." "Political instability" leading to "economic instability" creates uncertainties in funding bodies and causes difficulties in international fundraising. "Absence of governance is a foremost challenge to the biodiversity finance adoption system, resulting in problems in fundraising from foreign sources (Khan et al., 2022).

The assignment of 'X' to the barriers of row 3 shows that "perception-related barriers" and the different other barriers, including "SRI practices (Bakry et al., 2023), social and cultural practices, knowledge gap and psychological barriers, etc." have a bilateral relationship among these challenges of biodiversity finance adoption. Stakeholders' perceptions are changed by institutional and research collaboration, and likewise, the potential research outcomes can be influenced by the perceptions of stakeholders (Niemczyk et al., 2023). Perception is a psychological process; perception barriers, including language gaps, projections, and expectations, can influence psychological barriers like emotions, opinions, etc., or vice versa (Nilsson, 2009). The issuance of 'O' in row 4 presents that the barrier "lack of standardized criteria" is not related to "social and cultural practices" and "inflationary pressures" (Shehzad & Khan, 2024a), etc. respectively. Inflationary pressures present in an individual country do not impact the global criteria of the biodiversity finance adoption system (Aamir et al., 2011).

Table 4. Initial Reachability Matrix

Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	0	1	0	1	1	0	0
2	0	1	0	0	0	1	0	1	0	1	0	0	1	1	0	0	0	1	1	1	0	0	0	1	0	0	0
3	0	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	0	1	0	0	1	0	0	1	0	0	1
4	1	1	0	1	1	1	0	1	0	1	0	0	1	0	0	1	0	0	1	1	0	0	1	0	1	1	0
5	0	1	1	0	1	1	0	1	0	1	1	0	1	1	1	0	0	0	1	1	1	1	0	1	1	0	1
6	1	0	1	0	1	1	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1
7	1	0	1	0	0	1	1	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1
8	0	0	0	0	0	1	0	1	0	1	0	0	1	1	1	0	0	1	1	1	0	0	1	1	0	0	0
9	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	1	1	0	1	0	0	1
10	0	0	0	0	0	1	0	1	0	1	0	0	1	1	1	0	0	1	1	1	0	0	0	1	0	0	0
11	0	0	1	0	0	1	1	0	1	0	1	1	0	1	1	0	0	1	1	0	0	0	0	1	0	0	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0	0	1	0	0	0
13	0	1	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0
14	0	0	1	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1
15	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1
16	0	1	0	0	1	0	0	1	0	1	1	0	1	1	1	1	0	0	1	0	0	0	1	1	1	0	0
17	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0
18	0	1	1	0	1	1	0	0	1	0	1	0	1	1	1	0	0	1	0	1	1	1	0	1	0	0	1
19	0	1	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0
20	1	1	1	0	0	0	0	0	1	0	1	0	0	1	1	0	0	1	1	1	0	1	0	1	0	0	1
21	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0	1
22	0	1	0	0	0	1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	1	0	1	0	0	0
23	0	1	1	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	1	0	0	0	1	1	0	0	1
24	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0
25	0	1	1	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	1	0	1	1	1	0	1
26	0	1	0	1	1	0	0	1	0	1	0	0	1	1	1	1	0	0	1	1	0	0	1	1	1	1	0
27	0	0	1	0	0	0	1	0	0	0	1	0	0	1	1	0	0	0	1	0	1	0	0	1	0	0	1

Source: Authors' Estimation

An IRM was made for SSIM. The development and replacement rules for the construction of the IRM are as follows: with the input (w,z) 'V' in SSIM, input (w,z) will be '1' in IRM, and for input (z,w) it will be '0', with the input (w,z) 'A' in SSIM, input (w,z) will be '0' in IRM, and for input (z,w) it will be '1', with the input (w,z) 'X' in SSIM, input (w,z) will be '1' in IRM, and for input (z,w) it will be '1', and finally

with the input (w,z) 'O' in SSIM, input (w,z) will be '0' in IRM, and for input (z,w) it will be '0'. The results of the IRM are presented in Table 4.

The barriers in the first column with the input of 'V' in SSIM, including the obstacles, lack of global pressure, and difficulties in international fundraising, for instance, are assigned '1', and this '1' is replaced with '0' for the input: difficulties in international fundraising and lack of global pressure. Similarly, input factors like lack of global pressure and knowledge gap are 'A' in SSIM and '0' in the IRM. The input barriers of knowledge and lack of global pressure are '1'. When the lack of global pressure and perception-related barriers are assigned 'X' in SSIM, input in the IRM is '1', and input perception-related barriers and lack of global pressure are also '1'. Lastly, suppose input factors lack of global pressure and lack of subsidies and alternatives" is 'O' in SSIM, it is '0' in IRM, and the value of the input of lack of subsidies and alternatives and lack of global pressure is also '0'. The values of '0' and '1' are allocated to all other barriers presented in the matrix using the same rule of value allocation. The IRM is further used to construct the Final Reachability Matrix (FRM), presented in Table 5.

Table 5. Final Reachability Matrix

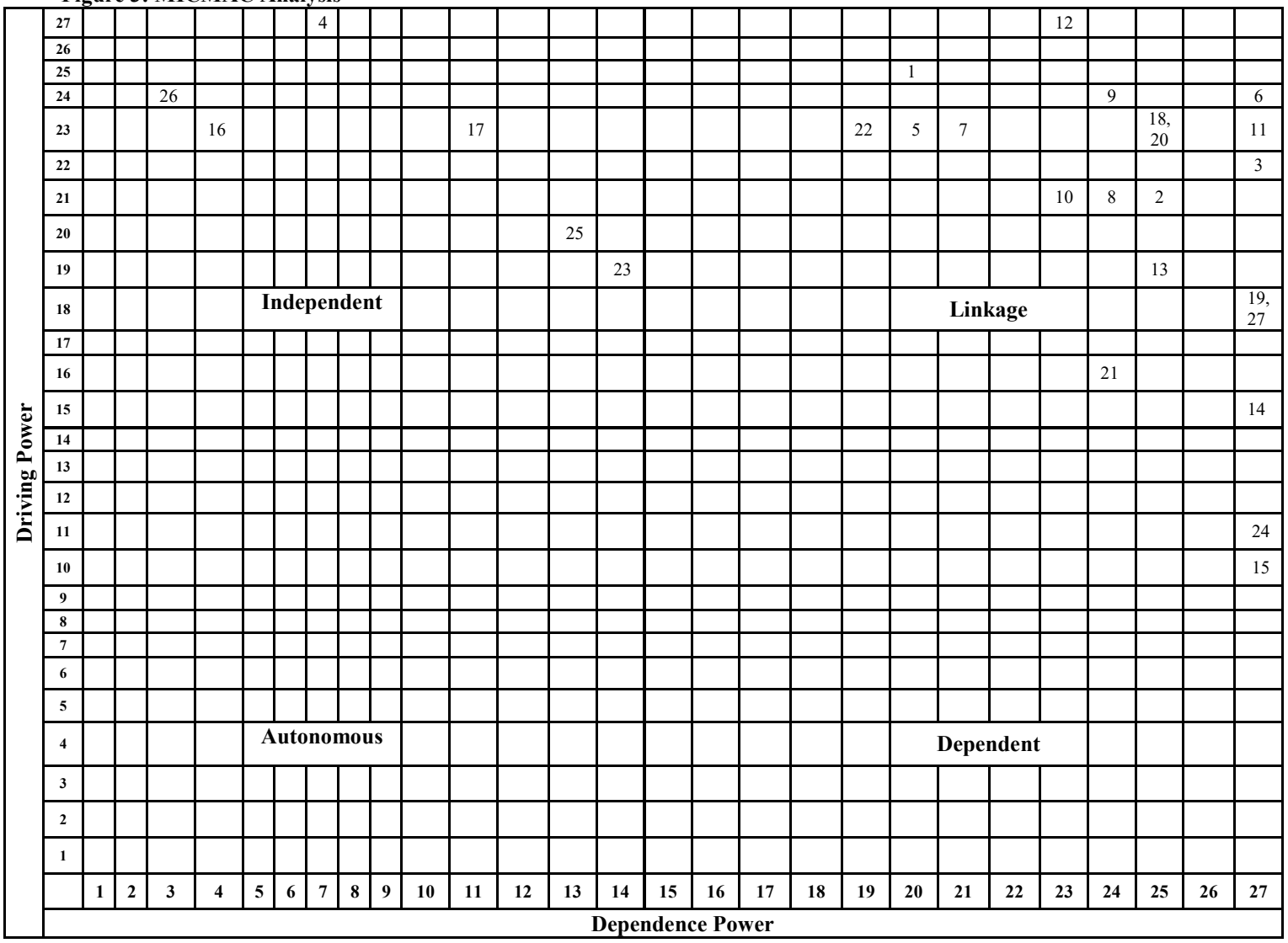
Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Driving
1	1	1	1	1*	1	1	1	1	1*	1	1	1	1	1	1	0	1	1	1	1	1*	1	1*	1	1	0	1*	25
2	1*	1	1*	0	1*	1	0	1	1*	1	1*	1*	1	1	1*	0	0	1	1	1	1*	1*	1*	1	0	0	1*	21
3	1*	1*	1	0	1*	1	1	1*	1	1*	1	1*	1*	1	1	0	1*	1	1*	1*	1	1*	0	1	0	0	1	22
4	1	1	1*	1	1	1	1*	1	1*	1	1*	1*	1	1*	1*	1	1*	1*	1	1	1*	1*	1	1*	1	1	1*	27
5	1*	1	1	0	1	1	1*	1	1*	1	1	1*	1	1	1	0	0	1*	1	1	1	1	1*	1	1	0	1	23
6	1	1*	1	1*	1	1	1*	1*	1*	1*	1	1	1*	1*	1	0	1*	1	1*	1*	1*	1*	0	1*	1*	0	1	24
7	1	1*	1	0	1*	1	1	1*	1*	1*	1	1*	1*	1	1	0	1*	1*	1*	1	1*	1*	0	1*	1*	0	1	23
8	1*	1*	1*	0	1*	1	0	1	1*	1	1*	1*	1	1	1	0	0	1	1	1	1*	1*	1	1	0	0	1*	21
9	1	1	1	0	1	1	1	1	1	1	1	1*	1	1	1	0	1	1	1	1*	1	1	1*	1	1*	0	1	24
10	1*	1*	1*	0	1*	1	0	1	1*	1	1*	1*	1	1	1	0	0	1	1	1	1*	1*	1*	1	0	0	1*	21
11	1*	1*	1	1*	1*	1	1	1*	1	1*	1	1	1*	1	1	0	1*	1	1	1*	1*	1*	0	1	0	0	1	23
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1*	1	1	1	1*	1*	1*	1	1*	1*	1*	27
13	1*	1	1*	0	1*	1	0	1*	1*	1*	1*	1*	1	1	1	0	0	1*	1	1	0	1*	0	1*	0	0	1*	19
14	1*	0	1	0	1*	1	1*	0	1*	0	1	1*	0	1	1	0	0	1*	1*	0	1*	0	0	1*	0	0	1	15
15	0	0	1*	0	0	1*	1*	0	0	0	1*	0	0	1	1	0	0	0	1*	0	1*	0	0	1*	0	0	1	10
16	0	1	1*	0	1	1*	1*	1	1*	1	1	1*	1	1	1	1	0	1*	1	1*	1*	1*	1	1	1	0	1*	23
17	1	1*	1	0	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	0	1	1	1*	1*	1	1*	0	1*	1*	0	1*	23
18	1*	1	1	0	1	1	1*	1*	1	1*	1	1*	1	1	1	0	1*	1	1*	1	1	1	0	1	1*	0	1	23
19	0	1	1*	0	0	1*	1*	1	1*	1*	1	1*	1*	1	1	0	0	1*	1	1*	0	0	1*	1	0	0	1*	18
20	1	1	1	0	1*	1*	1*	1*	1	1*	1	1*	1*	1	1	0	1*	1	1	1	1*	1	0	1	1*	0	1	23
21	0	1	1*	0	0	1*	1*	1*	0	1*	1*	0	1*	1	1	0	0	1*	1*	1*	1	0	0	1	0	0	1	16
22	1*	1	1*	1*	1*	1	1*	1	1*	1	1*	1	1	1	1	0	0	1	1*	1*	1*	1	1*	1	0	0	1*	23
23	0	1	1	0	0	1*	1*	1	1*	1*	1	1*	1*	1	1	0	0	1*	1	1*	1*	0	1	1	0	0	1	19
24	0	1*	1*	0	0	1*	0	0	0	0	1*	0	1	1	1	0	0	0	1*	1*	0	0	0	1	0	0	1*	11
25	0	1	1	0	0	1*	1*	1*	1*	1	1	1*	1*	1	1	0	0	1*	1*	1*	1	0	1	1	1	0	1	20
26	1*	1	1*	1	1	1*	0	1	1*	1	1*	0	1	1	1	1	0	1*	1	1	1*	1*	1	1	1	1	1*	24
27	1*	1*	1	0	0	1*	1	1*	1*	0	1	1*	1*	1	1	0	0	1*	1	1*	1	0	0	1	0	0	1	18
Dependence	20	25	27	7	20	27	21	24	24	23	27	23	25	27	27	4	11	25	27	25	24	19	14	27	13	3	27	

Source: Authors' Estimation

A transitivity test is applied to IRM to form FRM, and '*' fills the gap by inference. If barrier 'A' is related to barrier 'B,' and barrier 'B' is related to barrier 'C,' then 'A' is automatically associated with 'C'. '0' and '1' entries were verified to construct FRM. The final step is calculating the driving and dependence power of the barriers to biodiversity finance adoption. These powers are calculated after finalizing all relationships through accounting transitivity.

Dependence power represents the total number of the first row, and driving power is the total number of the respective column. The calculation of driving and dependence power is further used in MICMAC analysis, which classifies the barriers in different clusters, including dependent, autonomous, linkages, and independent. MICMAC analysis of the present study is presented in Figure 3. MICMAC analysis shows no challenge to biodiversity finance adoption in the autonomous cluster. At the same time, only two barriers, including the "absence of sustainable practices" and "eco-friendly projects," are present in the dependent cluster. Linkage cluster has the maximum number of challenges, including "absence of governance," "political conflicts," "inflationary pressures," "SRI practices," and "unavailability of regulatory framework," etc. Interlinkage of challenges presents their high dependence and driving powers, respectively. Changes and actions in one challenge can affect others and themselves easily.

Figure 3: MICMAC Analysis



Source: Authors' Estimation

FRM was further used to drive reachability and antecedent sets. These two sets were further used in constructing the intersection set, including all the common reachability and antecedent set challenges. The similarity of the intersection and the reachability set identifies the final levels. The final classification of barriers into VIII different levels is presented in Table 6.

Table 6. Summarizing Interactions

Code	Reachability Set	Antecedent Set	Intersection Set	Level
		Iteration *I*		
1	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,23,24,25,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,17,18,20,22,26,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,17,18,20,22,27	
2	1,2,3,5,6,8,9,10,11,12,13,14,15,18,19,20,21,22,23,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,16,17,18,19,20,21,22,23,24,25,26,27	1,2,3,5,6,8,9,10,11,12,13,18,19,20,21,22,23,24,27	
3	1,2,3,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	1,2,3,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,24,27	*I*
4	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	1,4,6,11,12,22,26	1,4,6,11,12,22,26	
5	1,2,3,5,6,7,8,9,10,11,12,13,14,15,18,19,20,21,22,23,24,25,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,16,17,18,20,22,26	1,2,3,5,6,7,8,9,10,11,12,13,14,18,20,22	
6	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,24,25,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,24,25,27	*I*
7	1,2,3,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,24,25,27	1,3,4,5,6,7,9,11,12,14,15,16,17,18,19,20,21,22,23,25,27	1,3,5,6,7,9,11,12,14,15,17,18,19,20,21,22,25,27	
8	1,2,3,5,6,8,9,10,11,12,13,14,15,18,19,20,21,22,23,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,16,17,18,19,20,21,22,23,25,26,27	1,2,3,5,6,8,9,10,11,12,13,18,19,20,21,22,23,27	

9	1,2,3,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,23,24,25,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,16,17,18,19,20,22,23,25,26,27	1,2,3,5,6,7,8,9,10,11,12,13,14,17,18,19,20,22,23,25,27	
10	1,2,3,5,6,8,9,10,11,12,13,14,15,18,19,20,21,22,23,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,16,17,18,19,20,21,22,23,25,26	1,2,3,5,6,8,9,10,11,12,13,18,19,20,21,22,23	
11	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,24,27	*I*
12	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,16,17,18,19,20,22,23,25,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,16,17,18,19,20,22,23,25,27	
13	1,2,3,5,6,8,9,10,11,12,13,14,15,18,19,20,22,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,16,17,18,19,20,21,22,23,24,25,26,27	1,2,3,5,6,8,9,10,11,12,13,18,19,20,22,24,27	
14	1,3,5,6,7,9,11,12,14,15,18,19,21,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	1,3,5,6,7,9,11,12,14,15,18,19,21,24,27	*I*
15	3,6,7,11,14,15,19,21,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	3,6,7,11,14,15,19,21,24,27	*I*
16	2,3,5,6,7,8,9,10,11,12,13,14,15,16,18,19,20,21,22,23,24,25,27	4,12,16,26	12,16	
17	1,2,3,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,24,25,27	1,3,4,6,7,9,11,12,17,18,20	1,3,6,7,9,11,12,17,18,20	
18	1,2,3,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,24,25,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,16,17,18,19,20,21,22,23,25,26,27	1,2,3,5,6,7,8,9,10,11,12,13,14,17,18,19,20,21,22,25,27	
19	2,3,6,7,8,9,10,11,12,13,14,15,18,19,20,23,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	2,3,6,7,8,9,10,11,12,13,14,15,18,19,20,23,24,27	*I*
20	1,2,3,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,21,22,24,25,27	1,2,3,4,5,6,7,8,9,10,11,12,13,16,17,18,19,20,21,22,23,24,25,26,27	1,2,3,5,6,7,8,9,10,11,12,13,17,18,19,20,21,22,24,25,27	
21	2,3,6,7,8,10,11,13,14,15,18,19,20,21,24,27	1,2,3,4,5,6,7,8,9,10,11,12,14,15,16,17,18,20,21,22,23,25,26,27	2,3,6,7,8,10,11,14,15,18,20,21,27	
22	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,18,19,20,21,22,23,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,16,17,18,20,22,26	1,2,3,4,5,6,7,8,9,10,11,12,13,18,20,22	
23	2,3,6,7,8,9,10,11,12,13,14,15,18,19,20,21,23,24,27	1,2,4,5,8,9,10,12,16,19,22,23,25,26	2,8,9,10,12,19,23	
24	2,3,6,11,13,14,15,19,20,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	2,3,6,11,13,14,15,19,20,24,27	*I*
25	2,3,6,7,8,9,10,11,12,13,14,15,18,19,20,21,23,24,25,27	1,4,5,6,7,9,12,16,17,18,20,25,26	6,7,9,12,18,20,25	
26	1,2,3,4,5,6,8,9,10,11,13,14,15,16,18,19,20,21,22,23,24,25,26,27	4,12,26	4,26	
27	1,2,3,6,7,8,9,11,12,13,14,15,18,19,20,21,24,27	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27	1,2,3,6,7,8,9,11,12,13,14,15,18,19,20,21,24,27	*I*
		Iteration II		
1	1,2,4,5,7,8,9,10,12,13,17,18,20,21,22,23,25	1,2,4,5,7,8,9,10,12,13,17,18,20,22,26	1,2,4,5,7,8,9,10,12,13,17,18,20,22	
2	1,2,5,8,9,10,13,18,20,21,22,23	1,2,4,5,7,8,9,10,12,13,16,17,18,20,21,22,23,25,26	1,2,5,8,9,10,13,18,20,21,22,23	*II*
4	1,2,4,5,7,8,9,10,12,13,16,17,18,20,21,22,23,25,26	1,4,12,22,26	1,4,12,22,26	
5	1,2,5,8,9,10,12,13,18,20,21,22,23,25	1,2,4,5,7,8,9,10,12,16,17,18,20,22,26	1,2,5,8,9,10,12,18,20,22	
7	1,2,5,7,8,9,10,12,13,17,18,20,22,25	1,4,7,9,12,17,18,20,22	1,7,9,12,17,18,20,22	
8	1,2,5,8,9,10,13,18,20,21,22,23	1,2,4,5,7,8,9,10,12,13,16,17,18,20,21,22,23,25,26	1,2,5,8,9,10,13,18,20,21,22,23	*II*
9	1,2,5,7,8,9,10,12,13,17,18,20,21,22,23,25	1,2,4,5,7,8,9,10,12,13,17,18,20,22,26	1,2,5,7,8,9,10,12,13,17,18,20,22	
10	1,2,5,8,9,10,13,18,20,21,22,23	1,2,4,5,7,8,9,10,12,13,16,17,18,20,21,22,23,25,26	1,2,5,8,9,10,13,18,20,21,22,23	*II*
12	1,2,4,5,7,8,9,10,12,13,16,17,18,20,21,22,23,25,26	1,4,5,7,9,12,17,18,20,22	1,4,5,7,9,12,17,18,20,22	
13	1,2,8,9,10,13,18,20,22	1,2,4,5,7,8,9,10,12,13,16,17,18,20,21,22,23,25,26	1,2,8,9,10,13,18,20,22	*II*
16	2,5,8,10,13,16,18,20,21,22,23,25	4,12,16,26	16	
17	1,2,5,7,8,9,10,12,13,17,18,20,21,22,25	1,4,7,9,12,17,18,20	1,7,9,12,17,18,20	
18	1,2,5,7,8,9,10,12,13,17,18,20,21,22,25	1,2,4,5,7,8,9,10,12,13,16,17,18,20,21,22,23,25,26	1,2,5,7,8,9,10,12,13,17,18,20,21,22,25	*II*
20	1,2,5,7,8,9,10,12,13,17,18,20,21,22,25	1,2,4,5,7,8,9,10,12,13,16,17,18,20,21,22,23,25,26	1,2,5,7,8,9,10,12,13,17,18,20,21,22,25	*II*
21	2,8,10,13,18,20,21	1,2,4,5,8,9,10,12,16,17,18,20,21,22,25,26	2,8,10,18,20,21	
22	1,2,4,5,7,8,9,10,12,13,18,20,21,22,23	1,2,4,5,7,8,9,10,12,13,16,17,18,20,22,26	1,2,4,5,7,8,9,10,12,13,18,20,22	
23	2,8,10,13,18,20,23	1,2,4,5,8,9,10,12,16,22,23,25,26	2,8,10,23	
25	2,8,10,13,18,20,21,23,25	1,4,5,7,9,12,16,17,18,20,25,26	18,20,25	
26	1,2,4,5,8,9,10,13,16,18,20,21,22,23,25,26	4,12,26	4,26	
		Iteration III		
1	1,4,5,7,9,12,17,21,22,23,25	1,4,7,9,12,17,22,26	1,4,7,9,12,17,22	
4	1,4,5,7,12,16,17,21,22,23,25,26	1,4,12,22,26	1,4,12,22,26	
5	5,12,21,22,23,25	1,4,5,7,9,12,16,17,22,26	5,12,22	
7	1,5,7,12,17,22,25	1,4,7,9,12,17,22	1,7,12,17,22	
9	1,5,7,9,12,17,21,22,25	1,9,12,22	1,9,12,22	
12	1,4,5,7,9,12,16,17,21,22,23,25,26	1,4,5,7,9,12,17,22	1,4,5,7,9,12,17,22	
16	5,16,21,22,23,25	4,12,16,26	16	
17	1,5,7,12,17,21,22,25	1,4,7,9,12,17	1,7,12,17	

21	21	1,4,5,9,12,16,17,21,25,26	21	*III*
22	1,4,5,7,9,12,22	1,4,5,7,9,12,16,17,22,26	1,4,5,7,9,12,22	*III*
23	23	1,4,5,12,16,23,25,26	23	*III*
25	21,23,25	1,4,5,7,9,12,16,17,25,26	25	
26	1,4,5,16,21,22,23,25,26	4,12,26	4,26	
		Iteration IV		
1	1,4,5,7,9,12,17,25	1,4,7,9,12,17,26	1,4,7,9,12,17	
4	1,4,5,7,12,16,17,25,26	1,4,12,26	1,4,12,26	
5	5,25	1,4,5,7,9,12,16,17,26	5	
7	1,5,7,12,17,25	1,4,7,9,12,17	1,7,12,17	
9	1,5,7,9,12,17,25	1,9,12	1,9,12	
12	1,4,5,7,9,12,16,17,25,26	1,4,7,9,12,17	1,4,7,9,12,17	
16	5,16,25	4,12,16,26	16	
17	1,5,7,12,17,25	1,4,7,9,12,17	1,7,12,17	
25	25	1,4,5,7,9,12,16,17,25,26	25	*IV*
26	1,4,5,16,25,26	4,12,6	4,26	
		Iteration V		
1	1,4,5,7,9,12,17	1,4,7,9,12,17,26	1,4,7,9,12,17	
4	1,4,5,7,12,16,17,26	1,4,12,26	1,4,12,26	
5	5	1,4,5,7,9,12,16,17,26	5	*V*
7	1,5,7,12,17	1,4,7,9,12,17	1,7,12,17	
9	1,5,7,9,12,17	1,9,12	1,9,12	
12	1,4,5,7,9,12,16,17,26	1,4,7,9,12,17	1,4,7,9,12,17	
16	5,16	4,12,16,26	16	
17	1,5,7,12,17	1,4,7,9,12,17	1,7,12,17	
26	1,4,5,16,26	4,12,26	4,26	
		Iteration VI		
1	1,4,7,9,12,17	1,4,7,9,12,17,26	1,4,7,9,12,17	*VI*
4	1,4,7,12,16,17,26	1,4,12,26	1,4,12,26	
7	1,7,12,17	1,4,7,9,12,17	1,7,12,17	*VI*
9	1,7,9,12,17	1,9,12	1,9,12	
12	1,4,7,9,12,16,17,26	1,4,7,9,12,17	1,4,7,9,12,17	
16	16	4,12,16,26	16	*VI*
17	1,7,12,17	1,4,7,9,12,17	1,7,12,17	*VI*
26	1,4,16,26	4,12,6	4,26	
		Iteration VII		
4	4,26	4,12,26	4,26	*VII*
9	9	9,12	9	*VII*
12	4,9,12,26	12	12	
26	4,26	4,12,26	4,26	*VII*
		Iteration VIII		
12	12	12	12	*VIII*

