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The Spatial Effects of Road Infrastructure on Employment in Pakistan: Quantifying the Role of Complementary Factors

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This study uses district-level panel data to measure the spatial effects of road infrastructure on employment while accounting for institutional quality, rural connectivity, and labour productivity in Pakistan. The estimates based on the spatial regression model show that road density positively and significantly impacts employment. A 10 percent increase in road infrastructure would lead to a 4.3 percent increase in employment directly and indirectly—the spillover effects of road infrastructure help optimise the benefits of public investment in infrastructure projects. Empirical results reveal that institutional framework and access to rural areas complement road infrastructure in channelising road development's employment effects. These findings suggest a call for a comprehensive policy to reap the potential benefits of road infrastructure. Apart from developing the road network, the government should also develop complementary factors, namely institutional reforms and rural connectivity.

Keywords: Road Infrastructure, Employment, Institutional Quality, Spatial Analysis, Pakistan

1. INTRODUCTION

The economic literature has recognised that transport infrastructure, mostly road, is essential for economic development (Arif & Iqbal, 2009; Aschauer, 1989; Banister & Berechman, 2001; Boopen, 2006; Laborda & Sotelsek, 2019).[1] It leads to economic development by promoting trade, enhancing competitiveness, and reducing transport costs by integrating regions and countries (Hassan, 2018; Hope & Cox, 2015; Kanwal, Chong & Pitafi, 2019; Melecky, Roberts, & Sharma, 2019; Sahoo & Dash, 2012; Tate, 2018).

Road infrastructure creates employment directly and indirectly (Berechman & Paaswell, 2001; Haynes, 1997; Rietveld, 1989). Road infrastructure makes three types of

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[1] There are two broad categories of infrastructure, namely physical infrastructure (economic infrastructure) such as road, energy and soft infrastructure (social infrastructure) like human capital and patents etc. (Arif & Iqbal, 2009; Laborda & Sotelsek, 2019).

employment. It includes direct jobs—created by the actual public spending on infrastructure, and the wages are paid from the project funds. It creates indirect jobs through expenditures the suppliers make to produce the materials used for the infrastructure projects and induced jobs–elsewhere in the economy as increases in income from the direct public spending that leads to a further rise in spending by workers and firms (Fageda & Gonzalez-Aregall, 2017; Hijazi, Syed, Shaikh, & Bhatti, 2017; Rashid, Zia, & Waqar, 2018).

However, recent studies tend to find a negligible and smaller effect on employment (Laborda & Sotelsek, 2019; Schwartz, Andres, & Dragoiu, 2009). Melecky et al. (2019) argued that employment creation depends on other "complementary factors [also called structural factors] that affect many aspects of the economy at the same time." These factors comprise initial conditions in the local economy, namely the availability of skilled labour, local connectivity–rural connectivity, and institutional structure. Melecky et al. (2019) further highlighted that infrastructure might also "*affect the complementary factors themselves*." Thus, road infrastructure may induce employment directly and indirectly through improving complementary factors, i.e., structural changes in the economy – a natural outcome of infrastructure development (Zia & Waqar, 2018).

This study revisits the impact of road infrastructure on employment after controlling for "complementary factors" in Pakistan. The literature identifies various complementary factors, including labour productivity, local connectivity, and institutional framework, among others, to induce employment (Arif & Iqbal, 2009; Khandker & Koolwal, 2010; Melecky, et al. 2019). Institutions—"the rule of the game" provides a favourable environment for channeling the impact of road infrastructure. Weak institutions reduce the marginal productivity of infrastructure investment by allowing rent-seeking activities, especially in developing economies (Iqbal & Daly, 2014; Nawaz & Mangla, 2018). The institutional framework enhances coordination and reduces information costs (Chijioke & Ugochukwu, 2015). Local connectivity enables the local citizens to reap the potential benefits of highways by engaging themselves in non-basic production such as retail, restaurants, construction, and personal services (Iqbal & Nawaz, 2017; Kanwal, et al. 2019; Lee & Clarke, 2019).

The literature highlights that road infrastructure benefits are not region-specific; they could spillover effects in other regions (Chen & Haynes, 2015). Infrastructure reshapes geographical connectivity and helps in the agglomeration of economic activities. It reduces trade costs and facilitates trade flows between regions (Cohen, 2010; Fujita & Krugman, 2004). This discussion leads us to measure the spillover effect of road infrastructure. Therefore, this study aims to quantify the spatial impact of road infrastructure on employment while accounting for Pakistan's *complementary factors*.

Based on district-level panel data, the empirical analysis shows that road infrastructure has a positive direct and spillover effect on employment. Empirical results reveal that institutional framework and access to rural areas complement road infrastructure in channelising road development's employment effects. A 10 percent increase in road infrastructure would lead to a 4.3 percent increase in employment directly and indirectly. The institutional quality index has a positive and significant direct and indirect impact on employment. This implies that institutional development would promote employment directly and indirectly. Rural connectivity has a positive and significant direct effect on employment while an insignificant indirect effect on employment. This shows that rural connectively play a more critical role in the respective district rather than neighboring districts. The interaction terms confirm the role of complementary factors in shaping the effects of economic corridors.

We add to the literature on the impact of infrastructure on employment in three ways. First, earlier literature signifies the role of proximate factors such as institutional quality to enhance road infrastructure effectiveness (Chen & Haynes, 2015; Esfahani & Ramírez, 2003). However, these studies do not explicitly include underlying factors in their modeling framework (Chen & Haynes, 2015; Esfahani & Ramírez, 2003). We contribute to the literature by adding institutional quality in the road-employment nexus. Second, we contribute to the literature by developing a comprehensive institutional quality index at the sub-national level in Pakistan. Earlier, Nifo & Vecchione (2014) developed a similar institutional quality index at sub-national levels for Italy. Lastly, we use spatial econometric techniques to find the spillover effect of road infrastructure at the district level using district-level panel data.

