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## Accessing the Impact of Infrastructure on Industrial Development and Technological Innovations; Evidence from Pakistan

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### ABSTRACT

This study aims at the active examination of the strength of accessing the impact of infrastructure on industrial growth and technological innovations in Pakistan, by using annual time series data is taken from the period 1996 to 2020. The study uses ADF for unit root and ARDL for empirical estimations. Several works have been done for different variables across the world but this work is only done for the developing country Pakistan. Positive results have been found among industry including construction value added, medium of high tech exports and research and development with Gross fix capital formation in long run but renewable electricity output is not given significant results for Pakistan's gross fix capital formation. The study reveals that IVA, R-D\_EX & MHTE thrice factors are essential contributors to infrastructure. Policy implications are a vital essence for the infrastructure of Pakistan, here are some policy suggestions for the Pakistani government. To strengthen infrastructure by new construct roads, modernized ways of transportation and innovative machinery installation. The government may take action with legislative measures according to the country's welfare on China Pakistan Economic Corridor; secure investment friendly environment, political stability which can strengthen the economy,

construction of modern transportation networks as well as several energy projects backward province KPK and Pakistan.

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### **1. Introduction**

The tradegrowth nexus is not a new topic of discussion. Trade has a long history of promoting economic progress and welfare. Smith (1959) emphasized trade as a method of releasing surplus production and broadening the market as early as the 16th century. In a similar spirit, Marshall (1890) recognized that the study of international trade includes factors that influence nations' economic expansion(ED). Since then, the question has remained a hot topic in research and policy discussions, resulting in a plethora of theoretical and empirical literature on the relationship between trade and economic growth. So, why is it necessary to reconsider the role of trade?

The present wave of globalization, which has been characterized by not just deep economic integration and trade openness, but also by technical change, has sparked renewed interest in the role of trade. Over the last few years, international trade has been continuously increasing last 20 years between 1980 and 2011, the value of universal merchandise trade expanded by more than 7 % each year on average (fourfold in volume terms) (WTO, 2013). Technology, telecommunications, and transportation advancements have made it possible to reorganize global production and distribution systems around "value chains." The rising role of trade in services, which rose even faster than merchandise trade, is another major element of this changing global landscape. It is thought that traditional metrics of services trade undervalue their role in global trade because of the difficulties in recording transactions (Subramanian and Kessler, 2013; WTO, 2013). Increased participation of developing economies in international trade has also shaped the global trade topography, beginning with the industrializing East Asian Tigers, who pursued an outward oriented trade policy leading to exported growth as early as the 1960s, followed by China and, more recently, India. Over the last decade, the world's exports have increased dramatically. The percentage of international exports held by developing economies climbed from 34% in 1980 to nearly half (47%) in 2011. (WTO, 2013) The rising proliferation of regional trade agreements and major commercial partnerships around the world exemplifies the search for broader trade expansion. Given the fiscal constraints that many nations throughout the world are facing, trade is seen as a crucial pillar of economic growth and development. As a result, any discussion of the global development agenda that ignores global trade dynamics is going to be incomplete. Regardless, the changing global dynamics and the general focus on the global picture can easily obscure the differential trade consequences. For example, even though the proportion of developing countries in global trade has been increasing in recent years, Africa as a continent still has a very low percentage of global trade.

The poorest countries, many of which are in Africa, continue to be especially vulnerable--the LDCs' share of the world exports is only about 1%, and as a group, the LDCs have systematically recorded a trade deficit except for 2006-2008 cycles of high commodities prices (Escaith and Tamenu, 2013). The debate on trade growth tie-up is nothing new. Theory trade boosts economic growth and welfare has a long history. As for the 16th century, Smith (1776) urged the trade to be a bent and a means of expanding the market for additional production. In this regard, Marshall (1890) acknowledged that the causes determining the economic development of nations relate to the study of international trade. Since then, this topic has been an important topic of discussion in research and policy debates, which has led to strengthening infrastructure. This established a lot of ideological and experimental literature on the link between trade and economic development. So why rethink the role of trade? The new Interest in

the role of trade is largely based on the latest wave of globalization, characterized not only by deep trade integration and trade openness but also by the technological uprising. International trade has steadily increased over the past three decades (Ali et al. 2021).