Source: Authors' Estimation

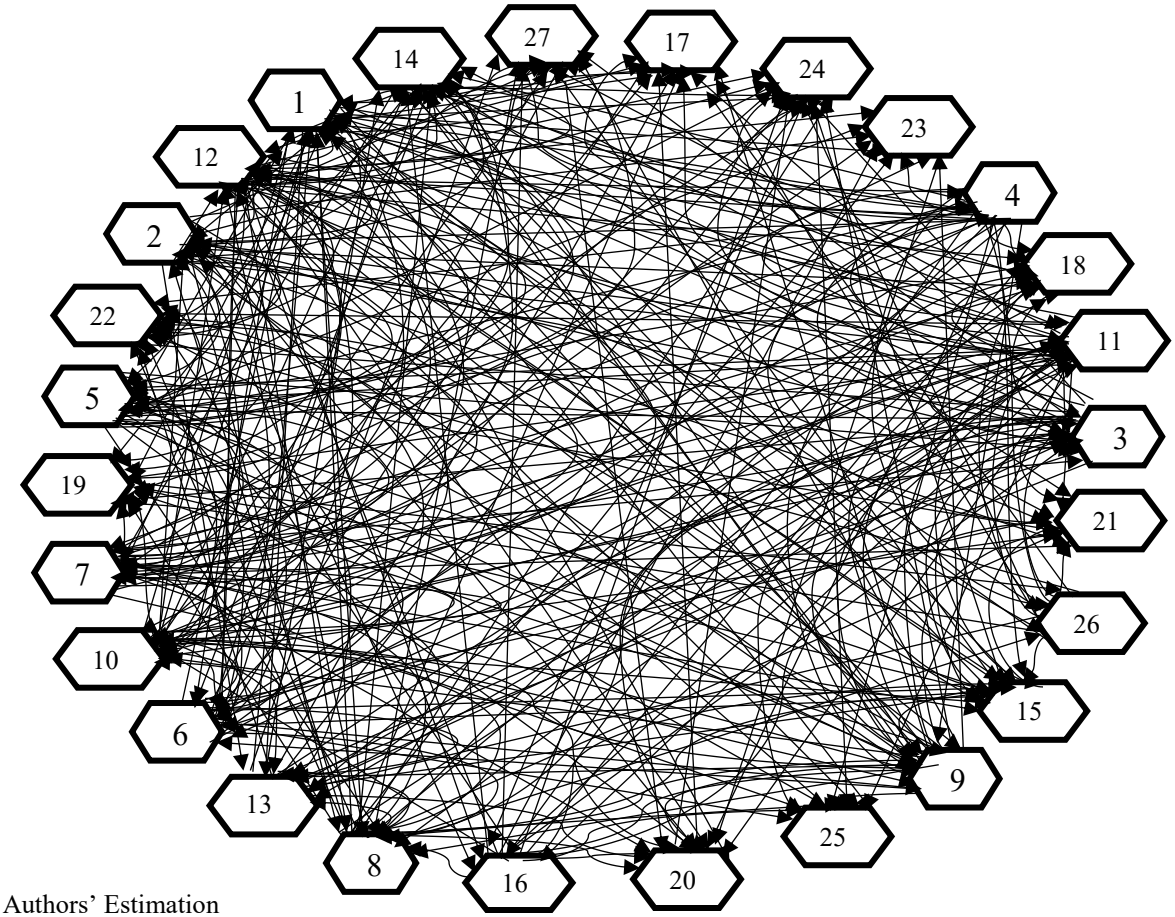
Table 7: Conical Matrix

Code	3	6	11	14	15	19	24	27	2	8	10	13	18	20	21	22	23	25	5	1	7	16	17	4	9	26	12
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0	1	0	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	1	1	0	1
14	1	1	1	1	1	1	1	0	0	0	0	0	1	0	1	0	0	0	1	1	1	0	0	1	1	0	1
15	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	1	0	0	0	1	0	1
24	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
27	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	1	1	0	0	0	0	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	1	0	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	1	0	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	1	0	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	1	0	0	0	0	1	0	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	0	1	0	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	0	1	0	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	0	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	0	0	0	1	0	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	1	0	0	0	1	0	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	0	1	0	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1	1	0	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	0	1	0	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Source: Authors' Estimation

A conical matrix was developed in the final steps of this ISM analysis, which is presented in Table 7. The sum of '1' in rows and columns was used to identify the driving and dependence powers, respectively. The driving and dependence powers were determined by the presence of '1', representing the presence of each barrier in rows and columns. This constructed conical matrix has assisted in creating the graphical representation of the obstacles to biodiversity finance presented in Figure 4, demonstrating the relationships of barriers.

Figure 4: Graphical Representation of the Relationship among Biodiversity Finance Challenges

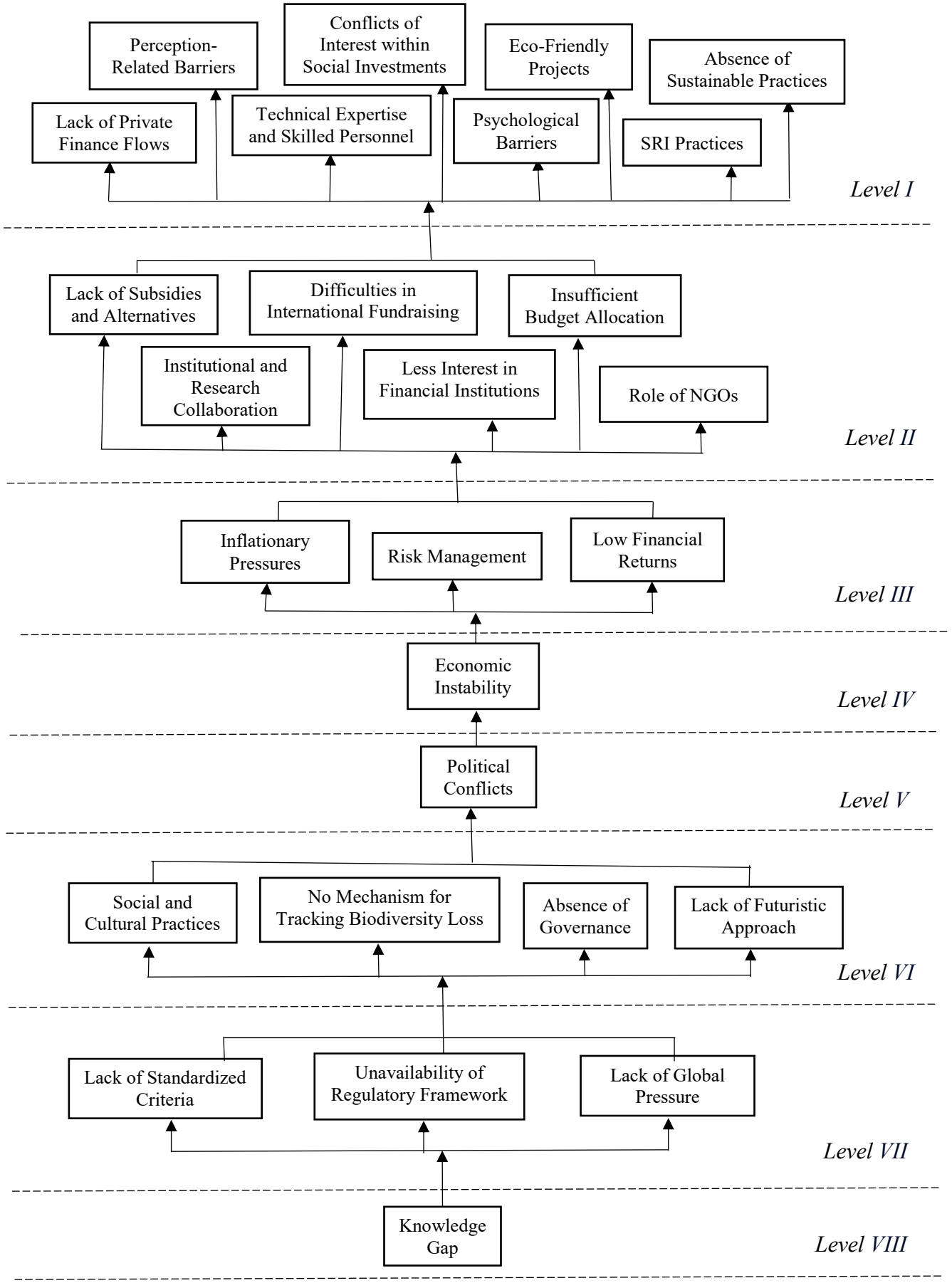


Source: Authors' Estimation

5. Key Findings and Discussion

The results of the present study are presented graphically through an ISM model, as shown in Figure 5. The challenges to biodiversity finance are categorized from levels I to VIII based on their challenging power. Barriers of level I have less impact on the implementation than those present below. Thus, level VIII comprises the most significant barrier in the biodiversity finance adoption system. "Knowledge gap" is challenging the international practice of biodiversity finance, affecting its' global adoption. It presents the "lack of standardized criteria" directly impeding the biodiversity finance implementation system. There are no defined rules and laws ensuring the protection and restoration of biodiversity. So, the "unavailability of the regulatory framework" intensifies biodiversity finance adoption challenges. The "lack of global pressure" is causing uneven adoption of conservation practices, and emerging economies are still lagging in its implementation.The ISM model presents the "absence of governance" as the first factor in level VI. The non-existence of and lack of social and cultural practices regarding biodiversity finance are directly hindering it. Investors usually follow typical investment practices and invest in financial assets (Khan & Mushtaq, 2020).

Figure 5: ISM Model for Barriers to Biodiversity Finance Adoption



Source: Authors' Estimation

"Social and cultural practices" and previous investment trends limit the flow of funds towards sustainability projects. "No mechanism for tracking biodiversity loss" and "lack of futuristic approach" also limit long-term goals for the protection and well-being of biodiversity and the flow of funds towards this practice. The two levels (IV and V) present that "political conflicts" and "economic instability" are country-level factors that directly impact investment objectives and policies. Challenging national situations restrict investors while making green investment decisions for sustainable biodiversity management. The unstable economic situation raises "inflationary pressures" in emerging economies, where investors usually avoid long-term risky investments (see Level III). The flaws in "risk management" techniques further reduce financial returns for investors. Socially responsible investment practices generate both social and monetary returns. Investors typically avoid the practices that create "low financial returns," which directly limits the adoption of biodiversity finance (Khan et al., 2023).

Levels I and II of this ISM model have the most minor challenges in biodiversity finance implementation, but these factors cannot be neglected entirely. "Difficulties in international fundraising" is a critical impediment arising due to the emerging nature of the concept. The misconception of the idea creates confusion among investors who consider it green finance, CSR, impact fund, etc. (John al., 2022). Hence, the lack of conceptualization directly limits the funding generation for biodiversity protection. The lack of "subsidies and alternatives" and "insufficient budget allocation" hinder the movement of capital towards sustainability practices. Similarly, the "fewer interests in financial institutions" limit loan proposals and schemes formulated for cultivators, eco-friendly projects, and startups (Baloch et al., 2022). The lack of "institutional and research collaboration" creates a vague image for practitioners and limits them from practicing biodiversity finance. The difficulties in international fundraising constitute a significant hurdle in pooling funds for preserving and protecting biodiversity.

The natural environment and biodiversity are declining at an alarming ratio, and there is no proper mechanism to track biodiversity loss. The lack of procedures to measure biodiversity loss limits the calculation of the proportion of biodiversity finance required. NGOs usually work to protect human rights and social welfare. Their attentiveness towards biodiversity finance is foremost for its adoption. Socially responsible investments typically generate less financial returns than other investment practices. Though sustainable management practices are becoming common, the adoption of fundraising for protecting natural ecosystems is becoming a global challenge. The conservation and restoration of biodiversity requires massive investment, which is not readily available in developing economies. Investors typically avoid investing in long-term risky "SRI practice," which gives them less financial and more social returns.

Risky investments with improper "risk management" mechanisms impede biodiversity finance and eco-friendly projects. "Technical and skilled personals" affect the successful execution of biodiversity finance. Likewise, "psychological and perception barriers" cause discrimination in the mindsets of investors and restrain them from practicing biodiversity finance. The system of biodiversity finance is limited in all stages of its adoption system. The constructed hierarchical model presents that the knowledge gap is the foremost challenge to its successful implementation. Lack of knowledge and conceptualization leads to subsequent impediments, including the unavailability of regulatory framework, lack of standardized criteria, etc. In sum, this study has explored the barriers to sustainable biodiversity management. It highlights the need to adopt sustainable practices, ensuring the flow of funds in the right direction.

6. Conclusion

The present study has developed a hierarchical model of the challenges to biodiversity finance adoption system through ISM analysis. The data was collected through an in-depth literature review to identify the barriers. Later, the list was shared with the panel of experts who finalized the challenges to biodiversity finance adoption. The ISM technique was applied to conduct the MICMAC analysis that classified the barriers into independent, dependent, and linkage clusters based on their dependence and driving powers. The ISM hierarchical model presents multiple biodiversity finance challenges categorized into eight levels based on intensity. The knowledge gap is the root cause of the limited practice of biodiversity finance. The lack of conceptualization further leads to global, national, and individual barriers to adoption. Sustainable

practices are mainly hindered in emerging economies with limited resources. The lack of factor endowments creates various economic problems in a country. However, biodiversity finance's complete adoption and successful implementation are challenging and cannot be achieved soon. However, sustainable biodiversity management will be ensured once this practice is common, and ecosystem cycles will continue. It will make the globe a better place to live for all.

6.1 Study Implications

The implications of the present study are for many stakeholders. First, the basic conceptualization of the emerging concept of biodiversity finance and adopting this practice will ensure the protection and restoration of natural ecosystem processes. Biodiversity finance is practiced in developed economies but is unpracticed in underdeveloped economies, which need it more. The identification of the barriers to biodiversity finance requires proper consideration. Hence, policymakers can take assistance from the presented model to study the challenges impeding the adoption of biodiversity finance. Second, the identified impediments and their hieratical distribution at eight levels will help adopt sustainable, eco-friendly practices and will guide the understanding of the intensity level of each barrier. Third, discussing the basic concept of biodiversity finance and explaining the relations between different variables will help scholars and researchers. They can study each level of the model separately or can analyze some theories allied with the challenges of the biodiversity finance adoption system. Fourth, the identified barriers will aid government and regulatory bodies in prescribing laws, ensuring the easy adoption of sustainable practices by all stakeholders.

6.2 Limitations and Future Directions

Initially, the present study has identified and finalized twenty-seven barriers to biodiversity finance adoption according to their intensity levels. Future researchers should explore more obstacles to get an in-depth view of the root causes of the factors hindering its adoption system. The present study has taken assistance from fifteen experts. The size of the experts' panel can also be increased to get more valuable comments and suggestions. Future researchers' involvement of more foreign experts will help to gain insight into the global challenges to biodiversity finance adoption. It will also help conceptualize and make theoretical frameworks accordingly. Further, in the initial phase of the study, the barriers are listed in the existing literature. Therefore, future researchers can conduct semi-structured or open-ended interviews with different stakeholders of biodiversity finance. It will help identify real-time impediments and further help conduct a categorical analysis or an empirical study.

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Disclaimer

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Appendix A. Finalized Barriers with Assigned Codes

Code	Barrier
1	Absence of governance
2	Difficulties in international fundraising
3	Perception-related barriers
4	Lack of standardized criteria
5	Political conflicts
6	Technical expertise and skilled personnel
7	Social and cultural practices
8	Lack of subsidies and alternatives
9	Unavailability of regulatory framework
10	Insufficient budget allocation
11	Psychological barriers
12	Knowledge gap
13	Less interest in financial institutions
14	SRI practice
15	Eco-friendly projects
16	No mechanism for tracking biodiversity loss
17	Lack of futuristic approach
18	Institutional and research collaboration
19	Lack of private finance flows.
20	Role of NGOs
21	Inflationary pressures
22	Risk management
23	Low financial returns
24	Absence of sustainable practices
25	Economic instability
26	Lack of global pressure
27	Conflicts of interest within social investments

Source: Authors' Estimation

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Fiscal and Monetary Policy, Energy Consumption, and CO2 Emissions: Unveiling the Green Impact of Liberalization in Pakistan

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ABSTRACT

Objective: The paramount aim of this study was to determine the influence of fiscal policy, monetary policy, and energy consumption on CO2 emissions in Pakistan before and after liberalization.

Research Gap: None of the earlier studies to date have been organized to examine the influence of contractionary and expansionary fiscal and monetary policies, along with energy consumption and trade liberalization, on carbon emissions in Pakistan. This study contributes to the literature by determining the influence of fiscal policy, monetary policy, and energy consumption on CO2 emissions with reference to liberalization in Pakistan.

Design/Methodology/Approach: This study utilizes the correlated component regression methodology, which is more suitable for multicollinear data sets.

The Main Findings: Our findings illustrate that contractionary fiscal and monetary policies have an inverse influence on CO2 emissions during the pre-liberalization, with the former being insignificant and the latter significant. In the pre-liberalization period, expansionary fiscal policy has a significant and positive influence on carbon emissions, whereas expansionary monetary policy affects carbon emissions positively but insignificantly. In the post-liberalization period, both contractionary fiscal and monetary policies have a negative effect on CO2 emissions, while expansionary fiscal and monetary policies positively affect CO2 emissions. Electricity, oil, and coal consumption also have a positive influence on CO2 emissions during the pre- and post-liberalization periods, whereas the effect of natural gas consumption on carbon emissions is positive only in the pre-liberalization.

Theoretical/Practical Implications of the Findings: Based on our findings, the government should raise environment-related expenditures through expansionary fiscal and monetary policies to achieve fair and sustainable economies with low carbon emissions. The expansionary fiscal policy would be focused on green budgeting with special emphasis on environmental protection, targeting renewable energy, and promoting green infrastructure in manufacturing.

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1. Introduction

Climate change is an urgent and challenging global issue. It is a threat multiplier, affecting the most vulnerable populations and intensifying existing inequalities. Developing countries, where there are insufficient resources to tackle climate change, are affected more by climate change than developed countries. Pakistan, although

contributing approximately 0.9% to global greenhouse gas emissions, is among the most negatively affected countries from climate change and air pollution. According to the long-run Climate Risk Index, Pakistan was identified as the 8th most adversely affected nation due to climate change from 2000 to 2019. During the period from 1999 to 2018, its position was even more worsened, placing it as the 5th most adversely affected country (Eckstein et al., 2021). Climate change requires immediate and collective responses worldwide to transform economies to low-carbon with sustainable growth. Krueger and Grossman (1991) introduced the idea of connecting economic development and environmental pollution, indicating that growth in GDP per capita increased pollution emissions at low income levels whereas diminishing environmental pollution at high income levels. Economic growth, in the absence of technological or structural change, would directly lead to an increase in pollution and other environmental degradation (Stern, 2004), which is referred to as the scale effect. Xue et al. (2021) found that environmental sustainability can be attained by enhancing economic growth, limiting fossil fuels and reducing foreign direct investment. Meanwhile, macroeconomic policies with the sole objective of economic growth would also negatively affect environmental quality. Specifically, during expansionary monetary policy, the central bank designs the monetary policy by increasing the money supply or reducing the bank rate. Fluctuations in interest rates would affect industrial energy consumption patterns, investment and aggregate demand, thereby causing more environmental pollution in the economy (Qingquan et al., 2020). In contrast, some studies in the literature highlight the significance of green monetary policy in reducing environmental consequences caused by expansionary policy. Green finance with rational market mechanisms can effectively allocate funds in mitigating environment-related risks and optimally allocate environmental and social resources (Wang and Zhi, 2016). After investigating this matter in China, He et al. (2019) concluded that green financial development increased the investment in renewable energy while it inhibited the bank loans in renewable energy companies. Meanwhile, Mughal et al. (2021) empirically investigated and demonstrated that contraction and expansion in monetary policies inhibited and enhanced emissions, respectively.

Regarding the influence of fiscal policy on environmental degradation, it is essential to understand the relationship between three components: government spending, economic performance, and environmental degradation (Oh, 2023). Economic theory provides a theoretical basis concerning the linkage between government spending and economic performance. As government spending, along with consumption, investment and net exports, is a crucial component of GDP, it is widely acknowledged that government spending is related to economic performance. Moreover, theoretical evidence regarding the linkage between government spending and the environment is shown for the ways in which fiscal spending can significantly influence the environmental quality. Fiscal policy instruments directly and indirectly affect the economy through aggregate demand, which in turn affects environmental quality through economic scale, industrialization, and energy consumption. Halkos and Paizanos (2013) analyzed and found that fiscal expenditure directly reduced per capita carbon and sulfur dioxide emissions. However, fiscal spending had a negative indirect effect on sulfur dioxide emissions at low income levels and a positive effect at high income levels, while it had a negative effect on carbon emissions at whole income levels. Grossman and Krueger (1995) explored that the initial phase of economic development increased environmental pollution, while it reduced environmental pollution when some critical level of income was reached. According to Ramlogan and Nelson (2024), expansionary and contractionary fiscal policies also have significant impacts on environmental quality. According to their findings, fiscal expansion mitigated the environmental quality through boosting economic performance and energy consumption, while contractionary fiscal policy inhibited carbon emissions due to slowing down the economic performance and reduction in energy consumption. In contrast, Halkos and Paizanos (2016) explored and authenticated that expansion in fiscal policy significantly alleviated consumption-generated and production-generated carbon emissions, while deficit-financed tax cuts increased consumption-based and production-based carbon emissions. Some academicians emphasized the role of carbon prices in mitigating the effects of global warming. For instance, Gaspar et al. (2019) proposed that climate change has now become a clear and current threat to the global economy. Its effects can be minimized by imposing carbon taxes on coal and other polluted fossil fuels. It would encourage economies to transition to clean energy sources. The authors further recommended that a carbon tax of $75 per ton of carbon emissions should be imposed on large-emitting economies to keep global warming to 2°C or below in 2030.

In addition to fiscal and monetary policies, some researchers also highlight the significance of energy use in affecting carbon emissions. Osobajo et al. (2020) authenticated that energy use had a significant and increasing influence on emissions. Soytas et al. (2007) empirically considered the linkages among pollution, income and energy use in the United States. Their findings demonstrated one-way causal links between energy use and pollution. Zhang and Cheng (2009) obtained similar results in China by establishing long-term one-way causality between energy use and pollution. In contrast, Zhou et al. (2018) analyzed and demonstrated that energy use escalated the pollution for both underdeveloped and developed nations. However, in developed nations compared to underdeveloped nations, energy consumption had a stronger influence on emissions. In Pakistan, Khan et al. (2019) authenticated that energy use, trade, financial development, social, political and economic globalization and FDI all have long-run impacts on environmental pollution.

The increasing trend of carbon emissions in recent years in many countries has sparked renewed interest among academicians to examine the influence of numerous factors, specifically focusing on how macroeconomic policies affect the emissions-generating mechanism. The nexus between energy consumption, monetary and fiscal policies and the environment has adopted the emerging interest in the literature. However, little research has analyzed the influence of contraction and expansion in fiscal and monetary policies, along with energy consumption, on CO2 emissions in Pakistan. Though no study to date has been organized to examine the influence of contraction and expansion in fiscal and monetary policies, along with energy consumption and trade liberalization, on carbon emissions in Pakistan. With this study, we will bridge this gap by determining the influence of fiscal policy, monetary policy, and energy consumption on CO2 emissions with reference to liberalization in Pakistan. In light of the present research gap, the primary objectives of the research described in this study are:

i. To determine if the expansion in fiscal and monetary policies results in increased CO2 emissions in Pakistan in the context of pre- and post-liberalization.
ii. To determine if the contraction in fiscal and monetary policies results in decreased CO2 emissions in Pakistan in the context of pre- and post-liberalization.
iii. To explore if the increase in disaggregated energy consumption results in increased CO2 emissions in Pakistan in the context of pre- and post-liberalization.

To analyze the above objectives, we utilized a correlated component regression technique, recently developed by Magidson (2013). The historical data from 1974 to 2020 is decomposed into two time windows: the 1974 to 1994 years, indicating the pre-liberalization period and the 1995 to 2020 years, representing the post-liberalization period. This division is based on the founding of the World Trade Organization in 1995, along with a substantial change in tariff structure in Pakistan. In Pakistan, before 1990, the tariff rate was 225%, which was further reduced to 70% in 1994-95. To some extent, this study contributes to filling the existing knowledge gap by determining how liberalization has affected CO2 emissions in Pakistan. To develop effective macroeconomic policies in Pakistan, it is necessary to understand the impacts of fiscal and monetary policies, along with energy consumption, on carbon emissions. Our findings will help to design strategies for creating a composition mix that is sustainable for developing economies like Pakistan.

