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Bridging the Digital Divide: The Impact of Public Investment on Urban-Rural Disparities in Pakistan

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ABSTRACT

This investigation aims to determine the impact of public investment in the digital economy on de-urbanization in Pakistan. Using secondary data, the researcher employed a quantitative research design to analyze various data related to the variables of interest, most notably the digital infrastructure score, internet penetration rate, GDP growth rate, employment rate, education level, and health index score. The process begins with brief descriptive findings indicating substantial investment discrepancies and digital infrastructure quality differences between rural and urban populations, with the urban population receiving much more investment on average. The comparative findings underscore the significant investment disparity, while the regression results demonstrate a positive correlation between the rate of internet penetration and GDP growth. The other variables, such as the digital infrastructure score, the afore-mentioned employment and education variables, and the health index, are all non-significant in the model. More investment appears necessary to reap such economic benefits, and the aforementioned complementary policies will be required to facilitate rural broadband access. Collectively, the results of this research will help policymakers further a more inclusive approach to economic policy and create conditions for sustainable development regardless of population density.

Keywords: Digital Economy, Public Investment, Urban-Rural Disparities, Digital Infrastructure, Internet Penetration, Economic Development, Pakistan, Socio-economic Indicators

1. Introduction

The digitalization process has progressed rapidly, fundamentally changing the world economy and society while providing new opportunities for growth and development. A digital economy has emerged as a powerful driver of economic development, especially for developing countries. Pakistan is among them, and the opportunities provided by a digital economy are critical for the country to overcome existing gaps and strengthen inclusive development (Jiang et al., 2022). However, for all types of places, there is a need for increased public investment in digital infrastructure to enable everyone to benefit from the development. This study will investigate the role of public investment in the digital economy, as well as its potential to bridge the gap between urban and rural areas and reduce the difference between them (APP et al., 2021).

The digital economy consists of many sectors and will only continue growing. These include not only e-commerce and other services, but could also include e-education and e-healthcare, as well as substantially increasing employment in various other sectors. A digitalized economy contributes to increasing productivity and innovation levels. Digitalization is strongly dependent on the ICT infrastructure (I-PRSP et al., 2001). However, only by investing in digital-related infrastructure, such as broadband connectivity, human capital, and a supportive policy framework, can economic development fully embrace digital transformation.

In Pakistan, rapid digitalization creates disparities between urban and rural areas. Disparities within digitalization create local inequalities, and the rural vs. urban gap prevents the rural population from fully utilizing the potential of the digital economy. The purpose of this research is to study whether investment in the digital economy by the public sector could help reduce the disparities between urban and rural places in Pakistan (Zhang et al., 2024). The study will be conducted using data on the level of investment, ICT infrastructure improvement level, level of

digitalization, and the level of economic development of areas in the country. The research will provide insights into the possibility of public investment in the digital economy, reducing the difference between urban and rural areas. Besides, it fills the knowledge gap and provides insights into the factors of success in digital investment (AlphaBeta et al., 2021).

1.1 Background

The rapid proliferation of digital technologies is offering a once-in-a-lifetime opportunity to advance economic growth and development across the world. The digital economy in Pakistan holds great promise for boosting productivity, innovation, and employment. Nevertheless, the uneven nature of digital infrastructure disproportionately expands disparities between urban and rural geographies (DEVELOPMENT COMMITTEE, 2022). Urban centers like Karachi, Lahore, and Islamabad have a privilege as they are equipped with strong digital infrastructure such as fast internet connection and more access to traditional digital services. On the other hand, rural areas still face challenges such as lack of connectivity, poor infrastructure, and low levels of digital skills that continue to inhibit their participation in the full benefits of the digital economy. The digital divide is not only increasing the preexistent economic inequalities between urban and rural populations but also reserving widespread essential services including education, healthcare, and e-commerce for the beneficiaries of commercial projects (Tu et al., 2024).