This study has enormous policy implications due to the massive investment in Pakistan's road infrastructure under the China-Pakistan Economic Corridor (CPEC).[2] The CPEC is widely recognised as a hub to connect regions through infrastructure development. Under CPEC, three road networks, namely eastern, central, and western, with a total road length of 3000 KM, are started.[3] The proposed transportation infrastructure will contribute positively to Pakistan and China's economic performance and have a spillover effect on other countries like Iran, the Middle East, Afghanistan, India, and the Central Asian Republic by enhancing geographical connectivity (Mirza, Fatima & Ullah, 2019). It is a significant stimulus for Pakistan, ensuring rapid economic growth with massive infrastructure development and employment creation (Blanchard, 2017; Kanwal, et al. 2019).

The rest of the paper is structured as follows: Section 2 briefly reviews the previous studies related to road infrastructure and job creation. Section 3 presents the modeling strategy; Section 4 gives data description and discussion on empirical methodology. Section 5 offers a situational analysis of critical variables/indicators and multivariate analysis, while the last provides concluding remarks and a policy framework.

2. LITERATURE REVIEW

The economic benefits of road infrastructure are stem from a reduction in transportation costs and an increase in economic activities (Estache, Ianchovichina, Bacon & Salamon, 2013; Forkenbrock & Foster, 1990). A bulk of the literature has shown positive spillover effects of infrastructure on economic growth (Dehghan Shabani & Safaie, 2018; Li, Wen & Jiang, 2017; Qi, Shi, Lin, Yuen, & Xiao, 2020; Wang, Lim, Zhang, Zhao, & Lee, 2020). The lower transaction and input costs through improved

[2]CPEC is a framework of regional connectivity. It is a collection of infrastructure projects including construction of modern transportation network, energy projects and special economic zones with the value of $62 billion. For further details, see official website http://cpec.gov.pk/introduction/1.

[3]Eastern alignment connects big cities like Karachi and Lahore, western alignment links Khyber Pakhtunkhwa and Balochistan while central alignment links Punjab, Balochistan and Khyber Pakhtunkhwa (for further detail see Appendix Figure 1).

roads can lead to more employment (Grimm, Lutz, Mayer, & Paffhausen, 2014). Employment creations through road infrastructure vary across different projects, working environment, human capital availability, other country infrastructure like energy, and so forth (Rashid et al., 2018). The employment generation of any project is measured through direct, indirect, and induced employment effects. Direct employment refers to employment generated by the activities to accomplish projects, while indirect employment refers to a job produced under input and output markets (Fageda & Gonzalez-Aregall, 2017; Rashid et al., 2018).

Fageda & Gonzalez-Aregall (2017) estimate the direct and indirect impacts of infrastructure on industrial employment using the spatial econometric method for the Spanish region for the period 1995-2008. This study finds that the density of motorways has a significant impact on industrial work. Chakrabarti (2018) estimates the effects of national highways on employment in India using state-level data. This study shows that a 10 percent increase in national highway density is associated with a 1 – 6 percent increase in India’s non-agricultural private sector employment. He, et al. (2014) found that a 10 percent increase in total highway capacity is estimated to create over 1.5 million new jobs for the entire economy in the long run in the USA. However, the employment effects vary across industrial sectors. Highway investment leads to employment growth, mainly in retail, trade, construction, manufacturing, and accommodation services sectors (He, et al. 2014).

The varying results show that the impact of road infrastructure differs across countries and sectors. Complementary factors reshape the contribution of road infrastructure in generating employment. Chijioke & Ugochukwu (2015) argue that strengthening institutions can promote employment. The enhanced coordination among public institutions is also pivotal in establishing peace and prosperity, and it also helps build the infrastructure in Nigeria.

Bülow (2015) investigates the impacts of institutional quality on the firms’ performance, and evidence obtains from emerging and transition facing economies. This study generates an institutional quality index by combining the six dimensions of governance indicators. These dimensions are voice and accountability, political stability, the effectiveness of government and regulations, law and order, and corruption. The study’s findings show that institutional quality is the source to expand the firms’ productivity and capacity, which ultimately leads to employment creation in emerging countries. The higher level of institutional quality provides grounds to exercise higher business activities in respective economies.

Udah & Ayara (2014) argue that sound governance structure and quality of institutions are the key drivers of economic performance and building infrastructure and a business enabling environment in Nigeria. Quality of government, physical infrastructure, and human capital are the key determinants of economic growth and employment in the European Union (Crescenzi, Di Cataldo, & Rodríguez-Pose, 2016; Di Cataldo & Rodríguez-Pose, 2017). Further, these studies focus on making better of low-skilled labour by bringing about improvement in government institutions. In addition to employment generation, government and institutions’ effectiveness also benefit marginalised people’s social inclusion.

Fujimura & Edmonds (2008) also found that cross-border infrastructure development complements the domestic road structure and fosters trade. Thus, connecting regional economies to global economies creates employment opportunities within the region through foreign direct investment. However, the infrastructure enhances growth by reducing inequalities in accessibilities at the city level, increasing disparities at the regional level (Gutiérrez, 2001). Thus, it calls for a cautious approach while analysing the impact of new infrastructure.

Human capital encompasses the knowledge, skills, competencies, and other attributes embodied in individuals relevant to economic activity. Vision 2025 also emphasises human capital development for inclusive growth in Pakistan. Local connectivity through roads, and transport is integral to connecting rural markets with urban hubs. The rural road is needed to interconnect all growth generating sectors in different regions and achieve a better and broader distribution of the economic growth benefits. Building a road network is a pre-requisite to developing remote and geographically difficult areas (Arif & Iqbal, 2009).

Infrastructure investments in rural areas lead to higher farm and non-farm productivity, employment, and income opportunities (Khandker & Koolwal, 2010). Fageda & Gonzalez-Aregall (2017) argue that investment in infrastructure has two effects. In the short run, this investment reactivates the construction sector while, in the long run, the investment is having a visible impact on production costs by reducing accessibility costs. These effects significantly increase employment in the industrial sector. Institutions play a significant role in attracting foreign direct investment to develop businesses across the CPEC route. The poor performance of institutional indicators constrains foreign direct investment inflows.