2. Literature Review

Between 1998 and 2019, Bletsas et al. (2022) analyzed the impact of institutional quality, monetary policy and fiscal policy on CO_2 and GHG emissions while using a panel of 95 countries. Their results indicated that economic growth reduced the environmental quality, whereas government effectiveness, independence and transparency of the central bank and fiscal expansion improved the quality of the environment as they reduced emissions. Over the period of 1990-2018, Lau et al. (2024) probed that expansionary monetary policy, fiscal policy and technology had a negative influence on CO2 emissions. In contrast, population and economic growth significantly reduced the environmental quality as they increased the emissions. Bildirici et al. (2023) empirically examined and concluded that expansionary fiscal and monetary policies had significant and positive impacts on CO_2 emissions, whereas contractionary monetary and fiscal policies reduced environmental pollution. In Trinidad and Tobago, Ramlogan and Nelson (2024) investigated the effects of monetary and fiscal

policies on CO2 emissions using the dataset spanning from 1970 to 2020. Estimated results of the study authenticated that fiscal expansion significantly increased CO2 emissions, whereas contraction in fiscal policy improved the environmental quality. In contrast, the monetary expansion increased environmental pollution, while monetary contraction significantly reduced emissions.

Ali et al. (2022) investigated and concluded that both land under cereal crops and agricultural land both had a significant and positive effect, whereas crop production index had an inverse effect on CO2 emissions. Between 1965 and 2015 in Pakistan, Khan et al. (2020) empirically analyzed and demonstrated that oil and coal consumption contributed positively to CO2 emissions both in the short and long run, while natural gas consumption and economic growth increased CO2 emissions only in the short run. From 1990 to 2019, Mahmood et al. (2022) explored and suggested that fiscal policy contributed positively to both consumption- and territory-related CO2 emissions, while the long-term impact of monetary policy on consumption- and territory-related emissions was negative.

In Pakistan, between the period of 1985-2019, Ullah et al. (2021) found a short-term inverse and positive shock in fiscal policy instruments contributed positively, while a long-term inverse and positive shock in fiscal policy instruments contributed inversely to carbon emissions. Moreover, a short-term inverse and direct shock in monetary policy instruments significantly increased the environmental degradation, while a long-term positive shock in monetary policy instruments significantly reduced the environmental pollution. From 1990Q1 to 2017Q4, Chishti et al. (2023) demonstrated that contraction in commercial policy improved the environmental quality by significantly reducing the carbon emissions, while expansion in commercial policy reduced the environmental quality by increasing the carbon emissions in the long run. Moreover, renewable energy consumption and exports contributed negatively to carbon emissions, while GDP per capita indicated a positive influence on carbon emissions. Between the period of 1994-2014, Osobajo et al. (2020) authenticated that energy consumption and economic growth both had a positive influence on carbon emissions. Gessesse and He (2020) showed that energy consumption and GDP had a positive long-run influence on carbon emissions in China. Chandia et al. (2018) determined the relation between energy consumption, economic performance and carbon dioxide emissions in Pakistan while considering data from 1971 to 2016. Findings authenticated that energy consumption and economic growth both contributed positively to carbon emissions in the long run. Gershon et al. (2024) investigated the connection between energy consumption, economic development, FDI, capital formation and carbon emissions in seventeen African nations while using data from 2000 to 2017. Empirical findings indicated that energy consumption and FDI showed an inverse influence on carbon emissions.

Wang et al. (2023) demonstrated that FDI had a positive influence on carbon emissions for both high- and low-middle-income countries, whereas its impact was inverse for upper-middle-income nations. Amoah et al. (2023) analyzed the influence of FDI on carbon emissions using panel data from 2000 to 2022 while considering a group of 30 sub-Saharan African countries. Empirical results suggested that FDI inflows showed a positive influence, while FDI outflows indicated a negative influence on carbon emissions. Wang and Huang (2022) studied the effect of trade openness, GDP per capita and FDI on carbon emissions in East Asian economies while considering data from 2011 to 2020. Results authenticated that GDP per capita, FDI, and trade openness all showed a significant positive effect on carbon emissions in selected East Asian countries. Yi et al. (2023) authenticated that FDI contributed negatively to carbon emissions in labor, capital and technology-intensive manufacturing industries. Kastratovic (2019) explored the influence of FDI on agricultural-based GHG emissions while covering data from 2005 to 2014 for 63 developing countries. The empirical results of the study authenticated that FDI showed a positive influence on GHG emissions in the agriculture sector. Mahmood (2012) studied and authenticated that FDI, manufacturing value added and population density showed a direct and significant influence on carbon emissions. Prakash and Sethi (2023) analyzed the influence of capital formation on carbon emissions using statistical data from 1971 to 2021 for the Indian economy. The whole dataset was divided between two time periods: before liberalization, indicating the period from 1971 to 1990 and after liberalization, representing the time span from 1991 to 2021. Empirical findings of the study found that capital formation showed a significant positive influence on carbon emissions for the period after the

liberalization, whereas its impact was insignificant before the liberalization.

3. Theoretical Framework

Several studies have utilized the Cobb Douglas production function to analyze the effect of fiscal and monetary policy on CO2 emissions by assuming that production processes are the primary source of environmental pollution, including CO2 emissions. Studies by You (1981), Sinai and Stokes (1989) and Hasan and Mahmud (1993) emphasized that real money balances can be viewed as an important component of production. Incorporating this variable as an input to the Cobb Douglas production function can produce a more precise specification. As a result, the modified Cobb-Douglas production function that includes real money balances as an additional factor input can be expressed as follows:

$$Y = AK^{\alpha}L^{\beta}MP^{\gamma} \quad (1)$$

On the other hand, according to Stern (1997), Cleveland et al. (2000), Murphy and Hall (2011), energy is also a crucial factor of production. By incorporating energy as a factor input, equation (1) can be rewritten as:

$$Y = AK^{\alpha}L^{\beta}MP^{\gamma}E^{\delta} \quad (2)$$

Where Y, K, L, MP, E and A represent the output, physical capital, labor, real money balances, energy and total factor productivity, respectively. α, β, γ, and δ represent the percentage change in Y in response to a small percentage change in K, L, MP and E, respectively. A number of economists argue that the production processes are the primary source of environmental pollution, including CO2 emissions. Consequently, we replace Y with CO2 in equation (2) to derive the production-related pollution function:

$$CO2 = AK^{\alpha}L^{\beta}MP^{\gamma}E^{\delta} \quad (3)$$

In equation (3), we employ gross fixed capital formation (GFC) and population size (POP) as proxies of K and L, respectively. Energy (E) is disaggregated into four components: electricity consumption (EC), oil consumption (OILC), coal consumption (COALC) and natural gas consumption (NGC). Thus, the modified production-related pollution function is expressed as follows:

$$CO2 = GFC^{\alpha}POP^{\beta}MP^{\gamma}EC^{\delta 1}OILC^{\delta 2}COALC^{\delta 3}NGC^{\delta 4} \quad (4)$$

Many earlier studies have theoretically and empirically emphasized that monetary policy plays a significant role in determining the environmental quality (Faria 1998; Qingquan et al. 2020; Chishti et al. 2021; Liguo et al. 2022; Faria et al. 2023; Attilio et al. 2023). In the literature, monetary policy has been disaggregated into two types: contractionary monetary policy showing the decrease in money supply and expansionary monetary policy indicating an increase in money supply. Juhro and Rummel (2022) argued that contractionary monetary policy slowed down economic activity by reducing the money supply. Expansion in monetary policy, on the other hand, stimulated economic activity by increasing the money supply. Monetary authorities or the central bank, during expansionary monetary policy, use various tools, such as purchasing treasury notes, lowering the interest rates on loans to commercial banks and reducing the reserve requirement. Using these tools, monetary authorities increase the money supply and decrease interest rates, thus dwindling the cost of borrowing. These actions provide incentives for businesses to borrow more money for investment purposes and banks to issue more loans, thereby increasing consumer spending and firms' investments and therefore stimulating aggregate demand. An increase in consumer purchases and lower borrowing costs will create an incentive for firms across the country to invest more in equipment and machinery. Since new plants and machinery require more energy, this situation will lead to more CO2 emissions in the economy. During contractionary monetary policy, monetary authorities also utilize different tools, including selling treasury notes, increasing the interest rates on bank loans and increasing the reserve requirement. In this way, the central bank or monetary authorities reduce the money supply and increase the interest rates, thereby increasing the cost of borrowing. This discourages banks from issuing loans and businesses from borrowing, thereby reducing consumer purchases and investment and consequently contracting aggregate demand. A decrease in consumer spending and higher borrowing costs

will discourage the firms from investing in plant and machinery. Energy sector enterprises also limit their investment due to higher borrowing costs, thereby decreasing CO2 emissions in the economy. Equation (4) can be adjusted to accommodate contractionary and expansionary monetary policies by decomposing MP into two variables: CMP for contractionary monetary policy or a negative change in MP and EMP for an expansionary monetary policy or a positive change in MP. Incorporating these monetary policy variables into equation (4) yields:

$$CO2 = GFC^{\alpha} POP^{\beta} CMP^{\gamma 1} EMP^{\gamma 2} EC^{\delta 1} OILC^{\delta 2} COALC^{\delta 3} NGC^{\delta 4} \quad (5)$$

In an economy, fiscal policy can also contribute to CO2 emissions and can be included in the pollution function. A number of previous studies have theoretically and empirically indicated that fiscal expenditure is an important determinant of environmental pollution (Lopez et al. 2011; Halkos and Paizanos 2013, 2016, 2017; Galinato and Islam 2017; Lau et al. 2024). These studies highlight the channels through which fiscal policy impacts environmental outcomes, particularly through changes in government spending and taxation. The literature categorizes fiscal policy into two ways: expansionary and contractionary fiscal policy. Expansionary fiscal policy stimulates aggregate demand in two manners (Weil, 2008). Firstly, the government boosts expenditures while leaving taxes unchanged, which immediately stimulates the aggregate demand. Secondly, the government reduces taxes or raises transfer payments, which boosts income and consumption and consequently aggregate demand. In order to meet this increase in aggregate demand, firms will produce more output. Higher output will require more energy use by the firms, and hence they will produce more CO2 emissions. In contrast, contractionary fiscal policy is described as a decline in government spending, a rise in taxes, or a decrease in transfer payments. These measures reduce aggregate demand through reductions in government expenditures or cuts in people's consumption. As a result, the firms will reduce their output and consume less energy, which leads to lower production of CO2 emissions. Equation (5) can be extended to accommodate contractionary and expansionary fiscal policies by incorporating two variables: CFP for contractionary fiscal policy or a negative change in government expenditure (FP) and EFP for an expansionary fiscal policy or a positive change in government spending (FP). Incorporating these fiscal policy variables into equation (5) yields the following equation:

$$CO2 = GFC^{\alpha} POP^{\beta} CMP^{\gamma 1} EMP^{\gamma 2} EC^{\delta 1} OILC^{\delta 2} COALC^{\delta 3} NGC^{\delta 4} EFP^{\theta 1} CFP^{\theta 2} \quad (6)$$

There are some other control variables that may affect the CO2 emissions. Inclusion of these control variables in equation (6) yields equation (7):

$$CO2 = GFC^{\alpha} POP^{\beta} CMP^{\gamma 1} EMP^{\gamma 2} EC^{\delta 1} OILC^{\delta 2} COALC^{\delta 3} NGC^{\delta 4} EFP^{\theta 1} CFP^{\theta 2} CV^{\rho} \quad (7)$$

In equation (7), GFC represents the gross fixed capital formation, POP indicates the size of the population, CMP and EMP specify respectively the contractionary and expansionary monetary policy, EC, OILC, COALC and NGC respectively indicate the electricity, oil, coal and natural gas consumption and EFP and CFP respectively show the expansionary and contractionary fiscal policy. Finally, CV includes three control variables, considering the gross domestic product (GDP), agricultural value added (AVA) and foreign direct investment (FDI). By incorporating these control variables into equation (7), we get the following equation:

$$CO2 = GFC^{\alpha} POP^{\beta} CMP^{\gamma 1} EMP^{\gamma 2} EC^{\delta 1} OILC^{\delta 2} COALC^{\delta 3} NGC^{\delta 4} EFP^{\theta 1} CFP^{\theta 2} GDP^{\rho 1} AVA^{\rho 2} FDI^{\rho 3} \quad (8)$$

Equation (8) indicates the mechanism through which monetary policy, fiscal policy and energy consumption, along with control variables, impact CO2 emissions.

4. Data and Methodology

4.1 Data

In this study, historical data ranging from 1974 to 2020 is used to investigate the influence of fiscal policy, monetary policy and energy consumption on carbon dioxide (CO2) emissions in the context of pre- and post-liberalization. The data (1974-2020) is decomposed into two parts: the 1974 to 1994 years indicating the pre-

liberalization period and the 1995 to 2020 years representing the post-liberalization period. CO2 emissions in kilotons, for measuring environmental degradation in Pakistan, is used as an outcome variable. Government expenditures, in constant local currency units, are used as a fiscal policy variable (FP), which is decomposed into contractionary fiscal policy (CFP), or a negative change in FP and expansionary fiscal policy (EFP), or a positive change in FP. Broad money as a percentage of GDP is served as a proxy for the monetary policy variable (MP), which is decomposed into contractionary monetary policy (CMP), or a negative change in MP and expansionary monetary policy (EMP), or a positive change in MP. Energy consumption is disaggregated into four components: electricity consumption (EC) in gigawatt-hours, oil consumption (OILC) in tons, coal consumption (COALC) in thousand metric tons and natural gas consumption (NGC) in million cubic feet. Population (POP) in numbers is taken as a proxy for labor and gross fixed capital formation (GFC) in constant local currency units is used as a proxy of capital. Furthermore, some other control variables, including gross domestic product (GDP) and agricultural value added (AV), are served in constant local currency units and foreign direct investment (FDI) is used in current US dollars. Data regarding EC, OILC, COALC and NGC is taken from an economic survey of Pakistan. Whereas data concerning all other variables is based on world development indicators (WDI).

4.2 Multicollinearity Diagnostics

Multicollinearity is defined as a strong linear relationship between two or more independent variables. The presence of multicollinearity significantly affects the estimation by inflating the standard errors of predicted coefficients; thereby they become unstable and statistically insignificant (Paetzold, 1992). Therefore, it is crucial to detect the multicollinearity before employing any econometric technique. One way to diagnose the multicollinearity is to analyze the simple pairwise correlations between the explanatory variables. The simple coefficient of correlation, r_{ij} determines the strength and direction of the linear association between two regressors. It is calculated utilizing the following formula:

$$r_{ij} = \frac{\sum(X_i - \bar{X}_i)(X_j - \bar{X}_j)}{\sqrt{\sum(X_i - \bar{X}_i)^2 \sum(X_j - \bar{X}_j)^2}} \tag{9}$$

Where X_i and X_j are explanatory variables, $r_{ij} = 1$ for all i = j, it is equal to the coefficient of correlation between X_i and X_j when $i \neq j$. According to this criterion, multicollinearity is severe if the simple correlation coefficient, in absolute value, exceeds 0.80 (Willis and Perlack, 1978). If there are more than two explanatory variables in a regression model, simple pairwise correlations between the predictors are informative but should not be the only criterion used to identify whether or not multicollinearity is a problem. Other diagnostic metrics, such as the VIF and the CI, should also be used and reported (Tu et al., 2005). The VIF is another metric for detecting the severity of multicollinearity between the explanatory variables. There is one VIF for each independent variable in an equation. It reveals the extent of increase in the variance of an estimated coefficient that arises due to multicollinearity. It is calculated using the following formula:

$$VIF_i = \frac{1}{1 - R_i^2} \tag{10}$$

Where R_i^2 is the proportion of the variation for each auxiliary regression when each predictor is regressed on the remaining predictors. According to this method, it is considered that no multicollinearity is if the VIF value is 1, whereas if the VIF value is more than 5 or 10, then it will be considered as severe multicollinearity (Kyriazos and Poga, 2023). The CI is another measure used for multicollinearity diagnostics. It is calculated by the following formula:

$$CI_i = \sqrt{\frac{\kappa_{max}}{\kappa_i}} \tag{11}$$

Where κ_{max} indicates the maximum eigenvalue and κ_i represents the minimum eigenvalue. According to this metric, there is no multicollinearity when all condition indices are unity. There is no exact rule for how large a CI must be to identify a multicollinearity problem. An informal rule of thumb for identifying multicollinearity is

that, if the CI value is 15, multicollinearity is severe (Midi et al., 2010).

4.3 Methodology

The paramount objective of this study is to determine the influence of fiscal policy, monetary policy and energy consumption on carbon dioxide (CO2) emissions in the context of pre- and post-liberalization in Pakistan. The influence of several macroeconomic policies on CO2 emissions was examined in previous empirical studies. We have modified the Cobb-Douglas production-related pollution function following earlier studies for different countries. Our econometric model can be presented as follows:

$$lnCO2 = \alpha + \beta_1\, lnGDP + \beta_2\, lnAVA + \beta_3\, lnEC + \beta_4\, lnOILC + \beta_5\, lnPOP + \beta_6\, lnGFC + \beta_7\, lnFP$$

$$+\beta_8\, lnFDI + \beta_9\, lnCOALC + \beta_{10}\, lnNGC + \beta_{11} lnMP + \varepsilon \quad (12)$$

In equation (12), ln shows the natural log, CO2 symbolizes the carbon dioxide emissions, GDP stands for gross domestic product, AVA denotes the agricultural value added, EC is the electricity consumption, OILC is the oil consumption, POP is the size of the population, GFC is the capital formation, FP is the fiscal policy variable, FDI is the foreign direct investment, COALC is the coal consumption, NGC is the natural gas consumption, MP is the monetary policy variable and ε is the random error term. We can modify equation (12) by decomposing the fiscal policy variable (lnFP) and the monetary policy variable (lnMP) into two variables, with the first one indicating a decrease in fiscal and monetary policy variables and the second one showing an increase in fiscal and monetary policy variables. We disaggregate these variables as follows:

$$lnCFP_t = \sum_{n=1}^{t} \Delta lnFP_t^- = \sum_{n=1}^{t} \min(\Delta lnFP_t^-, 0) \quad (13)$$

$$lnEFP_t = \sum_{n=1}^{t} \Delta lnFP_t^+ = \sum_{n=1}^{t} \max(\Delta lnFP_t^+, 0) \quad (14)$$

$$lnCMP_t = \sum_{n=1}^{t} \Delta lnMP_t^- = \sum_{n=1}^{t} \min(\Delta lnMP_t^-, 0) \quad (15)$$

$$lnEMP_t = \sum_{n=1}^{t} \Delta lnMP_t^+ = \sum_{n=1}^{t} \max(\Delta lnMP_t^+, 0) \quad (16)$$

Where lnCFP represents the contractionary fiscal policy, lnEFP denotes the expansionary fiscal policy, lnCMP indicates the contractionary monetary policy and lnEMP signifies the expansionary monetary policy. After incorporating these lnCFP, lnEFP, lnCMP and lnEMP policies into equation (12), we can get the following equation:

$$lnCO2 = \alpha + \beta_1\, lnGDP + \beta_2\, lnAVA + \beta_3\, lnEC + \beta_4\, lnOILC + \beta_5\, lnPOP + \beta_6\, lnGFC + \beta_{7EFP}\, lnEFP$$

$$\beta_{7CFP}\, lnCFP + \beta_8\, lnFDI + \beta_9\, lnCOALC + \beta_{10}\, lnNGC + \beta_{11EMP} lnEMP + \beta_{11CMP} lnCMP + \varepsilon \quad (17)$$

Equation (17) can be used to investigate the impact of fiscal policy, monetary policy and energy consumption on the CO2 emissions. We will estimate equation (17) using correlated component regression (CCR) methodology, recently proposed by Magidson (2013). The CCR technique provides more reliable and stable predictions even when there is near multicollinearity in the regressors. One important feature of the CCR metric is that it is a scale-invariant technique, implying that it provides identical results whether predictions are based on standardized or unstandardized predictors. In contrast, traditional techniques such as PLS-R and penalized regression, including Ridge Regression, Lasso and Elastic Net are very sensitive to the scale of predictors and thereby produce various results based on predictor scaling applied. In the previous economic literature, the CCR methodology used by Bullock (2021) to find out the state-level impact of corn and soybean production on their total corn and soybean production in the United States. Naveed and Hina (2023) have applied this technique to examine the extent to which division-level wheat production affects total wheat production in the Punjab province of Pakistan. Similarly, Naveed et al. (2024) also used the same method to identify district-level cotton impact on total cotton production in Punjab, Pakistan. The CCR technique has also been used in this study to determine the influence of fiscal policy, monetary policy and energy consumption on CO2 emissions.

The general procedure of the CCR analytic approach is described as follows:
At this first stage, we will fit the regression equations utilizing OLS for each and every regressor separately. This is indicated as follows:

$$ln\hat{Y} = \hat{\gamma}_g^{(1)} + \hat{\lambda}_g^{(1)} lnX_g \quad (18)$$

In equation (18), ln indicates the natural logarithm, Y is the explained variable and Xg specifies regressors, where g = 1, 2, 3,…, P, and $\hat{\gamma}_g^{(1)}$ and $\hat{\lambda}_g^{(1)}$ are the respective constant coefficient and regression coefficient for a specific explanatory variable g. The first component variable, lnS1 measures the effects of prime regressors, which have a direct effect on the explained variable. It is the weighted average of all 1-predictor effects, whereas the weights are regression coefficients obtained from equation (18). Its calculation is as follows:

$$lnS_1 = \frac{1}{P}\sum_{g=1}^{P} \hat{\lambda}_g^{(1)} lnX_g \quad (19)$$

The predictions for the explained variable lnY in the 1-component CCR model are generated by regressing a simple OLS of lnY on lnS1:

$$ln\hat{Y} = \hat{\alpha}^{(1)} + \hat{\beta}_1^{(1)} lnS_1 \quad (20)$$

The second correlated component variable, lnS_2, is derived by first estimating equation (21) for each predictor using simple OLS:

$$ln\hat{Y} = \hat{\gamma}_g^{(2)} + \hat{\lambda}_{1,g}^{(2)} lnS_1 + \hat{\lambda}_g^{(2)} lnX_g \quad (21)$$

The second component, lnS_2, then becomes the weighted mean of all the 2-predictor impacts and is calculated as follows:

$$lnS_2 = \frac{1}{P}\sum_{g=1}^{P} \hat{\lambda}_g^{(2)} lnX_g \quad (22)$$

Regressing a basic OLS of lnY on lnS_1 and lnS_2 produces the predictions for the outcome variable Y (in the form of a natural logarithm) in the 2-component CCR model:

$$ln\hat{Y} = \hat{\alpha}^{(2)} + \hat{\beta}_1^{(2)} lnS_1 + \hat{\beta}_2^{(2)} lnS_2 \quad (23)$$

Accordingly, the aforementioned procedure for obtaining the correlated component variables can be followed as far as the optimal number of component variables is reached. Usually, for any set of K (K< P) correlated component variables, we will fit the following regression equation for each regressor utilizing the OLS:

$$ln\hat{Y} = \hat{\gamma}_g^{(K)} + \hat{\lambda}_{1,g}^{(K)} lnS_1 + \hat{\lambda}_{2,g}^{(K)} lnS_2 + \cdots + \hat{\lambda}_{K-1,g}^{(K)} lnS_{K-1} + \hat{\lambda}_g^{(K)} lnX_g \quad (24)$$

Finally, the last component variable, lnS_k, is then found using equation (25):

$$lnS_k = \frac{1}{P}\sum_{g=1}^{P} \hat{\lambda}_g^{(k)} lnX_g \quad (25)$$

Regressing a simple OLS of lnY on lnS_1, lnS_2…, lnSk yields the predictions for the explained variable Y (in the form of a natural logarithm) in the k-component CCR model:

$$ln\hat{Y} = \hat{\alpha}^{(K)} + \hat{\beta}_1^{(K)} lnS_1 + \hat{\beta}_2^{(K)} lnS_2 + \cdots + \hat{\beta}_k^{(K)} lnS_k \quad (26)$$

Inserting equations (19), (22), and (25) into equation (26) yields equation (27):

$$\widehat{lnY} = \hat{\alpha}^{(K)} + \hat{\beta}_1^{(K)}\left(\frac{1}{P}\sum_{g=1}^{P}\hat{\lambda}_g^{(1)} lnX_g\right) + \hat{\beta}_2^{(K)}\left(\frac{1}{P}\sum_{g=1}^{P}\hat{\lambda}_g^{(2)} lnX_g\right) + \cdots + \hat{\beta}_k^{(K)}\left(\frac{1}{P}\sum_{g=1}^{P}\hat{\lambda}_g^{(k)} lnX_g\right) \quad (27)$$

Rearranging and simplifying equation (27) gives equation (28):

$$\widehat{lnY} = \hat{\alpha}^{(K)} + \sum_{k=1}^{k}\hat{\beta}_k^{(K)}\left(\frac{1}{P}\sum_{g=1}^{P}\hat{\lambda}_g^{(k)} lnX_g\right) \quad (28)$$

$$\widehat{lnY} = \hat{\alpha}^{(K)} + \sum_{g=1}^{P}\hat{\beta}_g\, lnX_g \quad (29)$$

Thus, the estimated regression coefficient $\hat{\beta}_g$ is a weighted mean of the loadings. The regression coefficients of the K-component CCR model, as expressed in equation (26), serve as weights:

$$\hat{\beta}_g = \frac{1}{P}\sum_{k=1}^{P}\hat{\beta}_k^K\hat{\lambda}_g^{(k)} \quad (30)$$

Substituting lnCO2 for lnY in equation (29) and including all relevant predictors produces an equation identical to equation (17), which we want to estimate.

