6 Does Infrastructure Investment Lead to Economic Growth?

Evidence from Central Asian Countries

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6.1 Introduction

This chapter explores the relationship between infrastructure investment and economic growth in Kazakhstan, Tajikistan, Uzbekistan, the Kyrgyz Republic, and Uzbekistan. The countries are rich in natural and human resources but quite diverse in terms of their stages of development despite their shared history as a part of the Soviet Union. Following independence, Kazakhstan and Turkmenistan moved to the upper-middle-income group, while the Kyrgyz Republic, Tajikistan, and Uzbekistan remained in the lower-middle income category. One of the obstacles faced by these landlocked countries is the lack of well-developed infrastructure. Since these countries are landlocked, intra-regional trade is a significant challenge due to various cross-border regulations, with limited transportation connections inside and outside the region. Despite some infrastructure investment in the last quarter-century, the lack of connectivity between Central Asia and the outside world remains a significant obstacle to trade and economic development (Batsaikhan and Dabrowski 2017). Similarly, as these economies are primarily dependent on the exports of oil, natural gas, metals, and agricultural raw materials, the development of infrastructure is crucial to obtain higher economic growth.

The trends in investment in infrastructure and the number of related projects show a high variation during the last two decades (Figure 6.1). One of the major bottlenecks for infrastructure investment is higher fiscal deficits and other budgetary constraints. The Asian Development Bank estimates that the countries of Central Asia require the investment of $33 billion for infrastructure development by 2030 to meet their domestic and international demand (ADB 2019). In this scenario, it is important to know how infrastructure investment affects regional economic growth.

Infrastructure reduces the cost of transportation and facilitates the mobility of goods and labor and the realization of economies of scale. It also enhances productivity and generates employment opportunities (Javid 2019). Further, increased public investment in infrastructure improves the business environment

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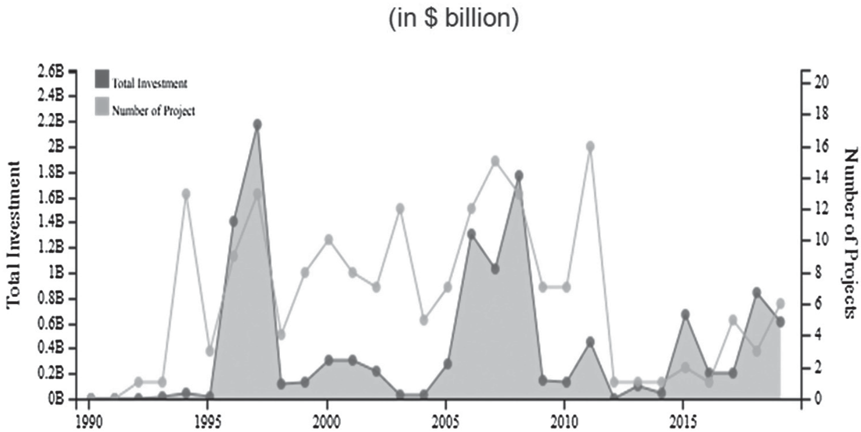

Figure 6.1 Trends in Central Asian Investment in Infrastructure and Number of Projects, 1990–2018 (in $ billion).

Source: World Bank.

of a country and thereby encourages the private sector to expand their economic activity (Aschauer 1989; Abiad et al. 2016). However, the impact of infrastructure investment on economic growth can vary across economies as well as different sectors of the economy. The empirical findings of the existing studies do not reveal any consistent patterns. For instance, a positive relationship is established between public infrastructure investment and economic growth by Aaron (1990) and Nourzad and Vriese (1995), whereas Pritchett (1999) finds that public investment in infrastructure may not produce a positive impact and can even adversely affect economic growth if these investments are inefficiently managed and crowd out private investment due to higher fiscal deficits. Some studies show a non-linear relationship between these two, stating the actual economic benefits of infrastructure investment may be observed after a certain level of threshold (Sutherland et al. 2009). Some studies even established a strong relationship running in reverse, from economic growth to infrastructure investment (Munnell 1992). It might well be the case that high gross domestic product (GDP) and high infrastructure investments are correlated without a causal relationship, which has important implications for public policy. Given these inconclusive findings from the existing literature, the present study repositions the infrastructure investment and economic growth relationship using Central Asian economies as an underexplored example. More specifically, the study addresses the following questions: 1) does higher investment in infrastructure lead to higher economic growth? and 2) is there any by-directional relationship between these two?

Our approach toward examining the above issues is as follows. We use quarterly data from 1990 to 2018 and the Autoregressive Distributed Lagged

(ARDL) approach to cointegration to test the long-run relationship between output and infrastructure investment. Our findings suggest that infrastructure investment has helped to achieve economic growth in Kazakhstan, Tajikistan, and Uzbekistan, while in the case of the Kyrgyz Republic, economic growth drives the infrastructure investment. Our findings also suggest that there is a bi-directional relationship between economic growth and infrastructure investment in the case of Uzbekistan.

The rest of the chapter is organized as follows. Section 6.2 presents the definition of infrastructure and its measurement issues. Section 6.3 and 6.4 provides a brief snapshot of infrastructure in Central Asia and a review of literature, respectively. Section 6.5 presents the empirical model and data, and section 6.6 presents the econometric methodology. Empirical findings and conclusions are given in sections 6.7 and 6.8.

