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The impact of infrastructure investment on economic growth in countries participating in the Belt and Road Initiative: A comparative analysis between Africa and Asia

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Abstract
The Belt and Road Initiative (BRI) key element is to accelerate infrastructure investment, which, in turn, improves the connectivity and enhances trade and foreign direct investment of BRI-participating countries. Thus, this study attempts to investigate and compare the impact of infrastructure investment on the economic growth of the African and Asian BRI-participating countries. The results reveal that infrastructure development imposed negative and significant impact on both African and Asian regions' economic growth in the long-run.

Conversely, the findings reveal a bi-directional Granger causality between economic growth and infrastructure development in both African and Asian regions in the short run. Nevertheless, the accumulation of capital formation only imposed a significant positive impact on the economic growth of the Asian region. As a result, policymakers from each region could exchange ideas on spurring economic growth of respective regions. However, they should formulate different policies to reap the BRI benefits.

Keywords: *Infrastructure index; BRI; economic growth; Principal Component Analysis; Asian and African regions*

1. Introduction

The President of China, Xi Jinping, announced the Belt and Road Initiative (BRI) in 2013. This initiative involves 72 countries, covers 60 per cent of world Gross Domestic Product (GDP) and 70 per cent of the world's population (Chen and Lin, 2018: 2). The five core elements of the BRI are policy coordination, facility connectivity, unimpeded trade, financial integration and people-to-people bonds, which are also known as the "five connectivities" (Chen et al., 2019: 3227). This initiative's key element is to accelerate infrastructure investment, which, in turn, improves connectivity and enhances trade and foreign direct investment (FDI) across the BRI countries (Chen and Lin, 2018: 2). Alff (2020) also mentioned that a goal stated by the BRI is to strengthen maritime connectivity between China, Asia, Africa and Europe through infrastructural development.

Baniya et al. (2019) noted that BRI transport projects would reduce trade times among the countries participating in the BRI by between 2.9 and 4.4 per cent, depending on whether exporters switched their transportation mode. Besides, with infrastructure improvements, the total

trade among the countries participating in the BRI will increase by between 2.5 and 4.1 per cent. These findings are imperative, especially for time-sensitive products and reveal the importance of infrastructure improvements on multilateral trade among the participating countries. Furthermore, through the reduction of trade cost due to the improvements of infrastructure stemming from the BRI, De Soyres et al. (2020) stated that the implementation of the BRI would increase the GDP of the participating countries by 3.4 per cent and by 2.9 per cent for the world as a whole. Consequently, the above findings suggest that the BRI implementation might bring considerable benefits to the participating countries and positively spill-over effects for the world. In addition, as of 2019, China's direct investment in BRI participating counties has achieved US$50 billion, while the value of newly signed foreign BRI-related contracted projects surpassed US$750 billion and set up more than 21,000 foreign enterprises (The State Council of the People's Republic of China, 12th December 2019).

March 2015 was selected as the based month for the comparison of the trade performance of Maritime Silk Road Trade Index in Table 1. Based on the indices above, it is noticeable that the trade performance for BRI improved significantly in recent years. The trade value index exceeding 160 mostly since the end of 2020. Furthermore, the export value also indicates an improvement sign in recent years with index value achieving 195.46 in December 2020 and 182.98 in both April and May 2021, respectively. Besides that, the import value also exhibits the similar trend and achieved the highest index of 160.42 in March 2021 despite the midst of global COVID-19 pandemic. However, De Soyres et al. (2020) also revealed that common transport infrastructure crossing the borders of a country would create challenges for the participating countries, as it has significant public finance implications. Such infrastructure developments might impose adverse effects on the GDP of

an individual country. This is because the trade gains, which contribute to GDP, are not commensurate with the high infrastructure cost. Likewise, Siu (2019) argues that the scale and range of the BRI network imposed many challenges in safeguarding its sustainability and that the impact could be detrimental to the participating countries.

