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An Economic investigation of analyzing the Impact of Infrastructure Development on Economic Growth in the Union Territory of Jammu and Kashmir

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Abstract

This study examines the influence of infrastructure development, in conjunction with two control variables namely population and per capita net state domestic product on the intricate dynamics of economic growth by utilizing the comprehensive time series data spanning from 2001-2019 within the specific context of the region of Jammu & Kashmir. By using the gauge of infrastructure indicators, study uses the principal component analysis (PCA) method for constructing the composite index of infrastructure development. The investigation utilizes the augmented Dickey Fuller (ADF) test to observe the stationary nature of the data series. Additionally, Granger causality models are employed to examine the causal relationship between economic growth and the composite index of infrastructure development, as well as per capita net state domestic product and population. The application of the auto regressive distributed lag model (ARDL) has been utilized to analyze the intricate relationship between economic growth and composite index of infrastructure development along with population & net state per capita domestic product. The empirical findings elucidate compelling evidence of a pervasive positive influence exerted by the composite index of infrastructure development, population, and net state per capita domestic product on the economic growth of Jammu and Kashmir, both in the short and long run. Moreover empirical results show that composite index of infrastructure development exerted the greatest impact on economic growth than population and per capita net state domestic product in the long run. The findings also signify that the development of infrastructure plays a central role in both expediting the progression of economic growth and ensuring long run convergence in Jammu and Kashmir. Moreover the study elucidates the presence of unidirectional relationship running from composite index of infrastructure development along with population to economic growth and by-directional relationship between economic growth and per capita net state domestic product. From the policy prospective the

findings of this study hold great significance to considering the extensive and inclusive economic growth in Jammu & Kashmir; care must be taken to remove bottlenecks in the creation of infrastructure development.

Key words: Economic Growth, Infrastructure Index, ARDL, Granger Causality test, Jammu& Kashmir, Causal relationship

1. Introduction

The enquiries into the factors that govern economic growth are a persistent concern among economists and policy makers. Various theories exist, each presenting competing perspectives on the determinants of economic growth and development. Solow's seminal work (1956) elucidates that under the assumption of constant return to scale and the absence of technological advancements, the long-term rate of output growth is contingent upon the rate of expansion of the labor force. According to Kaldor's seminal work (1957), he posited that the primary driver of economic growth lies in exogenous technological advancements. Endogenous growth theories place their emphasis on the significance of novel knowledge (Romer, 1990) and innovation (Aghion and Howitt, 1992) as pivotal factors in determining economic growth. The emerging Economic Geography models posit the significance of economic activity, agglomeration, and specialization in the context of fostering economic growth. In recent times, there has been a growing recognition of the significance of institutional economics, which emphasizes the influence exerted by non-economic factors such as institutional factors (as highlighted by North in 1990), socio-cultural factors (as explored by Knack & Keefer in 1997), the volatility of fiscal and monetary policies (as discussed by Brunetti in 1997), and demography (as examined by Brander & Dowrick in 1994). The observed growth rates appear to have exhibited a correlation with the progress made in infrastructure development. The works of (Banerjee et al., 2020; Auscher, 1989; Palei, 2015; Munnell, 1992) are of notable significance in this field. The World Bank, in its publication from 1994, provides valuable insights and analysis on a particular subject. According to the World Bank report (1994) a mere one percent augmentation in the accumulation of infrastructure yields a commensurate one percent elevation in the overall output level across all nations. Thus infrastructure development acting a paramount significance in cultivating economic progress and prosperity, serving as the bedrock upon which a thriving economy can be constructed. It is of utmost importance in ensuring the well-being and advancement of households, both in terms of their social and economic welfare. The availability

of quality infrastructure exert a pivotal influence on the trajectory of economic advancement, in both developed and developing nations(Srinivasu & Rao 2013; Bhattacharya et al., 2015; Holtz-Eakin & Schwartz, 1995;Canning & Pedroni, 2004). According to a study conducted by the University of Maryland, it has been determined that each dollar allocated towards infrastructure spending in the United States yields a noteworthy contribution of approximately three dollars towards the expansion of the Gross Domestic Product (GDP) and this impact becomes even more pronounced during periods of economic recession (Business Roundtable, 2015). On the contrary, inadequate infrastructure imposes significant economic burdens, resulting in elevated levels of unemployment, diminishing individual income, and a decline in the nation's global competitiveness. According to petroski's (2016) study the United States economy incurs yearly expenses of more than \$120 billion as a result of delays attributed solely to traffic congestion. At macro and micro level a plethora empirical investigations have been undertaken with the intent of ascertaining the influence of infrastructure development on economic growth (e.g. Chakamera & Alagidede, 2017; Calderon et al. ,2015; Kodongo&Ojah,2016; German-Soto & Bustillos, 2014; Sahoo & Dash, 2010; Calderón & Servén 2010).Munnell(1992)attributes the recognition of the significance of infrastructure in facilitating economic expansion to Aschauer(1989). The study conducted by Chakamera and Alagidede ,2017; Calderón &Servén (2008 Calderón (2009); Loayza & Odawara (2010) provides concrete empirical evidence that infrastructure have a significant and crucial role in fostering positive and substantial impact on economic growth. Within the Indian context, numerous empirical investigations have been undertaken to scrutinise the role of infrastructure in fostering regional economic growth, while also delving into the analysis of regional disparities pertaining to the extent of infrastructure development. These studies include the works of (Majumdar, 2012; Timilsina et al., 2023; Sahoo and Das, 2009; Bajjar & Rajeev, 2016; Dash & Sahoo, 2010; Singhal et al., 2011). The prevailing consensus among these studies suggests that the augmentation of infrastructure holds a positive and affirmative impact on the economic growth trajectory of India.

Despite notable advancements in infrastructure investment on a global scale, a substantial deficit in infrastructure remains prevalent within the global community. On a global scale, the current annual allocation of public funds towards infrastructure development, encompassing vital sectors such as transportation, energy, water, and telecommunications, stands at \$2.7 trillion. However, it is worth noting that experts from the World Economic Forum have suggested that

this figure should ideally be increased to \$3.7 trillion (World Economic Forum, 2016). As an illustration, it is noteworthy to mention that both China and Vietnam allocate approximately 10% of their Gross Domestic Product (GDP) towards infrastructure development. Nevertheless, it is imperative to acknowledge that these nations are encountering challenges in meeting the escalating requirements for electricity, telecommunications, and transportation services (Straub et al., 2008). In the Indian Union, the presence of a discernible disparity in the state of infrastructure is widely observed across a multitude of economic sectors and the current level of public infrastructure expenditure in India accounts only 3.3 per cent of Gross Domestic Product (India Brand Equity Foundation (IBEF)).