The above discussion reveals that road infrastructure investment’s impact on employment differs across countries and sectors. Various factors, especially existing human capital, rural connectivity, and institutional quality, determine road infrastructure investment contribution to employment. The present study investigates the complementary role of these factors in creating jobs through road investment in Pakistan.

3. MODELING STRATEGY

Road infrastructure generates economic benefits by reducing transportation costs. Lower production costs increase productivity and profits. Due to the high-profit margin, existing firms are induced to increase output while new firms are attracted, leading to higher labour demand. These business expansions lead to employment growth (Chakrabarti, 2018). Road infrastructure leads to an increase in production technology, which could affect overall labour demand. The decline in travel time and cost due to better road connectivity improves individuals’ accessibility to the job market and increases the overall labour supply (Jiwattanakulpaisarn, Noland, & Graham, 2011; Jiwattanakulpaisarn, Noland, Graham, & Polak, 2009).

These arguments provide a basis to develop an empirical model for analysis. Following Chakrabarti (2018), we can drive a reduced-form model for equilibrium employment that assumes road infrastructure, among other factors, could affect the levels of employment equilibrium in the labour market. The compact form of the model is given as:

$$E = f(R, X) \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (1)$$

where E is the equilibrium employment, R represents road infrastructure, and X is the vector of other socio-economic control variables. For empirical testing, the general specification of the equilibrium employment in log-linear form is given as follow:

$$LnE_i = \alpha + \beta_1 LnR_i + \gamma' LnX_i + \varepsilon_i \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where α, β, and γ' are coefficients, i represents the unit of analysis, i.e., district in this case, and ε_i is an error term.

As discussed in the previous section, numerous "*complementary factors,*" namely institutional quality, local connectivity, and labour productivity in the region, determine the efficacy of road infrastructure investment (Calderon, Cantu, & Chuhan-Pole, 2018; Iqbal, Din, & Ghani, 2012; Melecky et al., 2019). On the one hand, these factors directly impact employment, and on the other hand, these factors complement the road to scale up the contribution of road investment. This study augments the basic employment model given in equation (2) using institutional quality, local connectivity, and labour productivity along with interaction terms. The expanded version of the empirical model is given as:

$$LnE_i = \alpha + \beta_1 LnR_i + \beta_2 LnIQI_i + \beta_3 LnRCI_i + \beta_4 LnLPI_i + \delta_1 Ln(R * IQI)_i$$
$$+ \delta_2 Ln(R * RCI)_i + \delta_3 Ln(R * LPI)_i + \gamma' LnX_i + \varepsilon_i \quad \ldots \quad \ldots \quad (3)$$

where δ represents coefficient, IQI represents institutional quality, RCI denotes rural connectivity, LPI indicates labour productivity, $(R * IQI)$ is the interaction of road, and institutional quality, $(R * RCI)$ is the interaction of road, and rural connectivity and $(R * LPI)$ is the interaction of road and labour productivity. This model provides the following testable hypothesis:

(i) *Road infrastructure has a positive impact on employment implies that* $\frac{d(LnE_i)}{d(LnR_i)} = \beta_1$ *where* $\beta_1 > 0$

(ii) *Road infrastructure and institutional quality complement each other to promote employment imply that* $\frac{d(LnE_i)}{d(LnR_i)} = \beta_1 + \delta_1 IQI$ *where* $\beta_1 > 0$ *and* $\delta_1 > 0$. *This indicates that when institutional quality increases, given the road infrastructure, employment increases.*

(iii) *Road infrastructure and rural connectivity complement each other to generate employment imply that* $\frac{d(LnE_i)}{d(LnR_i)} = \beta_1 + \delta_2 RCI$ *where* $\beta_1 > 0$ *and* $\delta_2 > 0$. *This indicates that when rural connectivity increases, given the road infrastructure, employment increases.*

(iv) *Road infrastructure and labour productivity complement each other to enhance employment imply that* $\frac{d(LnE_i)}{d(LnR_i)} = \beta_1 + \delta_3 LPI$ *where* $\beta_1 > 0$ *and* $\delta_3 > 0$. *This indicates that when rural connectivity increases, given the road infrastructure, employment increases.*

The proposed model is further adjusted to measure the spillover effects of road infrastructure to analyse its spillover effects. The spatial modeling strategy is used to model spillover effects (LeSage & Pace, 2010).[4] This inclusion of spatial effects is

[4]This strategy is widely used in the exiting literature (Arbués, et al. 2015; Cohen, 2010; Li, et al. 2017; Ojede, Atems, & Yamarik, 2018).

motivated on practical grounds, owing to the peculiarities of data used in the analysis (Anselin, 2013). The spatially integrated regression model is given below:

$$LnE_i = \varrho \sum_{j=1}^{N} w_{ij} LnE_j + Lnx_i\beta + \sum_{j=1}^{N} w_{ij} lnx_j \, \varphi + \varepsilon_i \qquad \ldots \qquad \ldots \qquad (4)$$

where $\sum_{j=1}^{N} w_{ij} LnE_j$ is the spatially weighted effects of LnE_i. This helps to measure the spillover effects of the dependent variable. In this case, it implies that the employment of neighboring district j shaped by the employment in district i as a consequence of spillover effects. With LnE_j in neighboring districts, the parameter ϱ is the coefficient attached to the autoregressive term. It measures the power of spatial correlation between two districts and gives the impact of neighboring districts' employment. w_{ij} is a spatial weight matrix that captures the spatial interaction among districts. φ is a vector of coefficients linked with explanatory variables other than the lag of the dependent variable. These adjustments in the original model provide a basis to disentangle the direct and spillover effects of road infrastructure on employment after controlling *complementary factors*.

4. DATA AND EMPIRICAL METHODOLOGY

4.1. Data Sources and Construction of Variables

This study uses various secondary data sources to quantify the impact of road infrastructure on employment at the district level in Pakistan. These include Pakistan Social and Living Standards Measurement (PSLM)[5] Survey and MOUZA Statistics.[6] Apart from these sources, this study uses the Enterprise Survey data for Pakistan collected by the World Bank,[7] and the Provincial Development Statistics reports published by relevant provincial departments. A panel is developed for 111 districts across Pakistan for 2008, 2010, 2012, and 2014. The choice of districts and periods depends on data availability for required variables.