Besides that, the Maritime Silk Road's Trade Indices are exhibited as follows:

Table 1 Maritime Silk Road's Trade Indices

Month and Year	Index of Total Trade	Index of Export Value	Index of Import Value	Month and Year	Index of Total Trade	Index of Export Value	Index of Import Value
March 2014	116.11	117.87	114.32	March 2018	123.65	120.57	126.79
June 2014	119.47	129.49	109.28	June 2018	136.5	149.49	123.28
September 2014	138.47	148.08	128.69	September 2018	147.06	156.28	137.67
December 2014	141.64	157.69	125.31	December 2018	134.66	153.18	115.8
March 2015	100	100	100	March 2019	127.54	137.74	117.15
June 2015	116.77	131.41	101.86	June 2019	131.03	147.56	114.21
September 2015	122.49	142.08	102.55	September 2019	138.69	151.23	125.94
December 2015	135.24	154.7	115.43	December 2019	149.85	164.76	134.67
March 2016	99.77	107.53	91.86	March 2020	122.54	128.37	116.61
June 2016	107.66	122.44	92.62	June 2020	133.14	148.07	117.95
September 2016	114.16	127.18	100.91	September 2020	154.75	166.23	143.07
December 2016	132.39	144.97	119.58	December 2020	169.85	195.46	143.78
March 2017	117.43	124.27	110.46	January-February 2021	145.91	162.54	129
June 2017	121.8	135.03	108.34	March 2021	163.83	167.18	160.42
September 2017	128.87	137.24	120.36	April 2021	169.6	182.98	155.99
December 2017	143.11	160.53	125.37	May 2021	168.67	182.98	154.1

Compiled from Ningbo Shipping Exchange

For instance, debt sustainability stemming from the investment in infrastructure could be one of some BRI countries' main concerns. Based on the World Bank (18th June 2019) report, the BRI has received mixed reactions, both optimistic and anxious, from different countries. Apart from the above-mentioned facts, Gong (2019) mentioned that due to the nature of BRI and the lack of transparency of the BRI linked-projects, some analysts believe that the BRI would cause growing risks to the participating countries that involved in the BRI projects. Besides, the doubtful sources of financing and challenges of the apparently huge size of the initiative, will limit the expected positive outcomes. Also, Zhou and Esteban (2018) opined that BRI encompasses multifaceted policy elements: in order to reshape the global governance in favour of China's own values, interests, and status instead of the benefits of the participating countries.

Based on the above controversial view, it is therefore noteworthy to study the impact of infrastructure on the economic growth of the countries participating in the BRI from the African and Asian regions, respectively and to compare the impacts between the two regions to determine whether the BRI will benefit them equally. Although the past literatures have evaluated the benefits and costs of BRI infrastructure projects (see Ismail and Mahyideen, 2015; Chen et al., 2019; Wang et al., 2020; Khan et al., 2020), to our best knowledge, there were no past studies investigate and compare the economic outcome of Africa and Asia stemming from BRI infrastructure projects. The countries participating in the BRI from the Asian and African regions were selected in this study due to their common features. Based on the data derived from the Belt and Road Official Portal, as of 2019, there were a total of 40 African countries and 38 Asian countries who had joined the Belt and Road Initiative (BRI). There was one developed country, 23 developing countries and 16 least developed countries from Africa.

Meanwhile, there were ten developed countries, 21 developing countries and seven least developed countries from Asia. Based on these statistics, the countries participating in the BRI from these regions share a common feature. Most participating countries are either developing or least developed countries, requiring large FDI flows for infrastructure development and increased trade volumes to develop and sustain their economic growth. Therefore, it is crucial to identify and compare whether these regions' infrastructure development is imperative and carries equal weight on their economic growth. The findings of this study complement the burgeoning body on BRI research. Besides, it can provide insights for the two regions' policymakers to formulate effective policies, especially those related to infrastructure, to enhance economic growth and enjoy joint prosperity when the BRI is implemented fully.