## 2. Review of Literature

Palei (2015) investigated the degree of impact of competitiveness and infrastructures on economic growth. The study indicated several factors which put to affect the economic growth and national competitiveness like macroeconomic environment, technological readiness, market size, institution, primary education & health and infrastructure according to the World Bank, flexible functional forms used, VAR model employed to solve the causality problems, slice (cross section) regression analysis and given independent variable to estimate the conditional expectation of dependent variable and to explore these type of relationship employed the data from the Global Competitiveness Report-2012 covering 124 economies. The study found that national competitiveness was dependent upon the level of institutional development and all mentioned key variables, in turn, affect the high level infrastructure. Institutional reforms and effective economic policies both tools guided the policy makers and business leaders in the economy.

Javaid (2016) estimated the impact of FDI on gross domestic product from Pakistan while using time series data covering the period 1966 to 2014. To find the short run and long run effects simultaneously used autoregressive distributed lag and error correction model (ECM, ARDL) techniques. The study concluded that FDI and economic growth significantly positively related in both long term and short term and error correction model coefficients converged to the Equilibrium path. Inflation and population had a significant impact on GDP in long run but gross capital formation and trade had no significant role to explore the variations in GDF of Pakistan.

Were (2015) analyzed the differential impacts of trade on economic growth (EG) and investment by taking cross country data. The study used time series data taken from World Development Indicator covering the period 1991-2011. Heterogeneity of countries had taken into account to estimate the all regression analysis and predicted trade had a positive and significant impact on EG in developed and developing countries but insignificant in less developed countries mostly including African countries and found that trade important determinant of FDI for all countries respectively developed, developing and least developing countries. This research suggested adopting the new technologies for attracting FDI to unlock their potentials and alter their structure and pattern of trade that would lead to providing active integration for regional and global value chains for Africans and least developed countries.

Gilal et al. (2019) defined the structural changing and EG nexus in Pakistan. Time series data was taken from the World Development Indicator period 1976-2014. This research used GDP growth as a dependent variable and inflation (INF), external debt (EXD), foreign direct investment (FDI), gross fix capital formation (GFCF), gross national expenditures (GNEX), remittances (REM), domestic credit to the private sector (DCRPS), trade openness, real exchange rate and financial deepening (FDS) as independent variables and used Kalman Filter based time varying parameter approach to estimate the empirical analysis. The study showed a significant impact of GFC, INF, GNEX and REM on EG but the significant effects of macroeconomic determinants on the growth process was time varying not constant for Pakistan.

Zameer, Shahbaz and VO (2020) probable financial development, globalization and innovational technologies reinforced the poverty alleviation efficiency in China. The study employed the time series data covering the period of 2007-2018 with used to estimate super efficiency DAE model GMM with a system for estimation the study results. This research found that poverty alleviation efficiencies unevenly distributed in the different regions in China and increased over the years, relatively low in central and western provinces but due to financial and technological innovations show positive impact in China's spatial and also remained insignificant effects of globalization on poverty alleviation. Government should provide required based sectoral and regional new technological innovation advancement with resources endowment conditions from scientific research institutions that may prove fort the long lasting betterment for the economy as well as people of china and under considerations rural areas, the shortcoming of agriculture and provide financial services in form of subsidies to the agriculturalists to implement the accurate policies with the focus of improvement and establishment as well.

Hanif et al. (2020) disclosed the correlation of modern logistics industry(MLI) and EG in developing economy in Pakistan, used time span 1990 -2018 and the vector autoregression(VAR) model to estimate the dynamic variables and they are inter linkage impact in both short run and long run. The study found that EG had exerted a significant demand pull impact in Pakistan and unidirectional r/s between EG and MLI.MLI development was comparatively higher in geographical areas where there EG was quicker but in low where there EG was low. Result oriented based MLI may improve this industry in which it was developed in geographical areas as well and modern logistics and transportation both interrelated with technological advancement would cause sustainable economic growth (Ahmad et al. 2020).

Cao et al. (2020) explored the technological innovations and resource consumption interlink-age impact on EG and environmental regulations which were taken the analysis of spatial interaction patterns of urban agglomerations in Yangtze River Delta Region by using time span 2002 to2010 with the spatial panel data model. By the theoretical value of this study, the U-shape curve was still robust. The study inquired that technological innovations and resources consumption proved the main mechanism through environmental regulation to affect the EG. This study suggested that this region may provide important interaction for development for other urban regions agglomerations as well.