By Spending less than five per cent of GDP on infrastructure sector, this sector continues to hold significant importance in propelling the Indian economy through multiplier effect on demand (IBEF). The sector plays a significant role in enhancing the India's overall Growth & development and receives considerable attention from last few years from the government in formulating policies aimed at expediting the timely establishment of top-tier infrastructure within the nation. The infrastructure sector encompasses various components such as power generation and distribution, bridge construction, dam projects, road networks, and the development of urban infrastructure.. To achieve India's objective of attaining a US\$ 5 trillion economy by 2025, it is imperative to priorities the development of infrastructure. The government has implemented the National Infrastructure Pipeline (NIP) in conjunction with other initiatives such as the 'Make in India' campaign and the production-linked incentives (PLI) scheme in order to enhance the expansion of the infrastructure sector. Throughout history, a significant majority, exceeding 80%, of the nation's allocation of resources for infrastructure development has been directed towards financing projects related to transportation, electricity, and water and irrigation systems (NIP 2020). The presence of sufficient and high-quality infrastructure facilities enhances the effectiveness of factor inputs, diminishes transaction expenses, improves the effectiveness of production & consumption, facilitates market expansion, enhances competitiveness, generates positive-externalities, stimulates economic activities and elevates productivity in the economic system. All of these outcomes resulting from infrastructure contribute to the promotion of economic growth. Despite the major initiatives taken by the Union Government of India to escalate the development of infrastructure facilities in the region, still there exists large inter- state and intra –state infrastructure disparities in India. The occurrence of regional disparities in socio-

economic development is a widespread global phenomenon. However, the issue is more pronounced and conspicuous in developing and transitional economies compared to developed economies. In the context of India, the matter of regional imbalances has garnered significant attention, leading to dedicated endeavors during the planning phase aimed at mitigating prevailing disparities in economic development across different regions. Nevertheless, despite dedicated endeavors, significant disparities in socio-economic development between states continue to endure within the nation, serving as a crucial catalyst for social and political unrest as well as major hindrance in the overall economic growth of the nation. The studies which highlight the inter-state disparities include (Cash & Prakesh, 2021; Singh & Bhanumurthy, 2014; Oda 2011; Dasgupta et.al, 2000; Chotia & Rao, 2015). The presence of appropriate infrastructure significantly affects various economic activities, such as production, consumption, distribution, trade, and commerce. Hence, in order to attain expeditious and enduring economic growth, the allocation of resources towards infrastructure development serves as a pivotal catalyst. Moreover, the improvement of infrastructure facilities in any geographical context attracts the influx of resources from both domestic and external sources, thereby fostering the advancement of latent development.

The objective of this study is to analyze the impact of infrastructure development on economic growth in the Union territory of Jammu and Kashmir, by utilizing the time series data. A Study focusing on Jammu and Kashmir region constitutes a valuable addition to the existing body of literature, as there is hardly any systematic and comprehensive study to examine the impact of infrastructure development on output growth specifically within the Jammu and Kashmir context. Previous research has examined the impact of infrastructure on economic growth, focusing either on an international or country-specific level and majority of these studies have used a single indicator as a measure of infrastructure. Nenavath (2021) employed transport infrastructure within India as a metric for assessing infrastructure, while Donaldson & Hornbeck (2016) utilized railways as a means to gauge infrastructure. Banerjee et al., (2020) investigated the impact of transportation access on economic growth in china. Similarly Czernich et al. (2011) examined the relationship between broadband availability and economic growth. Cronin et al. (1991) focused on telecommunication infrastructure and its influence on economic growth. Gautam (2010) explored the effects of road transport infrastructure on economic growth. Pradhan et al. (2011) investigated the impact of health infrastructure on economic growth in

India. Lastly, Pradhan & Bagchi (2013) analysed the role of road transportation in economic growth. The concept of infrastructure encompasses a wide range of elements, making it difficult to adequately represent its comprehensive definition through the use of a single indicator. This study distinguishes itself from prior research by incorporating multiple indicators of infrastructure, such as Banking, roads, Post offices, Health Institutions, Godowns and education Institutions etc. Furthermore, it examines the impact of these indicators on the economic growth of JK. The primary aims of this study were to investigate the influence of infrastructure along with Population & per capita Net State Domestic Product (Per Capita NSDP) on economic growth through the utilization of principal component analysis (PCA) and the VAR estimation. This study addresses concerns related to reverse causation and spurious correlation resulting from non-stationary of the data through the utilization of Granger causality and unit root tests. Furthermore, the existing body of literature pertaining to the relationship between infrastructure and economic growth has predominantly concentrated on developing and emerging nations, with limited attention given to the micro level analysis at the state level particularly in Jammu and Kashmir. Therefore, this research makes a valuable contribution to the existing body of literature by specifically examining the impact of infrastructure development through broad set of indicators on economic growth by taking the Net State Domestic Product (NSSD) as proxy variable for economic growth along with the control variables Population (following Esfahani & Ramírez, 2003; Sahoo & Dash, 2009) and Per capita Net State Domestic Product (following Awan & Anum, 2014) in Jammu & Kashmir region. The incorporation of control variables in the model is important in order to mitigate the risk of omitted variables, as the economic growth dependent on numerous factors ((Zhang & Cheng, 2023). In conclusion, policymakers in both developed and developing nations or at the state level may utilize the findings of this study to formulate suitable policies aimed at enhancing infrastructure investment, thereby fostering economic growth within the state or at Country level. The subsequent sections of the paper are organized in the following manner. The second section provides an overview of the existing literature, whereas the third section outlines the methodology employed in this study. The fourth section of the paper provides an exposition of the findings and subsequent analysis, while the final section offers a concise summary of the conclusions drawn from the study and corresponding recommendations.

2. Literature review

This section of the paper provides a comprehensive review of the existing literature pertaining to the impact of infrastructure development on economic growth. The work of Nenavath (2021) examined the impact of transport infrastructure on economic growth in India from 1990 -2020 by using the ARDL model and revealed that in the long run infrastructure development has positive impact on economic growth. Moreover this paper highlights the unidirectional relationship between transport infrastructure and economic growth by using the Granger Causality test. Also Ghosh & Dinda (2019) analyzed the relationship between economic growth and transport infrastructure development in India from 1990-2017 by using the dynamic multivariate models in the framework of vector correction error model and revealed that road and air infrastructure has a significant impact on economic growth in the long run, while rail infrastructure has insignificant impact on economic growth. Their study also examines the macroeconomic nexus between composite index of transport infrastructure development and economic growth in post linearization period by using the technique of Principal Component Analysis and reveals the by- directional causality between macroeconomic transport infrastructure and economic growth in India. In a parallel investigation, Esfahani and Ramírez (2003) conducted a cross- country examination and discovered that the impact of infrastructure services on gross domestic product (GDP) significantly surpasses the expenses incurred in delivering said services. At a more nuanced level, researchers have unveiled that the availability of quality transportation infrastructure serves to enhance the facilitation of trade, reduction of poverty, enhancement of welfare, and expansion of market access (Donaldson & Hornbeck 2016; Michaels 2008; Normaz et al., 2015; Nuno & Venables, 2001; Aggerwal, 2018) thereby engendering the phenomenon of agglomeration (Kline & Moretti, 2014; Martin & Rogers, 1955). Similarly (Ighodaro (2010); Hong et al 2011; Pradhan & Bagchi, 2013; Achour & Belloumi, 2016) have conducted research that supports the notion that improvements in transportation infrastructure have a significant impact on economic growth. Dwivedi (2017) has devised an infrastructure index by amalgamating diverse indicators such as electric power consumption, road networks, internet users, railway lines, and air transport. This index, constructed using principal component analysis, serves as a tool to assess the present state of infrastructure within the Indian Economy. Furthermore, it delves into the examination of the pivotal role played by infrastructure in the Gross Domestic Product. The elucidations presented within this article have unveiled that infrastructure assumes a pivotal role in engendering the proliferation of the

economy. The study conducted by Pradhan and Bagchi (2013) employed the Vector Error Correction Model (VECM) to examine the relationship between transportation modes and economic growth in India. Their findings revealed a bidirectional causality between road transportation and both economic growth and capital formation. Conversely, a unidirectional causality was observed from rail transportation to economic growth and capital formation.