6.2 Infrastructure: Definition and Measurement Issues

In both the theoretical and empirical literature, there is no universally accepted definition of infrastructure. Hasan (2017) states that "there is no single way or international best practice to measure infrastructure investment" due to the lack of aggregate data. Thus, infrastructure is often considered a specific type of capital asset that is used to produce services fundamental to sectors like transport, energy, water, telecommunications, education, or healthcare. It is argued that the development of these types of capital assets can influence economic growth directly and factor productivity indirectly (Feng and Wu 2018). Therefore, the lack of infrastructure could create several obstacles for an economy, and hence an accurate measurement is crucial for policy action. Nevertheless, the lack of a widely accepted definition could yield more difficulty in measuring infrastructure accurately. A detailed explanation of the various challenges in measuring infrastructure was provided by Välilä (2020).

Table 6.1 broadly classified the measurement problem into a definitional issue and appropriateness of data. The first classification is associated with "a lack of an unambiguous definition," i.e., what exactly infrastructure covers, which forces researchers to quantify it using various proxies. For instance, "public investment" is commonly used to measure infrastructure due to the easy availability of data. Public investment refers to the capital expenditure on physical infrastructure (roads, government buildings, etc.) and soft infrastructure (human capital development, innovation support, research, and development, etc.) with a productive use that extends beyond a year and comprises both direct and indirect investment. Direct investment is defined as gross capital formation and acquisitions, less disposals of non-financial, non-produced assets during a given period, whereas indirect investment is defined as capital transfers, i.e., investment grants and subsidies in cash or in-kind made by subnational governments to other institutional units. While public investment measurements vary across countries, gross fixed capital formation is often used as the best available proxy for direct public investment (OECD 2014).

Table 6.1 Challenges in Measuring Infrastructure

Measurement Problems	*Proposed Solutions*	*Problems with Proposed Solutions*
Lack of unambiguous definition	a) Government investment or public capital as a proxy b) Consider a subset of individual sectors	a) Only part of government investment or public capital comprises infrastructure; exclude non-government infrastructure b) Conclusions limited to the sectors considered
Lack of appropriate data	c) Estimate aggregate-level stocks from investment flows d) Use physical (sectoral) measures e) Use project-level data	c) Extensive assumptions required d) Do not measure quality or value e) No centralized source; commercial confidentiality

Source: Välilä (2020).

The use of public investment is associated with implicit assumptions such as: first, a large amount of infrastructure originates from the government; and second, government investment mostly includes support (Välilä 2020). However, the lack of accuracy of these implicit assumptions makes it difficult to differentiate between government investment and government infrastructure investment. Further, the terms "public investment" and "public capital" are used interchangeably in the empirical literature, which should not be automatically considered as a good proxy for infrastructure development. The exclusive focus on government infrastructure and capital also leaves out private infrastructure investment and capital, a major omission in the infrastructure basket. To overcome this problem, many researchers have looked into the infrastructure sub-sectors, such as transport, energy, telecommunications, water, and sanitation. However, this approach is associated with the consistent availability of data, which subsequently leads to the second classification, i.e., lack of appropriate data. These sub-sectoral data are often limited and less accurate for both developed and developing economies. Finally, due to the above issues, another option is to utilize the project-level data related to infrastructure. However, as most of the project-specific information is sensitive to commercial consideration, the complete details are not publicly available to maintain confidentiality (Välilä 2020).

6.3 A Brief Snapshot of Infrastructure of Central Asia

Though the Central Asian countries, rich in resources and human capital, have adopted various reforms to alleviate poverty, they are still unable to attain higher economic growth. The average growth rate of Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan over three decades is 2.162%, 2.953%, 1.923%, 5.599%, and 4.338%, respectively. The growth rate of Turkmenistan is the

Table 6.2 Key Macroeconomic Indicators for Central Asian, Emerging Asian, and Developed Countries, 1997–2019

Indicators	*GDP growth rate (%)*	*Per capita GDP (in $)*	*Current account balance (% of GDP)*
Central Asian Countries			
Kazakhstan	2.953	7,096.69	-1.414
Kyrgyz Republic	1.720	816.462	-7.245
Tajikistan	1.854	701.392	-7.594
Turkmenistan	5.752	3,838.084	-3.566
Uzbekistan	4.215	1,379.754	2.214
Emerging Asian Countries			
PRC	9.432	3,256.01	3.377
India	6.333	1,105.193	-1.350
Indonesia	4.940	2,723.897	0.408
Advanced Countries			
Japan	1.135	43,327.93	2.879
UK	2.033	36,782.55	-3.073
US	2.467	45,197.56	-3.319

Source: Authors' calculation from World Economic Outlook, International Financial Statistics, and Balance of Payment Data. https://data.imf.org (accessed 18 March 2020).

Note
The GDP growth rate is expressed in terms of percent change to the previous year, whereas the current account is expressed in terms of percent of GDP. The per capita GDP is expressed in terms of US dollars.