Saeed & Awan (2020) inspected the impact of technological innovation has a strong effect on economic growth in Pakistan's economy or not. To check the r/s between technologies on EC growth, the study used many variables as patents applications, FDI, education expenditures, R&D expenditures, and unemployment. This study used time series data from 1998 to 2018. To check the stationary unit root employed and for long and short run relationship used ARDL model and Bound test. We found that inventions increased as the rate of GDP increased but the positive relationship incurred R&D and innovations.

Cheng et al. (2021) depicted belt and road (opening and reforms of china) initiative was improved or not the quality of EG interlink for china's cities. The study used micro data of 285 territory level cities of China from 2004 to 2018 by using the difference in difference model. The study resulted in a positive and significant effect of three instruments which was adopted by the using variables resource allocation optimization, upgrading industrial structure and technological

innovations and impact of belt and road initiative found most apparent in the first and second tier and nonspatial cities but the greater effect for cities with high sprawl and polycentric clusters and quality of EG improved in the external window and strategic hinge areas and silk belt break new ground as well.

### 3. Data

Time series data from 1996 to 2020 is used in this study by accessing the impact of infrastructure on industrial development and technologies changes which is derived by WDI. This study is used Gfcf to measure infrastructure as exogenous with many endogenous variables like IVA measures industrial development, MHTE, R-D expenditures and REO measure for technological innovations.

**Table 1: Description of Variables and their Expected Sign**

Variables description	Abbreviated form use	Unit of measurement	Data source	Exp signs
Gross fix the capital formation	GFCF	%	World Development Indicator	+ve
Independent variables				
Industry including construction value added	IVA	%	WDI	+ve
Research and development expenditure	R_D_EX	%	WDI	+ve
Medium of high tech exports	MHTE	%	WDI	+ve
Renewable Electricity output	REO	%	WDI	+ve

### 3. Methodology

ARDL is employed to analyze the short and long run r/s among under study variables. Earlier researchers were used ARDL to investigate the LR r/s b/w the variables. (Saeed & Awan, 2020; Javaid, 2016). To check the stationarity and order of integration, the study employed ADF, due to the Mixture of level and first difference employed ARDL applied and check the significances of variables and ARDL is not useful for integrated of order 2. The study has analyzed the casualty by Enger Granger Causality test as well with different diagnostics and stability tests. Our fundamental model of accessing infrastructure in Pakistan's Economy is shown by the ARDL method.

$$GFCF = f(INDD + TECH\ INNO)$$

$$GFCF = f(IVA, Mhte, REO, R-D-ex)$$

$$GFCF = \beta_0 + \beta_1 (IVA) + \beta_2 (Mhte) + \beta_3 (reo) + \beta_4 (R\_D\ ex)$$

Where

$\beta$  =Intercept

$\beta_0$  = slope of coefficients

Iva=industry of value added including constructions

Mhte= Medium of high tech exports

R\_D\_ Ex= research and development expenditure

Reo= Renewable electricity output

Gfcf=Gross fix capital formation

### Empirical Findings

**Table 2: Descriptive Statistics**

	GFCF	IVA	MHTE	R_D_EX	REO
Mean	2.372	3.2810	9.7472	0.3046	31.1271
Median	2.7559	4.5302	9.9925	0.3291	31.0333
Maximum	14.5501	8.4725	11.0838	0.6325	35.4919
Minimum	-11.2731	-5.2068	7.6746	0.1091	25.2422
Std. Dev.	7.3710	3.4722	0.8248	0.1366	2.97741
Skewness	-0.0458	-0.9067	-0.7610	0.2231	-0.3421
Kurtosis	2.1821	3.2198	3.2743	2.5171	2.4137
Jarque-Bera	0.6489	3.1984	2.3923	0.4143	1.0148
Probability	0.7228	0.2020	0.3023	0.8128	0.6020
Sum	54.5698	75.4644	233.9350	7.0061	933.8147
Sum Sq. Dev.	1195.299	265.2419	15.6495	0.4105	257.0844