Patra and Acharya (2011) conducted an study on the impact of infrastructure deficiencies on economic development, utilising data obtained from 16 prominent states in India. The findings of their research indicate a positive correlation between the infrastructure development index and per capita net state domestic product, as well as a negative correlation with poverty levels. In a study conducted by Kumar and Nagesh (2019), it was found that countries in Asia and the Pacific region face significant challenges in terms of social and infrastructure development. These challenges serve as obstacles in the pursuit of sustainable development goals. The research conducted demonstrates that addressing the disparities in social and physical infrastructure development contributes to the attainment of the ambitious objectives of sustainable development. This presents a favorable prospect for the region to cultivate a development that is more equitable and well-rounded. In a study conducted by Bhatia (1999), a rural infrastructure index was developed and utilized to examine the impact of infrastructure on the agricultural productivity of a state, specifically in terms of per-hectare output of food grains. The findings of the study revealed a significant influence of infrastructure on the aforementioned agricultural output. The primary factor hindering India's ability to sustain its high growth rate is the inadequacy of its infrastructure. In contrast to alternative forms of investments, infrastructure exhibits a notably elevated rate of return, accompanied by favorable spillover and positive externality effects (Mishra et al., 2013). The relationship between the growth of the infrastructure service sector and the overall socio-economic development in the Jammu and Kashmir Union Territory has been found to be positive and significant. However, it is important to note that there are disparities in infrastructure development across different districts within the region (Rather, 2017).The study conducted by Andrabi et.al (2013) delved into the analysis of inter-district disparities in agriculture development within the region of Jammu and Kashmir. Their findings revealed significant discrepancies in the level of agricultural development across the various districts of Jammu and Kashmir. Moreover, the study conducted by Chotia and Rao (2015) demonstrated a positive correlation between the composite infrastructure index and GDP per

capita, as well as an inverse correlation between poverty statistics and GDP per capita. This research aimed to examine the inter-linkages between the regional infrastructure gap, economic growth, and poverty in the Indian States.

Moreover by using completely modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) to 18 lower-middle income nations between 1995 to 2017 the study of Irshad et al., (2023) examined the relationship between infrastructure development and economic growth .Their study revealed that spending on transportation, energy, and telecommunications helps lower-middle-income nations economies to expand. Calderón et al., (2015) employed a synthetic infrastructure index constructed through a principal component analysis and conducted a dynamic panel analysis for a sample of 88 countries by employing the pooled mean group estimator (PMG) proposed by (Pesaran et al., 1999) to estimate the model, with a specific emphasis on examining the long-term production function relationship between infrastructure variables, other forms of manufactured capital, human capital, and GDP. Their study revealed a positive and statistically significant long-term impact of infrastructure on GDP , with an elasticity ranging from 0.07 to 0.1. The study of Mohd et al., (2012) examined the impact of information and communication technology (ICT) infrastructure, specifically mobile phones, on output levels in countries within the Association of South-east Asian Nations (ASEAN). The researchers employed the PMG estimator to analyse this relationship. Significant and substantial effects were observed for each of the four information and communication technology (ICT) technologies that were examined individually. Baba et al., (2015) analysed the impact of rural infrastructure on agriculture growth vis –vis labour productivity& land productivity in Jammu and Kashmir by using the five infrastructure parameters i.e., villages electrification, financial institutions, irrigation and agricultural cooperatives through the regression model .The results of their study revealed that several factors, including irrigation area, density of surfaced roads, literacy level, and cropping intensity, have a positive and significant impact on the productivity of agricultural labour and availability of bank branches ,consumption of fertilizers and electricity availability have positive and statistically significant impact on land productivity. By using the Principal component analysis Shameem & Rajeswari (2023) examines the inter-district disparities interms of infrastricture and econommic development vis-vis indices as well as finds the descriptive association between infrastructure and economic development. The results of their study revealed that better infrastructure development districts have better economic

development. From the existing body of literature, it has been ascertained that that no systematic study has been conducted in the Jammu & Kashmir which highlight the importance of infrastructure in enhancing the growth of the region , which is very important for the region's extensive growth.

Furthermore most of the existing studies (Nenavath 2021; of Mohd et al., 2012; Aggerwal 2018; and Achour & Belloumi 2016) uses single infrastructure component to examine its impact on economic growth. The current study makes composite index of Infrastructure development along with population & per capita NSSDP and examine its impact on economic growth (NSDP). The another important contribution of this study is that ,most of the existing studies have examine the impact of infrastructure on economic growth at the macro-level level and very less studies have been conducted at the micro-level or region level particular in Jammu and Kashmir .Thus conducted a study in the least studied region of the country, will indeed a noteworthy contribution to the mounting literature on growth and infrastructure studies related to India and will help the policymakers to create effective regional extensive growth policies at the state level which will enhance the economic growth and help in achieving the economic welfare in the UT. Moreover study findings will help the decision makers, policymakers in improving the development of infrastructure facilities and attaining the extensive growth which is vital for maintaining the national integration, political stability, unity of the state and more important the equitable growth in the state within the limited capacity of resources.

2.1 Jammu & Kashmir Economy

The Union Territory of Jammu and Kashmir holds significant importance within the Himalayan region due to its diverse demographic and dynamic economic, environmental, social, and political systems. The Indian Himalayan Region encompasses 13 states and union territories, with the union territory of Jammu and Kashmir being a significant component of this region. The Jammu and Kashmir Reorganization Act of 2019 facilitated the process of restructuring the state of Jammu and Kashmir into two separate Union Territories, namely the Union Territory of Jammu and Kashmir and the Union Territory of Ladakh (Jammu & Kashmir Reorganization Bill 2019) .The Union Territory of Jammu and Kashmir is situated in the northern Himalayan region of India. The region under consideration exhibits a population size of 1,226,701 individuals and encompasses a land area spanning 222,236 square kilometers. The Union territory of Jammu and Kashmir is agriculture dominated economy and service oriented in terms of tourism only. Before

the onset of 1989 turbulent period, tourism was the engine of economic growth in the region. Tourism has been recognized as the catalyst for both economic expansion and societal progress. Nevertheless, the advent of militant activities subsequent to the year 1989 has undeniably resulted in a substantial setback thereof and with result that imports account for a substantial 80 percent of the SDP, thereby resulting in a significant leakage effect that has precipitated the low growth of the state. Throughout the annals of history, a resounding testament emerges, attesting to the undeniable correlation between the proliferation of militancy or political instability and the subsequent deleterious impact inflicted upon the economic fabric of the afflicted region(Khan, 2022). The Net state Domestic Product at constant prices during the peak of militancy remain at Rs 1257.47 crores; Rs 1285.35crores;1359.89 corers and 1452.27 crores in the subsequent years of 1988-89; 1989-90; 1990-91 and 1991-91 respectively (Digest of Statistics 2020-21) which is very low. But from the last few years the Net state Domestic Product continuously showing increasing trend and remain 97334.73 crores during the year 2021-22 (Digest of Statistics 2020-21). According to the economic Survey document of Jammu and Kashmir (2022-23), an intriguing revelation emerges regarding the growth trajectory of the region's economy. Between the years 2014-2015 and 2021-22, Jammu and Kashmir experienced a commendable annual compound growth rate of 5.7 per cent. This rate surpasses the national average of 5.1 per cent, as well as the growth rates observed in four other northern states, namely Punjab (4.6 percent), Delhi (5.5 percent), Himachal Pradesh (4.9 per cent), and Uttar Pradesh (4.3 per cent).The Union Territory of Jammu and Kashmir is currently making a noteworthy contribution of 0.8 percent to the Gross Domestic Product, which is in line with its population share of 0.98 percent. The government is presently deliberating on strategies to enhance the Gross State Domestic Product of Jammu and Kashmir, with the ambitious goal of doubling it by the fiscal year 2027-28. Numerous endeavors are being undertaken in diverse sectors such as Agriculture, Horticulture, Tourism, Industries, and Service sectors, with the aim of addressing this matter(Jammu &Kashmir Economy Survey 2022-23).The region of Jammu and Kashmir is currently making significant strides in the realm of infrastructure development, thereby setting new standards and benchmarks in this domain. The fundamental aspects of connectivity, the equitable provision of potable water to all individuals, and the consistent availability of high-quality power supply throughout the day are among the paramount sectors that require immediate attention and focus. The expansion of the road network encompasses all human settlements with a population