GDP = gross domestic product, PRC = People's Republic of China, UK = United Kingdom, US = United States.

highest, whereas Tajikistan's remains low. The economic growth rate of Kazakhstan, the Kyrgyz Republic, and Tajikistan is small in comparison to Turkmenistan and Uzbekistan. Although the economic growth rate has increased for all these economies during 2010–2018, the growth rates of Kazakhstan (4.466%), and the Kyrgyz Republic (4.064%) are low in comparison to Tajikistan (7.034%), Turkmenistan (8.988%), and Uzbekistan (6.738%). Asymmetric infrastructure development may have resulted in growth difference across these countries.

Table 6.2 depicts the key macroeconomic indicators of these five countries, such as GDP growth, per capita income, current account balance, and international reserves. Kazakhstan and Turkmenistan's per capita GDP ($7,096.90 and $ 3,838.00, respectively) are much higher than the emerging Asian economies. By contrast, the Kyrgyz Republic and Tajikistan have the lowest per capita income in the region. More interestingly, most of these economies experienced high current account deficits except for Uzbekistan during 1997–2019, as compared to selected emerging economies (People's Republic of China [PRC], India, and Indonesia) and advanced economies (Japan, the United Kingdom [UK], and the United States [US]). The Kyrgyz Republic and Tajikistan incurred current account deficit of more than 7% of GDP, which needs to be financed using

Table 6.3 Net Official Development Assistance Received, Central Asian and Selected Emerging Asian Countries, 1993–2018

Variables	*Net official development assistance (% of GNI)*
Central Asian Countries	
Kazakhstan	0.392
Kyrgyz Republic	9.481
Tajikistan	7.293
Turkmenistan	0.584
Uzbekistan	0.850
Emerging Asian Countries	
PRC	0.133
India	0.254
Indonesia	0.473

Source: Authors' calculation from World Development Indicators Data. https://databank.worldbank.org/source/world-development-indicators (accessed 18 March 2020).

Note
GNI = gross national income, PRC = People's Republic of China.

domestic or foreign savings, and which restrict the government from undertaking any long-term infrastructure investment.

Table 6.3 shows the net official development assistance (ODA) for these five countries, with the Kyrgyz Republic (9.5%) and Tajikistan (7.3%) being the highest recipients of gross national income (GNI). The net ODA received by Kazakhstan, Turkmenistan, and Uzbekistan is low in comparison to the Kyrgyz Republic and Tajikistan, but high in comparison to other emerging countries. Moreover, Figure 6.2 shows that during 1999, the Kyrgyz Republic and Tajikistan received ODA of more than 17% and 10%, respectively, of GNI. As the purpose of ODA is mostly infrastructure development, these economies' infrastructure investment may be highly dependent on it. By contrast, Kazakhstan, Turkmenistan, and Uzbekistan are far behind receiving the assistance, indicating higher dependence on public infrastructure.

Table 6.4 details private participation in infrastructure (PPI), showing the number of projects and sectors that receive the highest investment in these five countries as compared with emerging ones such as the PRC, India, Indonesia, which receive much more. Among the Central Asian economies, Kazakhstan is associated with the highest number of projects (42) and the highest total investment ($5.12 billion). In contrast, the Kyrgyz Republic has the lowest total investment ($140 million), with six projects only. We can see that electricity occupied major investments in most cases, indicating that the power sector is the primary attraction for private investment in most countries. Further, the PRC has attracted high PPI in the road transport sector. From a policy perspective, Central Asian countries should improve PPI in all sectors to promote infrastructure.

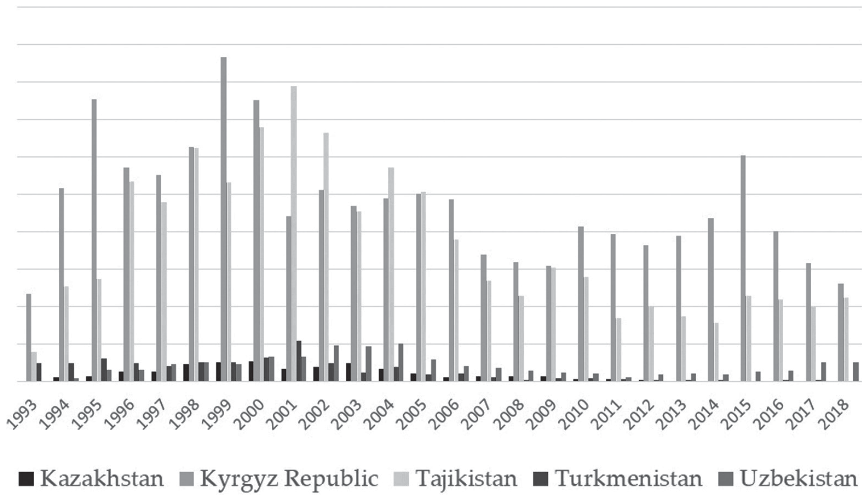

Figure 6.2 Net Official Development Assistance Received by Central Asian Countries, 1993–2018 (% of GNI).

Note: GNI = gross national income.

Source: World Development Indicators.

Table 6.4 Private Participation in Infrastructure, Central Asian and Selected Emerging Asian Countries, 1990–2019

Countries	*Total Number of Projects*	*Total Investment (in US$ billions)*	*Sector with Higher Investment*
Central Asian Countries			
Kazakhstan	42	5.12	Electricity
Kyrgyz Republic	6	.140	ICT
Tajikistan	5	.961	Electricity
Uzbekistan	7	.370	ICT
Emerging Asian Countries			
PRC	1,768	226.7	Roads
India	1,086	270.5	Electricity
Indonesia	141	67.5	Electricity

Source: World Bank-Private Participation in Infrastructure Database. https://ppi.worldbank.org/en/ppi (accessed 18 March 2020).