Source Developed by author

Descriptive statistics show mean of Gfcf 2.37 & median of 2.75 both are mostly the same with lower differences and negatively skewed. Gfcf has 2.18 flat top platy kurtosis with not normal distribution as p-value 0.7 > than 5%.Iva has a mean less than median which indicates –ive skewed with extreme top lapto kurtic , range 8.472 with min -5.2068.JB is used to test the normality of distribution as p value than 5% so ive not normally distributed. MHTE is also –ive skewed due to  $M < M - 0.761$  with extreme leptokurtic top. R and D expenditure in Pakistan not only skewed but also not normal as prob > 5%. Reo is -ive skewed with max is 35.49 part of range min25.24 and also not normally distributed because of p value also > than 5 % ( level of significance)

**Table 3: Correlation matrix**

	GFCF	IVA	MHTE	R_D_EX	REO
GFCF	1	0.4548	0.1006	0.1118	0.0255
IVA	0.4548	1	-0.2722	-0.0621	-0.0408
MHTE	0.1006	-0.2722	1	-0.3191	-0.0775
R_D_EX	0.1118	-0.0621	-0.3191	1	0.0307
REO	0.0255	-0.0408	-0.0775	0.0307	1

Source developed by author eviws9

This research expresses correlation b/w variables like GFCF, IVA, R\_D EX and REO which is measured linear r/s b/w two variables in multi problems by removing all other influence. IVA is weekly and positively related with GFCF, MHTE is positively associated with GFCF and weekly that is 0.1006. R-D-EX and REO both are also +ive, week r/s respectively 0.1118, 0.0255 in Pakistan. MHTE with IVA 0.272, -D-EX with IVA 0.062, REO with IVA 0.040, R-D-EX with MHTE 0.319, REO with MHTE 0.07 all have +ive and weekly r/s b/w each other reported in Pakistan.

**Table 4: Unit root test (ADF)**

Variable name	Level		1 <sup>ST</sup> difference		Decision
	Intercept	intercept and trend	Intercept	intercept and trend	I(0),I(I)
GFCF	-4.01684 (0.0068)	-	-	-	I(0)
MHTE	-3.0138 (0.0484)	-	-	-	I(0)
IVA	-4.2589 (0.0034)	-	-	-	I(0)
R_D_EX	-1.3786 (0.5727)	-0.6226 (0.9663)	-7.9610 (0.0000)	-	I(I)
REO	-3.0847 (0.0390)	-	-	-	I(0)

Source: calculated by the researcher using eviews 9

Unit root test is conducted to check the stationarity and order of integration because trendy and nonlinear give spurious regression or cannot lead to further estimation without it. R-DEX is stationer at 1<sup>ST</sup> difference but all other variables are at a level which gives the mixer of level and 1<sup>st</sup> order of integrations lead us to apply ARDL for estimation.

**Table 5: Bound Test**

Test Statistic	Value	K
F-statistics	4.106080	4
Critical value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06
co- int exists b/w variables		

Source: calculated by the researcher using eviews 9

For correct inference and estimations, the presence of LR associations is much more critical. Only LR coefficients can be estimated when LR equilibrium associations exist. According to Bound test T-stat value > than upper bound and lower than lower bound at 5% level of significance (LOS).  $H_0$  =Cointegration does not exist but  $H_1$ co-int exists, so F-stat is 4.106 and critical value 4.01 that is confirmed by the rule and reject the null hypothesis, alternate accept, so co- int exists.

**Table 6: Short run results of the model**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(IVA)	0.8764	0.4539	1.9307*	0.0756
D(IVA(-1))	-0.8031	0.4373	-1.8364**	0.0893
D(MHTE)	2.4903	2.0294	1.2270	0.2415
D(MHTE(-1))	-4.4453	2.0384	-2.1807**	0.0482
D(R_D_EX)	27.9420	12.1321	2.3031*	0.0384
D(REO)	-0.2812	0.4815	-0.5839	0.5692
CointEq(-1)	-1.1715	0.2376	-4.9288	0.0003

Table 6 exhibits short run r/s coefficients estimates as shown above.Co-intEq(-1) has a –ive value of -1.171582 with its T –stat -4.9288 and its substantially high probability value indicates long run causal term b/w dependent and independent variables. The high convergence toward the equilibrium position is expressed by coint Eq value -1.1715.IVA has –ive coefficient value in short run with significance in current and no lag respectively 0.075 and 0.089. Medium of high tech exports, research and development expenditures and renewable electricity output have –ive, +ive and –ive coefficients respectively and are significant. MHTE and R-D-EX are highly significant associations but REO is only one negligibly insignificant variable.