Equation (30) provides the estimates of unstandardized coefficients, whereas the standard errors of estimated coefficients can be estimated using the following formula:

$$SE(\hat{\beta}_g) = \frac{1}{P}\sqrt{\sum_{k=1}^{K}\left(SE(\hat{\beta}_k^K)\right)^2\left(\hat{\lambda}_g^k\right)^2} \quad (31)$$

Where $\hat{\lambda}_g^k$ indicates the loadings on all correlated component variables and $SE(\hat{\beta}_k^K)$ denotes the coefficient's standard error for the K-component CCR model, as represented in equation (26). Standardized regression coefficients in absolute values are employed to assess the relative significance of each explanatory variable with respect to CO2 emissions. These coefficients are produced by applying the following formula:

$$\hat{\beta}_g^* = \left(\frac{\hat{\sigma}_g}{\hat{\sigma}_y}\right) \times \hat{\beta}_g \quad (32)$$

Where $\hat{\beta}_g^*$ and $\hat{\beta}_g$ respectively denote the standardized and unstandardized coefficients of each of the regressors with g equaling 1, 2, 3…, P. Furthermore, $\hat{\sigma}_g$ and $\hat{\sigma}_y$ measure the dispersion as a standard deviation for each regressor and explained variable, respectively, with g indicating 1, 2, 3…,P. Standardized coefficients represent which explanatory variable has a higher influence on the explained variable. More specifically, the standardized regression coefficient calculates the marginal influence of each explanatory variable on the dependent variable. The relative contribution of each explanatory variable to CO2 emissions is calculated using standardized regression coefficients as an absolute value, which is then expressed as a percentage of their absolute sum. Explanatory variables with a greater contribution to CO2 emissions indicate that a one-standard deviation change in their value has a greater influence on the explained variable (CO2 emissions).

5. Results and Discussions

Table 1 provides a description of variables, whereas Table 2 displays the findings of summary statistics. The average carbon dioxide (CO2) emission, in natural log, of Pakistan studied between 1974 and 2020 was 11.27 kilotons, with 9.97 kilotons and 12.20 kilotons as the smallest and highest values, respectively. The extent to which the CO2 emission deviates from the average, measured by the standard deviation, is 0.67 kilotons. Further, the descriptive statistics indicate that the mean for all variables except lnCOALC is less than the median, implying a negative skewness as evidenced by negative skewness coefficients of lnCO2, lnGDP, lnAVA, lnEC, lnOILC, lnPOP, lnGFC, lnFP, lnFDI, lnNGC and lnMP. The kurtosis values for all variables other than lnMP are less than 3, indicating that all these variables exhibit the platykurtic distribution. However, the kurtosis value for lnMP is 3.41, thereby its distribution is leptokurtic.

Simple pairwise correlations between the predictors are obtained using equation (9), and the results are provided in Table 3. Correlation can be used to check the likelihood of multicollinearity between the predictors. All the pairwise correlations between the explanatory variables are positive, as indicated in Table 3, implying that all regressors are positively associated with each other. Since all the pairwise correlation coefficients, except those of lnMP with all other variables, are greater than 0.80. Therefore, the correlation matrix suggests the existence of severe multicollinearity among regressors.

Table 1: Description of Variables

Name of Variables	Abbreviation	Measurement Unit	Source
CO2 Emission	lnCO2	Kilotons	WDI & Our World in Data
Gross Domestic Product	lnGDP	Constant Local Currency Unit	WDI
Agricultural Value Added	lnAVA	Constant Local Currency Unit	WDI
Electricity Consumption	lnEC	Gigawatt-Hour	Economic Survey of Pakistan
Oil/Petroleum Consumption	lnOILC	Tons	Economic Survey of Pakistan
Total Population	lnPOP	Numbers	WDI
Gross Fixed Capital Formation	lnGFC	Constant Local Currency Unit	WDI
General Government Final Consumption Expenditure	lnFP	Constant Local Currency Unit	WDI
Foreign Direct Investment	lnFDI	Current US Dollars	WDI
Coal Consumption	lnCOALC	Thousand metric ton	Economic Survey of Pakistan
Natural Gas Consumption	lnNGC	Million Cubic Feet	Economic Survey of Pakistan
Broad Money	lnMP	Percentage of GDP	WDI

Source: Author's Compilation

Table 4 reports the results of the VIF and the CI. The VIF and the CI are calculated using equations (10) and (11), respectively. Both methods diagnose the likelihood of multicollinearity among the predictors. Since all the VIF values excluding lnMP exceed 10, indicating severe multicollinearity between the explanatory variables. In addition to the VIF, the condition index also supports the likelihood of severe multicollinearity among the predictors. As the highest value of the condition index is 160.39, which is greater than 15, therefore the multicollinearity is severe. The presence of strong multicollinearity among predictors leads to unstable and statistically insignificant coefficient estimates (Paetzold, 1992). Therefore, we need to apply an econometric technique suitable for collinear datasets. The CCR approach is particularly well suited for collinear and sparse datasets, as it provides more reliable and stable predictions even when regressors are severely multicollinear. (Magidson, 2013).

Table 2: Summary Statistics

Variables	Mean	Median	Max	Min	S.D	Skewness	Kurtosis	Jarque-Bera	Prob.	Obs.
lnCO2	11.27	11.40	12.20	9.97	0.67	-0.48	2.06	3.58	0.17	47
lnGDP	30.29	30.34	31.25	29.11	0.64	-0.27	1.95	2.71	0.26	47
lnAVA	29.04	29.12	29.73	28.23	0.48	-0.25	1.70	3.77	0.15	47
lnEC	10.45	10.67	11.63	8.74	0.86	-0.58	2.14	4.05	0.13	47
lnOILC	16.21	16.50	17.06	14.90	0.65	-0.72	2.14	5.48	0.06	47
lnPOP	18.72	18.77	19.24	18.01	0.38	-0.33	1.85	3.49	0.17	47
lnGFC	28.49	28.53	29.34	27.39	0.52	-0.37	2.23	2.26	0.32	47
lnFP	28.02	28.03	29.04	26.75	0.64	-0.32	2.14	2.27	0.32	47
lnFDI	19.74	20.04	22.44	15.20	1.76	-0.60	2.67	3.07	0.22	47
lnCOALC	8.27	8.15	10.14	6.97	0.80	0.32	2.40	1.54	0.46	47
lnNGC	13.27	13.30	14.19	11.81	0.73	-0.38	1.91	3.48	0.18	47
lnMP	3.75	3.77	4.00	3.36	0.14	-0.76	3.41	4.91	0.09	47

Source: Author's calculations

Given the likelihood of severe multicollinearity, we will apply the CCR approach to investigate the influence of fiscal policy, monetary policy and energy consumption on carbon dioxide (CO2) emissions in Pakistan.

Magidson (2010) showed that CCR effectively performs with 2, 3 or 4 correlated component variables. Following Magidson (2010), this study has used only 2 component variables, S1 and S2, omitting the third and fourth components due to having insignificant loadings, which also fail to significantly improve the prediction for the dependent variable. Moreover, we have retained all explanatory variables to assess the effect of fiscal and monetary policies, as well as energy consumption, on CO2 emissions.

Table 3: Correlation Matrix

Predictors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
lnGDP (1)	1										
lnAVA (2)	0.995	1									
lnEC (3)	0.992	0.987	1								
lnOILC (4)	0.960	0.961	0.979	1							
lnPOP (5)	0.997	0.998	0.992	0.967	1						
lnGFC (6)	0.988	0.976	0.987	0.954	0.981	1					
lnFP (7)	0.988	0.972	0.984	0.945	0.979	0.987	1				
lnFDI (8)	0.939	0.933	0.951	0.922	0.939	0.956	0.931	1			
lnCOALC (9)	0.965	0.953	0.945	0.874	0.951	0.959	0.959	0.902	1		
lnNGC (10)	0.990	0.989	0.987	0.954	0.993	0.982	0.973	0.956	0.949	1	
lnMP (11)	0.502	0.463	0.475	0.403	0.461	0.549	0.553	0.503	0.547	0.450	1

Source: Author's calculations

Table 5 shows the findings of unstandardized and standardized regression coefficients for the CCR model with two component variables before and after liberalization. Upper part of this table indicates the estimation of the component variables prior to the liberalization. The estimated results indicate that both correlated component variables S1 and S2 are significant at the 95% confidence level. The first component variable, S1, measures the prime variable's (direct) effect, accounting for 33.87 percent of the total contribution as an absolute sum of standardized regression coefficients. In contrast, the second correlated component, S2, represents the suppressor variable's (indirect) effect, accounting for 66.13 percent. Lower part of Table 5 reports the estimated results of the CCR model during the post-liberalization period. Both the correlated components in this period are also significant at the 99% confidence level. In this period, prime variables have a dominant effect, capturing 80.69 percent, whereas suppressor variables have contributed only 19.31 percent. It is worth noting that the impact of suppressor variables was stronger during the pre-liberalization period, while the prime variables were dominant during the post-liberalization period.

Table 4: Variance Inflation Factor and Condition Index

Predictors	Variance Inflation Factor (VIF)			Condition Index (C.I)	
	R_i^2	$1-R_i^2$	VIF	Eigenvalues	C.I
lnGDP	0.9992	0.0008	1254.7051	9.9553	1.0000
lnAVA	0.9971	0.0029	341.7635	0.7647	3.6081
lnEC	0.9969	0.0031	327.4394	0.1225	9.0132
lnOILC	0.9910	0.0090	111.1235	0.0887	10.5963
lnPOP	0.9994	0.0006	1612.9032	0.0310	17.9235
lnGFC	0.9940	0.0060	166.8892	0.0191	22.8554
lnFP	0.9893	0.0107	93.6067	0.0097	32.0859
lnFDI	0.9535	0.0465	21.4947	0.0052	43.6960
lnCOALC	0.9774	0.0226	44.2791	0.0022	67.7482
lnNGC	0.9960	0.0040	252.2704	0.0013	88.3634
lnMP	0.6724	0.3276	3.0523	0.0004	160.3880

Source: Author's calculations

Unstandardized and standardized regression coefficients of all explanatory variables during the pre-liberalization period are obtained from equations (30) and (32), respectively and the estimated results are summarized in Table 6. Empirical findings authenticate that gross domestic product has a positive and statistically significant impact on CO2 emissions. More precisely, a 1.0 percent increase (decrease) in gross domestic product results in a 0.2232 percent increase (decrease) in CO2 emissions, holding all other predictors constant. This suggests that a rise in GDP leads to an increase in pollution. Our findings regarding agricultural

value added indicate that agricultural value added has a positive but insignificant influence on CO2 emissions. According to results, a 1.0 percent increase (decrease) in agricultural value added would result in a 0.0366 percent increase (decrease) in CO2 emissions, implying a degradation of environmental quality.

Electricity consumption and oil consumption both have a positive significant effect on CO2 emissions, implying that a 1.0 percent increase (decrease) in electricity and oil consumption, respectively, leads to a 0.1248 percent and 0.0778 percent increase (decrease) in CO2 emissions. Population and GFC also have a positive significant influence on CO2 emissions. Our estimates authenticate that a 1.0 percent acceleration (deceleration) in population would cause a 0.4301 percent acceleration (deceleration) in CO2 emissions. On the other hand, a 0.0383 percent rise (fall) in CO2 emissions is associated with a 1.0 percent rise (fall) in gross fixed capital formation.

Table 5: Unstandardized and Standardized Regression Coefficients of the Correlated Component Regression Model with K = 2

Correlated Component	Un-Standardized Coefficients	Std.Error	T-Statistic	P-Value	Standardized Coefficients	Contribution (%)
CCR Model Before Liberalization						
lnS1	0.3642**	0.1450	2.5127	0.0217	0.3386	33.8675
lnS2	3.7890*	0.7722	4.9065	0.0001	0.6612	66.1325
CCR Model After Liberalization						
lnS1	0.9602*	0.0668	14.3664	0.0000	0.8141	80.6877
lnS2	3.4430*	1.0012	3.4388	0.0022	0.1949	19.3135

Source: Author's calculations. *, ** and *** respectively indicate that the coefficients are significant at 99%, 95% and 90% confidence level.

If the effects of fiscal policy FP are evaluated, asymmetric results are found in terms of contractionary and expansionary fiscal policy. CFP corresponds to contractionary fiscal policy, indicating declines in government expenditure, whereas EFP corresponds to expansionary fiscal policy, denoting an increase in government expenditure. Our results regarding contractionary fiscal policy indicate that a 1.0 percent contraction in government expenditure under contractionary CFP leads to a 0.05 percent reduction in CO2 emissions. However, its impact is statistically insignificant. On the other hand, expansionary fiscal policy has a significant positive influence on CO2 emissions, implying that a 1.0 percent increase in government expenditure under expansionary fiscal policy would result in a 0.0452 percent increase in CO2 emissions. It indicates that expansionary fiscal policy enhances CO2 emissions, which become the cause of environmental degradation in the country. Results concerning fiscal policy indicate that expansionary fiscal policy has a greater influence, in terms of standardized regression coefficients, on CO2 emissions than contractionary fiscal policy during the pre-liberalization period. Our results regarding foreign direct investment indicate that it has a positive but insignificant influence on CO2 emissions. COALC and NGC are positively and significantly associated with CO2 emissions. A 1.0 percent increase (decrease) in coal and natural gas consumption, respectively, would result in a 0.0834 percent and 0.0979 percent increase (decrease) in CO2 emissions.

Table 6: CCR Model Regression Results (Pre-Liberalization Period)

Predictors	Un-Standardized Coefficients	Std. Error	T-Statistic	Standardized Coefficients	Contribution (%)
lnGDP	0.2232*	0.0409	5.4547	0.1883	18.6971
lnAVA	0.0366	0.0205	1.7867	0.0199	1.9796
lnEC	0.1248*	0.0228	5.4779	0.1725	17.1298
lnOILC	0.0778*	0.0147	5.2814	0.0848	8.4184
lnPOP	0.4301*	0.0793	5.4228	0.2093	20.7785
lnGFC	0.0383**	0.0140	2.7264	0.0301	2.9877
lnCFP	-0.0500	0.0565	-0.8833	-0.0067	0.6605
lnEFP	0.0452*	0.0108	4.1672	0.0496	4.9259
lnFDI	0.0051	0.0037	1.3871	0.0146	1.4521

lnCOALC	0.0834*	0.0164	5.0735	0.0730	7.2449
lnNGC	0.0979*	0.0181	5.4012	0.0958	9.5103
lnCMP	-0.1278*	0.0342	-3.7378	-0.0423	4.1992
lnEMP	0.0469	0.0254	1.8451	0.0203	2.0159
Constant	-10.5011*	0.7486	-14.0274		

Source: Author's calculations. *, ** and *** respectively indicate that the coefficients are significant at 99%, 95% and 90% confidence level.

Evaluating the monetary policy (MP) effects, we find asymmetric results in terms of coefficients of CMP and EMP policy. CMP corresponds to contraction in the monetary policy, denoting a decline in money supply. On the other hand, EMP corresponds to expansion in the monetary policy, representing an increase in the money supply. Our empirical results indicate that a 1.0 percent decrease in the money supply under contractionary CMP policy would result in a 0.1278 percent decrease in CO2 emissions. Conversely, a rise in the money supply under expansionary EMP policy results in a 0.0469 percent rise in CO2 emissions following a 1.0 percent raise in the money supply. However, the CMP policy has a statistically significant influence, while the EMP policy has an insignificant influence on CO2 emissions. Based on the monetary policy effects, the CMP policy reduces environmental pollution in the country, while the EMP policy increases environmental pollution in the economy. The monetary policy results indicate that the CMP policy had a stronger impact on CO2 emissions than the EMP policy during the pre-liberalization period. Our findings regarding fiscal and monetary policies conclude that EFP and CMP policies are effective in changing CO2 emissions, while CFP and EMP policies are ineffective in changing carbon emissions in Pakistan during the pre-liberalization period.

Unstandardized and standardized regression coefficients of all explanatory variables during the post-liberalization period are obtained from equations (30) and (32), respectively and the estimated results are summarized in Table 7. Empirical findings point out that gross domestic product has a positive and significant effect on CO2 emissions. Specifically, a 1.0 percent acceleration (deceleration) in gross domestic product leads to a 0.1781 percent acceleration (deceleration) in CO2 emissions while holding all other regressors constant. This suggests that a rise (fall) in GDP would lead to an increase (decrease) in pollution in the country during the post-liberalization period. Agricultural value added positively and significantly affects CO2 emissions. A 1.0 percent change in agricultural value added results in a 0.1366 percent change in CO2 emissions, implying a degradation of environmental quality. Electricity and oil consumption both statistically and significantly impact CO2 emissions, implying that a 1.0 percent change in electricity and oil consumption, respectively, leads to a 0.1262 percent and 0.1208 percent change in CO2 emissions, ceteris paribus. Population and GFC also have a positive significant influence on CO2 emissions. Particularly, a 1.0 percent change in population would lead to a 0.0974 percent change in CO2 emissions. On the other hand, a 0.1229 percent acceleration (deceleration) in CO2 emissions is associated with a 1.0 percent acceleration (deceleration) in gross fixed capital formation, ceteris paribus.

Table 7: CCR Model Regression Results (Post-Liberalization Period)

Predictors	Un-Standardized Coefficients	Std. Error	T-Statistic	Standardized Coefficients	Contribution (%)
lnGDP	0.1781*	0.0337	5.2790	0.2063	19.5457
lnAVA	0.1366*	0.0137	9.9978	0.1034	9.8002
lnEC	0.1262*	0.0195	6.4586	0.1515	14.3560
lnOILC	0.1208*	0.0112	10.7632	0.0742	7.0257
lnPOP	0.0974*	0.0104	9.3349	0.0590	5.5853
lnGFC	0.1229*	0.0155	7.9120	0.1200	11.3704
lnCFP	-0.0615***	0.0298	-2.0666	-0.0262	2.4828
lnEFP	0.0724*	0.0092	7.8544	0.1242	11.7643
lnFDI	0.0175*	0.0012	14.2507	0.0511	4.8420
lnCOALC	0.0323*	0.0022	14.7102	0.0696	6.5945
lnNGC	-0.0023	0.0177	-0.1302	-0.0028	0.2650
lnCMP	-0.0264***	0.0131	-2.0112	-0.0230	2.1830
lnEMP	0.0404*	0.0087	4.6442	0.0442	4.1851
Constant	-7.4505*	1.0572	-7.0477		

Source: Author's calculations. *, ** and *** respectively indicate that the coefficients are significant at 99%, 95% and 90%

confidence level.

Evaluating the effects of fiscal policy (FP), asymmetric results are found in terms of CFP and EFP policies. The CFP and EFP policies have respectively, a negative significant and positive significant effect on CO2 emissions. The CFP policy results represent that a 1.0 percent reduction in government expenditure causes a 0.0615 percent decrease in CO2 emissions, implying the CFP policy improves the environmental quality. Conversely, a 1.0 percent reduction in government expenditure under the EFP policy leads to a 0.0724 percent reduction in CO2 emissions. This shows that EFP policy enhances CO2 emissions and mitigates environmental quality. Fiscal policy results authenticate that expansionary fiscal policy has a stronger influence on CO2 emissions as compared to contractionary fiscal policy during the post-liberalization period.

Foreign direct investment and coal consumption have a positive and statistically significant influence on CO2 emissions during the post-liberalization period, implying that CO2 emissions increase (decrease) 0.0175 percent and 0.0323 percent in response to a respective 1.0 percent increase (decrease) in foreign direct investment and coal consumption. However, natural gas consumption has an inverse but statistically insignificant influence on CO2 emissions.

Evaluating the effects of monetary policy (MP), similar to fiscal policy, we find asymmetric results in terms of coefficients of CMP and EMP policy. Both the CMP and EMP policies have a significant effect on CO2 emissions during the post-liberalization period, with the former being significant at the 10% level and the latter at the 1% significance level. The CMP policy results show that a 1.0 percent decrease in money supply, under contractionary monetary policy, represents a 0.0264 percent fall in CO2 emissions, indicating that the CMP policy improves environmental quality. Conversely, a 1.0 percent increase in money supply under expansionary monetary policy leads to a 0.0404 percent rise in CO2 emissions. This indicates that expansionary monetary policy increases CO2 emissions, which increases environmental pollution. Monetary policy results authenticate that expansionary monetary policy has a stronger effect on CO2 emissions than contractionary monetary policy during the post-liberalization period. Our findings regarding fiscal and monetary policies conclude that expansionary and contractionary fiscal and monetary policies are effective in changing carbon emissions during the post-liberalization period.

Each predictor's relative contribution to CO2 emissions is determined using the absolute values of standardized regression coefficients, expressed as a percentage of their absolute sum. Estimated results regarding each predictor's relative contribution are summarized in the last column of Tables 6 and 7. During the pre-liberalization period, among the included predictors, population had the largest contribution at 20.78 percent, followed by gross domestic product (18.70%), electricity consumption (17.13%), natural gas consumption (9.51%), oil consumption (8.42%), coal consumption (7.24%), expansionary fiscal policy (4.93%), contractionary monetary policy (4.20%), and gross fixed capital formation (2.99%). During the post-liberalization, gross domestic product had the largest contribution at 19.55 percent on average, followed by electricity consumption (14.36%), expansionary fiscal policy (11.76%), gross fixed capital formation (11.37%), agricultural value added (9.80%), oil consumption (7.03%), coal consumption (6.59%), population (5.59%), foreign direct investment (4.84%), expansionary monetary policy (4.19%), contractionary fiscal policy (2.48%), and contractionary monetary policy (2.18%).

Table 8: Diagnostic Tests of the Correlated Component Regression Model

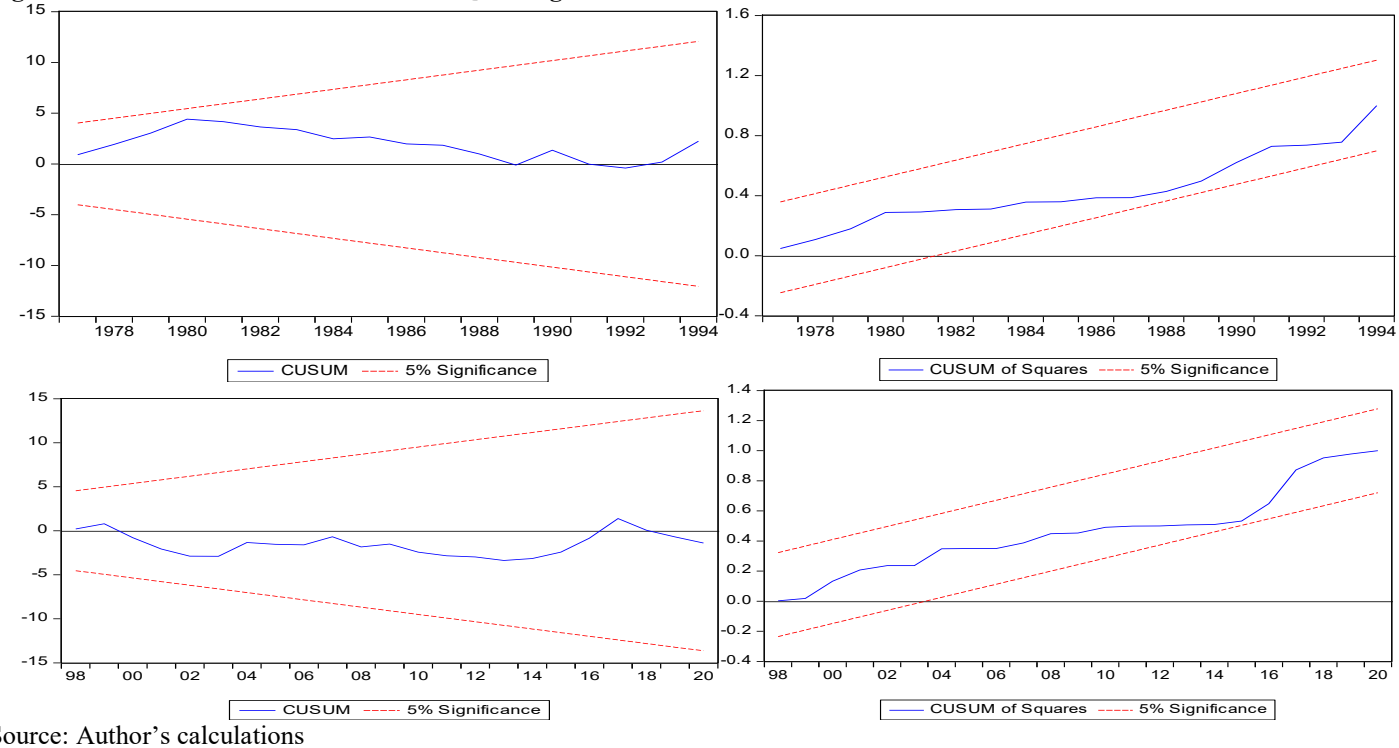
Before Liberalization			
Name of Test	**Critical value**	**Calculated value of Test Statistic**	**P-value**
Normality Test (Jarque Bera)	$\chi^2_{0.05(2)} = 5.99$	1.48	0.48
Serial Correlation LM Test	$\chi^2_{0.05(1)} = 3.84$	0.23	0.63
ARCH Test	$\chi^2_{0.05(1)} = 3.84$	`0.10	0.76
Ramsey Reset Test	$F_{0.05(1,17)} = 4.45$	0.18	0.67
After Liberalization			
Normality Test (Jarque Bera)	$\chi^2_{0.02(2)} = 7.82$	6.81	0.03

Serial Correlation LM Test	$\chi^2_{0.05(1)} = 3.84$	0.23	0.63
ARCH Test	$\chi^2_{0.05(1)} = 3.84$	0.01	0.93
Ramsey Reset Test	$F_{0.05(1,22)} = 4.30$	0.11	0.74

Source: Author's calculations.