Proponents of increased public investment in the digital economy argue that it will be essential to delivering more inclusive growth and reducing regional disparities. Proponents will argue that through strategic investments in broadband infrastructure, digital literacy programs, and regulatory frameworks, rural areas can now catch up with their urban counterparts as they bridge this formidable gap. A blockchain to fund rural roads could, for example, lead to these types of investments which can help make the flow of information more democratic and universal, improve education outcomes, and healthcare delivery in rural areas (DISA, 2020). Critics value governance, corruption, and resource allocation over urban-rural investment. Systems issues might reduce investment effectiveness and yield poor results. Responsible governance enables projects and beneficiaries to receive funding. Corruption wastes resources and lowers investment returns. Effective resource allocation prioritizes critical areas. Without fixing these concerns, digital infrastructure investment may be pointless. This issue need a strong framework with clear policy directions and stakeholder involvement to maximize public investments. Rural areas require clear digital investment strategies and partnerships between the government, business, and community. Engaging stakeholders recognizes multiple groups' needs and perspectives, leading to better, longer-lasting solutions. This essay examines government digital economy investments and Pakistani urban-rural inequality reduction. This study aims to promote public investment for more equal national growth by understanding these processes. (Cai et al., 2024).

1.2 Theoretical Framework

This study is theoretically anchored on different economic theories that explain the role of public investment in the digital economy and possibilities of the gap between the urban and rural areas in Pakistan. First, the theory of public goods and externalities offers the basis as to why government interference is crucial in the digital economy (WU et al., 2023). The digital infrastructure like broadband networks shares attributes of a public good in that they are non-excludable and non-rival so they are likely to suffer from market failure where private investment is unable to recover all the cost. Positive externalities such as enhanced productivity and innovation underscore the rationale for the public sector to intervene to achieve the socially optimal level of digital infrastructure which could spur economic growth and help alleviate spatial disparities (Gao et al., 2024).

Secondly, the endogenous growth theory emphasizes the role of knowledge externalities, technology transfer and human capital in sustaining long-run economic growth. This theory supposes that through investments in various technologies and innovations, the process of development of the economy becomes sustainable as productivity and new opportunities arise. Such growth can be amplified through public investment in digital infrastructure since it can enhance connectivity and access to information and promote innovation within both the urban and the rural populations (Zheng et al., 2023). In Pakistan, this could mean that, better availability of digital resources introduces better economic performance in the rural regions and thus decreases the rural-urban differential. But critics note that just turning up the volume of investment is not enough if the governance and other fundamentals such as corruption and efficient use of resources are not fixed enough to unlock the full potential of such investments (Jiang et al., 2022).

Thirdly, the cumulative causation theory of regional development also holds that advantages enjoyed by any region at the start of development process would continue to compound the disparities in economic development. This theory holds that the areas with early capabilities in infrastructure, human capital and economic activity continue to attract investment and development while the backward areas continue to be more backward (Li et al., 2023). These tendencies can be prevented by public investment in digital infrastructures that would enable the rural regions to avail the resources required to level with the urban civilization. This reiterates the governments' responsibility in nurturing fair policies and investment strategies in order to foster regional integration. However, these investments can only be effective if governance and, in particular, the issue of corruption is addressed to guarantee that the funds are spent properly and reach the respective projects and people (WU et al., 2023).

These theories are reflected in the hypothetical model connecting public investment, digital infrastructure, and regional inequalities. It implies a causal relationship where public investment causes development of digital infrastructure and therefore improves connectivity and access to digital services (Gao et al., 2024). This also helps in minimising regional disparities as it enhances economic facilities, education, health care, and living standards in the countryside. The model shows how different aspects of socio-economic life are amplified through digital infrastructure, which can potentially lead to total regional development. However, the effectiveness of this model can only be realized after the eradication of systemic barriers like governance as well as efficient management of resources (Zheng et al., 2023).

1.3 Research Problem

The study identifies the digital divide between urban and rural populations in Pakistan, which has caused economic and social disparities. While on one hand, a digital economy has the power to transform inclusive growth and development, on the other hand, there is massive marginalization of rural localities in Pakistani localities in terms of digital infrastructure and access density. With this agenda of equality and access to the digital economy, they are very likely to feel fewer economic opportunities, less education, and health investment, imprisoning them into a vicious circle of poverty and development less society (Peng et al., 2023). Governance, corruption, and faults of resource allocation in Pakistan are far greater to thwart the notion that public investment is a successful remedy in bridging this divide. The proposed study will try to test whether and under what conditions public investment in the digital economy is sufficient to reduce these divides in a meaningful way. Such contributions prove to be quite handy for the readers to make clear recommendations, making them competent enough to act well according to their problems in policy-making. (Cheng et al., 2023).