Note
ICT = Information and Communications Technology, PRC = People's Republic of China.

Table 6.5 World Bank Logistic Performance Index (Infrastructure) Score and Rank for Central Asian, Selected Emerging Asian, and Advanced Countries

Year	*2010*		*2014*		*2016*		*2018*	
Countries	*Score*	*Rank*	*Score*	*Rank*	*Score*	*Rank*	*Score*	*Rank*
Central Asian Countries								
Kazakhstan	2.66	57	2.38	106	2.72	68	2.55	81
Kyrgyz Republic	2.09	118	2.05	147	1.96	150	2.38	103
Tajikistan	2.00	127	2.36	108	2.13	130	2.17	127
Turkmenistan	2.24	101	2.06	146	2.34	103	2.23	117
Uzbekistan	2.54	70	2.01	148	2.45	91	2.57	77
Emerging Asian Countries								
PRC	3.54	27	3.67	23	3.75	23	3.75	20
India	2.91	47	2.88	58	3.34	36	2.91	52
Indonesia	2.54	69	2.92	56	2.65	73	2.90	54
Advanced Countries								
Japan	4.19	5	4.16	7	4.10	11	4.25	2
UK	3.95	16	4.16	6	4.21	5	4.03	8
US	4.15	7	4.18	5	4.15	8	4.05	7

Source: World Bank Logistic Performance Index. https://lpi.worldbank.org/ (accessed 18 March 2020).

Note
This index covers the 160 economies, which are ranked based on their score. Here, the high score (1=Low to 5=High) indicates a higher infrastructural facility, which enables the economies to face challenges to improve their trade logistics and performance.

PRC = People's Republic of China, UK = United Kingdom, US = United States.

Table 6.5 summarizes the infrastructure score and rank in the logistics performance index for Central Asian countries, emerging Asian countries (the PRC, India, and Indonesia), and advanced countries (Japan, the UK, and the US). The infrastructure score of Central Asian countries is very low in comparison to emerging Asian and advanced countries, and the Kyrgyz Republic, Turkmenistan, and Tajikistan rank more than 100. For this reason, developing infrastructure for utilizing Central Asia's rich natural and human resources can play an important role in promoting higher economic growth. As per Forbes' 2018 global 2,000 rankings, Kazakhstan provides 3.3% of the world's total oil exports and needs transport infrastructure like road, railways, and ports to obtain higher economic growth.

Table 6.6 shows the infrastructural capability of Central Asian countries compared to the emerging Asian countries and advanced countries. Various details can be observed as follows:

(1) Central Asian countries are relatively better compared with emerging Asian countries in terms of access to electricity and energy use, whereas they are far behind in infrastructure development compared to advanced countries except for access to electricity, which is nearly 100% of the population.

Table 6.6 Comparison of Infrastructure: Central Asian Countries Versus Selected Benchmark Emerging and Advanced Countries (average 2000–2018)

Infrastructure Variables	*Access to electricity (% of Population)*	*Railways, passenger carried (Millions of passengers-km)*	*Fixed telephone subscription (per 100 People)*	*Energy use (kg of oil equipment per capita)*
Central Asian Countries				
Kazakhstan	99.646	14,744.030	20.300	3,749.149
Kyrgyz Republic	99.654	62.040	7.995	550.776
Tajikistan	98.846	37.778	4.521	327.802
Turkmenistan	99.826	1,675.067	9.818	4,191.581
Uzbekistan	99.811	2,878.407	7.541	1,798.835
Emerging Asian Countries				
PRC	98.977	666,416.700	19.560	1,589.094
India	74.351	804,833.900	2.900	503.128
Indonesia	92.686	18,365.170	8.029	807.851
Advanced Countries				
Japan	100	243,069.100	47.738	3,830.645
UK	100	44,690.390	53.743	3,355.698
US	100	9,794.420	50.751	7,436.558

Source: Authors' calculation from World Development Indicators Data. https://databank.worldbank.org/source/world-development-indicators (accessed 18 March 2020).

Note
PRC = People's Republic of China, UK = United Kingdom, US = United States.

(2) Passenger railway density is far behind in comparison to other emerging economies and advanced economies. Indeed, it is very low in the case of the Kyrgyz Republic and Tajikistan.
(3) Information and communication technology (ICT), as proxied by fixed telephone subscriptions, is lagging Japan, the UK, and the US, but is more or less similar to Indonesia. This indicates a crucial area for policy action in Central Asia to enhance productivity, skill, and development.
(4) In the case of energy use, Kazakhstan and Turkmenistan are comparable to advanced economies, whereas the Kyrgyz Republic, Tajikistan, and Uzbekistan use much less in comparison to Japan, the UK, and the US. Except for Tajikistan, they are better than the PRC, India, and Indonesia. This comparative analysis indicates that Central Asian countries should cover the infrastructure needed to enhance economic growth.