2. The economic relationship between China and the BRI countries in Africa and Asia

2.1 International trade between China and the BRI countries

According to Forbes (3rd October 2019), China is the African continent's largest trade partner, with more than US$200 billion worth's trade per year. More than 10,000 Chinese-owned firms have settled in Africa, with a value of more than US$2 trillion. Over the last few years, the value of construction contracts in Africa has surpassed that of the Asian region. With the Belt and Road Africa infrastructure development fund with investments of more than US$60 billion, the China-African relations are set to grow. Despite this considerable investment, African countries still have massive infrastructure backlogs of between US$130 and US$170 billion per year. According to the John Hopkins University (2021), the China-Africa bilateral trade has been increasing over the last 16 years. The value of China-Africa international trade in 2019 was US$192 billion, increasing to US$185 billion in 2018. This relates to an annual increase of 3.7 per cent. In 2019, the largest exporter to China from Africa was Angola, followed by South Africa and the Congo. In

2019, Nigeria was the largest buyer of Chinese goods, followed by South Africa and Egypt.

In an analysis by China Briefing (20th May 2021), the trade relationship between China and Asia has been growing over the last three decades. This specific analysis focuses on Central Asia with small developing countries because Central Asia plays a role in two of the three proposed belts that make up the Silk Road Economic Belt. Firstly, the "North belt" runs through Central Asia and Russia to Europe and secondly, the "Central belt" transcends Central Asia and West Asia towards the Persian Gulf and the Mediterranean. Since the launch of the BRI in 2013, the trade value between the BRI countries and China has a total value of US$9.2 trillion to 2020. The total value of the investment by Chinese enterprises in the BRI countries amounted to US$136 billion. The trade relations with selected Central Asian countries are listed herewith. Firstly in 2019, Kazakhstan in total exported US$60.3 billion and imported US$41 billion worth of goods and services. Kazakhstan and China have strong trade relations. China is the second-largest trading partner, with Kazakhstan's importing 17 per cent of all goods and services from China and 13.6 per cent of exports are delivered to China. Trade between the two countries is increasing at an average of 16 per cent per annum. Secondly, Uzbekistan produced a total GDP with a value of US$57.92 billion, with total exports of US$14.1 billion and total imports of US$21.5 billion. China is Uzbekistan's largest trading partner, with 23.1 per cent of total imports to China, and regarding exports, Uzbekistan exports 12.3 per cent of total exports to China. Thirdly, Kyrgyzstan had a GDP of US$8.46 billion in 2019, with exports valued at US$2.93 billion and imports valued at US$9.58 billion. China is Kyrgyzstan's largest trading partner and imported 35.4 per cent of China's total imports. Fourthly, Tajikistan had a GDP value of US$8.12 billion in 2019. Tajikistan imports 18.2 per cent of its total imports from

China and exports 5 per cent of total exports to China. Finally, Turkmenistan had a GDP of US$40.76 billion in 2019. In terms of exports, China is Turkmenistan's largest trading partner, accounting for 80.2 per cent of Turkmenistan's total exports. China is Turkmenistan's third-largest trading partner, accounting for 14.3 per cent of its total imports. The BRI launch and the subsequent focus also on Central Asia has opened doors for China to Europe and the Middle East.

In a Nikkei Asia (15th July 2020) report, since 2019 with the US and China trade war, the South-East Asia region became China's largest trade partner. As China re-look their global supply chain, this region provides 14.7 per cent of China's overall trade. In addition, the European Union, which was previously the largest trade partner of China, experienced a decrease of 5 per cent in the same year, while the US had a 10 per cent drop in trade. The EU and the US contributed 14 per cent and 11.5 per cent of China's total trade in 2019 and 2020. In addition, China has continued to promote trade and build stronger trade relations with ASEAN countries as part of the BRI initiative.