2. Literature Review

Public investment in the digital economy has been narrowed to the gap between the rural and urban through time. Additional research has been able to prove that any investments made in the digital infrastructure always yield economic growth and reduce income disparity. For instance, Jiang, Li, and Si revealed that the gap between the urban-rural income depends on the level of investment in the digital economy (Jiang et al., 2022). According to APP (2021), various issues on the case have subjected the government in Pakistan to try and counter the issue based on creating a digital divide to make the opportunities of the economy accessible, especially in the rural areas (APP et al., 2021).

Public investment in this infrastructure can improve rural areas, but its effect can be different under various circumstances. For instance, the I-PRSP reports that if public investment fails to focus on underdeveloped rural areas, it could erode the economic fabric (I-PRSP, 2001). Zhang et al., who find high positive effects of digitalization in rural economies, primarily as a mediating factor of technological development in agriculture, support this view (Zhang et al., 2024).

In addition, Pakistan's digital potential is quite high. AlphaBeta asserts that digital investments have the potential to change a significant portion of the economy, with Google playing a significant role in this transformation. . AlphaBeta expect digital possibilities to lower entry barriers, expand the market, and increase productivity, thereby reducing the intra- and intersectoral problems that cause urban-rural disparities. However, policies' role is also critical. The Development Committee notes that the digital divide not only exists, but is also extensive and complex within rural areas (AlphaBeta et al., 2021). Tu et al. note that digital economy policy should be inclusive and comprehensive to reduce the urban-rural income gap (Tu et al., 2024).

Despite these efforts, numerous hurdles remain in digital inclusiveness. Jamil, for example, asserts that the digital divide and widespread digitalization persist, potentially preventing the benefits of public investment from reaching the most vulnerable due to insufficient digital literacy and affordability (Jamil et al., 2021). The DISA reinforces

this perspective by emphasizing the need to continuously modify the strategy to meet the needs of rural areas (DISA, 2020).

3. Research Methodology

The methodology of this study is a quantitative research approach, which primarily uses secondary data. The design is chosen as it will allow conducting a powerful statistical analysis of the available data, which will help to study this question by entering significant patterns or relationships existing between developing public investment in digital infrastructure and socio-economic gaps in urban and rural sectors (Zhu et al., 2023). A quantitative approach enable generalizing findings on a wider population, allowing to get an exhaustive picture of the impacts of investment in digital.

The study's data collection methods are focused on analysis of literature and data from previously published in articles, and government annual reports. The choice of secondary data is due the fact that it shows that the datasets on digital infrastructure and contemporary socioeconomic indicators exist. There is no necessity for respondent consent or any ethical considerations in the design of the research due to the use of secondary data (Zhao et al., 2024). Excellent data accuracy is additionally obtained with the reference of good sources to the study, which will ensure qualitative statistical analysis. The other credible sources include the government documents, which the study will refer to in means to enhance good research integrity. The data will be collected mainly using secondary data from databases and reports from government, international organizations, and academic research about public investment in digital infrastructure and any possible consequences on the possible socio-economic. (Deng et al., 2024).

Using Excel as a software tool to conduct regression analyses, correlation analyses, and ANOVA tests are the common statistical methods in data analysis. Especially, multiple regression analysis is essential in determining how public investment in the digital economy affects socio-economic outcomes while holding other variables constant. Such methods help establish the significant lenders to digital access, and socio-economic development and their coefficients, respectively, which provide me with strong evidence on the role played by public investments in the digital economy in bridging the regional disparities in Pakistan.

4. Data Analysis and Results

The data analysis and results section of this study commences with descriptive statistics that outline statistics concerning the main variables such as the investment amounts, digital infrastructure scores, and internet penetration rates. The comparative analysis reveals that urban areas and rural areas have significant differences, especially in digital infrastructure and access. The amounts invested in the digital infrastructure are much higher in the urban areas, resulting in the higher scores and the higher internet penetration rates in urban compared to rural areas (Jiang et al., 2022). The regression analysis indicates that public investment has a positive impact on digital infrastructure, which has a significantly positive impact on the selected economic indicators, i.e., GDP growth rate and the employment rate. The discussion segment in this study explains the findings while suggesting that increasing the public investment in digital infrastructure would be a useful measure in reducing the disparities. The literature adequately supports the findings as it indicates that the investment for digital economies matters greatly in achieving a more equitable economic development (APP et al., 2021).

Figure 1 below shows that 52% of the population lives in urban areas and 48% in rural areas. This suggests that both urban and rural areas house a significant portion of the country's population. Therefore, it is a need to minimize the digital divide in both areas.