4.1.1. *Employment and Road Infrastructure*

The dependent variable is the level of employment. It is defined as a percentage of people (all male/females ten years of age and older) who are currently employed. The data on employment are taken from various issues of the PSLM survey. Road length is used to measure the impact of road infrastructure on employment. The information on road length is taken from Provincial Development Statistics (PDS) of each province. Chakrabarti (2018) and Jiwattanakulpaisarn et al. (2009) use a similar measure to measure the highway's impact on employment in India and North Carolina, respectively.

4.1.2. *Institutional Quality Index (IQI)*

The institutional quality index (IQI) captures a broad range of governance indicators. The IQI follows the methodology proposed by the World Governance

[5]http://www.pbs.gov.pk/content/pakistan-social-and-living-standards-measurement-survey-pslm-2014-15-provincial-district

[6]http://www.pbs.gov.pk/content/mouza-statistics

[7]http://www.enterprisesurveys.org/data/exploreeconomies/2013/pakistan

Indicator (WGI) of the World Bank. Following the WGI, the IQI is based on six broad dimensions, such as government effectiveness, the situation of rule and law, voice and accountability, corruption, regulation quality, and political stability and avoidance of violence. Various studies have used the same dimensions to construct institutional quality index at sub-national levels (Bülow, 2015; Nifo & Vecchione, 2014; Udah & Ayara, 2014). A detailed discussion on these dimensions is given as follows.

(i) *Voice and Accountability (VA):* The VA dimension indicates that if people in any district have the right to vote and freedom of expression, it will exhibit institutions' quality. This dimension's indicators are participation in an election measured as the turnout in the election. The turnout data is collected from the Election Commission of Pakistan (ECP) for Pakistan's general election. The second available indicator is social cooperatives, which show that the higher level of social cooperatives signifies the higher quality of institutions, as Nifo & Vecchione (2014) described for Italy. Various other studies have used similar indicators to measure institutions' voice and accountability dimensions (Bülow, 2015; Udah & Ayara, 2014).

(ii) *Government Effectiveness (GE):* GE affects institutional quality positively. Two indicators are taken in this regard: the government's ability to provide social facilities such as schools, colleges, hospitals, and other social amenities. The data of these variables are taken from the PSLM. The vibrant institutions are supposed to provide social facilities by government agencies. Hence, the higher values of the social facilities indicate higher quality of institutions. Similarly, the government's ability to increase the tax base is also showing the quality of institutions.

(iii) *Regulatory Quality (RQ):* This dimension's main essence is to measure how much a government can formulate sound policies and regulations, ultimately providing a business enabling environment to the private sector. The higher-level quality of regulations is indicative of the higher quality of institutions. The study, in this regard, uses two indicators: (1) business density, which is measured by several industrial units established in each district, and (2) business environment indicator is computed by using further three indicators, i.e., several cooperative societies, membership of cooperative societies, and several commercial banks in each district of Pakistan. These indicators represent a business enabling environment for the private sector. The data of the indicators, as mentioned above, are taken from the Provincial Development Statistics of each province of Pakistan.

(iv) *Political Stability and Absence of Violence (PS)*: This dimension indicates how political stability is destabilised by unconstitutional means such as violent and terrorist activities. The study uses the terrorism index measured by violent events, murders, kidnappings, and blasts. Based on these indicators, the index of terrorism is generated, indicating how much a government is destabilised. This dimension is negatively affecting institutional quality. However, the study takes the inverse of the terrorism index, demonstrating the higher institutional quality as the value of the terrorism index increases.

(v) *Rule of Law (RL):* this dimension signifies the extent to which citizens abide by the rules of society, and it includes the safety of property rights, violation of the rule of law. The ability of institutions to ensure the establishment of the rule of law also indicates its quality. The study employs the crime rate of each district as the indicator of the rule of law dimension. Crimes include crimes such as theft, murder, snatching, etc. The data of these variables are taken from Provincial Development Statistics.

(vi) *Control over Corruption (CC):* The sixth dimension of the institutional quality is showing the extent to which public office holder is found indulged in exercising it for private gain. An index for corruption is used as Nifo and Vecchione (2014) for Italy have employed. Corruption is perceived as one of the critical dimensions of institutional quality. The study takes the inverse of this variable to construct the index.

In the first step, all indicators are normalised. In the second step, Principal Component Analysis (PCA) is used to compute each indicator's weight. PCA is a widely used method to obtain weights when required to construct the index based on numerical data (Nawaz, Iqbal, & Khan, 2014). The estimated weights are reported in table 1. Udah and Ayara (2014) also used this weighting method to generate an institutional quality index. The IQI ranges between 0 and 1; the higher the value of IQI, the higher the quality of institutions, and vice versa. The PCA-based weights show that dimensions such as regulatory quality, voice and accountability, and political stability, and avoidance of violence are conceding higher weights than other dimensions and indicators. The correlation matrix of these dimensions and indicators demonstrates relatively higher and reasonable coefficients of correlation amongst these variables. Further, all associations are found statistically significant, which are essential for the application of PCA.

Table 1

Dimensions and Indicators of Institutional Quality Index (IQI)

Dimensions	Indicators	Weights
VA	Participation in elections: turn out in the general election	0.0616
	Social cooperatives index	0.2146
GE	Social Facilities: index based on the provision of health, education, transport facilities.	0.1527
	Tax revenue collections by district-level departments	0.0460
RQ	Business density: number of industrial units in each district	0.1775
	Business environment: index is generated by using several cooperative societies and memberships, bank facilities	0.1478
PS	Violence and terrorist activities: an index used which is combined by murder, blasts, and other terrorist activities	0.1453
RL	Crime Rate: The crime rate is computed by different sorts of reported crimes in each Pakistan district.	0.0105
CC	Index of corruption	0.0436

Source: Author's formulation.

4.1.3. *Rural Connectivity Index (RCI) and Labour Productivity Index (LPI)*

Rural connectivity is measured using access to the metallic road within one kilometer range. Rural connectivity index (RCI) is defined as the percentage of MOUZA falling within a radius of less than one kilometer from a metaled road. The data is taken from MOUZA statistics. It is a census since it covers all mouzas in the country. The Human Development Index developed by the UNDP is used as a proxy to measure labour productivity index (LPI).