Table 8 reports the results of the different diagnostic tests that are used to assess the validity and stability of the CCR model during pre- and post-liberalization. The primary goals of these tests were to evaluate the non-normality of residuals, autocorrelation, heteroscedasticity and stability of the estimated parameters. The normality assumption of residuals was assessed using the Jarque-Bera test. Estimated results of this test indicate that residuals of the CCR model follow the normal distribution, implying that the normality assumption is satisfied during the pre- and post-liberalization period. The serial correlation LM test is also conducted to detect autocorrelation. Our findings concerning the LM test indicate the absence of autocorrelation, which means the one-time period's disturbances are uncorrelated with disturbances in another time period. The ARCH test is used to examine the heteroscedasticity, which shows the unequal variance of residuals. Estimated results of the ARCH test show that the equal-variance assumption of disturbances is satisfied, implying the absence of heteroscedasticity during pre- and post-liberalization. The Ramsey Reset test was also employed to investigate the specification and possible misspecification of the CCR model. Estimated results regarding this test indicate that the CCR model is correctly specified, indicating that the selected predictors explain the sufficient variance in the explained variable during pre- and post-liberalization.

Figure 1: The CUSUM and the CUSUMSQ during Pre- and Post-Liberalization.



Source: Author's calculations

Moreover, the estimated parameter's stability of the CCR model was investigated considering the plots of cumulative sum (CUSUM) and squares cumulative sum (CUSUMSQ) of residuals. The plots of CUSUM and CUSUMSQ are shown in Figure 1. This figure shows that, at a 95% confidence level, the CUSUM and CUSUMSQ plots fall inside the red straight lines. Therefore, the parameters of the CCR model are structurally stable, implying that the CCR model is reliable and consistent during pre- and post-liberalization periods.

6. Conclusion and Policy Recommendations

The paramount aim of this study is to determine the influence of fiscal policy, monetary policy, and energy consumption on CO2 emissions in Pakistan before and after liberalization, considering gross domestic product, agricultural value added, capital formation, population, and FDI as control variables. The historical timespan

from 1974 to 2020 has been subdivided into two separate spans: the 1974 to 1994 years, indicating the pre-liberalization period and the 1995 to 2020 years, representing the post-liberalization period. During the pre- and post-liberalization periods, empirical findings have been determined employing the correlated component regression methodology. Our findings illustrate that both the contractionary fiscal and monetary policies have an inverse influence on CO2 emissions during the pre-liberalization, with the former being insignificant and the latter significant. In the pre-liberalization period, expansionary fiscal policy has a significant positive influence on carbon emissions, whereas expansionary monetary policy affects carbon emissions positively but insignificantly. In the post-liberalization period, both contractionary fiscal and monetary policies have a significant negative effect on CO2 emissions, while expansionary fiscal and monetary policies affect CO2 emissions significantly and positively. Our findings regarding fiscal and monetary policies conclude that only expansionary fiscal and contractionary monetary policies are effective, whereas contractionary fiscal and expansionary monetary policies are ineffective in changing CO2 emissions during the pre-liberalization period. Conversely, all the fiscal and monetary policies, expansionary as well as contractionary, are effective in changing CO2 emissions during the post-liberalization period. Electricity, oil, and coal consumption all have a significant positive influence on CO2 emissions during the pre- and post-liberalization periods, whereas the effect of natural gas consumption on carbon emissions is significant and positive only in the pre-liberalization. Moreover, the results indicate that the GDP, population, and gross fixed capital formation significantly increase the environmental pollution both in the pre- and post-liberalization periods. Agricultural value added and FDI also enhanced the environmental pollution, having a significant effect on CO2 emissions only in the post-liberalization.

During the pre-liberalization period, among the included predictors, population had the largest contribution at 20.78 percent on average, followed by gross domestic product (18.70%), electricity consumption (17.13%), natural gas consumption (9.51%), oil consumption (8.42%), coal consumption (7.24%), expansionary fiscal policy (4.93%), contractionary monetary policy (4.20%), and gross fixed capital formation (2.99%). During the post-liberalization period, gross domestic product had the largest contribution at 19.55 percent on average, followed by electricity consumption (14.36%), expansionary fiscal policy (11.76%), gross fixed capital formation (11.37%), agricultural value added (9.80%), oil consumption (7.03%), coal consumption (6.59%), population (5.59%), foreign direct investment (4.84%), expansionary monetary policy (4.19%), contractionary fiscal policy (2.48%), and contractionary monetary policy (2.18%). Validity and stability of the CCR model during the pre- and post-liberalization periods were checked using various diagnostic tests. The main objective of these tests was to test the non-normality of residuals, autocorrelation, heteroscedasticity, and parameter stability. Our estimated results illustrated that the CCR model satisfied all these diagnostic tests. Moreover, the parameter's stability of the CCR model was examined considering the plots of cumulative sum (CUSUM) and squares cumulative sum (CUSUMSQ) of residuals.

Based on our findings, the government should raise environment-related expenditures through expansionary fiscal and monetary policies to achieve fair and sustainable economies with low carbon emissions. The expansionary fiscal policy would be focused on green budgeting with special emphasis on environmental protection, targeting renewable energy, and promoting green infrastructure in manufacturing. Moreover, the government should implement such policies with objectives to change fossil fuel-based technologies to environmentally friendly energy activities, including thermal, wind, hydro, and solar-based energies. Conversely, when implementing an expansionary monetary policy, the monetary authority should provide feedback on financing measures to ensure that increased money in circulation leads to productive and environmentally friendly activities. Along with the development and implementation of green financial instruments such as green equity, green bonds, green loans and green insurance.

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Evaluating De-Agriculturalization Patterns: Insights for Economic Sustainability and Policy Recommendations

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ABSTRACT

Objective: The research aims to analyze the transition from agriculture to non-agricultural activities in rural areas, focusing on the socioeconomic implications of this shift.

Research Gap: The study addresses the limited research on the de-agriculturization process in rural areas, particularly the socioeconomic outcomes for households that transition away from agricultural activities.

Design/Methodology/Approach: The study employs a mixed-method approach, combining quantitative data analysis with qualitative interviews to assess the impact of de-agriculturization on rural households. Using data from the World Bank on employment and output shares in agriculture and industry from 1991 to 2021, the study applies convergence criteria to determine the possibility of convergence in labour and output shares in the agricultural sector. Additionally, the study employs the Cobb-Douglas production function model to measure employment elasticities concerning agricultural output

The Main Findings: The research finds that de-agriculturization leads to both positive and negative socioeconomic outcomes, with some households experiencing improved income levels while others face challenges in adapting to non-agricultural employment. The findings contribute to the understanding of rural development by highlighting the complexities of economic transitions. Practically, the study suggests the need for targeted policies to support households in rural areas during the shift away from agriculture.

Originality/Value: The research is valuable as it provides a comprehensive analysis of the de-agriculturization process, a topic that has received limited attention in the context of rural socioeconomic development.

Critical and Policy implication: Therefore, the authors recommend that policymakers implement policies to support the agricultural sector, such as increasing investment in agricultural infrastructure, managing water resources, building dams, and promoting research and development to improve agricultural practices.

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1. Introduction

De-agriculturalization is a phenomenon characterised by a decline in the relative participation of a nation's populace in agricultural pursuits, accompanied by a concomitant rise in the number of individuals involved in alternative sectors, such as manufacturing and services. This phenomena may arise as a result of economic expansion and urban development, resulting in a transition of the workforce from agricultural activities to more efficient and lucrative non-agricultural sectors. The process of de-agriculturalization can provide both advantageous and disadvantageous consequences for a nation's economy, as it has the potential to foster enhanced

productivity and elevated revenues. However, it is important to note that this phenomenon can also lead to negative consequences such as unemployment and a downturn in associated sectors. Moreover, the process of de-agriculturalization carries significant social and environmental consequences, including alterations in land utilisation, shifts in population from rural to urban areas, and impacts on the availability and accessibility of food resources. Therefore, policymakers must possess an understanding of the potential ramifications of de-agriculturalization and implement suitable measures to alleviate any adverse effects.

According to (Matsuyama, 2008), de-agriculturalization refers to a reduction in the proportion of employment in the agricultural sector. This loss can be attributed to either labour push or labour pull factors. According to (Nurske, 1970), the labour push theory posits that breakthroughs in agricultural technology lead to the release of labour from the agricultural sector, resulting in a decrease in the share of employment in this sector. In contrast, (Lewis, 1954) referred to the labour pull theory, positing that an enhancement in industrial returns serves as a magnet for labour migration away from the agricultural sector.

The process of de-agriculturalization in Pakistan would incur significant costs, given the substantial progress made in the agricultural sector since the country's independence in 1947. The agricultural sector in Pakistan holds significant importance due to its contribution of around 20 percent to the national GDP, employment of around 42 percent of the labour force, and its substantial role in generating agricultural-related export earnings for the country. Pakistan is endowed with huge tracts of arable land and a highly efficient irrigation infrastructure. The significance of agriculture in any economy cannot be overstated, since it plays a crucial role in ensuring food security. Approximately 70% of the people in Pakistan are engaged in agricultural activities (The Economic Survey of Pakistan, 2018). The presence of de-agriculturalization in an economy is a matter of great concern in Pakistan, particularly due to the significant role it plays in generating foreign exchange revenues, driving growth in industrial and manufacturing sectors, and addressing unemployment challenges. This is especially important considering the substantial proportion of individuals who are directly or indirectly reliant on the agriculture sector. By implementing contemporary agricultural methods, the productivity of agriculture can be significantly enhanced, particularly concerning the cultivation of main crops such as cotton, wheat, and rice.

The current progress can be ascribed to key initiatives such as providing financial assistance to farmers, enhancing water accessibility, lowering tariffs for tube wells, improving credit disbursements, ensuring subsidised availability of fertilisers, and reducing customs duties on machinery imports for the dairy, and livestock, poultry, and cold chain industries.

Table 1: Agriculture Sector Growth, Major Crops Production (2003-2018)

Crop	2003–2004	2005–2006	2007–2008	2009–2010	2011–2012	2013–2014	2015–2016	2017-2018
Agri growth (%)	2.8	1.2	1.8	1.9	3.6	2.5	2.0	3.8
Wheat production (Tons)	19.5	21.3	20.9	23.3	23.5	26.0	25.6	25.5
Rice production (Tons)	4.8	5.5	5.6	6.9	6.2	6.8	6.8	7.4
Sugarcane (Tons)	53.4	44.7	63.9	49.4	58.4	67.5	65.5	82.1
Cotton production	10	13.0	11.7	12.9	13.6	12.8	9.9	11.9
Maize Production	1052	950	1087	1060	1168	5044	5700	6300

Source: Agriculture, Industry Drive Robust Growth in Pakistan. (Figures in MillionTon)

The agricultural sector has exhibited a largely steady growth pattern over the years, except for the 2017-18 period, during which there was a general improvement observed across all regions (refer to Table 1). The complete version was demonstrated through the growth in sugarcane production, while the contribution of wheat remained unchanged. The agricultural sector warrants support and should get increased focus throughout its various sub-sectors to serve as the foundational pillar of our economy. To facilitate the advancement of this sector, all government officials together must propose a comprehensive plan at the national level to restore the previous magnificence seen during the Green Revolution era.

Approximately 60% of the population resides in rural areas and derives their living directly or indirectly from agricultural activities. The agricultural industry also plays a crucial role in mitigating poverty in rural areas. The Green Revolution, characterised by advancements in irrigation technology, the utilisation of improved seeds, and

the application of fertilisers, significantly contributed to the augmentation of agricultural output, leading to a subsequent rise in GDP and a more equitable distribution of income among the populace.

Livestock constitutes a distinct sub-category within the broader domain of the agriculture sector. During the fiscal year 2017-18, it constituted around 58% of the total value added. However, on a smaller scale, Pakistan's total exports are only marginally influenced by this sector, accounting for a mere 5% contribution. This can be mostly attributed to the limitations imposed by European markets, which have imposed limits due to the current lack of quality standards in Pakistan. According to the Economic Survey of 2018, Pakistan experiences an annual population growth rate of approximately 2%, which consequently necessitates attention towards the matter of food availability. The agricultural industry has the potential to contribute significantly to the fulfilment of growing food demands. Furthermore, it has the potential to mitigate the need for food imports and bolster export profits through the cultivation and sale of diverse agricultural products. Table 2 displays the primary export of Pakistan with the greatest monetary worth. The percentage distribution of each export is indicated within brackets.

Table 2: Pakistan's major export in highest dollar value

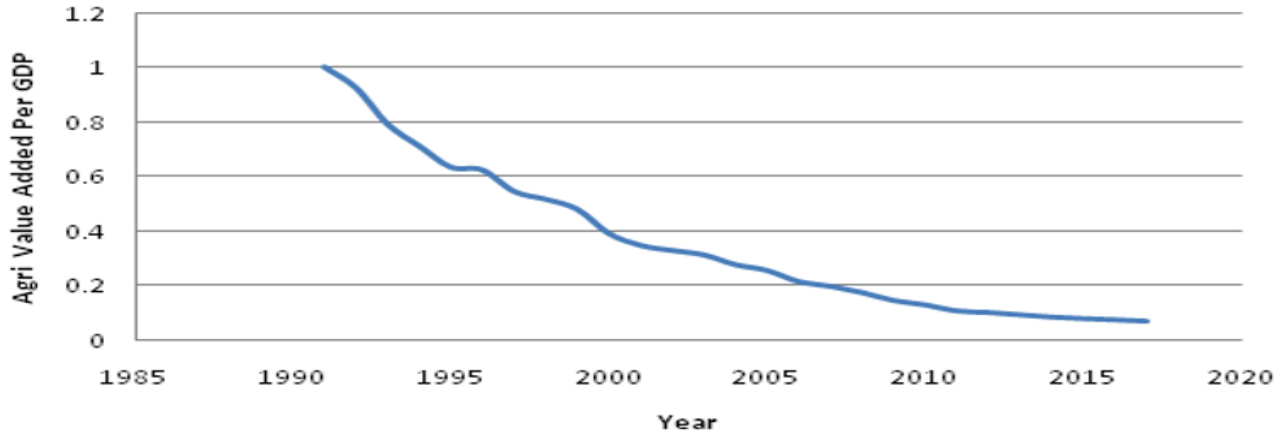
Miscellaneous textiles, and worn clothing: US$4 billion (18.1% of total exports)
Cotton: $3.5 billion (16%)
Knit or crochet clothing, and accessories: $2.5 billion (11.5%)
Clothing, accessories (not knit or crochet): $2.5 billion (11.3%)
Cereals: $1.8 billion (8%)
Sugar, sugar confectionery: $511.9 million (2.3%)

Source: International Monetary Fund, World Economic Outlook Database

Pakistan is recognised as the third largest global producer of milk. The anticipated annual milk production is approximately 50 billion litres. Although Pakistan has limitations in exporting milk, its dairy sector exhibits significant immaturity in terms of essential facilities such as infrastructure, processing capabilities, milk productivity, storage, and transportation provisions.

Within the agricultural sector, the livestock industry comprises the largest proportion of contributors, with key crops such as rice, cotton, wheat, and sugarcane following closely behind. The contributions made by lesser crops are placed in third position.

Figure 1: Trend in Agriculture Value Added per GDP

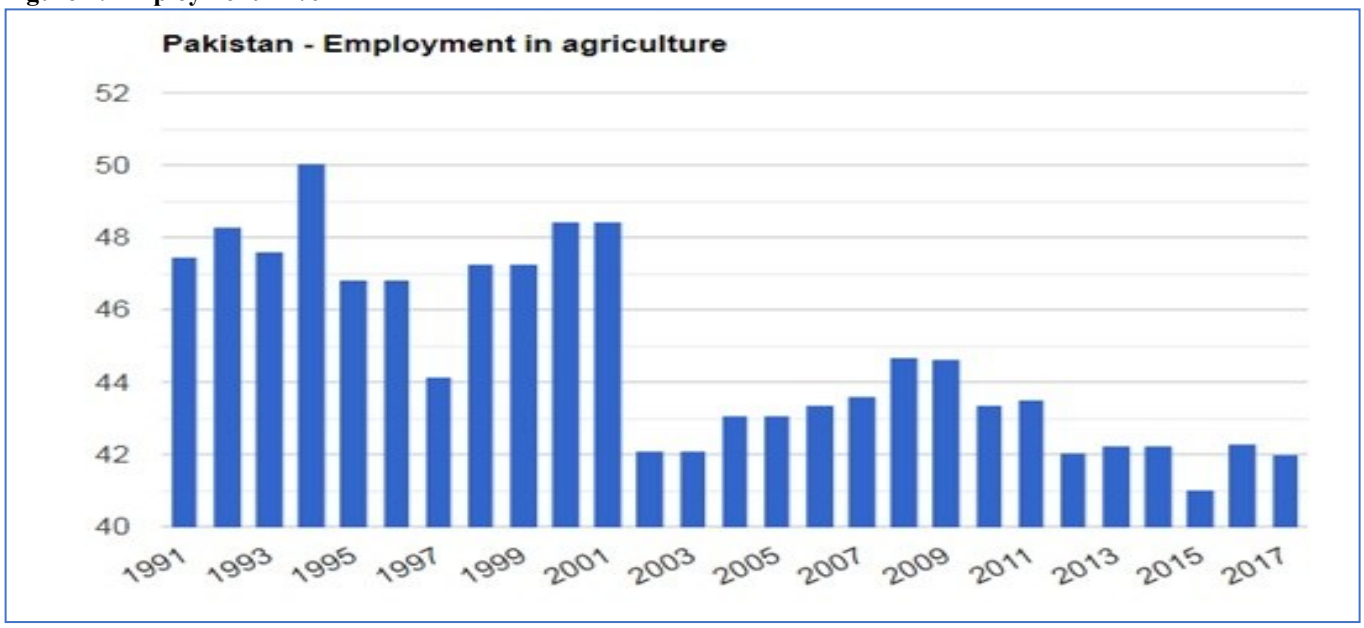


Source: WDI

Figure 1 above does not represent a favourable value added per GDP trend for the agriculture sector, which includes the cultivation of crops and livestock production. Such a trend is perhaps reflecting de-agriculturalization in Pakistan.

The importance of agriculture to Pakistan's economy is reflected by the fact that this sector is a key source of national employment.

Figure 2: Employment in %



Source: WDI

In Figure 2, the trend of percentage employment in the agriculture sector is given. The sign of de-agriculturalization is quite visible as, since 1991, the employment proportion has declined in 2017. Apart from the areas mentioned above, the agriculture sector also supports industrial development via farm mechanization tools as they are utilized in agricultural activities.

As a backbone for the Pakistani economy, the role of textile industries cannot be neglected as these industries depend on raw agricultural output, thus contributing to economic growth. Finally, sugarcane production is also a significant contributor to economic growth, which is vastly produced and supplied to sugar manufacturing units to produce sugar and byproducts, raising employment levels.

1.1 Objective of the Study

This paper aims to analyze de-agriculturalization trends and their implications in Pakistan, where agriculture holds significant value in economic performance. The research specifically determined whether de-agriculturalization is occurring by analyzing employment and output shares in both the agricultural and manufacturing/industrial sectors. The purpose of this research is to examine the factors of structural changes, including shifts in labour preferences and sectoral productivity, along with their socio-economic ramifications. The study investigates the issues stemming from diminished agricultural participation by analyzing effects on other sectors and rural income-generating activities. This effort seeks to enhance policy-making by mitigating adverse effects and promoting beneficial growth patterns within the agricultural-industrial sector interface.

1.2 Problem Statement

The phenomenon known as de-agriculturalization, which is characterized by a falling contribution of agriculture to the economy of a nation, has substantial implications for the establishment of economic policy and for the maintenance of economic sustainability. In the context of Pakistan, there is an urgent requirement to assess the patterns of de-agriculturalization and the impact that these patterns have on the entire developmental process of the economy. To address this matter comprehensively, the purpose of this study is to ascertain whether or not de-agriculturalization and deindustrialization are prevalent in Pakistan. This will allow for the provision of insights into economic sustainability as well as policy recommendations.

1.3 Significance of the Study

This research is valuable as it systematically examines de-agriculturalization trends in Pakistan, a nation where agriculture remains significant due to its contribution to the gross domestic product and employment for numerous citizens. This study has significant consequences for comprehending the relative changes in employment and output shares within agriculture and other industries in Pakistan. The study has theoretical implications as it

enhances understanding of economic development and structural change, particularly in emerging economies. It expands upon the understanding of how the transition from agrarian societies restructures socioeconomic relations, culture, rural livelihoods, industrialization, and economic development. The research is beneficial for policymakers as it offers tangible, legally grounded ideas for effectively managing transition processes. It emphasizes the necessity to formulate targeted plans for many sectors, including the enhancement of infrastructure in the concerning livestock farming sector, the advancement of the industrial base, and the creation of social protection systems for disadvantaged populations. The analysis of challenges related to de-agriculturalization, including market issues that result in unemployment and decreased production rates in related sectors, demonstrates that the study highlights the importance of benefits that are equitable and sustainable for the economic development of vulnerable farming communities.

2. 2. Literature Review

2.1 De-Agriculturalization

Recently, the process of de-agriculturalization has gained significant attention from scholars, politicians, and practitioners. De-agriculturalization is the process in which agriculture's economic significance decreases in a country, while there is a corresponding increase in the importance of non-agricultural industries. This literature review consolidates recent research findings on de-agriculturalization tendencies, clarifying its consequences for economic sustainability and providing policy solutions to tackle related difficulties.

Sharma and Gupta (2024) analyzed the patterns of de-agriculturalization in India, emphasizing the intricate relationship between changes in the economic structure, migration from rural to urban areas, and developments in technology. Their research emphasized the necessity of specific policy measures to reduce the negative impacts of the decline in agriculture on rural lives and promote inclusive economic growth.

Zhang et al. (2023) expanded on this research by conducting a thorough examination of the de-agriculturalization patterns in East Asian economies. Their investigation unveiled notable disparities in the speed and path of de-agriculturalization among countries, influenced by factors such as industrialization, urbanization, and trade liberalization. The authors proposed a policy strategy that takes into account the unique circumstances of each country to encourage economic In addition, Wang and Li (2022) investigated the impact of technical innovation on the process of de-agriculturalization in China. The authors conducted a case study on agricultural mechanization to illustrate how technical progress has sped up the replacement of workers in the agricultural industry, while also generating prospects for other economic activity in rural regions. Their study highlighted the need to utilize innovation to improve agricultural productivity and competitiveness in response to the pressures of de-agriculturalization, Diversification and resilience.

Martinez et al. (2022) examined the de-agriculturalization patterns in Latin America within a distinct geographical framework, with a specific emphasis on the consequences for both food security and rural development. Their study highlighted the susceptibility of smallholder farmers to market volatility and environmental hazards, which are worsened by the de-agriculturalization processes. The authors advocated for governmental interventions to foster sustainable agriculture, bolster rural entrepreneurship, and improve the accessibility of markets and resources for marginalized farming communities.

Using the pre and post-hydrocarbon development and observing employment shares in manufacturing and agriculture sectors, Matallah & Proops (2006) found that the development of oil & gas and hydrocarbon sectors in Algeria had resulted in industrialization. Thus de-agriculturalization in the economy has taken place.

Developing a model that explained the impact on employment share in the agriculture sector of agrarian constraints' vector and productivity in agriculture activities and tested for the data of various countries around the globe for the yearly period of 1963-2005, Ungor (2013) found that the decline in the employment share of agriculture sector is caused by the declining growth of productivity in agriculture sector such that de-agriculturalization is not just associated with an increasing percentage of industrialization in an economy.

Hosein's (2007) Study compared (the only country in the Caribbean region with oil reserves) Trinidad and Tobago's oil boom of the 1970s and early 2000 and found the positive signs of industrialization in agricultural

subsectors - like sugar manufacturing - as output per worker rose. This structural transformation is considered phenomenal by the author as the sectors like tourism, manufacturing, and mining were considered the impetus for the economic growth in the Caribbean region, hinting at a de-agriculturalization in the region but at the cost of food security issues.

Zaman et al. (2012) analyzed the causal link between energy utilization and agricultural-based technological factors in the Pakistani rural sector by applying Granger causality tests on energy demand and agricultural technical-based factors such as fertilizers from 1975 to 2010, inferred that a bi-directional relationship across energy demand and agricultural technological based factors in Pakistan. They highlighted that among the key variables that cause demotion of the agricultural sector in the Pakistani economy, the usually included factors are water deficiency, electricity load shedding for the farmers, inactive land reforms, high costs of fertilizers, underutilization of arable land, conventional practices of farming, unavailability of crop insurance, and lack of upgraded agrarian sector related technologies. Authors thus suggested that the above-highlighted issues are fundamental to improving agricultural performance, avoiding de-agriculturalization, and increasing its share in the economy.

Fry (2011), in a case study on rural Mexico, analyzed how an increase in mining activities negatively affects rural agricultural arable lands and residents' livelihoods. Arable land's changes were compared on Global Positioning System (GPS) field maps, and around 70 interviews were conducted with the region's residents. It is found that from 1995 to 2006, mines' surface area increased by four times. The author reported factors such as higher prices, demand for homes, and falling returns from the agriculture sector. The author believes that diminished agricultural scope could force farmers to migrate to urban areas to get employment.

Huang et al. (2010) identified key changes in the agriculture economy in China to avoid any possibility of a decline in the rate of agricultural contributions to national income. Chinese policies are found to be directed toward achieving sustainable development in agriculture.

Lee et al. (2010) investigated the causes of the growth phase in Vietnam after the Doi Moi reform of 1986 and further attempted to find why a decline in agricultural employment was occurring. It is found that the Vietnamese economy has significantly grown since 1986 but has increased reliance on factors like technological capabilities that are more parental towards enhancing the industrialization process and thus the industrial sector's contribution to GDP.

Imrohoroglu et al (2014) examined the growth patterns in Turkey; found that the main cause behind its relative stagnation was its low agricultural productivity growth due to policies that discriminated against the rural side of the economy and; deserve to understand why low productivity in the Turkish agricultural sector is prevailing. The authors conducted an experiment in which it was indicated that if Turkish policies were pro-Spanish agricultural policies then de-agriculturalization would have been even faster from the present scenario. The authors further extended their Study by providing some evidence that import substitution policies and highly overvalued foreign exchange rates are hampering the agriculture sector in Turkey.