**Table 7: Long Run Coefficients**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IVA	1.6964	0.7340	2.3110	0.0379
MHTE	7.9367	2.4300	3.2660	0.0061
R_D_EX	23.8498	10.1664	2.3459	0.0355
REO	-0.2400	0.4134	-0.5805	0.5715
C	-80.4369	26.6251	-3.0210	0.0098

Source: calculated by the researcher using eviews 9

In the table, industry including construction value added positive and considerable significance that implies one percentage increase in IVA lead to a 1.696 % augment in GFCF . Due to advancement in the industrial sector, manual to machine era that leads to automation which created skill personals jobs, increase production and decline costs in LR, all behind invisible hand was infrastructural accessing in Pakistan those connect forward regions to backward areas(Stojkove 2008). These results are matched by Kong et al(2021) Akram, Ajmair and Farooq(2019)Hanif et al (2020) but Renewable Electricity output (REO) has –ive & insignificant influence GFCF in Pakistan as 1 % increase in REO leads -0.240 % decline in GFCF.



Medium of high tech exports (MHTE) and R-D-EX have +ive and high significant impact on GFCF in Pakistan. Technological advancement enhances the efficiency of labor and productivity, exports that change the K/I ratios, R-d expenditures as well in Pakistan. MHTE emulsifies 1% 7.936 % add in GFCF and 1% R\_D EX will 23.849 % increase in GFCF. These results are matched by Were (2015), Zameer, Shahbaz and VO (2020), Cao et al (2020).

**Table 8: Diagnostics and Stability Test**

<b>Breusch –Godfrey LM test</b>			<b>Conclusion</b>
<b>F stat</b>	<b>Obs R*-squared</b>	<b>Prob. Chi –square</b>	
1.755520	5.564999	0.2179	No autocorrelation in the model
<b>Heteroskedasticity Test Breusch –pagan-Godfrey test</b>			
<b>F stat</b>	<b>Obs R*-squared</b>	<b>0.1132</b>	
2.359601	14.26661		No hetero in model
<b>Ramsey RESET Test</b>			
<b>F stat</b>	<b>Prob</b>		
1.154462	0.3037		No wrong specification

The fallout of several diagnostic and stability tests indicate in table which indicates the probability of the LM test is > than 5% that is 0.2179 means that no serially correlated identify in the model. Heteroskedasticity PBG test s prob is 0.1132 is greater than 5% mean that accept the null hypothesis and no hetero in the model found. Ramsey test is used for the stability checking in the model which indicates no specification error in this model due to prob 0.3037.

**Table 9: Granger Causality test**

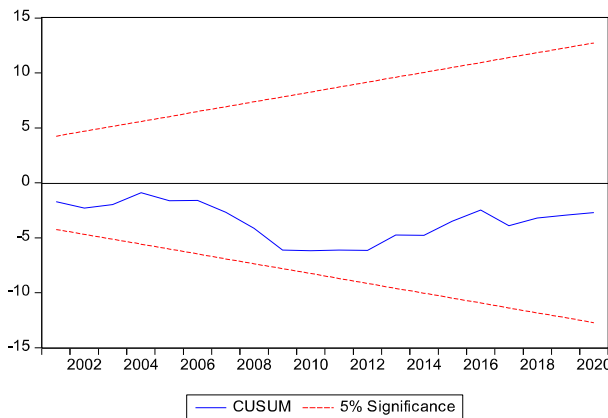
Null Hypothesis:	Obs	F-Statistic	Prob.	Conclusion
IVA does not Granger Cause GFCF	21	0.16958	0.8455	none
GFCF does not Granger Cause IVA		1.29116	0.3021	
MHTE does not Granger Cause GFCF	21	2.61199	0.1043	Univariate
GFCF does not Granger Cause MHTE		3.05122	0.0754	
R_D_EX does not Granger Cause GFCF	21	0.14196	0.8687	none