exceeding 250 individuals, in accordance with the 2001 Census. This endeavor serves to foster progress and advancement throughout the Union Territory. The imminent development of globally renowned national highways, expressways, tunnels, bridges, flyovers, and ring roads is poised to revolutionise transportation infrastructure. By the end of December 2022 under Pradhan Mantri Gram Sadak Yojana (PMGSY) programme, 97 percent of the homes (2096), covering 17781 km of roads have been linked. When it comes to the total, Jammu & Kashmir has placed third in the nation for two years (2020–21 and 2021–22) in terms of total length of roads built as part of PMGSY (Jammu Kashmir, Economy Survey 2022-23). The anticipated integration of Jammu and Kashmir's railway network with the entirety of India is projected to materialise by the year 2023. Airports are undergoing a process of modernisation and enhancement. Urban development is currently a prominent focus of attention, as evidenced by the implementation of intelligent urbanization initiatives in the capital cities of Jammu and Kashmir. It is highly probable that the power generation capacity will experience a twofold increase within a span of four years, followed by a threefold increase in the subsequent eight years. Two Metropolitan Region Development Authorities have been established to oversee the urban growth and development of the cities of Jammu and Srinagar. The urban local authorities are being incentivized to undertake transformative measures in their operational framework. The initiatives such as My Town My Pride (MTMP) have been warmly embraced by the urban populace, while the rural communities have anxiously anticipated the arrival of Back to Village Four (B2V4) (Jammu Kashmir, Economy Survey 2022-23). The Government of Jammu and Kashmir and central government of India have aspired to attain a state of Sustainable Integrated Development, with a particular emphasis on enhancing Connectivity and establishing Eco-friendly Modern Infrastructure. This endeavour is driven by the objective of meeting the populace's expectations while ensuring a system of Transparent Governance. This ambitious vision is projected to be realised within the span of the forthcoming 25 years. The realization of vision 2047 shall be predicated upon the convergence of tourism, agriculture, horticulture, and power, synergistically amalgamated with enhanced infrastructure, connectivity, logistics, superior health and education provisions and digital governance

3. Data source and Methodology

3.1 Data Sources

In this study, secondary sources of time series data from 2001-02 to 2019-2020 pertaining to infrastructure development indicators, NSDP which is taken as proxy variable of economic growth(followed Henderson et al., 2012 ; Macanas, 2020) population and Per capita NSDP (followed Esfahani & Ramírez2003 and Awan & Anum 2014) were utilized and obtained from the following sources: Directorate of Economics & Statistics, J &K; Indicators of Regional Development (2011–12); Directorate of Economics & Statistics, J&K, 46th edition of Digest of Statistics (2020–21) (refer to Appendix A—Table A₁ &—Table A₂). Henceforth, the following indicators (following Timilsina et al., 2023;Chakamera & Alagidede, 2018; Kaur & Ghuman, 2009) have been employed to compute the amalgamated Time series composite index of infrastructure advancement (Notion of the technique is discussed in below sub-section) in Jammu &Kashmir. Total Install Capacity of Power (MWs); Total Primary Agriculture Credit Societies; Total number of Godowns; Total number of Medical Institutions; Total number of Bed Strength in the Hospitals; Total number of Medical Persons; Total number of education Institutions; Total number of SSI units; Total number of commercial Bank Branches; Total state road Length; Total Road length of National Highways and State Highways; Net irrigated Area (Hectares) and Total number of Post offices.

3.2 Methodology

After careful consideration, it was determined that Principal Component Analysis (PCA) emerged as the most suitable approach for consolidating the diverse array of infrastructure metrics. The utilisation of a frequently employed multivariate methodology is observed, wherein the reduction of data is facilitated, ensuring that solely the most pertinent and significant information is preserved (Karamizadeh et al., 2013; Calderon et al., 20015 ;Davo et al., 2016). Hence, Principal Component Analysis (PCA) effectively extracts pivotal information from a given data-set and represents it in the form of a collection of novel orthogonal variables (Rencher 2003; Abdi & Williams 2010). Furthermore, it is worth noting that Principal Component Analysis (PCA) possesses the capability to unveil underlying structures that may be concealed within the data (Markaki et al., 2014) and it unveils discernible patterns within datasets and facilitates the process of analysis (Unglert al.,2016). Last but certainly not least, it is worth noting that Principal Component Analysis (PCA) effectively mitigates the presence of noise within data by strategically identifying and prioritising the most significant sources of variation. Consequently, this method inherently disregards the comparatively minor fluctuations that may

exist within the background, as elucidated by Karamizadeh et al., (2013). Notwithstanding the aforementioned advantages, we are cognisant of the predicaments associated with PCA. If not meticulously orchestrated, the application of Principal Component Analysis (PCA) may yield outcomes devoid of any discernible economic ramifications, given that the methodology is solely rooted in mathematical principles (Zhang et al., 2015). Notwithstanding, we maintain the conviction that Principal Component Analysis (PCA) possesses the capacity to effectively accomplish our objective. In order to ascertain the suitable weights for the selected indicators, the utilisation of Principal Component Analysis (PCA) has been employed. This decision stems from the method's extensive applicability and its widespread implementation in various other pertinent research endeavors. Principal Component Analysis (PCA) stands as the preeminent statistical methodology for determining optimal weights assigned to selected indicators. Numerous scholars have employed the principal component methodology to allocate weights to selected indicators, as evidenced by the works of Gosh & De (2005); Mohanty & Bhanumurthy (2019) and Raychaudhary & Halder (2009). The selected indicators pertaining to infrastructure exhibit variations in their units of measurement. To address this disparity, we have employed a normalisation technique to render them devoid of any specific unit. Normalisation is a necessary step when dealing with data that is expressed in diverse units, as it enables us to establish a uniform and unit-free representation of the data. The provided information has been subjected to normalisation using the min-max technique, as outlined by Sharpe and Andrews (2012). The chosen indicators of infrastructure have been subjected to normalisation formulas in order to analyse their influence on variables. The normalization technique for selected infrastructure development Indicators is given as below:

$$NZ_i = GA_i - \text{Min}_i / \text{Max}_i - \text{Min}_i$$

Where NZ_i represents the normalised value of a specific indicator pertaining to J & K. GA_i on the other hand denotes the actual value of said indicator. Additionally, Min_i signifies the minimum value observed for the indicator, while Max_i represents the maximum value recorded for the same indicator.

The following formula has been employed in order to compute the weights assigned to the chosen indicators of infrastructure development

$$W_{iID} = \sum_{i=1}^{12} (|C_{in}| \times IEV_n)$$

Where W_{iID} is the weight of the i th indicator of infrastructure development. Specifically, C_{in} represents the n th component of the i th indicator. Additionally, IEV_n represents the total initial Eigen value associated with that particular component.

After calculating weight of every Indicator, the time series composite Index of infrastructure develop has been prepared by using the following formula

$$TCIID = \sum_{i=1}^{12} (|NZ_i| \times W_{iID}) / \sum_{i=1}^{12} W_i$$

Where $TCIID$ is the time series composite Index of Infrastructure Development, NZ_i is the normalized value of the i th indicator of infrastructure development, W_{iID} is the weight of the i th indicator of infrastructure development.