Liu (2012) quantitatively analyzed unbalanced urban agglomeration near the Yangtze River from 2002 to 2012 on industry and de-agriculturalization. It was found that there are three elements on the rise near the Yangtze River, including the behaviour of residents' willingness to promote urban development; the emergence of a high degree of urbanization has increased an unbalanced growth in the area, and the degree of arable land used for agriculturalization has greatly reduced.

2.2 Deindustrialization

Rasiah and Nazeer (2016) questioned the earlDeindustrialization Pakistan faced and attempted to explore the causes. Since the fluctuating trends in manufacturing growth remain linked with import substitution strategies policies and a relatively depreciated local currency, the lack of a consistent industrial policy to target technological catch-up mattered most.

Hamid and Khan (2015) believed that Deindustrialization is a normal phenomenon for the developed world, such that several developing nations have a high employment share in the manufacturing sector thus coining the term "premature deindustrialization" for developed economies specifically. The authors focus on growth patterns in the manufacturing sector and the possibility of premature Deindustrialization in Pakistan. They found that Pakistan's industrial base has stagnated and suggested that Pakistan need to adopt proactive industrial strategies to overcome shortcomings in the manufacturing sector.

Brady & Denniston (2006) examined manufacturing employment and economic globalization in prosperous democratic economies. They found that globalization has different effects across various capitalistic regions and other effects under historical events of a global nature. This academic outcome is matched with Kollmeyer & Pichler (2013), who relate Deindustrialization and high unemployment rates across many developed countries from 1975 onwards and noted that the manufacturing sector is a significant factor of low employment in the OECD bloc for 34 years. From a different perspective, Rowthorn & Coutts (2004) refers to Deindustrialization as a decline in manufacturing employment. Examining the experience of Britain and America, the authors found rapid Deindustrialization in these two economies and concluded that balance of payments issues and non-manufacturing GDP contributions like inroads towards the agriculture sector made declining performance in the manufacturing sector.

Inchausti-Sintes (2015) reported a decline of around 25 million jobs in industrialized European countries. Thus Inchausti-Sintes found that a process of such a degree of Deindustrialization has a significant adverse effect on the growth potentials of manufacturing sector-related employment and investments. This rapid fall in industrial employment is referred to as the Dutch Disease1.

Tregenna (2008) developed a new decomposition inquiry approach to analyze changing employment patterns in the manufacturing sector. It separates the share of employment manufacturing into two components; one is linked with a share of manufacturing in GDP, and the other is connected with the growth of value-added by the labour in the manufacturing sector. The authors found that in most countries, declining manufacturing employment is due to falling labour intensity in the manufacturing sector and is not the manufacturing sector's role.

Sabitino (2016) analyzed that due to the Italian GDP's fall in the 2000s (which is a decline of more than 7 percent), industrial performance was also in decline, hinting that the Italian economic growth prospects would be alarming. The crisis of the industrial sector in the last two decades was reported to be caused by three factors; the overall Italian production failed to adapt to the innovative global changes mainly because of the inability to transform into new structural standards, having a structural disadvantage over other economies. Finally, the stagnant domestic demand caused a significant economic growth contraction.

Yahya, Mehboob & Lopez (2018) observed that Pakistan experienced a rise in the share of services GDP while the manufacturing sector share has remained constant. In their Study, the authors traced Deindustrialization's effects on GDP growth using annual data from 1972 to 2017 and applied the ARDL modelling technique. They conclude that Pakistan has become a service sector-based economy, indicating signs of Deindustrialization, and advised that progress in the services sector must not accompany unsustainable manufacturing.

Bernard, Smeets, and Warzynski (2017) use employer-employee data to examine the possibility of Deindustrialization from 1994 to 2007 in Denmark. Authors claim that one of the key reasons is that firms are opting to switch from manufacturing to the services sector. Still, they also found that employment at manufacturing businesses exaggerates the losses incurred in manufacturing units.

Ike et al. (2016) pointed out that for any economy, the transmission mechanism is usually reflected by crowding out phases via direct and indirect Deindustrialization and may improve agriculture sector performance. Authors analyzed the connection between oil dependence and the GDP growth in the Nigerian economy with ARDL regression modelling and found that oil dependence had a significant inverse link with GDP growth but in the short run only, thus suggesting the existence of the Dutch disease in the Nigerian economy.

[1] The Dutch Disease is the possible causal relationship between the increase in the economic growth of a particular sector and a fall / decline in sectors like manufacturing or agriculture sectors.

Rising de-agriculturalization in an economy is one of the key concerns in Pakistan when a large percentage of people are directly or indirectly attached to the agriculture sector. The eclectic literature summarized above suggests the industrial and agriculture sectors' influential role in economic growth. Still, the two sectors should not be opponents of each other in designing a sustainable policy framework. Thus, this study intends to explore the determinants of de-agriculturalization in Pakistan.

3. Data & Methodology

Using the World Bank's data source2, we have obtained Pakistan's annual data of employment share in agriculture & industrial sectors, and output share in agriculture & industrial sectors of Pakistan from 1991 to 2021, and GDP at constant 2010 US$. All the data series are also transformed into natural log series for further estimations.

For employment data, we considered the United Nations definition that the labor force comprises people at least 15 years old who offer their labour hours for the production process for goods and services in a given time and are employed by either service agricultural or industrial sectors.

3.1 Estimation Methodology

We estimated the model (3.1) to find the possibility of convergence in shares of labour and output in the agricultural sector.

$$S_{eat} = \alpha_1 + \beta_1 t_{jat} + \mu_{1t} \quad (1)$$

$$S_{emt} = \alpha_2 + \beta_2 t_{jmt} + \mu_{2t} \quad (2)$$

$$S_{qat} = \alpha_3 + \beta_3 t_{jmt} + \mu_{3t} \quad (3)$$

$$S_{qmt} = \alpha_4 + \beta_4 t_{jmt} + \mu_{4t} \quad (4)$$

Where S is the share, e is employment, q is output, a is the agriculture sector, m is the manufacturing sector, α is the intercept, β is the slope of how much S will change over time t_3, and μ is the residual term. Among subscripts, e represents employment, q represents agriculture (a) and manufacturing (m) output, and t is the time period.

Convergence criteria refer to a situation if β in equation 3.1-3.4 is found to be negative. This means the employment or output shares in question are declining, reflecting that de-agriculturalization / deindustrialization is taking place in the economy through employment and output criteria. We will also test the possibility of de-agriculturalization via the returns to scales approach. To get the returns to scale parameters, we estimate a model, a variant of the Cob Douglas production function, given in the following form.

$$Y_t = A(Ea)^{\alpha}(Em)^{\beta}\mu_{5t} \quad (5)$$

$$\ln Y_t = A + \alpha \ln(Ea) + \beta \ln(Em) + \mu_{5t} \quad (6)$$

In equation 3.5, Y is GDP, Ea is employment share in the agriculture sector, and Em is employment share in the industrial/manufacturing industry.

The parameter α is the elasticity of employment share in the agriculture sector on GDP growth, β is the elasticity of employment share in the manufacturing sector on GDP growth, and μ is the residual term. The log transformation of (3.5) will give (3.6), which will be tested using OLS regression.

4. Results

Table 3 explains the results of beta convergence applied to Employment share in the Agriculture Sector, Employment share in the Manufacturing Sector, Output share in the Agriculture Sector, and Output share in the Manufacturing Sector. The results show that beta convergence was achieved in employment share in agriculture, suggesting a possibility of de-agriculturalization in Pakistan.

The finding further strengthens this that a significant and diverging beta in the manufacturing sector suggests an expansionary employment share in the manufacturing sector, offering employees the choice to leave agricultural opportunities.

The possibility of de-agriculturalization in Pakistan is validated again by the prevalence of a significant beta convergence of output share in the agriculture sector. However, it is not supported by output share in the manufacturing sector as an un-diverging beta in the manufacturing industry prevailed.

Table 3: Regression Results on Convergence Criterion

Sector	Coefficient	Std. Error	t-Statistic	Prob.
Employment Share in Agriculture	48.18	0.52	91.12	0.0000
	-0.21	0.03	-6.29	0.0000
Employment Share in Manufacturing	18.71	0.38	48.29	0.0000
	0.05	0.02	2.05	0.0507
Output Share in Agriculture	25.74	0.51	49.72	0.0000
	-0.08	0.03	-2.41	0.0238
Output Share in Manufacturing	25.52	0.53	48.08	0.0000
	-0.21	0.03	-5.83	0.0000

Source: Author Estimation

Not accounting for the role of the service sector, table 4 provides regression results for equation 3.6. Employment share in the agriculture sector and employment share in the manufacturing industry were significant variables that affected the combined output of the agriculture and manufacturing sectors.

Table 4: Returns to Scale Criteria

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(EMP_A)	0.863277	0.147606	5.848516	0.0000
LOG(EMP_M)	-0.459648	0.170437	-2.696883	0.0123
R-squared	0.671027	F-statistic		24.47716
Adjusted R-squared	0.643613	Prob(F-statistic)		0.000002

Source: Author Estimation

Table 5: Wald Test of Coefficient Restrictions.

Test Equation: C(1) + C(2) = 1

Test Statistic	Value	Df	Probability
F-statistic	7.476339	(1, 24)	0.0116
Chi-square	7.476339	1	0.0063

Source: Author Estimation

Wald test rejects the hypothesis of constant returns to scale and supports that the sum of two beta coefficients is found to be 0.41 (less than unit), implying decreasing returns to rise in the agriculture sector via employment factor, thus suggesting a possibility of de-agriculturalization in Pakistan. [Table 5].

The results presented in this study corroborate with the developments presented in the literature regarding de-agriculturalization processes in developing and emerging countries. For example, Zhang et al. (2023) found that East Asian developing economies followed similar patterns of change, featuring not only industrial growth and urbanization as having a strong role in depressing the agricultural sector's employment and output shares. In similar vein, Martinez et al (2022) identified in Latin America that de-agrarianisation is correlated to transition to other non-agriculture sectors; a transition which as been shown to have both beneficial and adverse socio-economic effects, on the rural folks. Wang and Li (2022) showed that this process intensified with development and changes in agricultural mechanization technology indicating a trend of a declining number and proportion of people engaged in agriculture in China and increased dependence on industrial development. Together, these studies confirm the findings of this research including changes in labour and output preferences from agriculture to

manufactures and industries in Pakistan. The similarity of the results obtained within different contexts underscores the generality of structural economic changes in emerging economies.

5. Conclusion

As our results suggest, there are signs of a decline in agricultural share in total employment and GDP. The employment preferences are moving away from the farming sector, and the de-agriculturalization phenomenon is occurring. We tested de-agriculturalization through the beta convergence approach and found people associated with the farming sector prefer to leave. We found a similar conclusion about the possibility of de-agriculturalization in Pakistan using returns to scale analysis. The sum of the elasticities is less than one, which is also verified by the Wald coefficient restriction test. Being the second largest sector and accounting for around 22 percent of national income, this sector is the biggest employer in Pakistan; it absorbs roughly 45 percent of total labour, and the importance of the agriculture sector cannot be ignored.

De-agriculturalization is just not associated with the agriculture sector only. Still, it is a very vital factor that can cause Deindustrialization in agricultural-related goods and services providing industries, e.g., firms manufacturing tractors, fertilizers, biotechnology developers, pesticides/herbicides for unwanted green growth can face recessions or shutdowns at the cost of those alternatives in which they may meet through quality and pricing competitions. Concerning Table 6 provided below, it is notable that the trends in per capita freshwater availability are declining and hence becoming an alarming issue that could further cause a setback to the agriculture sector in Pakistan as its availability for the agriculture sector is becoming scarce over time. A decline in such a vital resource is thus an important cause of de-agriculturalization.

Table 6: Trends in Per Capita Renewable Freshwater Resource[3]

1977	1982	1987	1992	1997	2002	2007	2012	2017 [p]
775	659	559	483	426	380	343	309	286

Source: WDI (In cubic meters)

World Bank's data on renewable freshwater resources per capita (cubic meters) in Pakistan is showing a declining trend and thus would back the severity of the issue undertaken in this Study.

5.1 Policy Recommendations.

Hence, the challenge of de-agriculturalization and the inability to achieve sustainable economic development warrant the design and formulation of friendly agriculture sector policies. These policies should aim at greatly boosting the financing of basic facilities necessary for the expansion of agricultural value chains; including facilities required in making and improving irrigation systems, storage, packing and transport facilities among others with the view of improving production and minimizing wastage. First, there is the urgent need to help maintain and cultivate R&D culture amongst the agricultural sector. This can be done through creation of institutions specialized in research, offering grants for companies to undertake innovation and supporting the development of improved agricultural technologies through cooperation between government and private industries.

Pakistan should learn from those developing countries which have enjoyed successful results in adopting precision scale farming and scientific practices in farming as well. The application of new geo-spatial sensors for multi-hazard risk mapping can be very useful for knowing the weather conditions and producing a forecast that farmers can respond to and reduce vulnerability due to climate change. They are useful not only in terms of developing the higher stability of the agricultural sector but also in creating new conditions for its sustainable growth through efficient resource management and demographic security of a population.

[3] Renewable freshwater resources flows refer to internal renewable resources (internal river flows and groundwater from rainfall) in the country. Renewable internal freshwater resources per capita are calculated using the World Bank's population estimates.

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Individual author contribution

Nasir Munir: conceptualization, Introduction, Literature Review
Farooq Rasheed: data, methodology, estimation,
Adiqa Kiani: interpretation of results and editing.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on request.

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Non-Linear Effect of Quality of Education on Social Development

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ABSTRACT

Objective: This study aims to test the role of the quality of education in improving the social development of HDR-listed countries. Moreover, the role of labor and capital is also included as controlling factors of the described model.

Research Gap: This study is instrumental in exploring the role of quality of education globally. Further, this study tests the determining as well as the moderating role of institutions in improving social development

Design/Methodology/Approach: For the analysis, secondary data is collected from the period 2008 to 2018, and the results are estimated using panel quantile regression. The study sample is classified as country groups based on human development.

The Main Findings: The estimated results indicate that the quality of education and social development have a U-shaped relationship. While capital and institutions are increasing but labor force is decreasing social development. The cross-product of the quality of education institutions is reducing social development.

Theoretical / Practical Implications of the Findings: These results have confirmed the implementation of targeted education reforms to enhance access and quality, cater to diverse learner needs, maximize education's positive impact on social progress, and ensure sustainability.

Originality/Value: The nonlinear role of education quality is assessed with the moderating role of institutions.

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1. Introduction

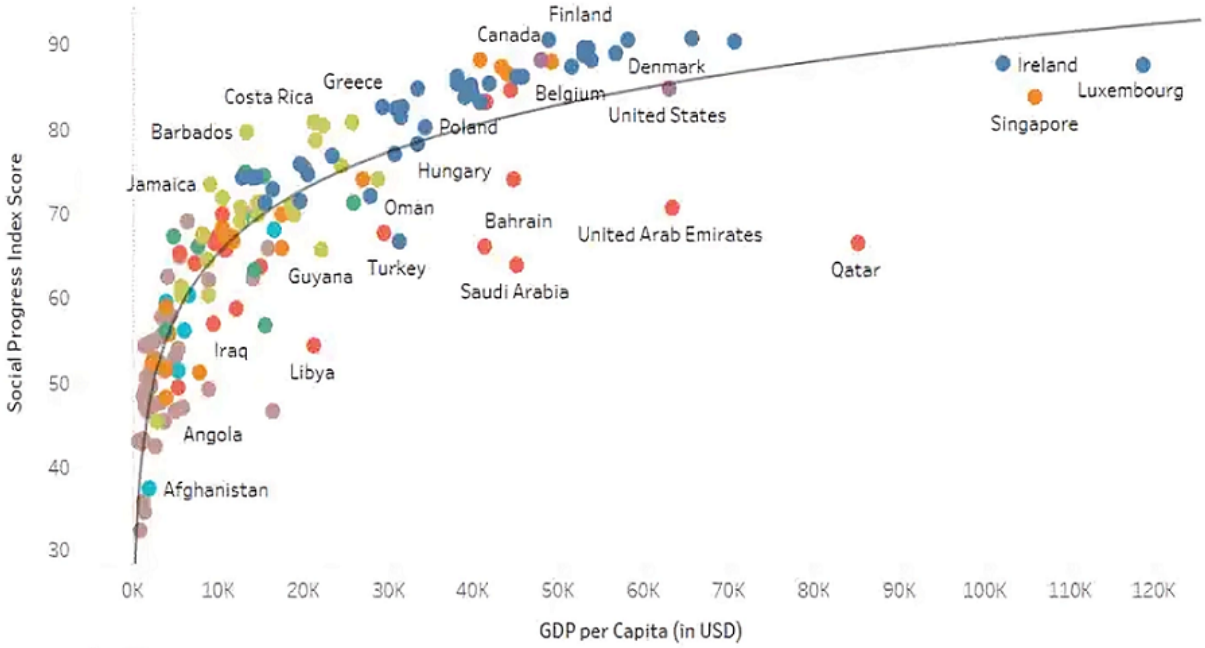
Optimum utilization of resources is essential for social progress vis à vis economic development (Ghannam, 2002; Turiel, 2002). Most people cannot afford decent living standards because of limited resources even if they desire a life full of satisfaction and prosperity (Mankiw, 2018). Social progress arrives here because social progress means improving every individual's well-being in society via economic development (Bilan et al., 2020). Whilst, only economically developed countries have a sound base for the socially developed atmosphere (Qerimi & Sergi, 2015). No doubt, income level matters (Iqbal et al., 2019), but social progress is a necessary

tool to understand the social development of an economy (Ali & Bibi, 2017). However, social progress is significantly connected to Sustainable Development Goals (SDGs)1. Specifically, the 4th, 11th, and 16th goals of SDGs are directly related to this study.

The question is, which factors are responsible for determining social progress or which factors are essential to increase its pace? In this context, the quality of education is a master key (Hillman, 2023). A sound education system provides a sense-making and goal-setting strategy for all and sundry (Opstoel et al., 2020). Education improves awareness among the masses (Godonoga & Sporn, 2023). The mechanism of education in improving social progress is quite clear. It improves economic, political, and cultural development that paves the way for social well-being (Alam & Mohanty, 2023). Education advances human development, leading to social progress and overall sustainability (Kalim et al., 2023). The crux of social progress is spending on people to improve their lives, education is vital to attain sustainable challenges (Iqbal et al., 2023b). Studies have shown the role of education in income distribution, poverty, growth and business development (Hanif & Arshed, 2016; Arshed et al., 2018, Bukhari et al., 2021; Arshed et al., 2021).

Economic and social progress is a simultaneous process (Astakhova et al., 2016), as both go hand in hand. Figure 1 reflects the positive association between economic growth and social progress in the rest of the world. According to this, in the beginning, an expansion in economic growth leads to a rapid increase in social progress, but after a specific level, this rapidity becomes slow.

Figure 1: Social Progress and Economic Growth Trend



Source: https://www.socialprogress.org/social-progress-across-worlds-regions/

Many factors determine productivity (Arshed et al., 2021). For the development process, factors of production have an important role (Doughan, 2020). The labor force is the elementary factor of production and essential for economic development (Clark, 1999). In recent times, demographic variations altered the behavior of the labor force (Iqbal et al., 2021), but production still depends upon this factor (Wijaya et al., 2021). As the productivity of this factor increases, it leads to improvement in all the social aspects. With an increase in the employment level, social improvement increases (Bazzhina, 2015). Whereas, capital can formulate the overall structure of social progress (Susetyo et al., 2018) because higher capital accumulation is linked with higher social well-being (Khan et al., 2021).

This study dug out essential factors behind social development by considering social progress as an important

[1] https://sdgs.un.org/goals

mechanism. Therefore, the objective of the present study is to find out the non-linear impact of quality education on social development. It is further aimed to test the role of institutions as a determinant and cross-product with the quality of education. The role of labor and capital as control variables in social development is also tested.

As customary, the study is divided into several parts. The second part reviews the empirical and theoretical literature to identify the research gap to be fulfilled. The third section discusses data and methodology. The results and discussion are part of section four. Finally, section five concludes the major findings of the study, and policy implications are presented in the light of estimated results.

2. Literature Review

Many studies had highlighted social progress using different indicators. Simon Kuznets (1955) had contributed significantly to this pehnomena. Later, some studies considered income inequality as a standard tool for social progress. Kakwani (1980), Solt (2009; 2016), and Aboagye and Bolt (2021), had also discussed the relationship between income inequality and social progress. Furthermore, Thompson (1978), Atkinson (1987), Lipton and Ravallion (1995), Alcock (1997), Lister (2004), Apata et al. (2010), Churchill and Smyth (2020) and Fusco and Kerm (2022) linked poverty with social development.

As discussed earlier, the role of education is crucial for social progress/development. Desjardins (2015) advocated that education can transform society. Similarly, Mok (2015) believes education is important for global competitiveness and social consequences. Astakhova et al. (2016) have discussed that education is vital for social progress. But Posselt and Grodsky (2017) had a different view on education. They urged that higher education is responsible for increasing economic inequality. Bongaarts et al. (2017) discussed that education could change the trend of society. Opstoel et al. (2020) have pointed out that physical education is imperative for social progress. Further, Osuntuy and Lean (2023) and Biancardi et al. (2023) have confirmed the role of education in sustainable social setup.

As significance of education in social development cannot be neglected. In this context, the findings of Hillman (2023), Godonoga and Sporn (2023), and Alam and Mohanty (2023) have validated the same thing. Further, the literature has evidence of the impact of education on social progress through poverty and income inequality alleviation. However, considering poverty as social progress, some recent studies like Assari (2018), Arsani et al. (2020), Liu et al. (2021), and Bukhari et al. (2021) have found that education has an impact on poverty reduction. Alternatively, some studies have used income inequality to measure social progress. Recent studies by Coady and Dizioli (2017) and Tchamyou et al. (2019) have found that education reduces income inequality. However, Lee and Vu (2020) found negative and positive evidence with different education indicators on income inequality.

There is immense literature on social progress and institutional quality in the context of poverty and income inequality. By considering reducing poverty as a tool for social progress, some recent studies like; Rizk and Slimane (2018), Zhao (2020), Hassan et al. (2020) and Dossou et al. (2021) have talked about it. Similarly, Singh (2021) believes that poor institutional quality increases poverty, and Aracil et al. (2022) and Ouechtat (2022) have found that institutional quality through financial development reduces poverty. Some recent studies like; Ferrara and Nisticò (2019), Adams and Klobodu (2019) and Madni (2019) have found that institutional quality can reduce income inequality. However, Hartwell et al. (2019) have found that if the institutional quality is improved, income inequality can be reduced using the country's natural resources.

In determining social progress, labor force participation has an obvious role. Bazzhina (2015) and Arshed et al. (2018) discussed that labor activity could improve social well-being, while as per Faridi et al. (2016), employment is the major source of poverty alleviation. Thompson and Dahling (2019) believe that an increase in employment opportunities helps formulate such a policy mix which would be helpful in an increase in social progress via a reduction in poverty and income inequality. Osabohien et al. (2019) have found that increasing labor force earnings can increase social progress by escaping the poverty trap, and Fields (2019) and Aziz et al.

(2020) argued that poverty could be reduced by self-employment.

Another important and basic factor is capital formation, which plays a role in social development and is also responsible for reducing poverty and income inequality (Arshed et al., 2018). According to Isa et al. (2019), capital expenditure positively impacts poverty, while Leasiwal (2021) has found that capital expenditure is responsible for reducing poverty. On the other hand, according to Omodero (2019), public sector capital expenditure does not impact poverty reduction. Bengtsson and Waldenström (2018) findings indicate that capital expenditures can reduce income inequality. Artiningsih (2020) states that capital expenditure can increase social progress by increasing income levels. On the other hand, Purba (2019) and Liu et al. (2021) indicate that capital expenditures are increasing income inequality. Whereas, Ishak (2018) argued that capital expenditure has no significant impact on reducing income inequality.

The studies discussed above have used different indicators for measuring social progress (poverty and income inequality). There is a need to use comprehensive indicators, so this study fulfills the gap by using the social progress index in the analysis. Moreover, the above studies have tested the role of education in social progress, but its non-linear impact on social development has never been tested. Moreover, the present study also tests the role of institutional quality, labor force, and capital formation in social progress. Further, the analysis is distributed into overall estimated results and classified based on the development status of countries.

3. Research Methods

This section details the methods relevant to the study.

3.1 Variables and Sample

To catch on to those factors crucial for social progress, this study has focused on secondary data collected from the Social Progress Imperative (SPI), World Development Indicators (WDI), and World Economic Forum (WEF). The available data covers the time from 2008 to 2018. This period is selected based on data availability. Further, the sample of the study is the overall world. The analysis is done on an aggregate as well as a disaggregated basis. At the disaggregate level, four classifications of countries as per their development status listed in the human development report are analyzed (Iqbal et al., 2023a). Two models will be estimated to test the relationship between quality education and social progress. Model 1 is the baseline model, while the 2nd model contains the moderating effect of institutions on the quality of education to ensure sustainable social progress. Table 1 presents all the symbols and the definitions of those indicators taken in models. By using these variables, regression equations 1 and 2 are formulated.

3.2. Theoretical Framework

This study explores the relationship between the quality of education and social progress (Elman & Woodside, 2023). However, this study posited a U-shaped trajectory wherein initial concentration on education initially diminishes social progress. However, as education quality improves, it subsequently enhances social progress (Posselt & Grodsky, 2017; Biancardi et al., 2023). Institutional factors moderate this dynamic, suggesting that effective institutional frameworks mitigate the negative impacts of poor education quality and amplify the positive effects of high-quality education on social progress (Sanbonmatsu et al., 2023). Research propositions include a U-shaped relationship between education quality and social progress, alongside the moderation effect of institutions on this relationship. The model offers theoretical and practical implications, contributing to our understanding of the complex dynamics between education, institutions, and social progress, thereby guiding policymakers in designing interventions that promote sustainable development through improvements in education quality and institutional strengthening.