4.1.4. *Other Control Variables*

We use various control variables, including urbanisation and provincial dummies, to control area-specific heterogeneities and other socio-economic differences at the district level. The descriptive statistics of all variables are given in Table 2. The last column presents the correlation of explanatory variables with employment.

Table 2

Summary Statistics

Variables	Mean	S.D.	Min	Max	Correlation
Ln(EMP)	3.55	0.24	2.64	4.17	1.0000
Ln(Road)	6.96	0.74	4.87	8.33	0.2301*
Ln(IQI)	3.99	0.13	2.99	4.24	0.1173*
Ln(RCI)	3.83	0.78	0.33	4.56	0.0582*
Ln(LPI)	3.87	0.46	1.10	4.49	-0.1171*

Source: Author's calculation. The last column presents the correlation matrix with Ln(EMP). * Indicates a significant correlation at the 10 percent level.

4.2. Estimation Methodology

This study uses panel data to estimate the impact of road infrastructure on employment at the district level. As discussed earlier, there is a spillover effect of road infrastructure due to connected boundaries and easy access to the neighboring region (Fageda & Gonzalez-Aregall, 2017). Generally, two types of spatial dependence are observed in the literature (Bailey & Gatrell, 1995; Fageda & Gonzalez-Aregall, 2017). First occurs due to spatial error terms, suggesting that the different geographical units' errors are correlated with each other. While the second exists when the dependent variable of one location is influenced by the outcome variable of other locations (Higazi, Abdel-Hady, & Al-Oulfi, 2013). The spatial econometric techniques are used to address these issues (Maddison, 2006).

Following Fageda and Gonzalez-Aregall (2017), this study uses a spatial Durbin model (SDM), which measures the dependent and independent variables' spatial interaction. The spatial analysis helps examine the direct effect on the areas in which the road infrastructure is located and the spillover effects on neighboring districts (LeSage, 2014; LeSage & Pace, 2010). The spatial regression model produces unbiased and efficient parameters because the ordinary least square (OLS) may not produce unbiased estimates due to spatial autocorrelation. It shows when a value is estimated in one area may depend on the neighboring location. This study defines the following SDM using the model given in Equation 4:

$$\begin{aligned} LnE_{i.t} &= \varrho \textstyle\sum_{j=1}^{N} w_{ij} LnE_{j,t} + \beta_0 + \beta_1 LnR_{i,t} + \beta_2 LnIQI_{i,t} + \beta_3 LnRCI_{i,t} \\ &+\beta_4 LnLPI_{i,t} + \delta_1 Ln(R*IQI)_{i,t} + \delta_2 Ln(R*RCI)_{i,t} + \delta_3 Ln(R*LPI)_{i,t} \\ &+\varphi_1 \textstyle\sum_{j=1}^{N} w_{ij} LnR_i, t + \varphi_2 \sum_{j=1}^{N} w_{ij} LnIQI_{i,t} + \varphi_3 \sum_{j=1}^{N} w_{ij} LnRCI_{i,t} \\ &+\varphi_4 \textstyle\sum_{j=1}^{N} w_{ij} LnLPI_{i,t} + \varphi_5 \sum_{j=1}^{N} w_{ij} Ln(R*IQI)_{i,t} \\ &+\varphi_6 \textstyle\sum_{j=1}^{N} w_{ij} Ln(R*RCI)_{i,t} + \varphi_7 \sum_{j=1}^{N} w_{ij} Ln(R*LPI)_{i,t} + \varepsilon_i \quad \ldots \quad (5) \end{aligned}$$

Global Moran's I test is applied to detect spatial dependence, which depends on the weight matrix (Higazi et al., 2013).[8] The Moran test is usually used after OLS, which suggests whether the spatial regression model is applicable or not. After finding spatial autocorrelation, the study endeavors to observe the required analysis using the spatial regression model given in equation 5 above. To estimate the optimal spatial model, the OLS may not be the appropriate approach. It tends to produce biased or inefficient results due to a weighted spatial matrix (You & Lv, 2018). This study uses Maximum Likelihood (ML) estimators (Arbués, Banos, & Mayor, 2015; Nawaz & Mangla, 2018; You & Lv, 2018). The construction of w_{ij} is very important in the spatial econometric model as different specifications capture different channels of spillovers (LeSage & Pace, 2010). This study uses a physical contiguity matrix in which a value 1 is assigned for two districts having a common border while 0 for all other districts (Arbués, et al. 2015; Nawaz & Mangla, 2018).

Up to now, we consider road infrastructure as an exogenous variable to the economic system. However, this may not be the case, as literature has pointed out the endogenous nature of road infrastructure due to reverse causality (Arbués, et al. 2015). The issue is compounded when the road infrastructure variable is added to the equation with other variables like institutions and human capital (Nawaz & Khawaja, 2019). The use of ML resolved the issues associated with the endogeneity arises due to the inclusion of spatially weighted lag of the dependent variable. The spatial fixed effects technique may also address the omitted variables bias (Nawaz & Mangla, 2018).