3.3 Model Specification

To examine the impact of Infrastructure development on Economic Growth in Jammu & Kashmir following model Specification has been used by following (Mohanty & Bhanumurthy 2019; Owusu-Manu et al., 2019; Sahoo & Dash, 2009; Awan & Anum 2014) for empirical analysis:

$$LNSDP = \alpha_0 + \alpha_1 LCIID + \alpha_2 LNSDPPC + \alpha_3 LPOPT + \mu_0 \dots\dots\dots (1),$$

Where $LCIID$ = Log of Composite Index of Infrastructure Development; $LNSDP$ = Log Net state Domestic Product; $LNSDPPC$ = Log of NSDP Per captia Income; $LPOPT$ = Log of Population and μ_0 = error term and is presumes to follow a normal distribution. Econometric quandaries such as spurious regression, stationary, autocorrelation, and multicollinearity can be effectively mitigated through the application of various statistical methodologies. Nevertheless, the estimation of mode 1 shall be conducted through the utilization of an econometric technique, employing time series data of Jammu and Kashmir spanning the fiscal years 2001-2 to 2019-20

This study employs the autoregressive distributed lag (ARDL) bounds testing method to estimate equations (1). Its objective is to investigate the impact Infrastructure development one economic growth. The selection of the ARDL methodology for this investigation was motivated by a multitude of advantages. These encompass, but are not limited to, the following: the superiority of the Auto-Regressive Distributed Lag approach over conventional co-integration methods has been widely acknowledged. The efficacy of this approach lies in its inherent flexibility, allowing for its application regardless of the nature of the core regressors, be it purely integrated of order zero $I(0)$, integrated of order one $I(1)$ or mutually co-integrated. Furthermore,

it is of utmost significance and possesses greater credibility when the sample size is limited (Pesaran & Pesaran 1997; Pesaran et al. 2000; Pesaran et al., 2001; Bahmani-Oskooee & Ng 2002). The VAR (Vector Autoregressive) model has demonstrated its efficacy in elucidating the intricate dynamics inherent in economic and financial time series, thereby facilitating accurate forecasting capabilities. Frequently, it yields forecasts of superior quality when compared to univariate time series models and intricate theory-based simultaneous equations models. The flexibility of forecasts derived from VAR models lies in their ability to incorporate conditional considerations regarding the potential future trajectories of specified variables within the model ((Zivot & Wang, 2006. The selection of this particular methodology was predicated upon the advantageous attributes that the Autoregressive Distributed Lag (ARDL) approach proffers with regards to the examination and interpretation of empirical data.

3.4 Granger causality Analysis

The Study also examines the casual relationship between infrastructure development (CIID) and NSDP; per captia NSDP and population for the period 2001-02 to 2019-20. The conventional Granger causality test has been employed to examine the causal nexus between the chosen variables. Prior to conducting the Granger causality test, it was imperative to assess the stationarity properties of the variables through the utilisation of the Augmented Dickey-Fuller test. The establishment of a long run and enduring connection is effectively guaranteed through the utilisation of the Autoregressive Distributed Lag (ARDL) bounds testing methodology. Hence, it becomes imperative to ascertain the orientation of the causal association between the variables under scrutiny, specifically whether it is unidirectional or bidirectional in nature. Hence, an adapted iteration of the Granger causality test, as suggested by Toda and Yamamoto (1995), is employed to investigate the causal direction between Economic Growth, Composite Infrastructure Index, population and Per capita Net state Domestic Product. One notable benefit of this test lies in its applicability to all series, regardless of whether they are of order $I(0)$, $I(1)$, or $I(2)$, and irrespective of their cointegration status. This methodology is employed to estimate a conventional vector autoregressive (VAR) model in the original levels of the variables, regardless of their degree of integration. Hence, the potential risk pertaining to erroneously determining the integration order of the series is mitigated. The initial procedure entails the determination of the order of integration (d_{max}) for the series being analysed, as well as identifying the optimal lag, k . Next, estimation is conducted for a VAR (Vector Autoregressive)

model of order (k+dmax). However, the coefficients of the lagged dmax vector at the final position are disregarded. By employing the Toda and Yamamoto (1995) procedure, one can guarantee that the conventional test statistic for Granger causality adheres to the standard asymptotic distribution, thereby enabling the derivation of valid inferences. The methodology employed by Toda and Yamamoto (1995) is implemented within the framework of a Vector Autoregressive (VAR) system and following models will be established:

For Infrastructure development (CIID)

$$NSDP_t = \alpha + \sum_{i=1}^m \xi_i NSDP_{t-i} + \sum_{i=1}^n \beta_i CIID_{t-i} + \mu_t \quad (2)$$

$$CIID_t = \beta + \sum_{i=1}^m \hat{\alpha}_i CIID_{t-i} + \sum_{i=1}^n \check{\epsilon}_i NSDP_{t-i} + \epsilon_t \quad (3)$$

Where NSDP is Net State Domestic Product, CIID is the Composite Index for Infrastructure Development, μ_t and ϵ_t are the error terms. The following four distinct hypotheses regarding the Causal relationship between CIID and NSDP has been formulated for equation 2 and 3.

1. **Unidirectional Granger causality running from CIID to NSDP:** In this case, CIID Granger causes NSDP and not vice-versa. Thus, $\neq 0$ and $= 0$.
2. **Unidirectional Granger causality running from NSDP to CIID:** In this case, NSDP Granger causes CIID and not vice-versa. Thus, $= 0$ and $\neq 0$.
3. **Bidirectional Granger causality:** In this case, CIID Granger causes NSDP and vice-versa. Thus, $\neq 0$ and $\neq 0$.
4. **No causal relationship between NSDP and CIID:** In this case, there does not exist any Granger causality in any direction. Thus, $= 0$ and $= 0$

For Population (POPT)

$$NSDP_t = \alpha + \sum_{i=1}^m \xi_i NSDP_{t-i} + \sum_{i=1}^n \beta_i POPT_{t-i} + \mu_t \quad (4)$$

$$POPT_t = \beta + \sum_{i=1}^m \hat{\alpha}_i POPT_{t-i} + \sum_{i=1}^n \check{\epsilon}_i NSDP_{t-i} + \epsilon_t \quad (5)$$

Where NSDP is the Net State Domestic Product, POPT is the Population and μ_t and ϵ_t are the error terms. The following four distinct hypotheses regarding the Causal relationship between NSDP and POPT are formulated for equation 4 and equation 5

1. **Unidirectional Granger causality running from POPT to NSDP:** In this case, POPT Granger causes NSDP and not vice-versa. Thus, $\neq 0$ and $= 0$.
2. **Unidirectional Granger causality running from NSDP to POPT:** In this case, NSDP Granger causes POPT and not vice-versa. Thus, $= 0$ and $\neq 0$.

3. Bidirectional Granger causality: In this case, POPT Granger causes NSDP and vice-versa. Thus, $\neq 0$ and $\neq 0$.

4. No causal relationship between NSDP and POPT: In this case, there does not exist any Granger causality in any direction. Thus, $= 0$ and $= 0$

For NSDP Per captia (NSDPPC):

$$NSDP_t = \alpha + \sum_{i=1}^m \xi_i NSDP_{t-i} + \sum_{i=1}^n \beta_i NSDPPC_{t-i} + \mu_t \quad (5)$$

$$NSDPPC_t = \beta + \sum_{i=1}^m \hat{\alpha}_i NSDPPC_{t-i} + \sum_{i=1}^n \check{\epsilon}_i NSDP_{t-i} + \epsilon_t \quad (6)$$

Where NSDP is the Net State Domestic Product, NSDPPC is the Population, μ_t and ϵ_t are the error terms. For equation (5) and (6) we can formulate four distinct hypotheses regarding the Causal relationship between NSDP and NSDPPC

1. Unidirectional Granger causality running from NSDPPC to NSDP: In this case, NSDPPC Granger causes NSDP and not vice-versa. Thus, $\neq 0$ and $= 0$.