3.2 Empirical Specification

Panel Quintile Regression (PQR) proposed by Powel (2016) is incorporated to estimate these regression equations 1 and 2. The advantage of this technique in estimating the regression equation is the usage of median as a central tendency in robust estimates while fixed effect specification controls for unobserved heterogeneity (Iqbal et al., 2023; Iqbal & Kalim, 2023). Moreover, for the nonlinearity, the square term of quality of education

is included. The benefit of the square term is to test whether there exists an inverted U or U-shaped relationship (Chiang &Wainwright, 2005; Iqbal et al, 2023c). After that, a derivative method is incorporated to calculate the cut-off value from where a non-linear curve changes its slope (Takayama & Akira, 1985). The moderating effect is demonstrated using Dawson's (2014) methodology. It helps in analyzing the effect of interaction terms through curve shifting.

$$SPI = \beta_1 QES + \beta_2 QES^2 + \beta_3 INS + \beta_4 LAB + \beta_5 CAP + \xi \quad (1)$$

$$SPI = \beta_1 QES + \beta_2 QES^2 + \beta_3 INS + \beta_4 LAB + \beta_5 CAP + \beta_6 QES*INS + \xi \quad (2)$$

Table 1: Description of the Variables

Symbol	Definition	Source
SPI	Social progress index	SPI
QES	Quality of the education system	WEF
QES^2	Square of quality of the education system	WEF
INS	Institutions	WEF
LAB	Natural log of the labor force, total	WDI
CAP	Natural log of gross fixed capital formation (% of GDP)	WDI

Source: Authors' Compilation

This study has taken the social progress index (SPI), a dependent variable for social progress. This index measures human well-being (nutrition and medical care, water and sanitation, housing and safety). To determine social progress determinants, the study has selected quality of education, institutional quality, labor force, and capital formation. Equations 1, β1 to β5 represent the coefficients of education quality, its square, institutional quality, labor force, and capital formation. In regression equation 2, β6 is the coefficient of cross-product of quality of education and institutional quality. In these equations, ξ is the normally distributed error term.

The discussed determinants are also evidence-based and have been used in the literature. The role of education is aligned with; Mok (2015), Astakhova et al. (2016), Bongaarts et al. (2017) and Opstoel et al. (2020). The role of institutional quality in the literature is relapsed by; Rizk and Slimane (2018), Zhao (2020), Dossou et al. (2021), Ouechtat (2022). Similarly, the role of labor in social progress is also part of some studies like; Bazzhina (2015), Faridi et al. (2016), Osabohien et al. (2019) and Fields (2019). The role of capital formation is coined by studies like Ishak (2018), Isa et al. (2019), Artiningsih (2020) and Leasiwal (2021).

4. Results

For the descriptive analysis of the selected series of variables, this study has presented Table 2, in which the mean and median are for the average and the central values of these series. Minimum and maximum values are also reported. After that, standard deviation is used to test how much the values of these series differ from the mean value. The most important technique is the Jarque-Bera test, which determines the normality of data. This test shows that the selected series are not normally distributed (as the P-value of this test is significant, resulting in the rejection of the null hypothesis). The total number of observations is reported in the end.

Table 2: **Descriptive Statistics**

Statistic	SPI	QES	INS	LAB	CAP
Mean	69.776	3.882	4.137	16.346	23.536
Median	70.175	3.718	3.956	16.188	23.089
Maximum	92.270	6.189	6.163	21.054	29.414
Minimum	27.980	1.852	2.544	12.553	19.018
Std. Dev.	14.859	0.916	0.883	1.639	2.087
Jarque-Bera	36.228	30.992	58.885	10.931	28.346
P-Value	0.000	0.000	0.000	0.0042	0.000
Obs	1500	1387	1387	13197	8062

Source: Authors' Calculation

Figure 1 shows a curvilinear association between the quality of education and the social progress index for the sample covered in the study. Table 3 depicts regression results for the overall data representing the whole world,

which are statistically significant. The sign of the coefficients of quality of education, its square, institutional quality, labor force, and capital formation is the same in both regression equations. The coefficient of education is negative, while its square term positively impacts social progress. Education is initially deteriorating social progress, but it improves social progress after a specific level of maturity in the education sector.

The main reason is that initially, society was not inclined toward education, and due to a lack of awareness, the few educated, skilled workers earn surplus incomes leading to income inequality (Arshed et al., 2018). However, after a specific period, a further increase in the quality of education improves social progress (Arshed et al., 2019). It means that both negative and positive impacts coexist, as Lee and Vu (2020) and Arshed et al. (2018; 2019) discussed. These results of an increase in social progress are consistent with; Grodsky (2017), Rustagi et al. (2018), and Liu et al. (2021).

According to these results, institutional quality has improved social progress. Improving law and order, individual rights, and high-quality government regulation along with services would improve social progress. These results are also consistent with studies like; Fehder et al. (2019), Zhao (2020), Dossou et al. (2021), and Ouechtat (2022). The labor force is reducing social development, partially, because the abundance of the labor force creates a problem of unemployment, poverty, and inflation. So, the upsurge in labor force is harmful. Several studies like Faridi et al. (2016), Thompson and Dahling (2019), Osabohien et al. (2019) and Fields (2019) are of the view that only the employed labor force is beneficial for social progress otherwise, it would be harmful. A capital increase would create new opportunities and boost the industrial and corporate sectors of the economy, and developing countries need to break the vicious circle of poverty. These results are aligned with Leasiwal (2021) and Bengtsson and Waldenström (2018).

Equation 1 does not have any cross-product, but equation 2 has a cross-product of institutional quality and the quality of education. However, its coefficient is negative, which means that institutional quality and the quality of education reduce social progress. But the noticeable thing is, that the cut of the value of the educational quality is now reduced in equation two. It means strong institutional quality and the quality of education can help achieve the desired quality of education as soon as possible where education is increasing social progress.

Table 3: Quantile Regression Results for SPI

	Model 1		Model 2	
Variables	**Coefficient**	**P-Value**	**Coefficient**	**P-Value**
QES	-4.000	0.004	-6.643	0.000
QES^2	0.573	0.003	1.521	0.000
INS	7.623	0.000	12.710	0.000
LAB	-2.509	0.000	-2.703	0.000
CAP	2.098	0.000	2.098	0.000
QES*INS			-1.205	0.000
Cut-Value	3.490		2.184	

Source: Authors' Calculation

Further, the models have been estimated for different development-wise categorized country groups. These results are slightly different from the overall sample results. The non-linear existence is only proved in the very high development group and is also statistically significant. However, these results represent the inverted U-shaped relationship between the quality of education and social progress, which means social progress will start to decline after a specific level of education. Further institutions in all the development groups are responsible for increasing social progress.

The labor force is increasing social progress only in very high development groups, but the scenario is inverse in other groups. Capital has increased social progress in very high and low-developed country groups, but it is decreasing in medium-developed groups. Institutions and quality of education jointly (as cross-product) are increasing social progress only in very highly developed group, but the scenario is inverse in other groups.

Table 4: Development Wise Quintile Regression Results

	Very High HDI		High HDI		Medium HDI		Low HDI	
Variables	**Coeff.**	**P-value**	**Coeff.**	**P-value**	**Coeff.**	**P-Value**	**Coeff.**	**P-Value**
QES	8.787	0.000	-3.219	0.218	13.196	0.222	14.548	0.000
QES^2	-1.072	0.000	0.671	0.264	-2.139	0.130	2.057	0.011
INS	1.156	0.033	5.996	0.008	28.552	0.000	33.670	0.000
LAB	0.352	0.000	-0.928	0.000	-2.889	0.000	-0.383	0.086
CAP	0.349	0.000	-.0103	0.419	-0.974	0.058	1.878	0.000
QES*INS	0.421	0.000	-1.000	0.199	-3.165	0.039	-8.420	0.000

Source: Authors' Calculation

Figures 2 and 3 are presented to test the quadratic behavior of the estimated results (see Dawson, 2014). Figure 1 plots simple quadratic effects, and Figure 2 plots quadratic effects moderated by one variable. Figures 1 and 2 show U shaped relationship between social progress and quality of education, as discussed above. In Figure 3, the quadratic curve shifted above, which shows a higher level of social progress because of the interaction of institutions and quality of education. So, the interaction between quality of education and institutional quality can improve social progress.

Figure 2: SPI and Education Scatter Plot

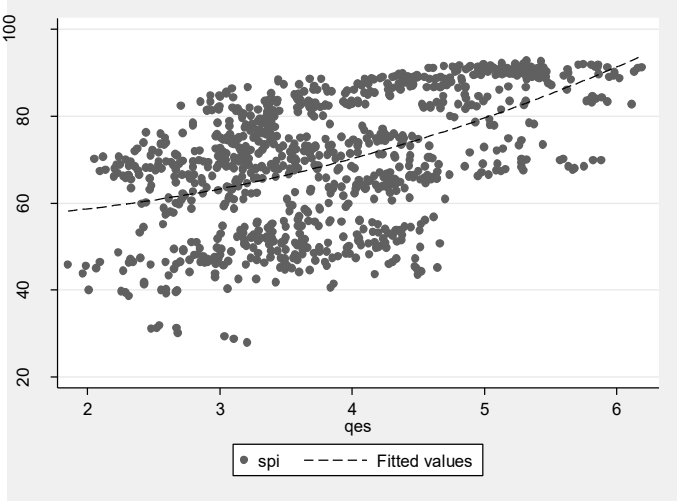


Figure 3 – Model 1 Non-Linear Impact

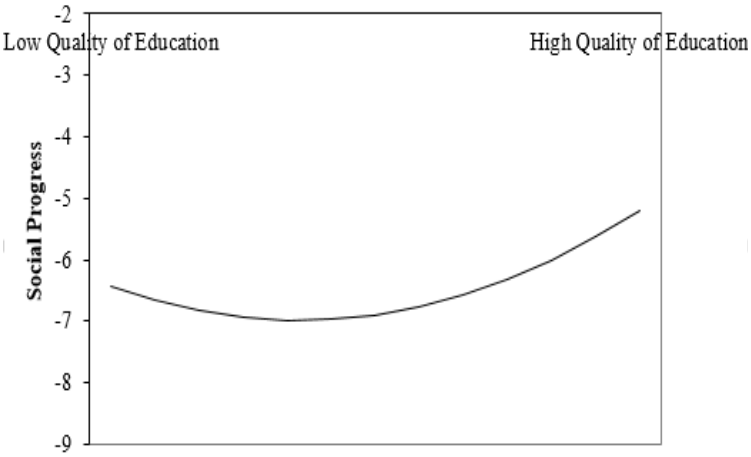
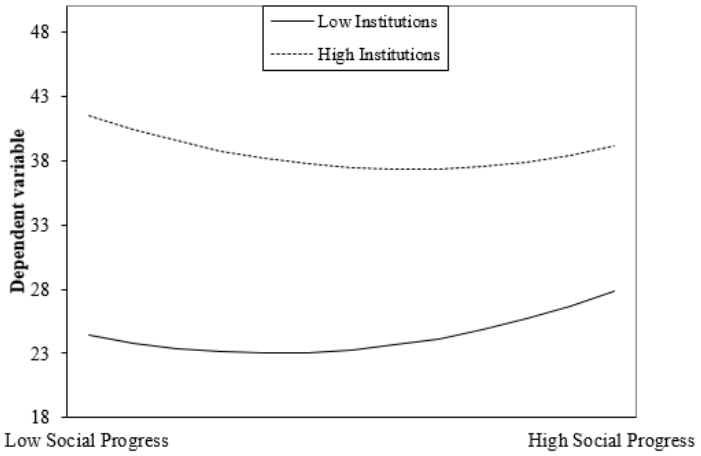


Figure 4 – Moderating Role of Institutions



5. Policy Implications

The main objective of this study was to test the role of quality of education in attaining social progress. In this context, this study has confirmed the U-shaped relationship between these two when estimations are made for the overall world. This means that progress in the quality of education initially is responsible for reducing social development, but after a specific level, further increase in the quality of education increases social development. It is because initial educational growth would restore awareness and a sense of consciousness. In this way, a

societal transformation would emerge, leading to mass conflicts. So, initially quality of education would reduce social progress. But when the quality of education builds its place, society will grow.

The role of institutions is also crucial for social well-being, and the estimated results confirm the same. The more betterment in institutional quality more social progress will be. Capital formation is also showing similar results. Thus, there is a need for strong institutions and more capital formation to attain social progress. However, the labor force harms social progress. Because excess labor supply would increase unemployment. The cross-product of institutions and quality of education is reducing social progress. But the noticeable thing is, that this interaction term has reduced the cut-off value, which means that social well-being could be achieved more quickly.

The importance of quality education is quite clear. There is a need to enhance the quality of education by updating education content. It will lead to attaining social progress/social development. Governments of developing countries should also enrich their culture to minimize the conflict among the people at the early stage of education spread. So, social progress would start to emerge when quality education sustains its growth. Similarly, governments should also strengthen their institutions including law institutions.

Factors of production are the key factors of growth. The two key factors, labor and capital are crucial for social progress, as the estimated results confirmed that capital formation is essential for social progress. So, access to capital should be easy for investors and entrepreneurs. Moreover, there should be a focus on skilled manpower. According to the estimated results, labor force is reducing the social progress level. To tackle this, the government may especially focus on human capital and skilled labor formation.

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The Association of Organizational Justice and Organizational Commitment with Organizational Trust as a mediating factor; Employees Perceptions in Universities

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ABSTRACT

Objective: This quantitative study aims to investigate the employees' perceptions with respect to the organizational justice, organizational trust and organizational commitment.

Research Gap: The research on organizational justice, organizational trust and organizational commitment is scarce particularly in higher education sector.

Design/Methodology/Approach: The article administered a survey questionnaire on 201 faculty members to study the relationship among variables in the higher education sector particularly universities in Lahore, Pakistan. The questionnaire consisted of 72 questions primarily using 7-point and 5-point Likert scale.

The Main Findings: One way ANOVA explained the variation among the age, academic positions, and job tenure. Significant relationship among the variables was found using Pearson's Product Moment Correlation and path coefficients. The research shows differences in employees' perception with regard to organizational justice, trust, and commitment.

Theoretical / Practical Implications of the Findings: This study offers valuable insights into the literature of and the relationships between organizational justice, trust, and commitment. Also, it unfolds dimensions to improve the organizational performance and employee productivity. Actionable strategies may set in place addressing gender disparities through mentorship, transitioning temporary roles to permanent ones, standardizing processes for evaluations, and fostering authentic leadership.

Originality/Value: The study research also presents insights for the academic sector for improvement of organizational values and behavior. The research is limited to faculty and doesn't include administrative staff. The research can be conducted in manufacturing and other service sectors to better understand the phenomenon of interest.

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1. Introduction

In the age of information and technological advancement, employees have begun to be treated as human capital with the transformation of modern organizations into social systems. Organic organizations struggle to keep their workforce motivated in order to extract maximum productivity from them. These attempts have led to the development of the human resource management across the globe. Various component disciplines have given rise to numerous benchmark practices that target towards the betterment of the organizational performance as well as gaining the competitive edge in the era of cut-throat competition. Every employment has an assortment of aspects eliciting sundry employees' attitudes and behaviors. These factors engender either positive or negative perspectives in the workforce with respect to their professional work. Among them are numerous

factors such as the organizational justice which accounts for the fairness in treatment of employees. Organizational trust relates to the fulfilment of expectations in social interactions.

The concept of organizational justice relates to the employee's perceptions of fair treatment in the organization. Scholars state that the justice process plays a vital role in the organization and affects how people deal in organization with each other. This perception influences employees' beliefs, attitudes, feelings, and behavior. It includes i) distributive justice which refers to the fairness in rewards and outcomes given to employees, ii) procedural justice means the fairness of the procedures and processes which are used to determine such rewards and outcomes, iii) interactional justice means the manner through which an organization conducts communication between supervisor to his followers (Abrrow, 2013).

George et. al. (2021) state that social exchange theory explains the development of trust in an organization and its factors. These scholars describe organizational trust as a result of the processes involved in human resource activities which further affects organizational outcomes. It refers to the employees' reliance on the organization including their perception in organization's fair treatment towards all and safeguarding their interests. Alomran et. al. (2024) explains organizational commitment as the sense of belongingness prevailing in the organization and the engagement and the willingness of the employees to contribute towards its social structure and positivity. It includes affective (feeling of association with organization and its objectives), normative (being responsible towards organization and goal achievement) and continuance commitment (willingness to stay with the organization).

1.1 Statement of the Problem

Organizational performance depends upon the employees' productivity, which in turn is dependent upon the feelings and perceptions they have about the organization. In this regard, the organizational justice, trust and commitment render a significant role in motivating the employees. Often the absence of these ideals is expected to breed lack of motivation and performance. So, there is a need to study the impact of the presence of organizational justice, and organizational commitment with organizational trust to improve the condition of human resource and organizational outcomes. Thus, the study aims to determine the association of perceived organizational justice, commitment and trust among the employees in the academic sector.

1.2 Significance of the study

The study is significant for the following reasons;

1. The present inquiry would help to explain the organizational trust with reference to its definition, its antecedents and outcomes, and its relationship with the organizational justice.
2. The research would facilitate the local understanding of the phenomenon by probing into concepts as prevalent in the academic sector.
3. The research would also guide policy makers and practitioners to focus on capitalizing on organizational justice, trust and commitment level to improve the organizational outcomes.
4. This study would open new avenues for scholarly research and academic researchers.

1.3 Objectives of the Study

Following are the research objectives of the study;

1. To know the perception of employees with regard to the organizational justice.
2. To study the perception of employees with regard to the organizational trust.
3. To study the perception of employees with regard to the organizational commitment.
4. To assess if there is a significant relationship between the employees' fairness perceptions of organizational justice and organizational trust in determining employees' organizational commitment.
5. To examine the role of organizational trust in mediating between organizational justice and the organizational commitment.

2. Literature Review

Moorman (1991) explain organizational justice as the perception of employees about the treatment they receive as fair or not. Folger & Cropanzono (1998) state that it comprises the methods of making decisions that concern the distribution of organizational sources and application of the social rules and norms that regulate the social relationships.

Equity theory by Adams (1965) initiated the research investigations on organizational justice and its various dimensions. The distributive justice explaining the employees' perceived fairness of organizational outcomes received major focus. Further to this, the procedural justice was deemed vital component in the discussion on organizational justice to elaborate the response of employees to perceived injustices. The new dimension illustrated the fairness perception of the process leading to the outcomes. Dearth was still felt that called for the addition of the interactional justice that focused upon the management's communication with and treatment of employees. According to Malik & Naeem (2011), the presence of organizational justice influences the employees' commitment and the development of their behaviors.

Organizational justice, which includes distributive, procedural, and interactional dimensions, plays a central role in influencing employee perceptions of fairness. Studies highlight that distributive justice, focusing on the fair allocation of resources, directly impacts trust by reinforcing employees' belief in organizational fairness, while procedural justice ensures transparency in decision-making processes, further strengthening employee satisfaction and loyalty. Interactional justice, emphasizing respectful and transparent communication, significantly enhances trust and employee commitment, particularly in sensitive situations like organizational layoffs or restructuring (Qi et al., 2023; Kurian,& Nafukho, 2022; Abasilim et al., 2019).

Researchers have inquired the concept of organizational trust and thrown light on its significance (Aulakh, et.al., 1996). The phenomenon has been profoundly explored and expanded with the ability to determine not only the intra-organizational but also the inter-organizational social interactions. In continuation to the establishement of trust, the organizations empower workforce and build teams to increase employees' motivation, organizational performance, productivity and competitive edge. In these objectives of the organizations, the trust renders essential role of binding among and supervision over the employees (Bigley & Pearce, 1998). The presence of organizational trust is substantial to minimize the other legal modes of maintaining control (Davis, 1991).

Organizational trust is a key mediator between organizational justice and commitment, fostering positive work attitudes and reducing turnover intentions. Authentic leadership, characterized by integrity and fairness, strengthens trust, thereby enhancing affective commitment, which reflects an emotional attachment to the organization. Studies also reveal that employees' perception of justice shapes their trust in leaders and institutions, which in turn influences their willingness to invest in the organization emotionally and professionally (González-Cánovas, 2024).

The phenomenon of organizational trust has been defined in numerous ways and from individual to institutional level. The researchers have often capitalized upon the theory of trust to inquire the subject. It is defined as given the inability of the employees to influence the decision makers, the employees still believe in the organization's sincerity towards their benefit along with the removel of any harm to them (Cetinel, 2008). Moreover, it is perceived to be including mutual honesty and truth which spreads and develop over with time (Koc & Yazıcıoglu, 2011). Trust would be studied for its two dimensions here; trust in supervisors and trust in the organization.

The academic scholars have investigated the association between the organizational justice and trust. Organizational justice comprising three dimensions i.e. distributive, procedural and interactional justice has association with the organizational trust (Alexander & Ruderman, 1987). Also, the justice and trust promotes the moral and fair behaviors and the concern for the rights of others (Ozer & et.al., 2006).

Organizations also, in the competitive age, have to enhance the employees' commitment to retain them and

obtain competitive advantage. Mowday & et al. (1979) state that organizational commitment is employees' bond or loyalty to the organization, which has three components i.e. commitment to the organization's objectives and values, feelings of belongingness towards organization and working for the benefits of the organization.

Allen & Meyer (1990) developed the organizational commitment model comprising three dimensions i.e. affective, continuance and normative commitment. Affective component relates to the employees' adherence to, and contentment and integration with the organizational identity. Continuance commitment pertains to the occurrence of gains or penalty upon employees' continuation or discontinuation of working for the organization respectively. Normative commitment includes the individual's responsibility for and faith in the organization.

Organizational commitment, particularly affective commitment, is shaped by fair treatment and trust within organizations. Employees who perceive justice in processes and resource distribution are more likely to feel a sense of belonging and loyalty, reducing turnover intentions and promoting higher levels of performance. Procedural and interactional justice are especially influential in fostering emotional bonds with the organization, making them critical factors for retaining talent and maintaining a motivated workforce (Bai et al., 2023; Jiatong et al., 2022; Hadian & Afshari, 2019).

Also, scholars have studies organizational justice, trust and commitment in relation to various factors. These factors are related to individual aspects/ characteristics (gender, age, marital status) and differences, and the work related organizational factors (employment status, tenure, position)/ differences (Uygur & Kilic, 2009). Therefore, these variables would be studied for organizational justice, trust and commitment.

2.1 Research Gap

Though the concepts of the organizational justice, commitment and trust have been adequately investigated in developed nations, there is a dearth of studies in the local context. Therefore, the present study would inquire the subject in Pakistan's perspective especially education sector and higher education institutes. Regarding this gap, the research on the association between organizational justice, trust and commitment in the higher education sector can provide several valuable insights with respect to Pakistan; The study focuses on employee perceptions specific to Pakistan's socio-cultural and organizational context, which differ significantly from developed nations due to varying workplace norms, management practices, and employee expectations. The focus on universities in Lahore provides findings and actionable insights to enhance fairness, trust, and commitment within Pakistan's higher education sector, leading to better faculty retention, satisfaction, and performance. The study serves as a guide for policymakers in formulating strategies to improve organizational outcomes in academic institutions. It emphasizes creating fair and transparent systems, enhancing trust, and fostering stronger organizational commitment. While the study centers on the academic sector, its methodology and findings can be adapted to other sectors in Pakistan, such as manufacturing and services, enriching understanding across diverse organizational contexts. It bridges the gap in literature by exploring organizational dynamics in a collectivist culture like Pakistan's, where interpersonal trust and group cohesion are integral to organizational success.

2.2 Research Questions

The present inquiry shall find answers to the following research questions;

1. What are the employees' perceptions with regard to organizational justice?
2. What are the employees' perceptions with regard to organizational trust?
3. What are the employees' perceptions with regard to organizational commitment?
4. Does there exist a significant association/ relationship among the employees' fairness perceptions of organizational justice and organizational trust in determining employees' organizational commitment?
5. Does the organizational trust play a mediating role between organizational commitment and organizational justice?

2.3 Research Paradigm

Ontologically, the study takes the reality as existing out there and objective and entails a positivist epistemology which implies that the facts derived from the scientific methods make legitimate claims of knowledge.

3. Research Design and Methodology

The research employed the cross-sectional/ co-relational research design. The investigation was c conducted in the selected University (including main and sub-campus, Lahore) by administering a survey questionnaire.

3.1 Population & Sampling

The population chosen for the study comprised of all the faculty teaching at the sample University. Sampling was done in two stages. In the first phase, the population was divided into fifteen distinct faculties of selected University. The in the second stage, the questionnaires were distributed to all the faculty members employed in the sample University to obtain maximum responses.

3.2 Sample Size

The sample University (Lahore Campus) had 105 faculty members whereas University, Main Campus had 518 faculty members to whom the questionnaires were distributed. So, the questionnaires were distributed to a total of 623 faculty members. After rigorous follow up, the number of responses received were 210. Among these, nine questionnaires were incomplete, so they were disposed off. The issue of missing values was solved by plugging in the mid-point in the SPSS. Therefore, a total of 201 questionnaires reaching a response rate of 33.7 percent was achieved and later utilized for analysis.

3.3 Measurements

3.3.1 Organizational Trust

The survey consisted of 72 questions. The questions to study the role played by organizational trust (trust in supervisor and trust in organization) among the organizational justice (distributive, procedural and interactional or informational justice) and organizational commitment (continuance, normative and affective commitment) were based on existing measures.