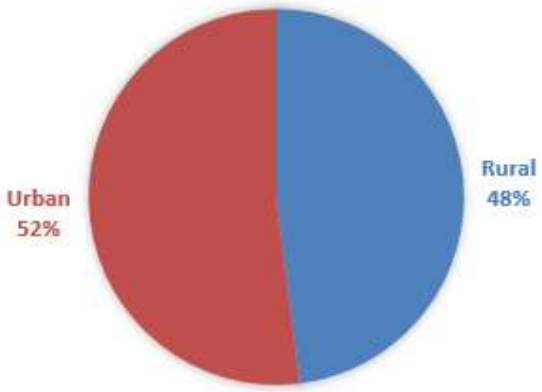

Figure 1 Urban and Rural Areas

Figure 2 represents the investment levels in different urban and rural areas, revealing peaks in Sukkur and Rawalpindi. According to the data, public investments are high in these districts, and other areas need to increase their investment opportunities (I-PRSP et al., 2001).

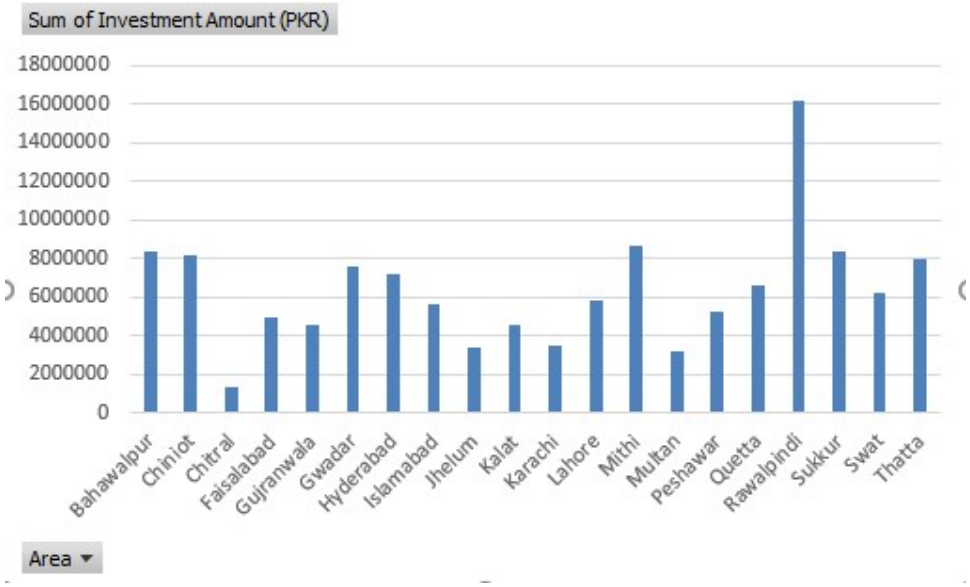

Figure 2 Invest amount in both Urban and Rural Areas**4.1 Descriptive Statistics**

The descriptive statistics in Table 1 provide the key parameters characterizing the study's primary and independent variables. The mean Digital Infrastructure Score is 74.8, with a standard deviation of 14.77, which means there is a moderate measure of variability around the mean. The mean Internet penetration rate is 75.07%, and its standard deviation is 14.00, which indicates there is a relatively equal distribution across the sample (Zhang et al., 2024).

Table 1 Descriptive Statistics

Digital Infrastructure Score		*Internet Penetration Rate (%)*		*GDP Growth Rate (%)*		*Employment Rate (%)*		*Education Level (Avg. Years)*		*Health Index Score*	
Mean	74.8	Mean	75.07	Mean	3.122	Mean	85.22	Mean	13.65	Mean	77.29
Standard Error	1.476893	Standard Error	1.400307	Standard Error	0.11316	Standard Error	0.933396	Standard Error	0.212904	Standard Error	1.121984
Median	75.5	Median	77	Median	3.1	Median	86	Median	14	Median	76
Mode	78	Mode	83	Mode	2	Mode	96	Mode	12	Mode	65
Standard Deviation	14.76893	Standard Deviation	14.00307	Standard Deviation	1.131601	Standard Deviation	9.333961	Standard Deviation	2.129044	Standard Deviation	11.21984
Sample Variance	218.1212	Sample Variance	196.086	Sample Variance	1.280521	Sample Variance	87.12283	Sample Variance	4.532828	Sample Variance	125.8847
Kurtosis	-1.15247	Kurtosis	-1.07332	Kurtosis	-1.33566	Kurtosis	-1.40147	Kurtosis	-1.24156	Kurtosis	-1.00907
Skewness	-0.00476	Skewness	-0.16645	Skewness	0.136742	Skewness	-0.14512	Skewness	0.060317	Skewness	0.282169
Range	49	Range	48	Range	3.5	Range	29	Range	7	Range	39
Minimum	50	Minimum	51	Minimum	1.5	Minimum	70	Minimum	10	Minimum	60
Maximum	99	Maximum	99	Maximum	5	Maximum	99	Maximum	17	Maximum	99
Sum	7480	Sum	7507	Sum	312.2	Sum	8522	Sum	1365	Sum	7729
Count	100	Count	100	Count	100	Count	100	Count	100	Count	100