GFCF does not Granger Cause R_D_EX		0.74246	0.4916	
REO does not Granger Cause GFCF	21	0.71201	0.5056	none
GFCF does not Granger Cause REO		2.53143	0.1109	
MHTE does not Granger Cause IVA	21	1.66379	0.2206	none
IVA does not Granger Cause MHTE		0.52443	0.6017	
R_D_EX does not Granger Cause IVA	21	0.13009	0.8789	none
IVA does not Granger Cause R_D_EX		2.50014	0.1135	
REO does not Granger Cause IVA	21	0.70979	0.5066	none
IVA does not Granger Cause REO		1.06209	0.3689	
R_D_EX does not Granger Cause MHTE	21	0.59023	0.5658	none
MHTE does not Granger Cause R_D_EX		0.39746	0.6785	
REO does not Granger Cause MHTE	22	0.55695	0.5831	none
MHTE does not Granger Cause REO		0.01979	0.9804	
REO does not Granger Cause R_D_EX	21	1.03900	0.3765	none
R_D_EX does not Granger Cause REO		0.40171	0.6757	

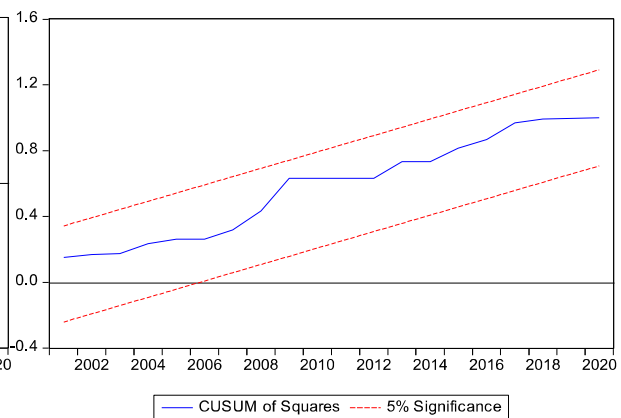
Source: calculated by the researcher using eviews 9

Granger causality test applied to check casual impact b/w variables in 5.7 tables. This research express that there is no causality found neither uni variant or nor bivariate among the variables. Only GFCF causes MHTE as univariate causality in this table.

### CUMSUM and CUMSUMSQ Test



**Figure 1: CUSUM Test**



**Figure 2: CUSUM of Square**

CUSUM & CUMSUMSQ exhibits in the 5.8 table to show the recursive residuals for relevancy of policy implications. In this stability test, two red straight lines show a critical limit which is significant at 5%, plotted model is located b/w these two critical limits lines & top and lower bounds. The model is well fitted and no deviation is found in it. This leads to more useful, support and strength for a recommendation of policy implication.

### Conclusion and Policy Recommendation

This study aims at the active examination of the strength of accessing the impact of infrastructure on industrial growth and technological innovations in Pakistan, by using annual time series data is taken from the period 1996 to 2020. The study uses ADF for unit root and ARDL for empirical estimations. Several works have been done for different variables across the world but this work is only done for the developing country Pakistan. Positive results have been found among industry including construction value added (IVA), medium of high tech exports (MHTE) and research and development with Gross fix capital formation(GFCF) in long run but renewable electricity output is not given significant results for Pakistan's gross fix capital formation. The study reveals that IVA, R-D\_EX & MHTE thrice factors are essential contributors to infrastructure. According to WEFS Pakistan is at 67<sup>th</sup> out of 125 countries in the basic infrastructure category 2006-2007 and Pakistan's grade is bottom 20(110) out of 144 economies of the world which is an alarming position at world level competitiveness (2019). The overall decline in the south Asia region despite covid 19 Pakistan has progressed in one belt and road 2021 at 5<sup>th</sup> rank globally in infrastructure development Transport and telecommunication sector accounts for about 22.0% on GFCF, construction 2.5% 2007FY/2008. The global innovation index(GII) Pakistan at 99<sup>th</sup> out of 132 and score of at 24.4 (2021)

Policy implications are a vital essence for the infrastructure of Pakistan, here are some policy suggestions for the Pakistani government. To strengthen infrastructure by new construct roads, modernized ways of transportation and innovative machinery installation. The government may

take action with legislative measures according to the country's welfare on CPEC; secure investment friendly environment, political stability which can strengthen the economy, construction of modern transportation networks as well as several energy projects backward province KPK and Pakistan as well & will increase economic development, quality of life and efficiency of labor and technologies access boost. In the case of infrastructure(INFRA) may focus on including green INFRA policy. The government may focus and expense on R-D in all sectors.

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