2. Unidirectional Granger causality running from NSDP to NSDPPC: In this case, NSDP Granger causes NSDPPC and not vice-versa. Thus, $= 0$ and $\neq 0$.

3. Bidirectional Granger causality: In this case, NSDPPC Granger causes NSDP and vice-versa. Thus, $\neq 0$ and $\neq 0$.

4. No causal relationship between NSDP and NSDPPC: In this case, there does not exist any Granger causality in any direction. Thus, $= 0$ and $= 0$

4. Results and Discussion

4.1 Results of the PCA (Principal Component Analysis) of Infrastructure Indicators

By following the Strategy of Calderon & Servén (2004) and Sanchez-Robles (1998) the utilization of Principal Component Analysis (PCA), as discussed in the sub section 3.2, has been employed to assign appropriate weights to the selected indicators of infrastructure development. Prior to conducting the analysis, it is imperative to employ the normalization technique in order to eliminate the different units associated with the selected indicators (refer to Appendix A—Table A2). Subsequently, the Kaiser-Meyer-Olkin (KMO) Barlett's Tests of statistics are performed to assess the suitability of factor analysis for the dataset (refer to Table 1). Based on the findings presented in Table 1, it can be deduced that the KMO ($p > 0.5$) and Bartlett's test ($p < 0.05$) are statistical significance, therefore these results affirm the feasibility of employing principal component factor analysis in the given context. The Table 2 presents the outcomes of the principal components analysis, encompassing factor loadings, Eigen values, Communalities

and computed weights. The application of the Eigen value rule has been utilized to determine the appropriate quantity of principal components to be selected for the purpose of extracting weights. It is pertinent to note that only those principal components that possessed Eigen value equal to or greater than 1 have been extracted and subsequently utilized to determine the weights. The PCA technique has the capability of reducing the dimensionality of the data by using the Eigen value extraction method (Zeng et al., 2017) .The Table 2 exhibits the presentation of three primary Principal Components, the Eigen value of which are greater than 1.The cumulative contribution of these three primary components accounts for 82.485% of the overall variance in the data. Specifically, the initial component elucidates 55.613% of the variation, while the second and third component accounts for 18.123% and 8.749 of the variation respectively. The table also demonstrates that the Communalities exhibit a notable magnitude, spanning from 0.453 to 0.985 thereby signifying a robust relationship among the selected Indicators employed for assessing infrastructure development. The factor loading, as illustrated in Table 2, elucidates the extent of association between the selected variables with each of the three principal components.

Table 1 KMO and Bartlett Test

KMO and Bartlett's Test	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	.651
Bartlett's Test of Sphericity	.000

Source: Authors Calculation

Table2 Principal Components along with Eigen Values & Communalities and Weight of Chosen Indicators

Rotated Component Matrix				Communalities	Initial Eigen value			Weight
Indicator	Component				1 (7.230)	2 (2.356)	3 (1.137)	
	Loading 1	Loading 2	Loading 3					
Total Install Capacity of Power	.914	-.310	.097	.940	6.608	0.730	0.110	7.4483
Total Primary Agriculture Societies	-.197	.924	.099	.903	1.424	2.177	0.113	3.714

Total number of Godowns	-.269	.006	-.617	.453	1.945	0.014	0.702	2.661	
Total number of Medical Institutions	.962	-.064	-.069	.934	6.955	0.151	0.078	7.184	
Total number of Bed strength in Hospitals	.865	-.464	.110	.975	6.254	1.093	0.125	7.472	
Total number of Medical Persons	.839	-.020	.183	.737	6.066	0.0471	0.208	6.3211	
Total number of Education Institutions	-.048	.029	.829	.690	0.347	0.068	0.943	1.358	
Total number of Small scale Industries	-.263	.655	-.251	.562	1.901	1.543	0.285	3.729	
Total number of Commercial Banks	.948	-.289	.043	.985	6.854	0.680	0.049	7.583	
Total StateRoadLength	.902	-.169	.308	.938	6.521	0.398	0.350	7.269	
Total road length of State and national highways	.940	-.272	.059	.962	6.796	0.641	0.067	7.504	
Total number of post offices	-.094	.912	.094	.848	0.679	2.149	0.679	3.507	
Total net irrigated Area	.732	.479	.179	.797	5.292	1.129	0.204	6.625	
Percentage of Variance	55.613	18.123	8.749						ΣW=72.3754
Cumulate Variance	55.613	73.737	82.485						
Eigen Value	7.230	2.356	1.137						

Source: Authors Calculation

Notes: Extraction method: principal component analysis; rotation method: Varimax with Kaiser Normalization

The results indicate in the table 2 reveals that the total number of Medical Institutions(.962) has the highest loading with the first Principal Component first principal and thus has the strong correlation with the Component first. The other indicators that exhibit the highest loading with the first principal component are the total number of Commercial banks (.948), total state road length (.902), total road length of state and national highways (.940) and total Install Capacity of power (.914). The variables that exhibit a strong correlation with the second principal component are the aggregate number of Post offices (0.912) ,total number of small scale Industries(.655) & total number of Primary agriculture societies(924) and the Indicator that shows strong correlation with the third component are total number of education Institutions(.829). The assigned weights for the selected infrastructure indicators exhibit a range spanning from 1.358 to 7.583 From the table it becomes apparent that the total number of commercial banks has the maximum weight (7.583) while total number of education Institutions has the lowest weight(1.358) .Thus aforementioned findings of Principal Component Analysis (PCA) elucidate that the total number of commercial banks , total road length of State and national highways ,total Install Capacity of Power and total number of bed strength in Hospitals are the paramount variables in unveiling the time dimension infrastructure disparities within the context of Jammu and Kashmir. These results are in line with the study conducted by (Chotia & Rao, 2015).

Moreover the calculated time series composite Index of Infrastructure development ranging from 0.1138 to 0.8037 and net state domestic Product along with growth rate from 2001-02 to 2019-2020 is shown in the table 3. It is evident from the table the overall infrastructure composite Index and NSDP shows upward trend during the period of analysis. The year 2018-2019 has the highest index value with 0.8029, followed by year 2017-18 and 2016-17 respectively. The NSDP grew at an average growth rate of 11 percent from Rs14184.90 to 90791.49. The year 2014 – 15 and 2019-20 shows decreasing annual growth rate of NSDP in the Jammu & Kashmir; this may is due the worst floods that hit the Jammu & Kashmir and causes nearly five corer loss to the state economy(The Hindu 2014; Malik & Hashmi 2021) and due to the changing of erstwhile state into union territory(Jammu & Kashmir Reorganization Bill 2019) that cause the lockdown entailed restrictions in the Kashmir Valley and negatively impact the state economy of Jammu and Kashmir(Shah & Akhoon2022) respectively.