From the above tables and graphs, it can be concluded that the highest-growing countries in Central Asia, such as Kazakhstan, attracted higher PPI. In contrast, the lowest-growing countries, such as the Kyrgyz Republic and Tajikistan, depend on official development assistance. Further, these two low-growth countries have a higher infrastructure gap and lower infrastructure score and experienced a higher current account deficit. These facts induce us to examine whether infrastructure investment plays any role in determining the economic performance of these countries. Is there any by-directional relationship between these two?

6.4 Infrastructure Investment and Economic Growth: A Brief Review

The literature on the economic importance of infrastructure can be classified into three major strands. The first strand focuses on the micro aspect of an infrastructure project by analyzing its social cost-benefit (Aschauer 1989; Gramlich 1994; Marcelo et al. 2016), i.e., its negative externalities. The second strand deals with the demand side of the infrastructure, thereby measuring the infrastructure investment gap (Fay 2000; Gill and Kharas 2007; Kennedy and Corfee-Morlot 2013; McKinsey 2013; OECD 2006; Ruiz-Nuñez and Wei 2015). The third strand investigated the role of infrastructure in promoting economic growth through productivity and trade (Bougheas et al. 1999; Cavallo and Daude 2011; Vijil and Wagner 2012). As the present study mainly focuses on infrastructure investment and economic growth, the research papers related to this issue are reviewed.

The effect of infrastructure on aggregate economic growth or output has been a long debate in the literature. The initial work related to the role of infrastructure by Rosenstein-Rodan (1943) and Hirschman (1957) indicated the importance of capital in enhancing growth. Theoretical attempts by Romer (1986), Lucas (1988), and Barro (1990) included public capital into the production function to capture the effect of infrastructure on output. Investment in infrastructure can enhance productivity and competitiveness through trade facilitation, reduce transportation costs, and create employment, thereby improving economic development and reducing poverty (Démurger 2001; Estache and Limi 2008). It is argued that the marginal productivity of public infrastructure spending is more than twice that of private capital (Aschauer 1989).

The empirical studies of infrastructure primarily focused on transportation and electricity and their link to economic growth. For instance, better transport leads to increased market access and thereby affects growth in Kenya (Jedwab and Moradi 2016). It is also found that rail and road infrastructure helped to increase the real income of colonial India by reducing the trade cost, interregional price differences, and increasing trade (Donaldson 2018). Similar findings have also been found in the case of the US at the end of the nineteenth century (Donaldson and Hornbeck 2016).

Equally, there have been many attempts to analyze how electricity consumption affects economic growth, with evidence suggesting that higher consumption leads to higher economic growth, as in the cases of Indonesia (Chen et al. 2007), Fiji (Narayan and Singh 2007), and Australia (Narayan and Prasad 2008). On the other hand, it is also found that higher economic growth leads to electricity consumption in Australia (Narayan and Smyth 2005), Bangladesh (Mozumder and Marathe 2007), and the United Arab Emirates (Shahbaz et al. 2014). Likewise, telecommunication infrastructure is found to have a positive impact on the economic growth of the Organization for Economic Co-operation and Development (OECD) countries (Röller and Waverman 2001). Similarly, Mitra et al. (2002) found that infrastructure investment has a strong positive effect on the total factor productivity of the Indian manufacturing sector. Likewise, Fedderke and Bogetić (2009) observed a strong positive effect of infrastructure investment on economic growth in South Africa.

It is also argued that infrastructure investment, especially in the case of publicly financed projects, may not produce a positive effect on economic growth due to corruption, poor maintenance, and cost overruns (Arezki et al. 2017; Warner 2013). Roy (2018) found that infrastructure investment negatively impacts economic growth and contributed to large cost overruns of Indian projects during 1980–2014. As the existing literature did not give enough attention to the Central Asian countries, the present study attempts to find their relationship between infrastructure investment and economic growth.

6.5 Empirical Model and Data

We propose the following econometric model to examine the relationship between infrastructure investment and economic growth.

$$Y_t = \beta_0 + \beta_1 Infra_t + \varepsilon_t \tag{1}$$

$$Infra_t = \alpha_0 + \alpha_1 Y_t + \varepsilon_t \tag{2}$$

where Y represents the output and *Infra* represents infrastructure investment. Equation 1 shows the effect of infrastructure investment on economic growth, whereas equation 2 shows the effect of economic growth on infrastructure investment. β_1 and α_1 are the parameters to be estimated. β_0 and α_0 are the intercepts and *t* stands for time, while ε_t indicates the error term. All variables are measured in logarithmic form. We expect a positive relationship between infrastructure investment and output as higher investment in infrastructure enhances economic growth. So, we expect $\beta_1 > 0$. Similarly, higher economic growth can lead to higher investment in infrastructure, thus the expected relationship is positive, $\alpha_1 > 0$. The above equations are estimated using ARDL co-integration technique to find the long-run relationship of these variables. Economic growth is proxied by real GDP, whereas infrastructure investment is proxied by Gross Fixed Capital Formation due to the paucity of infrastructure investment data for these countries. Annual data related to the above variables covering the period 1990 to 2018 were collected and interpolated into the quarterly series due to the unavailability of related long time-series data. Moreover, data are largely available from 1990 onwards, and using annual data with fewer than 30 observations significantly reduces freedom. Therefore, the linear interpolation method is adopted to convert the annual data series into quarterly series.