2.2 Chinese foreign direct investment in the BRI countries

Since China's strategy in recent years has been to simultaneously open up its markets whilst having rapid economic development and implementing the BRI, it has successfully achieved significant economic collaboration with many regions (see, Chen et al., 2019; Huang et al., 2019; Chan, 2017; Drummond and Liu, 2015). Over the past few decades, China has focused on Africa, with many large-scale investments in the continent (Zhao, 2014). Chinese FDI annual flows to Africa have been increasing steadily since 2003. From 2003 to 2019, the number has surged from US$75 million in 2003 to US$2.7 billion in 2019. Flows peaked in 2008 at US$5.5 billion because of the purchase of

20 per cent of the shares in Standard Bank of South Africa by the Industrial and Commercial Bank of China (ICBC). Chinese FDI flows to Africa have exceeded those from the US since 2014, as US FDI flows have been declining since 2010. The top 5 African destinations of Chinese FDI in 2019 were the Democratic Republic of Congo, Angola, Ethiopia, South Africa, and Mauritius. Although infrastructural investment assists with economic development and growth, China's agenda is economical and strategic (Dollar, 2019). To a large extent, China is investing in Africa to establish a continent's footprint to exert political and diplomatic influence (Forbes, 21st September 2019). Marais and Labuschagne (2019) analysed China's investment strategy in Africa. The BRI was first launched in 2013, aiming to achieve improved connectedness, which could help drive trade and economic development among countries participating in BRI. A total of 40 African countries are included in the initiative. The African continent has enormous infrastructure backlogs, which serve as a stumbling block for its growth and development. The African Development Bank (AfDB) calculates that the infrastructural requirement, or backlog, in Africa is approximately US$130 billion to US$170 billion per annum (Marais and Labuschagne, 2019). China has stepped forward as the leading financier of Africa and is currently financing one project in every five projects. The majority of the projects financed in Africa are related to the transport, shipping and port sectors (52.8 per cent), and energy (17.6 per cent) (Marais and Labuschagne, 2019). Chinese involvement in Africa is widespread, and many projects have been completed, such as 30,000km of highways; 2,000km of railways in Kenya, Ethiopia, Angola, Djibouti and Nigeria; 85 million tonnes per year of port throughout capacity, more than nine million tonnes per day of clean water treatment capacity, about 20,000MW of power generation capacity, and more than 30,000km of electricity transmission lines (Marais and Labuschagne,

2019). Dollar (2019) also analysed the BRI in Africa as part of the Brookings Institution paper series. According to Dollar (2019), the initiative was originally formulated as a regional economic corridor plan. However, the initiative became global and had a strategic focus on China. The initiative intends to support developing countries by trying to fill their infrastructural gaps. The initiative has been criticised due to its lack of transparency. The loans provided could drive some of the poorer African countries more deeply into a debt crisis. Investment in African infrastructure by China has been substantial since 2012, and the average value of loans to the region has been more than US$15 billion per annum. Chinese infrastructure loans and financing contribute more than a third to all of the investments on the continent. From 2015 to 2017, Angola received the highest amount, US$8.1 billion, followed by Kenya, South Africa and Egypt. Massive projects have included railway lines in Ethiopia (US$1.3 billion) and Kenya (US$2 billion), and hydropower stations in Uganda (US$1.4 billion), and Cameroon (US$500 million). However, lending is well spread across the entire continent, and lending practices do not discriminate between governance levels. In conclusion, China has a comprehensive infrastructure investment strategy for the African continent. The investment strategy includes most countries, and the investment is critical for the continent's economic development and growth. African countries should ensure that Chinese investment does not place them in a debt trap. All of the projects are sustainable and contribute to development.