Table3 Time Series Composite Index of Infrastructural Development & GSDP and Annual Growth of Index and GSDP

Year	NSDP	GRNSDP	Index Value	Growth of Index Value
2001-2002	14184.90		0.1138	26%
2002-2003	14907.16	5%	0.1433	39%
2003-2004	15673.17	5%	0.1995	12%
2004-2005	23292.21	49%	0.2234	14%
2005-2006	24371.09	5%	0.2552	-7%
2006-2007	25794.32	6%	0.2370	-1%
2007-2008	27387.31	6%	0.2336	-7%
2008-2009	29102.03	6%	0.2164	16%
2009-2010	30513.15	5%	0.2520	23%
2010-2011	32255.89	6%	0.3096	18%
2011-2012	65319.61	103%	0.3653	5%
2012-2013	67315.56	3%	0.3829	36%
2013-2014	70535.83	5%	0.5220	18%
2014-2015	67153.76	-5%	0.6175	16%
2015-2016	80602.31	20%	0.7133	12%
2016-2017	82635.73	3%	0.7954	1%
2017-2018	87550.73	6%	0.8029	0%
2018-2019	95208.37	9%	0.8037	-20%
2019-2020	90791.49	-5%	0.6444	
Average Annual Growth Rate of NSDP=			11%	

4.2 Empirical Analysis

After analyzing the trends in NSDP and infrastructure Index, this study applies the unit root test to scrutinize the stationarity of the variables. Prior to assessing the inferential estimation between variables, it is imperative to meticulously scrutinize the time series properties linked to said variables. The fundamental aim of this endeavour was to tackle the inherent constraints of the ARDL model, which demonstrates compatibility with variables of integrated order zero (I (0))

and integrated order one (I (1)), but falls short in accommodating variables of integrated order two (I (2)) (Pesaran et al., 2001). This investigation employs the Augmented Dickey-Fuller (ADF) tests to examine the stationarity of the variables. The null hypothesis of the ADF unit root test posits that the series under consideration possesses a unit root, thereby indicating its non-stationarity. The outcomes of the unit root test are eloquently displayed in the below table 4.

Table 4: Results of the Augmented Dickey-Fuller test

Variable	ADF(At level)	ADF(At first Difference	Order of Integration	
LNSDP	-2.2863*	-4.6876*	I(1)	
LCIID	-3.6442*	-12.0322*	I(0)	
LNSDPPC	-1.8095*	-4.5956*	I(1)	
LPOPT	-1.4573*	-2.5233*	I(1)	

Source: Authors calculation

Note. The refutation of the null hypothesis is predicated upon the utilization of critical values as established by MacKinnon (1996). The determination of the lag length is predicated upon the utilisation of the Schwartz Information Criterion (SIC), a comprehensive metric that encompasses a spectrum ranging from lag zero to lag two. The utilisation of the symbols *, **, and *** serves as an indication of the repudiation of the null hypothesis pertaining to non-stationarity, with the respective levels of significance being 1%, 5%, and 10%.

The results of ADF test reveal that the variables LCIID exhibit stationarity at the level while the remaining variables LNSDP, LNSDPPC and LPOPT exhibit a stationary behaviour at first difference. The findings derived from the unit root analysis suggest that the variables under investigation in this specific study demonstrate a convergence of stationary tendencies, which can be described as a blend of both I (0) and I(1) processes. Consequently, the utilisation of the Auto Regressive Distributive Lag Model (ARDL) appears to be a suitable econometric procedure in order to circumvent the occurrence of spurious outcomes of regression. The present study employs a methodology that entails the utilisation of a co-integration test within a bounds framework. This methodology is based on the premise of scrutinising and contrasting the maximum limit values alongside the corresponding computed F values. If the computed F ratio exceeds the predetermined upper bound value, commonly referred to as the critical value, it can be inferred that the vectors in question are deemed to be co-integrated. The Wald test is commonly employed as a means of assessing the presence of co-integration.

In order to assess the statistical significance of the lagged level variables in equation 1, we shall employ either the Wald coefficient test or the joint significance F-test. The null hypothesis posits that equation 1 is devoid of any long-term variables or variables from the previous period, as they do not have a collective influence. We engage in the application of the Wald test methodology to assess the significance of lagged level variables, subsequently computing the F-statistics. The computed F-statistics shall be juxtaposed with the Tabulated F-statistics. The inception of the table was pursued by Pesaran et al. in the year 2001. The tabulated F-statistics are accompanied by two critical bounds, specifically the lower bound $I(0)$ and the upper bound $I(1)$. If the computed F-statistic surpasses the upper threshold, it indicates the existence of a long term relationship within the variables. If the calculated F-statistic falls below the lower threshold, it can be deduced that a long term relationship does not exist. Conversely if the calculated value reside within the spectrum delineated by the two boundaries, the resultant conclusion remains indeterminate. The outcomes of the Wald coefficient examination for all lagged explanatory variables utilised in equations 1 are displayed in table 1.4. The null hypothesis postulates that the lagged coefficient of explanatory variables is equal to zero or nonexistent within the model. If we refrain from rejecting the null hypothesis, it signifies the absence of a sustained relationship between the variables over an extended long period of time.

Table 5: The Results of the Bound (Wald) Test pertaining to Co-integration

Equation	F-Statistics	Upper bound(Critical Values)	Outcome
Model Specification 1	5.218 (0.0007)	3.78 (95%)	Existence of Co-integration

Source: Authors calculation. Note The critical values corresponding to $k = 6-1 = 5$ and $k = 4-1 = 3$ are referenced from the scholarly work of Pesaran et al. (1999), specifically Table CI (iii), under Case 111, which pertains to the scenario of an unrestricted intercept and the absence of a trend. The numerical values enclosed within parentheses denote the probabilities associated with the F-statistic.

Based on the ARDL approach, the explanatory variables in equation 1 demonstrate a long-term association with the targeted explanatory variables due to the fact that the estimated F value surpasses the upper limit threshold. The null hypothesis, which posits the absence of co-integration, is deemed inadequate and thus cannot be accepted. Instead, it is evident that a long-term relationship does indeed exist among the variables under scrutiny. The table 6 below

illustrates the co-integration of the variables in equation 1, thereby indicating that enquiries pertaining to the long-term relationships between these variables are not spurious.

Table 6: Co integration test results in Long-run

Dependent Variable= LNSDP			
Independent Variable	Coefficient	Standard Error	Prob.
Constant	37.148***	3.7890	.000
LCIID	0.2317***	0.061017	0.005
LNSDPPC	2.003***	0.27925	.001
LPOPT	0.5839***	0.14816	.002

Authors Calculation

Based on the findings presented in Table 6, it is evident that the regression coefficient pertaining to the infrastructure development index (LCIID) stands at 0.2317. This signifies that a mere one percent augmentation in infrastructure development leads to a notable 23.17 percent rise in the Net State Domestic Product (GDP) and this effect is statistically very significant. This empirical finding aligns seamlessly with the study of Fosu & Twumasi(2022), wherein they revealed that an 1 % increase in aggregate infrastructure index creates 0.011 per cent economic growth in US economy and Sahoo & Dash (2009) revealed the positive impact of Infrastructure development index on economic growth in India. The other empirical studies which are inline our finding are Srinivasu and Rao (2013) (Calderón ,2009 Chakamera & Alagidede (2017). Furthermore, it has been duly noted from the table 6 that the regression coefficient pertaining to the population variable (LPOP) exhibits a value of 0.5830, which implies that a mere one percent augmentation in population yields a commensurate 0.58 percent escalation in the net state domestic product (NGDP) and this impact is significant. This result is in line with the previous studies of Befikadu & Tafa(2022) and Sahoo & Dash, (2009), which shows that one percent increase in population creates 39% in economic growth in Ethiopia by using the ARDL model.

and increase in labour have positive impact on economic growth in India respectively. From the table 6 it is also revealed that the coefficient value pertaining to NSDP per capita is the 2.003 which shows that one unit increase in NSDP per capita will result in a corresponding augmentation of 2.0 percent in overall NSDP in the Jammu & Kashmir and thus confirms a affirmative influence of per capita income on the NSDP of the economy.