The mean GDP growth rate is 3.122; its standard deviation is 1.13, which shows that this measure of economic development is relatively consistent. The mean employment rate is 85.22%, with a standard deviation of 9.33; however, the data varies throughout the regions. The mean education level is 13.65 years, and the standard deviation is 2.13, indicating that the level of education is relatively consistent. The mean Health Index Score is 77.29, and the standard deviation is 11.22, meaning its variability level is moderate (AlphaBeta et al., 2021). As a result, descriptive statistics provide a complete picture of the study's socio-economic and digital infrastructure context, covering an entire range of central tendencies and variances.

4.2 Comparative analysis between urban and rural areas

According to the data presented in Figure 3, investment in urban areas is significantly higher, as confirmed by a longer, leading line. The contrast in investment levels may indicate pronounced investment in urban development and even socio-economic factors, which could be the reason for regional discrepancies (DEVELOPMENT COMMITTEE, 2022). Still, it is an argument for a more balanced approach to ensure that all areas receive support and coordinated development.

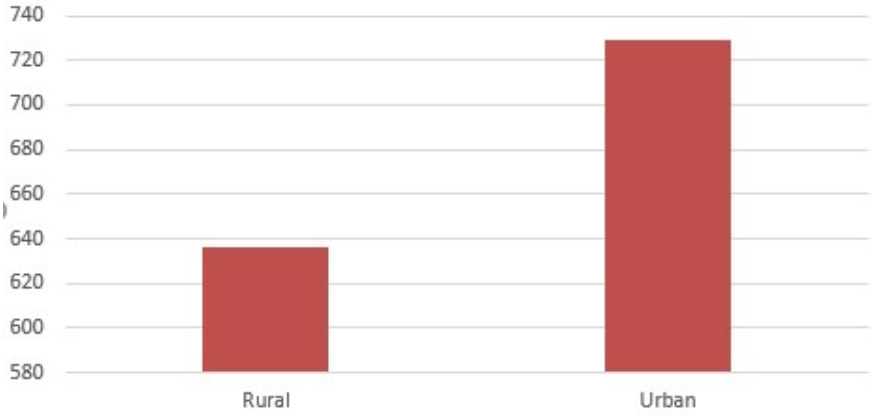

Figure 3 Overall Investment in Urban and Rural Areas

4.3 Regression analysis

Table 2 presents the results of a regression analysis examining the impact of the selected variables on the GDP growth rate. The regression model's low value indicates a low fit, explaining only 5.8% of the GDP growth rate variability with the predetermined values. The adjusted R square value is 0.008, which indicates that the explanatory power of the model does not increase greatly relative to the number of predictors (Tu et al., 2024). The F statistic is equal to the t-test value of 0.335, indicating that the overall model is not statistically significant at 5%. However, the independent variable Internet PeHowever, the independent variable Internet Penetration Rate% of the remaining variables only exhibits a statistically significant positive effect ($p = 0.044$), whereas the

Digital Infrastructure Score, Employment Rate%, Education Level Average Years, and Health Score did not demonstrate any statistically significant effects (DISA, 2020). te variable can explain the variation in the GDP growth rate (db). The coefficients indicate that an increase in the Internet penetration rate positively correlates with GDP growth, as the other variables have no explanatory power in this context.