2.3 Chinese foreign aid in the BRI countries

China's BRI, which was announced in 2013, is the flagship aid and investment programme for China. Within this programme, they have supported different countries and regions around the world in different way (Centre for Global Development, 9th July 2020). According to Gelpern et al. (2021), Chinese foreign aid spending had grown exponentially from 2003, when spending accounted for US$631 million to US$3.1 billion in 2019. From 2013 to 2018, more than 45 per cent of foreign aid was directed to Africa. China's development aid is provided in eight different formats, including "turnkey" infrastructure-based projects; Commodity aid in terms of equipment, goods, and materials; Technical support and cooperation projects; Cooperation and training focused on human resources; Medical support; Emergency humanitarian aid; Volunteers programmes; and Debt forgiveness projects (Centre for Global Development, 9th July 2020). Chinese development support and assistance is provided via a grant or a donation, interest-free loans, and concessional loans at low rates. Globally, in terms of aid and investment, the BRI includes 140 countries. This includes 97 per cent of Asian countries and 73 per cent of African countries.

According to AidData (2020), Chinese official development assistance (ODA) is mostly spent on transport and storage (US$23 billion); aid related to debt to developing countries (US$12.3 billion); energy supply and generation (US$11.3 billion), communications and the development of economic sectors such as mining and manufacturing. Many African countries are in the top 10 of countries receiving Chinese ODA, including Cote d'Ivoire with US$4 billion, Ethiopia (US$3.7 billion), Zimbabwe (US$3.6 billion), Cameroon (US$3.4 billion), Nigeria (US$3.1 billion), Tanzania (US$3.0 billion) and also a few Asian countries such as Cambodia (US$3.0 billion) and Sri Lanka (US$ 2.8 billion).

In terms of sectoral involvement, the Chinese aid has its focus on humanitarian issues (UNDP, 21st September 2016; Krebs, 2014); health facility and training support (Itad, 12th July 2017); economic support including infrastructure financing with a focus on construction or renovation of roads, railways, airports and harbours (Hwang et al., 2016), and also agricultural sector development involving agribusiness, contract farming, technology demonstration, and training (Scoones et al., 2016: 9); Socio-cultural support (Zhang, 2017) include training scholarships for university study in China; the Chinese youth volunteer corps (Bräutigam, 2009: 122-124).

3. Literature review

Over the last decade, since the global financial crisis in the year 2008, China has played a significant role in driving global growth (Liu and Dunford, 2016). However, the recent slowdown in Chinese economic growth (a decline from 10.5 per cent on average during the 2000s to about 6.5 per cent in 2018) has generated concern around the world and has led China to enter a so-called "new normal" phase of development (Hu, 2015; Liu and Dunford, 2016). The "new normal" model of development aims to move the Chinese economy forward to a stage that involves; diversifying the country's economy, exploring innovation, embracing a more sustainable growth level, expanding the domestic market, and distributing economic benefits evenly and deepening open development. This implies that China must review its current globalisation strategy (Liu and Dunford, 2016).

Similarly, to the work of other developed or developing economies across international regimes to promote trade and FDI, China proposed the BRI in the year 2013 and hoped that it would further the nations globalisation (Liu and Dunford, 2016). The BRI seeks to expand trade

and investment and spread benefits to areas and people who have not benefited from neoliberal globalisation. The BRI offers mutual benefits and opportunities for both developed and developing countries; for instance, infrastructure investment creates employment and income by renewing developed countries' infrastructure. In contrast, in emerging economies, it can create infrastructure for growth and market expansion (Liu and Dunford, 2016). Therefore, the BRI implementation has revived interest in assessing and studying the viability of growth theories, studying the determinants of economic growth and growth convergence, particularly among those participating in the BRI.

Many research studies related to the determinants of economic growth have been conducted over the past few decades. However, the determinants of economic growth may have changed as time has passed. A few common specific factors related to economic growth have always been examined in the empirical literature, for instance, capital and labour (Mihaela et al., 2017). As emphasised in both the neoclassical economic growth model and the Keynesian economic growth model, particularly the Solow-Swan model (Solow, 1956; Swan, 1956) and the Harrod-Domar model (Harrod, 1939; Domar, 1946), capital and labour are cardinal to the economic growth of a country. Since BRI offers trillion of dollars investment, mainly in the transportation, energy, telecommunications infrastructure, industrial capacity, and technical capacity building (UNEP, n.d.) which in turn creates job opportunities in the market and promotes the economic growth, it is vital to include capital and labour as one of the determinants of economic growth among the countries participating in BRI. Gross capital formation and labour force participation rate have always been used as a proxy of capital and labour, respectively. The significant positive impacts of these variables on economic growth have been further proven by recent studies, for instance Owusu-Nantwi (2015) and Fomina et al. (2018). Nevertheless,