Thus, the above equations are estimated using quarterly data from 1990Q1 to 2018Q4, drawn from the World Bank and International Monetary Fund. Moreover, because the continuous time-series data related to the above variables for Turkmenistan are not available, this country is excluded from the analysis.

6.6 Econometric Methodology

The ARDL approach to cointegration by Pesaran and Shin (1999) and Pesaran, Shin, and Smith (2001) is employed to estimate equations 1 and 2. This test can be performed irrespective of whether variables in the model are purely stationary, i.e., I(0), purely non-stationary, i.e., I(1), or mutually cointegrated. This test is widely applied when the macroeconomic variables are mixed in order (Prabheesh and Laila 2020; Prabheesh and Vidya 2018; Vidya and Prabheesh 2019). There are two steps involved in this test. The first step is to identify whether any cointegrating or long-run relationship exists between the variables in the model. If yes, the next step is to estimate the coefficients associated with long-run and short-run models using the error correction model. The error correction model of the ARDL model of equation (1), which can be written as:

$$\Delta \Upsilon_t = \lambda_0 + \lambda_1 \Upsilon_{t-1} + \lambda_2 Infra_{t-1} + \sum_{j=1}^{n} \varnothing_j \Delta \Upsilon_{t-j} + \sum_{j=1}^{n} \gamma_j \Delta Infra_{t-j} + \varepsilon_t \tag{3}$$

where parameter λs represents the long-run relationship, and $\varnothing_j$ and γ_j represent the short-run dynamics of the model. F-test procedure is followed to examine the long-run relationship between variables by testing the joint significance of the coefficients of the lagged levels of the variables, i.e., $H_1 : \lambda_1 = \lambda_2 = 0$ against $H_2 : \lambda_1 \neq \lambda_2 \neq 0$. A rejection of the null hypothesis indicates the evidence of cointegration. A lower and upper bound critical value for the F-statistic is proposed by Pesaran et al. (2001) by assuming all variables are I(0) for the lower bound and I(1) for the upper bound. The null of no cointegration can be rejected if the calculated F-statistic exceeds the upper critical value, irrespective of the order of integration. Contrariwise, the null of no cointegration cannot be rejected if the F-statistic is less than the lower critical bound. The result is inconclusive if the F-statistic lies between the lower and upper critical values. The present study follows the critical values suggested by Narayan (2005) for the small sample size.

6.7 Empirical Findings

6.7.1 Findings from Unit Root Tests

Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) tests are employed to examine the stationarity of the variables, before estimating the empirical models. The results reported in Table 6.7 show that the null hypothesis of the unit root (non-stationarity) cannot be rejected at the level for both variables for

Table 6.7 Results of Unit Root Test

Variables	*ADF Test Statistic*		*PP Test Statistic*	
	Levels	*First Difference*	*Levels*	*First Difference*
Kazakhstan				
Y	2.597 (0.991)	-1.850 (0.092)***	-1.329(0.613)	-1.730 (0.062)***
Infra	0.499 (0.818)	-3.473 (0.000)*	-0.192 (0.624)	-2.463(0.019)**
Kyrgyz Republic				
Y	1.430 (0.976)	-3.167 (0.000)*	0.831(0.885)	-2.179 (0.030)**
Infra	0.724 (0.865)	-3.714 (0.000)*	0.437 (0.801)	-3.703 (0.000)*
Tajikistan				
Y	-1.043 (0.721)	-3.593 (0.000)*	0.061(0.694)	-1.668 (0.089)***
Infra	-0.703 (0.400)	-2.437 (0.017)**	-0.969 (0.287)	-6.981 (0.000)*
Uzbekistan				
Y	1.626 (0.971)	-1.266 (0.183)	2.883 (0.998)	-3.051(0.000)*
Infra	1.586 (0.969)	-4.797 (0.000)*	1.990 (0.986)	-3.222 (0.000)**

Source: Authors' calculation.

Note
The table shows the results of the stationary test of the variables based on Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP). The null hypothesis is the variable is non-stationary and the alternative hypotheses series is stationary. Where, *, ** and *** denotes rejection of unit root at 1%, 5%, and 10% level respectively.

all countries, whereas, in the case of first-difference, the null can be rejected in all cases, implying the variables are non-stationary at levels I(1). As all these two variables are non-stationary, it is possible to check for long-run relationships by following the cointegration framework.

6.7.2 Findings from ARDL Analysis

The findings from the F-test are reported in Table 6.8. In the case of Kazakhstan, when the output becomes the dependent variable, i.e., equation 1, the calculated F statistic is found to be 9.238, which is higher than the upper bound critical value of 4.428. This indicates that the null hypothesis of no cointegration can be rejected, and there exists a unique cointegration relationship between output and infrastructure investment. Whereas in the case of equation 2, where the dependent variable is infrastructure investment, the null of no cointegration cannot be rejected, indicating economic growth does not drive infrastructure investment in the long-run in the case of Kazakhstan. Interestingly, in the case of the Kyrgyz Republic, the finding suggests the calculated F statistic, 0.931 is smaller than the lower bound critical value of 3.538, which implies no cointegration relationship. However, the long-run relationship is established from output to infrastructure investment (Equation 2). This finding suggests that output is the long-run driving force of infrastructure investment. Similarly, it can be seen that, in the