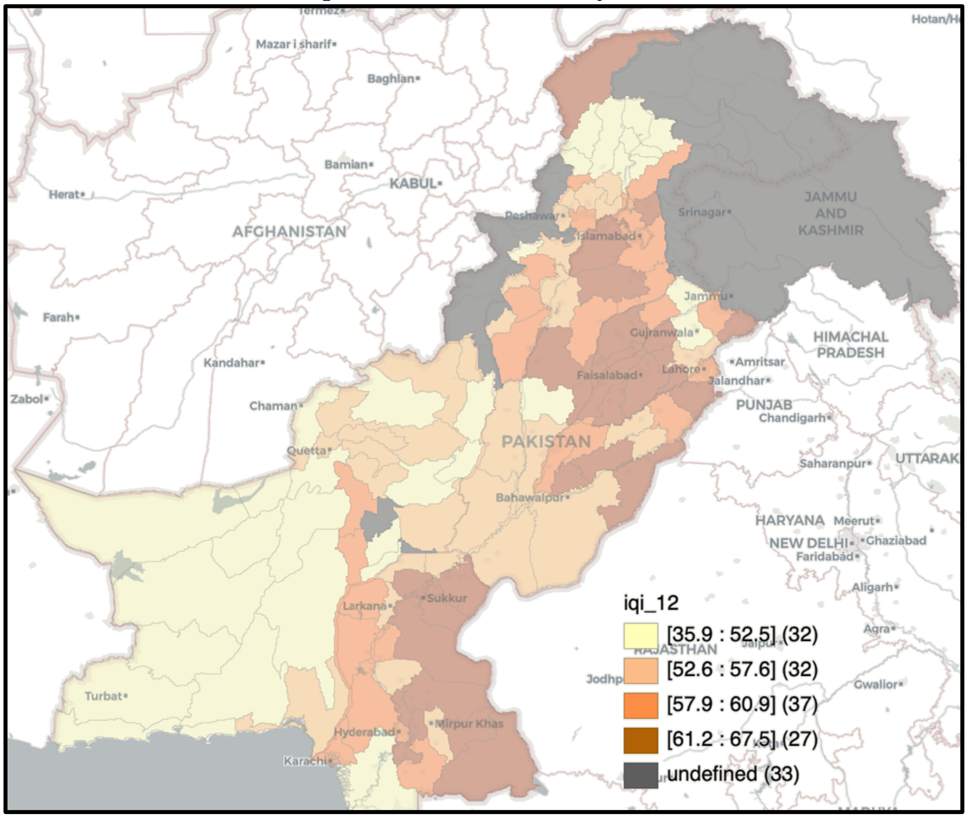
5. RESULTS AND DISCUSSION

5.1. Situational Analysis

The situational analysis highlights the relationship between road density, employment, and other complementary factors at the district level. The districts are divided into four groups based on the institutional quality index score, including high quality, moderate quality, low quality, and very low-quality institutions. The institutional quality index (IQI) indicates that most districts from Punjab show a better ranking than districts from Sindh and Balochistan. Most of districts from Balochistan are found facing poor institutional quality (Map 1). Peshawar is the top-ranked district from KPK. The weak institutional quality may act as a binding constraint to induce employment in the region.

[8]Spatial weights are generated by using STATA command "***spatwmat***" in STATA 15.

Map 1. Institutional Quality Index



Source: Author's formulation using GeoDa software.

Similarly, the districts are divided into four groups based on RCI, including high connectivity, medium connectivity, low connectivity, and very low or no connectivity. The map shows that most of the districts from Balochistan and KPK either have very low or no connectivity and low rural connectivity. On the other hand, Punjab districts have a high level of rural connectivity (Appendix Map 1). A similar situation has been observed in labour productivity across the districts (Appendix Map 2). This analysis reveals that institutions' quality is deficient, coupled with low human capital and weak rural connectivity in most Balochistan, KPK, and interior Sindh districts.

5.2. Multivariate Analysis

This study uses various diagnostic tests to establish the adequacy of the spatial econometric model. First, we apply the Moran's I test for reach year, and the outcome is presented in Table 3. The Moran I validates the existence of spatial autocorrelation. The test values show that the employment variable has a positive autocorrelation at the district level. The spatial dependence across the districts among all variables is confirmed by the Cross-sectional Dependence (CD) test (Table 3). These tests confirm spatial dependency among the variables; hence the estimation without controlling for spatial dependency may produce biased estimators.

Table 3

Moran I and CD Tests

CD Test		Moran, I Test for each year	
Variables	Value	Year	Statistics (P-Value)
Ln(EMP)	95.79***	2008	39.97 (0.000)
Ln(Road)	63.54***	2010	74.00 (0.000)
Ln(IQI)	14.91***	2012	81.32 (0.000)
Ln(RCI)	26.85***	2014	94.69 (0.000)
Ln(LPI)	61.05***		

Source: Author's calculation. The CD test is performed using the "xtcd" STATA 16 command. The test is performed under the null hypothesis of cross-section independence CD ~ N(0,1). ***Indicates significant at the 1 percent level. Columns 3 & 4 presents the Moran's I test for each year. P-values are given in parenthesis.

To start with multivariate analysis, we have estimated the non-spatial regression panel model. The results are presented in Table 4. Four different specifications are estimated. Model 1 is estimated using pooled OLS by employing road, IQI, RCI, and LPI variables. Model 2 is estimated using a fixed-effect estimation technique based on the same variables. In Model 3, interaction terms of IQI, RCI, and LPI with the road are used. In the last model, urbanisation is used as a control variable apart from all other variables.

Table 4

Estimation Results of the Non-spatial Panel Model

	(1)	(2)	(3)	(4)
Variables	Pooled OLS	FE	FE	FE
Ln(Road)	0.095***	0.082***	0.699*	1.064*
	(0.015)	(0.013)	(0.416)	(0.597)
Ln(IQI)	0.194**	0.145*	1.553	2.101*
	(0.088)	(0.078)	(1.028)	(1.082)
Ln(RCI)	0.026	0.027*	0.318**	0.360**
	(0.017)	(0.015)	(0.136)	(0.175)
Ln(LPI)	-0.119***	-0.136***	-0.739***	-0.660**
	(0.029)	(0.025)	(0.277)	(0.334)
Ln(Road)*Ln(IQI)			0.199	0.259*
			(0.145)	(0.152)
Ln(Road)*Ln(RCI)			0.042**	0.0458*
			(0.019)	(0.0242)
Ln(Road)*Ln(LPI)			0.088**	0.0618
			(0.040)	(0.0474)
Ln(Urban)				0.0926***
				(0.0171)
Constant	2.478***	2.637***	-1.756	-4.769
	(0.355)	(0.314)	(3.812)	(4.277)
Observations	444	444	444	418
R-squared	0.114	0.325	0.339	0.390

Source: Author's own calculation. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05 and * p<0.1 indicate the 1 percent, 5 percent and 10 percent level of significance, respectively. Where FE represents fixed-effects model.