Table 2 Regression analysis

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.240937
R Square	0.058051
Adjusted R Square	0.007947
Standard Error	1.127096
Observations	100

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	7.35919	1.471838	1.158613	0.335438
Residual	94	119.4124	1.270345		
Total	99	126.7716			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.27196	1.789192	1.269824	0.207282	-1.28052	5.8244 43	-1.28052	5.82444 3
Digital Infrastructure Score	0.00061 6	0.007804	0.078 95	0.937 24	-0.01488	0.0161 11	-0.01488	0.01611 1
Internet Penetration Rate (%)	0.01675 1	0.008209	2.040 637	0.044 091	0.000452	0.0330 49	0.00045 2	0.03304 9
Employment Rate (%)	-0.00861	0.012242	-0.703 68	0.483 369	-0.03292	0.0156 92	-0.03292	0.01569 2
Education Level (Avg. Years)	0.04429 7	0.053489	0.828 139	0.409 689	-0.06191	0.1505 01	-0.06191	0.15050 1
Health Index Score	-0.00419	0.010308	-0.406 71	0.685 144	-0.02466	0.0162 75	-0.02466	0.01627 5

5 Findings and Discussion

This study's findings provide valuable insights into the impact of public investment in digital infrastructure on the reduction of disparities between urban and rural areas in Pakistan. Descriptive statistics provide an overview of the central tendencies and central variations of the leading socioeconomic and digital infrastructure indicators (Cai et al., 2024). The comparative summary between urban and rural areas helps identify statistically significant differences in their level of investment and infrastructure quality, while the regression summary examines the

pattern of public investment and economic outcomes (WU et al., 2023).

According to the descriptive statistics, DES and IPR have higher mean scores in urban areas than in rural areas, as determined by the observation of digital infrastructure and internet penetration region-wise. The average Digital Infrastructure Score was 74.8, with a standard deviation of 14.77, whose variation around the average was moderate (Gao et al., 2024). This implies that although some regions had excellent infrastructure, others fell far short. This study scored the digital infrastructure between 0 and 100. This method calculated the percent of the upper broke for which the infrastructure was greater than or equal to the lower broke; the mean of the IPR was 75.07% with a standard deviation of 14.00. This mean trend of internet courses was relatively constant over regions, showing a slight variation between region averages (Zheng et al., 2023).

The comparative summary presents the gap between urban and suburban compositionality. For instance, Figure 2 highlights the significant variation in investment levels between urban and rural areas. The lowest level of investment was in rural areas, while the most inland areas, which include cities, had a high level of investment (Jiang et al., 2022). Based on the trend, it appears that the noted peaks were in Sukkur and Rawalpindi. While the rural areas may slow down, the urban regions may continue to grow, resulting in an even more significant difference. Thus, the study findings imply that public investment in urban infrastructure is greater than in rural infrastructure (Li et al., 2023).

The regression summary resulted in a weaker pattern. For instance, the regression summary revealed that the model accounted for only 5.8% of the variation in the GDP growth rate. R-Square = 0.058 suggests that many factors affect economic growth. Similarly, when I added more predictors, the predictability factor remained static at 0.008 (Dai et al., 2022). For example, among IPR, DES, ER, EL, and HI, IPR (%) was the only predictor that was significantly more positive in terms of GDP growth rate than the others, with a P-value of 0.044. The remaining predictors, DES, ER (%), EL, and HI, indicate a non-significant change in the GDP growth rate. Despite being considered a supporting factor for economic growth, the DES exhibits an insignificant change in the GDP growth rate (Cheng et al., 2023). Thus, the pattern suggests that while the GDP grows with various SD outcomes, the urban areas remain equipped with an adequate structure that may not require public investment due to their effective governance, while the rural areas lack infrastructural investment and are lagging in terms of internet penetration.

6. Conclusion

To conclude, the present study illustrates that public investment in digital infrastructure can play a vital role in mitigating the urban-rural socio-economic gap in Pakistan. The findings show that urban areas exhibit higher levels of investment, leading to increased digital infrastructure development and internet penetration. However, this is not sufficient, as rural areas are left behind and therefore require additional concentrated funds. The regression analysis has shown that increasing internet penetration increases GDP growth, demonstrating the need to enhance internet accessibility to facilitate economic development. Nonetheless, the study points to other measures that would still be required to capture all benefits of digital investments—such as improving digital literacy and affordability. Taking a coherent policy landscape that addresses each of these multifaceted needs will help policymakers achieve more equitable and comprehensive growth, bridging the digital divide and resulting in sustainable development throughout all regions of Pakistan.

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