Table 6.8 Results of F-Test

Models		*Optimum lag (SBC)*	*Calculated F-statistic*	*Critical values (95% level)*		*Conclusion*
				I(0)	*I(1)*	
Kazakhstan						
Equation 1	$Y = f(Infra)$	4	9.238*	3.538	4.428	Co-integration
Equation 2	$Infra = f(y)$	4	3.469	3.538	4.428	No Co-integration
Kyrgyz Republic						
Equation 1	$Y = f(Infra)$	4	0.931	3.538	4.428	No Co-integration
Equation 2	$Infra = f(y)$	4	7.314*	3.538	4.428	Co-integration
Tajikistan						
Equation 1	$Y = f(Infra)$	4	5.993*	3.538	4.428	Co-integration
Equation 2	$Infra = f(y)$	4	3.120	3.538	4.428	No Co-integration
Uzbekistan						
Equation 1	$Y = f(Infra)$	4	13.639*	3.538	4.428	Co-integration
Equation 2	$Infra = f(y)$	4	4.999**	3.538	4.428	Co-integration

Source: Authors' calculation.

Note

The table presents the Auto Regressive Distributed Lag (ARDL) cointegration test developed by Pesaran and Shin (1999) and Pesaran et al. (2001). The null hypothesis of no integration is tested against an alternative of integration. The critical values for the lower and upper bound of I (0) and I (1) for the F statistic with constant and trend are obtained from (Narayan 2005). Where, *, ** and *** denotes rejection of null of cointegration at 1%, 5% and 10% level respectively. SBC = Schwarz lag selection criteria.

case of Tajikistan, whereas the evidence of cointegration is established from infrastructure investment to output but not from output to infrastructure investment, in the case of Uzbekistan, the cointegration is established in both ways, i.e., bi-directional. Table 6.9 reports the long-run coefficients of ARDL models suggested by Schwarz lag selection criteria (SBC).

Table 6.9 shows the long-run effect of infrastructure investment on output in the three economies, where the cointegration is found based on Equation 1. As we measured the variables in the model in natural logarithmic form, the coefficients associated with the variables can be interpreted as the elasticity of the dependent variable in response to the changes in the independent variable. In all cases, the sign of the coefficient of *Infra* is found to be positive and statistically significant, implying that higher investment in infrastructure leads to higher output. The highest positive impact is found in Uzbekistan, where a 1% increase in investment in infrastructure leads to 0.6% increase in output. Similarly, in Kazakhstan and Tajikistan, the impact is found to be 0.54 and 0.39, respectively. The high sensitivity of output to infrastructure investment in Kazakhstan and Uzbekistan is clear evidence of fixed assets, such as infrastructure, promoting

Table 6.9 Long-run Coefficient Estimates by the ARDL Approach (Equation 1) (Dependent variable, Y)

Regressor	*Kazakhstan*	*Tajikistan*	*Uzbekistan*
Infra	0.542 (3.027)*	0.396 (3.401)*	0.688 (2.98)*
Constant	3.467 (0.819)	-0.043 (-0.022)	0.459 (0.082)

Source: Authors' calculation.

Note
The table reports the long-run coefficients estimated by Auto-Regressive Distributed Lag (ARDL) after the long-run relationship is established for model 1. Here, *, ** and *** denote statistical significance at 1%, 5 % and 10% levels, respectively and values in parenthesis indicate t values.

Table 6.10 Long-run Coefficient Estimates by the ARDL Approach (Equation 2) (Dependent variable, *Infra*)

Regressor	*Kyrgyz Republic*	*Uzbekistan*
Infra	0.544 (4.911)*	0.799 (18.163)*
Constant	-1.233 (-2.703)*	-3.931 (-14.268)*

Source: Authors' calculation.

Note
The table reports the long-run coefficients estimated by Auto-Regressive Distributed Lag (ARDL) after the long-run relationship is established for model 2. Here, *, ** and *** denote statistical significance at 1%, 5 % and 10% levels, respectively and values in parenthesis indicate t values.

growth. The higher infrastructure score and ranking in the logistic performance discussed in the previous section could be the reason for the higher impact of infrastructure investment on output.

Similarly, Table 6.10 shows the long-run effect output on infrastructure investment in the case of the Kyrgyz Republic and Uzbekistan. The findings suggest that the variable *Infra* is positive and statistically significant in determining the output. The impact is found to be 0.54 and 0.79 for the Kyrgyz Republic and Uzbekistan, respectively. It can be observed that the coefficient of *Infra* (0.79) is higher than the coefficient associated with Υ (0.54) in the case of Uzbekistan. This is a clear indication of a strong relationship that runs from economic growth to infrastructure investment, as compared to the other way around.