The results show that road has a positive and significant impact on employment. This implies that the development of road infrastructure induces direct employment in the respective districts. These findings are supported by existing literature (Aschauer, 1989; Babatunde, 2018; Calderón, Moral-Benito, & Servén, 2015; Égert, Kozluk, & Sutherland, 2009). Fageda and Gonzalez-Aregall (2017) find that the motorway directly impacts employment in the manufacturing sector in Spain. Chakrabarti (2018) finds that a 10 percent increase in road density leads to a 1 to 6 percent increase in employment in India's private sector. It can be concluded that districts with a better road infrastructure endowments generate higher employment. This evidence implies that expansion in road networks is appeared as beneficial for generating employment in respective districts.

The result shows that IQI has a positive and significant impact on employment. This finding implies that other things remain the same; the improvement in institutional quality would increase the employment level. Similarly, RCI has a positive and significant impact on employment, implying that promoting rural connectivity enhances employment. Rural connectivity means connecting far-flung areas with main roads. The estimated results highlight that connecting local areas with main roads also contribute to employment generation's beneficial influences.

We find that the labour productivity index hurts employment. Various studies have found similar results (Junankar, 2013; Kaplanis, 2010). One can argue that the quality of human capital (skill composition) is not matched with employment opportunities in the region. The skill mismatch may also contribute negatively to employment (Farooq, 2011). The educated youth fail to obtain jobs, hence induce a lower employment ratio. This calls for further investigation to find the nexus between the nature of education and job requirements.

We further test the implication of interaction terms on employment. The results show that road, accompanied by good quality institutions, positively and significantly impacts employment. Similarly, the interaction term of the road with RCI has a positive and significant impact on employment. These findings reveal that complementary factors play an essential role in channelising the effects of road infrastructure.

Table 4 shows a positive relationship between road and employment for a penal of 111 districts across Pakistan. This leads to extending the analysis by looking at the spillover effects of road infrastructure. Table 3 also confirms the existence of spatial autocorrelation and cross-section dependency in the data. We have estimated the spatial regression model to address spatial dependence and measure the spillover effect. The results are presented in Table 5, while direct, indirect, and total impacts are presented in Table 6. The results show that spatial autocorrelation is statistically significant in both specifications, employing the existence of spatial dependence in the data.

The results show positive impacts of the spatial lag of the dependent variable, ranging from 0.87 to 0.86. The estimated effects are statistically significant at a 1 percent level in all specifications. This implies that employment in neighboring districts positively influences employment in a particular district. A 10 percent increase in employment in a neighboring district would lead to an 8 percent increase in employment in a particular district.

Table 5

Results of Spatial Regression Model

Variables	(1)	(2)
Ln(Road)	0.026*	0.398*
	(0.015)	(0.240)
Ln(IQI)	0.029**	0.980*
	(0.015)	(0.523)
Ln(RCI)	0.030**	0.196
	(0.014)	(0.129)
Ln(LPI)	–0.076***	–0.527*
	(0.027)	(0.283)
Ln(Road)*Ln(IQI)		0.133*
		(0.076)
Ln(Road)*Ln(RCI)		0.024
		(0.018)
Ln(Road)*Ln(LPI)		0.069*
		(0.041)
W*Ln(Road)	0.135***	0.048**
	(0.043)	(0.023)
W*Ln(IQI)	0.155*	0.122***
	(0.094)	(0.041)
W*Ln(RCI)	0.044	0.340
	(0.041)	(0.388)
W*Ln(LPI)	0.113*	-0.466
	(0.070)	(0.906)
W*Ln(Road)*Ln(IQI)		0.017*
		(0.010)
W*Ln(Road)*Ln(RCI)		0.042*
		(0.025)
W*Ln(Road)*Ln(LPI)		0.050
		(0.131)
e.Ln(EMP)	0.870***	0.866***
	(0.031)	(0.032)
Constant	3.383***	0.706
	(0.305)	(3.100)
Observations	444	444
sigma_u	0.102***	0.099***
	(0.010)	(0.010)
sigma_e	0.115***	0.115***
	(0.005)	(0.005)
Wald test of spatial terms	809.00(0.00)	785.35(0.00)
Number of groups	111	111

Source: Author's calculation. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05 and * p<0.1 indicate the 1 percent, 5 percent and 10 percent level of significance, respectively.

Table 6 shows that the direct elasticity of road infrastructure (0.39) is positive and statistically significant. This shows that a 10 percent increase in road infrastructure would lead to a 3.9 percent increase in employment in the district. Road infrastructure also has a positive and significant spillover effect. The indirect elasticity of infrastructure is 0.04 and is statistically significant at the 10 percent level, implying that a 10 percent increase in road infrastructure in neighboring districts would lead to a 0.4 percent increase in employment of a particular district. The institutional quality index has a positive and significant direct and indirect impact on employment. This implies that institutional development would promote employment directly and indirectly.

RCI has a positive and significant direct effect on employment while an insignificant indirect effect on employment. This shows that rural connectively play a more critical role in the respective district rather than neighboring districts. LPI has either a negative or insignificant impact on employment. The interaction terms show that IQI and RCI enhance both direct as well as indirect impact of road infrastructure on employment. This confirms the role of complementary factors in shaping the effects of economic corridors.

Table 6

Direct, Indirect and Total Effect based on Spatial Regression Model

Variable	Coefficient	P-Value	Coefficient	P-Value
Direct Impact				
Ln(Road)	0.026	0.078	0.398	0.066
Ln(IQI)	0.029	0.059	0.980	0.034
Ln(RCI)	0.030	0.028	0.196	0.028
Ln(LPI)	-0.076	0.005	-0.527	0.063
Ln(Road)*Ln(IQI)			0.133	0.055
Ln(Road)*Ln(RCI)			0.024	0.184
Ln(Road)*Ln(LPI)			0.064	0.114
Indirect Impact				
Ln(Road)	0.113	0.002	0.040	0.094
Ln(IQI)	0.129	0.100	0.102	0.085
Ln(RCI)	0.037	0.283	0.284	0.081
Ln(LPI)	0.094	0.129	-0.389	0.170
Ln(Road)*Ln(IQI)			0.014	0.094
Ln(Road)*Ln(RCI)			0.035	0.044
Ln(Road)*Ln(LPI)			0.042	0.700
Total Impact				
Ln(Road)	0.139	0.000	0.438	0.035
Ln(IQI)	0.158	0.071	1.081	0.056
Ln(RCI)	0.067	0.105	0.481	0.056
Ln(LPI)	0.018	0.016	-0.916	0.316
Ln(Road)*Ln(IQI)			0.146	0.088
Ln(Road)*Ln(RCI)			0.059	0.318
Ln(Road)*Ln(LPI)			0.106	0.419

Source: Author's own calculation based on point estimates reported in Table 5.