The items borrowed from existing measures primarily used 7-point Likert scales comprising of the anchors “strongly disagree”, “moderately disagree”, “slightly disagree”, “neither disagree nor agree”, “slightly agree”, “moderately agree” and “strongly agree”. Since there was no clear difference between “moderately disagree/agree” and “slightly disagree/agree” so a 5-point Likert Scale instead of existing 7-point Likert Scale was used. The anchors on the 5-point scale were “strongly disagree”, “disagree”, “neither disagree nor agree”, “agree” and “strongly agree” except for demographic variables. Similarly for some responses five point Likert scale was also used having response categories of “very frequently,” frequently,” “occasionally,” “rarely” and “very rarely” were used. For some items the coding of “always”, “often”, “sometimes”, “rarely” and “never” were used. The codes were reversed for negatively worded responses.

3.3.2 Organizational Justice

Questions related to organizational justice were divided into four separate constructs: distributive justice, procedural justice and interactional justice. A 5-point scale developed by Thibaut & Walker (1975) and Leventhal (1980) was used.

3.3.3 Distributive Justice

The scale used for this dimension included items indicating judgments about degree to which rewards received by employees are perceived to be related to performance inputs. Each item referred to the extent to which employees are rewarded fairly in terms of their performance, education and so on. These were measured by four items ranging.

3.3.4 Procedural Justice

Procedural justice was measured using the 5-point scale from Thibaut & Walker (1975) and Leventhal (1980). The items included in this scale indicate general decisions made by the supervisor regarding employee’s job. In

this questionnaire, the dimension of importance of fair procedures in an organization were measured by three items and the dimension of fair use of those procedures by employees were represented by four items.

3.3.5 Interactional Justice

The scale used for this dimension included items indicating perceived fairness regarding perceived fairness of how employees are treated in the organization. These dimensions were measured by four items.

3.3.6 Organizational Commitment

The scales used to measure organizational commitment were adapted from Allen & Meyer (1990). A 5-point likert scale was used for this purpose. A total of 24 items were included in this study to measure all three components of organizational commitment with eight items included for each component.

3.3.7 Affective Commitment

The Affective Commitment Scale (ACS) measured the identification with organization, emotional attachment and involvement with organization. Employee's emotional attachment to the organization was measured by three items. Involvement in the organization was measured by 02 items. Identification with the organization was measured by three items.

3.3.8 Continuance Commitment

The Continuance Commitment Scale (CCS) focused on the reasons employee had to continue with an organization. It also focused upon the cost associated with an employee leaving the organization. The element of cost associated with employee leaving the organization was measured by four items. The elements why an employee had to continue with an organization was measured by three items.

3.3.9 Normative Commitment

The Normative Commitment Scale measured feelings of obligation and loyalty to remain with the organization. The dimensions of feelings of loyalty and obligation to remain with the organization were measured through four items each.

4. Results and Discussions

The data was analyzed statistically using PASW (formerly SPSS) statistical software. The findings are;

4.1 Perception of Employees by their Gender

In order to explain the difference among employees regarding organizational trust, commitment, and organizational justice by their gender, an independent sample t-test was conducted. The findings show that there was a significant difference between males (M= 94.453, SD= 8.628) and females (M= 91.617, SD= 4.693) regarding their perceptions about organizational trust (t= 4.704, df=122.316, p= .000, n=201). Similarly difference existed significantly between males (M= 80.209, SD= 15.759) and females (M= 66.322, SD= 10.081) regarding their perceptions about organizational commitment (t= 7.151, df=135.522, p= .000, n=201). The difference was also statistically significant between males (M= 69.058, SD= 14.380) and females (M= 56.556, SD= 8.259) regarding their perceptions about organizational justice (t= 7.221, df=126.376, p= .000, n=201). Summarily, males perceived greater trust, commitment and justice towards the organizations than females.

Table 1: Gender wise Difference in Employees' Perceptions Regarding Organizational trust, Commitment and Justice (N= 201)

Organizational Variable	Gender	N	M	SD	t	d*f*	*p*
Organizational Trust	Male	86	96.453	8.628	4.704	122.316	0.000
	Female	115	91.617	4.693			
Organizational Commitment	Male	86	80.209	15.759	7.151	135.522	0.000
	Female	115	66.322	10.081			
Organizational Justice	Male	86	69.058	14.380	7.221	126.376	0.000
	Female	115	56.556	8.259			

Source: Authors' Own Work

4.2 Perception of Employees by their Marital Status

In order to explain the difference among employees regarding organizational trust, commitment, and organizational justice by their marital status, an independent sample t-test was conducted. The findings show that there was a significant difference between married (M=95.047, SD=8.786) and unmarried (M=92.138, SD=3.856) regarding their perceptions about organizational trust (t=3.101, df=149.402, p=0.002, n=201). Similarly difference existed significantly between married (M=76.001, SD=15.598) and unmarried (M=68.000, SD=11.906) regarding their perceptions about organizational commitment (t=4.119, df=195.312, p=0.000, n=201). The difference was also statistically significant between married (M=65.374, SD=14.178) and unmarried (M=57.957, SD=9.827) regarding their perceptions about organizational justice (t=4.350, df=189.158, p=0.000, n=201).

Table 2: Marital Status wise Difference in Employees' Perceptions Regarding Organizational trust, Commitment and Justice (N= 201)

Organizational Variable		N	M	SD	t	d*f*	*p*
Organizational Trust	Married	107	95.047	8.786	3.101	149.402	0.002
	Unmarried	94	92.138	3.856			
Organizational Commitment	Married	107	76.001	15.598	4.119	195.312	0.000
	Unmarried	94	68.000	11.906			
Organizational Justice	Married	107	65.374	14.178	4.350	189.158	0.000
	Unmarried	94	57.957	9.827			

Source: Authors' Own Work

4.3 Perception of Employees by their Employment Status

In order to explain the difference among employees regarding organizational trust, commitment, and organizational justice by their employment status, an independent sample t-test was conducted. The findings show that there was a significant difference between temporary (M= 90.114, SD= 4.853) and permanent (M= 95.595, SD= 7.334) regarding their perceptions about organizational trust (t= 5.626, df=199, p= .000, n=201). Similarly difference existed significantly between temporary (M= 80.514, SD= 12.374) and permanent (M= 67.855, SD= 13.673) regarding their perceptions about organizational commitment (t= 6.459, df=199, p= .000, n=201). The difference was also statistically significant between temporary (M= 69.614, SD= 9.135) and permanent (M= 57.786, SD= 12.680) regarding their perceptions about organizational justice (t= 6.902, df=199, p= .000, n=201).

Table 3: Employment Status wise Difference in Employees' Perceptions Regarding Organizational trust, Commitment and Justice (N= 201)

Organizational Variable		N	M	SD	t	d*f*	*p*
Organizational Trust	Temporary	70	90.114	4.853	5.626	199	.000
	Permanent	131	95.595	7.334			
Organizational Commitment	Temporary	70	80.514	12.374	6.459	199	.000
	Permanent	131	67.855	13.673			
Organizational Justice	Temporary	70	69.614	9.135	6.902	199	.000
	Permanent	131	57.786	12.680			

Source: Authors' Own Work

4.4 Perception of Employees by their Age:

In order to explain the difference among employees regarding organizational trust, commitment, and organizational justice by their age, a one-way Analysis of Variance (ANOVA) was conducted. Age was split into five categories (viz. >21-30, >31-40, >41-50, >51-60, and 60+) The findings show that there was no significant difference between among different age categories by level of organizational trust (F= 1.778, df= 4, 196, p=.135), organizational commitment (F= .538,, df= 4, 196, p=.708), and organizational justice (F= .741, df= 4, 196, p=.565).

Table 4: Age wise Difference in Employees' Perceptions Regarding Organizational trust, Commitment and Justice (N= 201)

Variables		N	M	SD
Organizational Trust	>21-30>	104	93.8269	7.43443
	>31-40>	23	91.0870	5.02641
	>41-50>	24	92.5000	5.81602

	>51-60>	25	94.1600	6.51716
	60+	25	96.1600	8.14801
Organizational Commitment	>21-30>	104	71.3846	13.82435
	>31-40>	23	70.5217	14.61590
	>41-50>	24	73.7917	15.45535
	>51-60>	25	72.9600	15.74135
	60+	25	75.3600	15.67875
Organizational Justice	>21-30>	104	61.4038	12.77780
	>31-40>	23	59.5652	12.46386
	>41-50>	24	62.4167	12.27906
	>51-60>	25	62.0000	12.81601
	60+	25	65.5600	14.29767

Source: Authors' Own Work

Analysis of Variance

Variables		**SS**	***df***	**MS**	**F**	**p**
Organizational Trust	Between Groups	349.823	4	87.456	1.778	.135
	Within Groups	9639.431	196	49.181		
Organizational Commitment	Between Groups	457.992	4	114.498	.538	.708
	Within Groups	41725.033	196	212.883		
Organizational Justice	Between Groups	492.520	4	123.130	.741	.565
	Within Groups	32550.684	196	166.075		

Source: Authors' Own Work

4.5 Perception of Employees by their Academic Position

In order to explain the difference among employees regarding organizational trust, commitment, and organizational justice by their academic positions, a one-way Analysis of Variance (ANOVA) was conducted. Academic position was split into four categories (viz. Lecturer, Assistant Professor, Associate Professor, Professor). The findings showed that there was a significant difference among employers position-wise regarding their level of organizational trust (F= 13.838, df=3, 197 , p=.000), organizational commitment (F= 5.582, df=3, 197 , p=.001), and organizational justice (F=13.832 , df=3, 197, p=.000). However, digging deep into the difference, the Tukey HSD showed that regarding organizational trust the real difference exists between Lecturer and Assistant Professor, Lecturer and Professor, Assistant Professor and Professor, and Associate Professor and Professor. The Tukey HSD also showed that regarding organizational commitment the real difference exists between Lecturer and Associate Professor, Lecturer and Professor. Regarding organizational justice the real difference exists between Lecturer and Professor, Assistant Professor and Professor, and Associate Professor and Professor.

Table 5: Descriptives Position wise Difference in Employees' Perceptions Regarding Organizational trust, Commitment and Justice (N= 201)

Variables		**N**	**Mean**	**Std. Deviation**
Organizational Trust	Lecturer	97	93.7010	1.39317
	Assistant Professor	23	89.4348	8.43060
	Associate Professor	45	91.4222	9.52864
	Professor	36	99.1944	8.46107
Organizational Commitment	Lecturer	97	68.9381	13.24120
	Assistant Professor	23	69.1739	10.24984
	Associate Professor	45	76.1333	18.75876
	Professor	36	78.3611	11.02245
Organizational Justice	Lecturer	97	58.1237	11.01160
	Assistant Professor	23	59.8696	7.88730
	Associate Professor	45	62.4000	14.55772
	Professor	36	72.7778	11.90465

Source: Authors' Own Work

Analysis Of Variance

Variables		Sum of Squares	df	Mean Square	F	Sig.
Organizational Trust	Between Groups	1738.655	3	579.552	13.838	.000
	Within Groups	8250.599	197	41.881		
Organizational Commitment	Between Groups	3304.586	3	1101.529	5.582	.001
	Within Groups	38878.439	197	197.352		
Organizational Justice	Between Groups	5749.058	3	1916.353	13.832	.000
	Within Groups	27294.146	197	138.549		

Source: Authors' Own Work

Pairwise Comparison using Tukey HSD

Organizational Variable			*p*
Organizational Trust	Lecture	Assistant Prof.	.025
	Lecture	Professor	.000
	Assistant Prof.	Professor	.000
	Associate Prof.	Professor	.000
Organizational Commitment	Lecture	Associate Prof.	.026
	Lecture	Professor	.004
Organizational Justice	Lecturer	Professor	.000
	Assistant Prof.	Professor	.000
	Associate Prof.	Professor	.001

Source: Authors' Own Work

4.6 Perception of Employees by their Job Tenures

In order to explain the difference among employees regarding organizational trust, commitment, and organizational justice by their job tenure, a one-way Analysis of Variance (ANOVA) was conducted. Job tenure was split into three categories (viz. >1, <1-2<, <3-5<). The findings showed that there was a significant difference among employers job tenure-wise regarding their level of organizational trust (F= 58.551, df=2, 198, p=.000), organizational commitment (F= 24.797, df=2, 198 , p=.000), and organizational justice (F=36.236 , df=2, 198, p=.000). However digging deep into the difference, the Tukey HSD showed that regarding organizational trust the real difference exists between job tenures of >1 and <1-2<, >1 and <3-5<, <1-2< and <3-5<. For organizational commitment the real difference exists between job tenures of >1 and <1-2<, >1 and <3-5<. For organizational justice the real difference exists between job tenures of >1 and <1-2<, >1 and <3-5<, <1-2< and <3-5<.

Table 6: Tenure wise Difference in Employees' Perceptions Regarding Organizational trust, Commitment and Justice (N= 201). Descriptives

Variables		N	Mean	Std. Deviation
Organizational Trust	>1	137	91.9416	4.30418
	<1-2<	50	94.1800	8.75678
	<3-5<	14	109.0000	.00000
Organizational Commitment	>1	137	67.8832	11.66131
	<1-2<	50	82.5600	17.62206
	<3-5<	14	78.3571	1.33631
Organizational Justice	>1	137	57.9124	9.58896
	<1-2<	50	67.5000	15.44212
	<3-5<	14	81.0000	.00000

Source: Authors' Own Work

Analysis of Variance

Variables		Sum of Squares	df	Mean Square	F	Sig.
Organizational Trust	Between Groups	3712.341	2	1856.170	58.551	.000
	Within Groups	6276.913	198	31.702		

Organizational Commitment	Between Groups	8449.359	2	4224.680	24.797	.000
	Within Groups	33733.666	198	170.372		
Organizational Justice	Between Groups	8853.755	2	4426.878	36.236	.000
	Within Groups	24189.449	198	122.169		

Source: Authors' Own Work

Pairwise Comparison using Tukey HSD

Organizational Variable			***p***
Organizational Trust	>1	<1-2<	. 045
	>1	<3-5<	.000
	<1-2<	<3-5<	.000
Organizational Commitment	>1	<1-2<	.000
	>1	<3-5<	.013
Organizational Justice	>1	<1-2<	.000
	>1	<3-5<	.000
	<1-2<	<3-5<	.000

Source: Authors' Own Work

4.7 Relationship among organization trust, organizational commitment, and organization justice

In order to find out the relationship between organization trust (M= 93.687, SD= 7.067), organizational commitment (M= 72.264, SD=14.523), and organization justice (M=61.906, SD=12.854), Pearson's Product Moment Correlation test was conducted. The finding showed that OT was statistically correlated with OC (r= .486, p=.000, n=201) and OJ (r= .583, p= .000, n= 201). Also OC was significantly correlated with OJ (r= .929, p=.000, n=201.

Table 7: Relationship among in Employees' Perceptions Regarding Organizational trust, Commitment and Justice (N= 201)

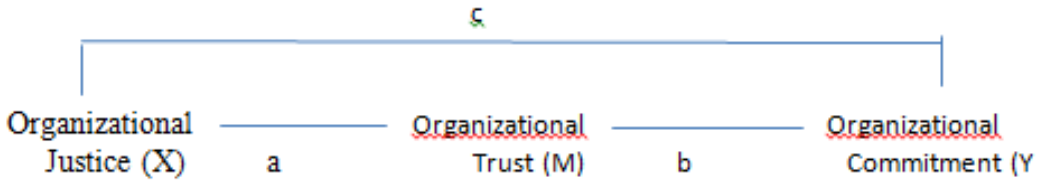
Variables	**M**	**SD**	**1**	**2**	**3**
1. Organizational Trust	93.687	7.067	-		
2. Organizational Commitment	72.264	14.523	.486**	-	
3. Organizational Justice	61.906	12.854	.583**	.929**	-

**. Correlation is significant at the 0.00 level (2-tailed).

Source: Authors' Own Work

4.8 Testing the mediation effect of OT

In order to test whether OT had a significant mediator of relation between OJ and OC, a path analysis was used. Below model was used to test the direct and indirect effect of the mediator:



Direct Effect : Path c: Y= B0 + B1X+ e
Indirect Effect: Path a: M= B0 + B1X+ e
Path b: Y= B0 + B2M+ e

Source: Authors' Own Work

In order to establish a mediation effect, there must not be a direct relation i.e zero relation between X & Y. Since there is a non-zero relationship between X & Y, the condition for Mediation does not fulfill; therefore Organizational Trust, though a significant predictor, is not a mediating variable for Organizational Justice and

Organization Commitment.

Table 8: Direct and Indirect relation between organizational Justice (X), Organizational Trust (M) Organizational Commitment (Y)

Path	Source	*B*	*SE B*	β	*t*	*p*
Path c	Organizational Justice	1.050	0.030	.929	35.399	.000
Path a	Organizational Justice	0.321	0.032	.583	19.133	.000
Path b	Organizational Trust	0.999	0.127	.486	7.851	.000

Source: Authors' Own Work

5. Discussion

The research questions # 1, "What are the employees' perceptions with regard to organizational justice?" has been satisfactorily answered. There are significant differences among the employees regarding the organizational justice in respect of gender, marital status, employment status, position wise, and tenure wise except age-wise. This is in line with the literature that the different variables contribute differently to employees perceptions about the organizational justice. Uygur & Kilic's (2009) individual aspects/ characteristics (gender, age, marital status) and differences, and the work related organizational factors (employment status, tenure, position)/ differences stand valid through the findings except age.

The research questions # 2, "What are the employees' perceptions with regard to organizational trust?" has been sufficiently answered. There are significant differences among the employees regarding the organizational trust in respect of gender, marital status, employment status, position wise, and tenure wise except age-wise. This supports the literature that the employees' perceptions differ for the organizational trust in respect of specific variables. Uygur & Kilic's (2009) individual aspects/ characteristics and differences, and the work related organizational factors / differences are verified through the findings except age.

The research questions # 3, "What are the employees' perceptions with regard to organizational commitment?" has been adequately answered. There are significant differences among the employees regarding the organizational commitment in respect of gender, marital status, employment status, position wise, and tenure wise except age-wise. The findings are in line with literature that the employees perception for organizational commitment vary with respect to different variables. Uygur & Kilic's (2009) individual characteristics (gender, age, marital status), and the work related factors (employment status, tenure, position) are correlate with the findings except age.

There is a significant relation between the employees' perception of the organizational justice and commitment with trust. This is in consonance with the literature about organizational justice, trust and commitment as was explained by Ozer (2006) in terms of improvement organizational justice, trust and commitment are associated in terms of fairness and concern for rights of all. This answers the fourth research question;

"Does there exist a significant association/ relationship among the employees' fairness perceptions of organizational justice and organizational trust in determining employees' organizational commitment?"

However, a non-zero association exists between organizational justice and commitment, the condition for Mediation does not fulfill. Organizational trust, though a significant predictor, is not a mediating variable for Organizational Justice and Organization Commitment. This study does not support the mediating role of organizational trust which supports Malik & Naeem (2011) view about the organizational justice and its association with employees' commitment. This helps to answer the fifth research question;

"Does the organizational trust play a mediating role between organizational commitment and organizational justice?"

The findings of this study reveal significant differences in perceptions of organizational justice, trust, and commitment across variables such as gender, marital status, employment status, and academic positions. These outcomes highlight the ways in which social interactions and roles within the organizational hierarchy influence employee relations. While the study focuses on quantitative differences, a closer examination of the social

interactions underlying these findings offers valuable insights into the relational dynamics in the workplace.

Moreover, the results indicate that male employees perceive higher levels of organizational justice, trust, and commitment compared to their female counterparts. This disparity may stem from differences in social interactions and access to networks within the workplace. Men, in many organizational cultures, often have greater opportunities to engage in informal networks and mentor-mentee relationships that enhance trust and commitment. Conversely, women may face challenges in workplace social interactions, such as exclusion from key decision-making discussions, which could lead to perceptions of lower justice and trust.

Married employees report higher levels of trust, justice, and commitment than their unmarried peers. This finding suggests that marital status may influence the quality of social interactions within the organization. Married employees might have more stable personal lives, which could contribute to their ability to form and sustain positive workplace relationships. Additionally, married employees may be perceived as more dependable and committed, potentially fostering more favorable interactions with supervisors and peers.

The findings show that permanent employees report significantly higher levels of organizational justice, trust, and commitment compared to temporary staff. Permanent employees often have greater access to formal and informal social structures within the organization, including mentorship, training opportunities, and stronger ties with supervisors and colleagues. These interactions may reinforce their sense of belonging and trust, leading to higher perceptions of fairness and commitment. Temporary employees, on the other hand, may face social marginalization, limiting their ability to form meaningful connections that foster trust and justice.

Academic rank also plays a pivotal role in shaping social interactions. Professors report the highest levels of trust, justice, and commitment, likely due to their position of influence and established networks within the organization. Junior faculty, such as lecturers, may face barriers to social integration and limited access to collaborative opportunities, resulting in lower perceptions of justice and trust. This highlights the need for institutions to create inclusive platforms for interaction and mentorship across all hierarchical levels.

The findings suggest that social interactions are central to shaping employees' perceptions of justice, trust, and commitment. These interactions occur not only in formal settings, such as team meetings or evaluations, but also in informal contexts, such as peer discussions and mentorship. The disparities observed across demographic and organizational variables point to the need for fostering equitable and inclusive social environments.

To enhance positive social interactions and improve perceptions of justice, trust, and commitment: establish structured mentorship opportunities that connect employees across hierarchical levels to promote inclusion and knowledge sharing; train leaders and employees to recognize and mitigate biases in social interactions, particularly concerning gender and employment status; encourage open and transparent communication to reduce perceived inequities and build trust;create platforms for temporary employees to engage in organizational life and form connections that enhance their sense of belonging.

While the findings from this research provide valuable insights into organizational justice, trust, and commitment in one academic institution, generalizing these results to other educational settings requires caution. Different universities may exhibit distinct organizational cultures, structural dynamics, and management practices, which can influence employee perceptions and behaviors. Therefore, while the findings are significant within the context of the selected university in Lahore, they may not directly apply to other institutions without further investigation.

To enhance the credibility and applicability of these findings across different educational setups, it would be beneficial to incorporate secondary data from similar studies conducted in various universities, particularly those within similar socio-cultural contexts. Research such as that by Uygur & Kilic (2009) on organizational commitment in Turkish universities, and Gonzalez-Canovas et al. (2024) on trust in leadership in academic institutions, supports the idea that while organizational justice, trust, and commitment are universally important,

their expression may vary significantly depending on the specific organizational practices, employee demographics, and institutional culture.

By adding secondary data from such studies, a more comprehensive understanding of how organizational justice, trust, and commitment are interrelated in diverse educational settings can be adopted. This comparison would enhance the robustness of the study's findings and suggest the extent to which the results can be applied to other educational contexts.

Table 9. Secondary Data Comparison

Study & Source	Organizational Justice Focus	Trust Focus	Commitment Focus
Uygur & Kilic (2009)	Procedural and distributive justice in Turkish universities	Trust in supervisors and organizational systems	Affective commitment linked to job involvement and values
Gonzalez-Cánovas et al. (2024)	Procedural and distributive justice in academic institutions	Trust in leadership and its impact on faculty satisfaction	Affective commitment and its correlation with trust
Malik & Naeem (2011)	Distributive justice in Pakistani higher education	Trust in leadership and organizational fairness	Normative and affective commitment within universities
Al-Abrrow (2013)	Interactional justice and its role in job involvement	Trust in supervisors and its relationship to motivation	Commitment through job satisfaction and emotional attachment
Author's Own Study (2025)	Distributive, procedural, and interactional justice	Trust in supervisors and organizational processes	Affective and normative commitment, with emphasis on trust

Source: Authors' Own Work

6. Recommendations

The research explains employee behavior with reference to their perception of organizational justice, trust and commitment. The research should be conducted on the administrative staff of the universities. It can offer valuable insights in manufacturing and service sector such as banking. Also, qualitative research can highlight important themes underlying the variables of interest.

7. Conclusion

Thus, the research shows differences in employees' perception with regard to organizational justice, trust, and commitment. It further supports the relation of organizational justice with organizational trust, and organizational trust with commitment. Though, the organizational justice and organizational trust are associated with each other, however; the organizational trust does not mediate the relationship between organizational justice and organization commitment as the association between the two does not establish.

This study examined the relationships between organizational justice, trust, and commitment among higher education employees in Lahore, Pakistan, revealing several key insights. Significant differences in perceptions of organizational justice were observed across demographics, with male, married, and permanent employees, as well as senior staff, reporting higher fairness perceptions. Statistical analyses, such as t-tests, confirmed these disparities (e.g., males had higher distributive justice scores than females, $t=7.22$, $p<0.001$).

Organizational trust also varied by gender, marital status, and employment type, with permanent employees showing higher trust scores ($M=95.59$) compared to temporary staff ($M=90.11$). Trust was closely linked to job security and stability. Similarly, commitment levels were higher among permanent and senior staff, with a strong correlation between trust and commitment ($r=0.48$, $p<0.001$). Professors had the highest commitment scores ($M=78.36$) compared to lecturers ($M=68.93$). The study confirmed a positive relationship between justice and trust ($r=0.58$, $p<0.001$), with procedural justice as a key factor. However, trust did not fully mediate the justice-commitment link, indicating other influencing factors.

Nevertheless, the research has significant insights for the education sector and there are possibilities of further insights in other sectors. So, the research endeavors must be carried on to investigate new dimensions and additional knowledge pertaining to the organizational justice, trust, commitment and other factors to improve the organizational performance and employee productivity. Actionable strategies include addressing gender disparities through mentorship, transitioning temporary roles to permanent ones, standardizing processes for

evaluations, and fostering authentic leadership. Initiatives like employee recognition programs and anonymous feedback mechanisms were also proposed to improve organizational equity, trust, and loyalty.

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