Table7: Short-run outcomes of the co integration test

Variable	d(LNSDP)	Standard Error
Constant	37.67	5.870
d(LNSDP1)	0.273	0.096
D(LCHID)	0.039	0.126
d(LNSDPPC)	0.207	0.598
D(LPOPT)	0.571	0.223
ECM(-1)	-0.516	0.113
Durbin Watson=1.608; R-Square=0.81 ; Adjusted R- Square=0.73 Akaike Information Criterion(AIC)=51.74; Schwarz Bayesian Criteria =43.47		

Source: Authors Calculation

The Table7 presents the outcomes observed in the short run, as this analysis holds significance in illustrating the response mechanisms that occur when there are shocks or imbalances in the variables under scrutiny in the current study. In essence, the short-term analysis pertains to the quantification of error mitigation within a specified time interval. In order to ensure the validity of the research findings, this study employed the error correction model within the autoregressive distributed lag framework to conduct a short-term analysis. The results of the short-term analysis are displayed in table7 .Based on the obtained results, it can be c deduce that the't' ratio pertaining to the error correction coefficient exhibits statistical significance. This indicates that there prevails a short-term relationship between the variables of interest within the duration of the study. The findings indicate that the error correction term (ECM) coefficient displays a negative sign. This observation demonstrates the high efficacy of the responsive mechanism and the convergence is observed in our model from the short run to the long run equilibrium in

Jammu and Kashmir. It is commonly referred to as the rate of adaptation. The findings suggest that the coefficient of $ecmt-1$ in the short-run model is -0.516, indicating a correction rate of 51.6% from the short run to the long run

Table 8 Results of Granger Causality Test

Null hypothesis	Lags	N	F -statistics	Prob.	Outcome
Composite Index of Infrastructure does not Granger cause NSDP	2	19	4.73**	0.023	Reject the Null Hypothesis
NSDP does not Granger cause Composite Index of Infrastructure Development	2	19	0.93	0.2901	Failed to Reject the Hypothesis's
NSDP does not Granger cause Population	2	19	0.81	0.4321	Failed to Reject the Null hypothesis
Population does not Granger cause NSDP	2	19	2.61**	0.0422	Reject the Null Hypothesis
NSDP does not granger cause Per capita Net state Domestic Product	2	19	6.43*	0.0942	Reject the Null Hypothesis
Per capita Net State Domestic Product does not Granger cause NSDP	2	19	9.48***	0.0942	Reject the Null Hypothesis

Source:Authors Calculation Notes: significant at 1%*** level; 10%* level; ** 5%** level.

The outcomes of the Granger causality testing are presented in Table 8. The selection of the most suitable lag length has been determined by employing the Akaike Information Criterion (AIC), which has yielded a value of two. The findings suggest that there exit a unidirectional causal relationship between the composite index of infrastructure development and Net State Domestic product (NSDP). The directionality of causation is observed to flow from

infrastructure to Net State Domestic product (NSDP), with no evidence of reverse causality being identified. Therefore, the Net State Domestic product (NSDP) is contingent upon the progress and investment in infrastructure development. This suggests that the availability of infrastructure such as total Install Capacity of power, total primary agriculture Societies, total number of godowns, total number of medical institutions, total number of bed strength in hospitals, total number of medical persons, total number of education institutions, total number of small scale industries, total number of commercial banks, total road length, total number of post offices and total net irrigated area significantly influence the level of NSDP (a proxy for economic growth) in the region of Jammu & Kashmir. This finding (Causality between infrastructure and economic growth) are in line with previous studies of (Sahoo & Dash 2009; Gosh 2020 & Chakamera & Alagidede 2018). Next from the table 8 it revealed that there is a bi-directional relationship exist between Per capita NSDP and NSDP in Jammu and Kashmir, which means increase in NSDP enhance the Per capita NSDP & Vice versa and lastly from the table 7 it is also revealed that there exist unidirectional relationship NSDP and population and causality running from Population to NSDP, while NSDP does not possess the ability to Granger cause population. Based on the empirical analysis conducted using the granger causality test, we have arrived at the conclusion that the null hypothesis, which posits the absence of a causal relationship between population and NSDP is to be rejected. Hence, we have discovered a unidirectional causal relationship wherein population in the region of Jammu & Kashmir positively influences NSDP. The findings align with prior research conducted by (Savaş 2008; Chang et al., 2017)

5. Conclusion and Policy Implications

The primary aim of this study was to investigate the influence of infrastructure on the phenomenon of economic growth. This analysis was based on annual data spanning from 2001-02 to 2019-2020, and employed the principal component analysis technique as well as the VAR estimation method. The study encompassed a range of infrastructure metrics, specifically pertaining to roads, banking, storage facilities, health, education and small scale industries. This comprehensive approach was adopted to ensure a more comprehensive understanding of the overall infrastructure landscape. The Principal Component Analysis (PCA) methodology was employed to create an index or composite measure of infrastructure. This approach effectively

minimized the complexity and interdependence of the various infrastructure variables by reducing their dimensionality and correlation. The empirical findings, presented in this study suggests that the advancement of infrastructure holds a pivotal and substantial position in fostering economic progress within the Union territory of Jammu and Kashmir in long run by creating 23.17 per cent increase in Net state Domestic Product (NSDP) when infrastructure is increased by one per cent and findings also demonstrate the unidirectional relationship running from infrastructure to economic growth (Proxy-NSDP). Moreover study also reveals that one per cent increase in NSDP per capita and one per cent increase in population leads to 2 and 0.58 per cent increase in NSDP of the UT of Jammu and Kashmir respectively. The presence of an error correction term suggests that a long-term relationship is inherently stable, and any temporary imbalances that arise in the short run will eventually be rectified over time. The previous scholarly enquiries have delved into the ramifications of infrastructure on the advancement of economies at the country level or at macro -level; this particular study distinguishes itself by scrutinizing the consequences of multiple infrastructure indicators on economic growth through the employment of Principal Component Analysis (PCA) and Vector Auto regression (VAR) estimation strategy at the State level(Micro-level). The aforementioned findings of the study possess discernible policy implications for both the central and state governments, as well as for the existing decentralised system within the Union Territory of Jammu and Kashmir. The findings suggested that the implementation of economic policy measures aimed at enhancing infrastructure development in Jammu and Kashmir ,and setting of policy priorities and the strategic allocation of public investments towards sectors with the greatest potential for growth would effectively enhance both regional and national economic prospects. In this regard, the augmentation and enhancement of the roads, storage facilities, banking, education Institutions, and SSI units would facilitate the establishment of efficient and competitive markets, as well as the dissemination of economic progress. The implementation of effective project identification, efficient construction completion, proper service operation and organization, and consistent maintenance are essential for fostering a competent infrastructure in the J&K economy. This infrastructure serves as the foundation upon which the 'superstructure' can be built, enabling the achievement of sustained economic growth objective.

Though revealing the remarkable outcomes from this study, the key drawback of this study is the omission of telecommunication indicators, due to the non availability of time series data on these

indicators in Jammu and Kashmir. Furthermore, certain deficiencies may be discerned within the quality metrics, as delineated by Calderon and Servén in (2004). This particular aspect has posed a formidable obstacle within the existing body of scholarly literature. We propose that forthcoming investigations should endeavor to ascertain enhanced metrics for evaluating the quality of infrastructure. The study presents an opportunity to delve into the efficacy of hybrid indices in assessing the performance of distinct infrastructure sectors on economic growth. Despite having certain limitation, the findings of this study have the impending to function as a valuable set of policy recommendations for Jammu and Kashmir economy and other economies as well.

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