The short-run dynamics estimated by error correction representation of the ARDL associated with Equation 1 is reported in Table 6.11. In the case of Kazakhstan, the coefficient of Δ is found to be positive and statistically significant. It is important to see that the coefficient of these variables is small, i.e., 0.04, indicating a low impact of infrastructure investment on output in the short run. Similarly, a positive and low impact can be seen in the case of Uzbekistan as well, whereas, in the case of Tajikistan, the short-term impact

Table 6.11 Error Correction Representation for the ARDL Model (Equation 1) (Dependent variable, Y)

Variables	*Kazakhstan*	*Tajikistan*	*Uzbekistan*
	ARDL (4,1)	*ARDL (2,2)*	*ARDL (3,2)*
ΔY_{t-1}	0.826 (4.121)*	0.627(5.351)*	0.341
ΔY_{t-2}	0.716 (4.104)*		0.326
ΔY_{t-3}	0.531 (5.163)*		
$\Delta Infra_t$	0.045 (3.134)*	-0.045(-2.655)*	0.021 (2.655)*
$\Delta Infra_{t-1}$		-0.078 (-3.189)*	
Ecm (-1)	-0.255 (-4.353)*	-0.130 (-3.971)*	-0.192 (-7.314)*
Adjusted R^2	0.329	0.239	0.323
χ^2_{AC}	0.965 [0.456]	1.553(0.244)	1.846[0.169]
χ^2_{Arch}	0.152 [0.958]	0.125 [0.970]	0.910[0.479]
χ^2_{Norm}	2.128 [0.541]	13.900[0.000]	0.026[0.986]
CUSUM	Stable	Not stable	Stable
CUSUMQ	Stable	Not stable	Stable

Source: Authors' calculation.

Note

Where Δ and Ecm (-1) denote the first difference and the error correction term, respectively. χ^2_{AC} and χ^2_{Arch} and χ^2_{Norm} are LM statistics for serial correlation, ARCH effect and normality in residuals respectively. *.**and***are statistically significantly different from zero at 1, 5 and 10% levels respectively. Figures in parenthesis show t- statistics.

of the infrastructure variable is found to be negative and statistically significant. This finding indicates that higher investment in infrastructure leads to a reduction in output. This could be due to the crowding out of private investment in the short run due to higher public investment in the fixed capital. It is important to note that, in both models, the error correction terms are statistically significant at 1% level and expected negative sign. The error correction term varies from -0.13 to -0.25, indicating around 13%, and 25% of the deviation from equilibrium is eliminated within a quarter. Further, diagnostic statistics indicate no serial correlation and autoregressive conditional heteroscedasticity (ARCH) effect in the residuals. Likewise, the models confirm the residuals are normal. The cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) on the recursive residuals indicate the coefficients' stability across sample periods.

Similarly, the error correction representation of the ARDL associated with Equation 2 for the Kyrgyz Republic and Uzbekistan is reported in Table 6.12. It can be observed that the short-run effect of output on infrastructure investment is positive for both quarters. The coefficient is found to be more than one in the case of Uzbekistan, indicating a higher impact of output on public spending. The statistics reported in the bottom part of the table show that the model passes all diagnostics tests.

Table 6.12 Error Correction Representation for the ARDL Model (Equation 2) (Dependent variable, *Infra*)

Variables	*Kyrgyz Republic*	*Uzbekistan*
	ARDL (2,2)	ARDL (2,4)
$\Delta Infra_{t-1}$	0.647 (2.897)*	0.826 (4.531)*
ΔY_t	0.411 (2.911)*	1.200 (1.672)
ΔY_{t-1}	0.674 (2.162)*	1.774 (1.940)***
ΔY_{t-2}		1.163 (3.079)*
ΔY_{t-3}		1.054 (2.542)**
Ecm (-1)	-0.362 (-4.241)	-0.488 (-4.365)
Adjusted R^2	0.487	0.840
χ^2_{AC}	1.183[0.346]	1.491[0.26]
χ^2_{Arch}	0.700[0.410]	0.266[0.890]
χ^2_{Norm}	0.557[0.753]	0.158[0.924]
CUSUM	Stable	Stable
CUSUMQ	Stable	Stable

Source: Authors' calculation.

Note
Where Δ and Ecm (-1) denote the first difference and the error correction term, respectively. χ^2_{AC} and χ^2_{Arch} and χ^2_{Norm} are LM statistics for serial correlation, ARCH effect and normality in residuals respectively. *, **and***are statistically significantly different from zero at 1, 5 and 10% levels respectively. Figures in parenthesis show t- statistics.

6.8 Conclusion

The countries of Central Asia are rich in natural and human resources but quite diverse in their stages of development. One of the obstacles to their economic transformation is the lack of well-developed infrastructure. Kazakhstan, the highest-growing country, attracted higher PPI, while the Kyrgyz Republic and Tajikistan, the lowest-growing countries, depend upon official development assistance. Further, the low-growing countries have a higher infrastructure gap and lower infrastructure score and a higher current account deficit. Hence this study addressed the role of infrastructure investment and economic growth in these economies. Using quarterly data from 1990 to 2018 and ARDL approach cointegration, the study finds that the economic growth in Kazakhstan, Tajikistan, and Uzbekistan is significantly driven by infrastructure investment, while, in the case of the Kyrgyz Republic, economic growth drives infrastructure investment. Similarly, in the case of Uzbekistan, a bi-directional relationship between infrastructure investment and economic growth is observed, which may stem from efficient use of infrastructure with the help of private participation, along with strong macroeconomic fundamentals. Thus, attracting more private participation can accelerate growth and thereby maintain a sustainable infrastructure investment in Uzbekistan. Lastly, certain interventions such as efficient use of official development assistance and increased private participation may bring the positive effect of infrastructure investment on economic growth, especially in the case of the Kyrgyz Republic and Tajikistan.

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