6. CONCLUDING REMARKS AND POLICY FRAMEWORK

The efficient transport network is vital in today's economy as they connect the underdeveloped region with development, attach markets, and create demand, which is essential for economic growth. The broader economic advantages of road infrastructure development can come from urbanisation and job creation around this new infrastructure. However, local complementary factors play a critical role in this regard. The present study examined the impact of road infrastructure on employment while accounting for rural connectivity, institutional quality, and labour productivity. The critical takeaway from empirical analysis is that road has a significant impact on employment. Furthermore, institutional quality and rural connectivity considerably contribute to promote employment. It is also evident that institutional quality and rural connectivity complement with road infrastructure to encourage employment.

Based on the empirical findings, the following are policy implications:

(i) Road infrastructure development will boost employment in Pakistan. Apart from developing main highways and motorways, the government should also focus on local roads, especially those linking rural areas with the central hub. Rural connectivity is essential to facilitate local labour to get connected with services, especially hoteling along the highways and motorways. The development of local roads is also significant to link local or rural industries, especially agriculture, and the leading industry established in megacities. Intuitively, road infrastructure development links the cities and far-flung regions to transport goods and services from manufacturing hubs to high demand locations and destinations. The main advantage of investing in road networks is related to job creation around new road infrastructure. Despite these, the construction of vast roads and highways open new avenues for international trade with neighbouring countries. Despite the expansion of road networks, local connectivity, which links local areas to main roads, also provides opportunities to enhance people's access to the major amenities offered by governments such as education and health facilities, employment, and other facilities. The study also finds the combination of local connectivity and road density caters significant and favourable impacts on the employment level. Hence, connecting the rural and backward areas with main roads and building heavy roads are the key drivers of achieving a higher level of employment and economic growth.

Policy intervention: The government should expand the local road network connecting rural markets with the central hub along with highways and motorways development.

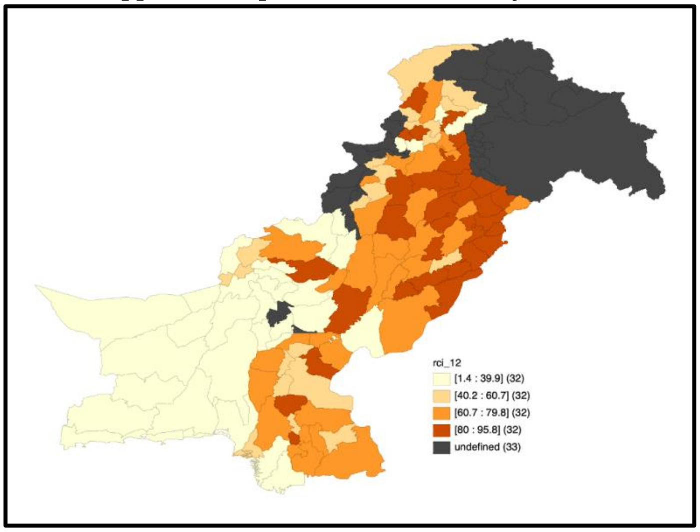
(ii) It is evident that well designed and enforced institutional framework is a prerequisite to reap the potential benefits of road infrastructure. Empirical analysis reveals that institutional quality has a significant impact on employment. This suggests that the government should invest in promoting institutional reforms, especially implementing the rule of law, ensuring political stability, and providing a productive business environment. And ultimately, improved institutional quality increase the employment level. The conducive institutional environment encourages investors to invest in these areas, which untimely leads to higher employment.

Policy intervention: The government should focus on institutional reforms at the national level and the area-specific reforms that should be introduced, especially in CPEC related districts. The government provides incentives to local investors to establish local industries along the CPEC route.

In a nutshell, a comprehensive policy framework is required to mobilise the local labour force to benefit from infrastructure investment under CPEC. Apart from developing a road network, the government should also focus on developing complementary factors, namely institutional reforms, rural connectivity, and primary education.

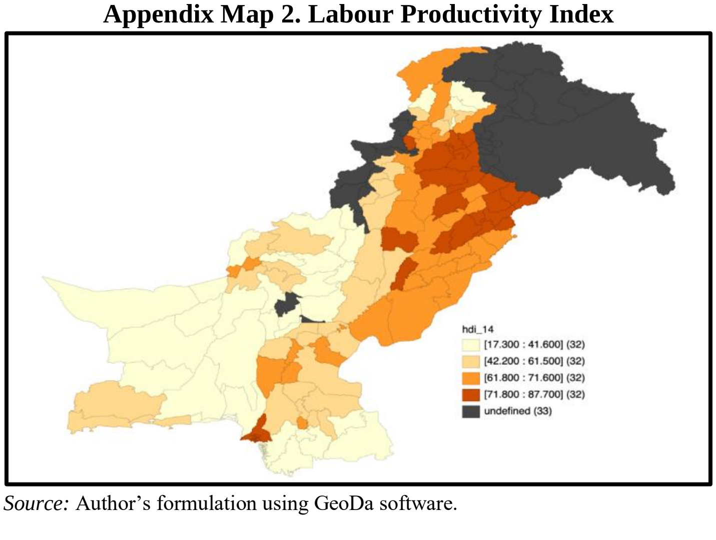
APPENDIX

Appendix Map 1. Rural Connectivity Index



Source: Author's formulation using GeoDa software.

Appendix Map 2. Labour Productivity Index



Source: Author's formulation using GeoDa software.

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