Siddique and Majeed (2015) found positive but insignificant impact of labour force on economic growth in five South Asian countries (Bangladesh, India, Sri Lanka, Nepal and Pakistan) in the short run, although gross capital formation plays a vital role in driving economic growth. By using ordinary least squares (OLS) regressions and generalized method of moments (GMM), Awolusi and Adeyeye (2016) provided evidence that gross capital formation and labour force participation rate promote the economic growth in South Africa, Egypt, Nigeria and Kenya, except Central African Republic, where economic growth is negatively affected by gross capital formation.

Besides capital and labour, the empirical work that has been carried out, based on the endogenous growth model, has revealed that public infrastructure is indispensable in boosting the economy's long-term economic growth (Vedia-Jerez and Chasco, 2016: 172). Public infrastructure is believed to provide services that are part of the residents' consumption bundle, for instance, electricity and water supply, and in the meantime to assist capital and labour as inputs into the production process (Ayogu, 2007: 76), eventually, facilitating trade and commerce (Mbaku, 2013) while mitigating poverty and the level of income inequality in a country (Ndulu, 2006: 227). In addition, raising in energy consumption has always been linked directly to the economic growth and improvement in human welfare (Kebede et al., 2010: 534). Energy is served as one of the essential inputs to fulfil the basic human needs and business needs in the society, particularly to supply heat motive power for human daily activities and business production process. Besides that, energy also improves the productivity of capital, labour, and other production factors, which in turn drives the industrialisation as well as urbanisation, and eventually leads to economic growth (Paul and Bhattacharya, 2004: 977-978). Thus, it is crucial to include energy consumption as one of the infrastructures when

studying the economic development of country. As the key element of BRI is to escalate infrastructure investment, which includes investments in transportation, energy, telecommunications infrastructure, industrial capacity, and technical capacity building (UNEP, n.d.), to advocate the facility connectivity and economic development (Chen and Lin, 2018: 2), infrastructure should not be omitted in the study of economic growth across the countries participating in BRI.

There is some empirical evidence from countries located in Sub-Saharan Africa that has shown the positive effects of infrastructure development on economic growth. Kodongo and Ojah (2016) revealed that the spending on infrastructure and increment in the access to infrastructure drive the economic growth, especially for less developed countries of the region. Similarly, the results of Chakamera and Alagidede (2018) also showed a strong evidence for a positive effect of infrastructure development on economic growth in the region, while most of the contribution is coming from the infrastructure stock. On the other hand, low infrastructure investment has also indicated reduced international competitiveness, increased costs of doing business, etc., in other Sub-Saharan African countries, which have both, directly and indirectly, contributed to lower economic growth rates (Calderón and Servén, 2010: i35-i37). In addition, Owusu-Manu et al. (2019) examined the impact of infrastructure development on economic growth of Ghana and their findings demonstrated that infrastructure development, particularly the electricity generation, leads to higher economic growth rate. As electricity transmission and distribution losses impede the economic growth of Ghana, Owusu-Manu et al. (2019) recommended that policymakers should focus on expanding electricity-generating capacity while taking steps to restrain electricity transmission and distribution losses concurrently to achieve higher rate of economic growth.

There have also been studies in the Asian region that have supported infrastructure in accelerating economic growth. The study of Ismail and Mahyideen (2015) stressed the importance of infrastructure on economic growth in Asia. Their findings showed that quantity of infrastructure promotes the economic growth, however, having quality infrastructure benefits the economy more in terms of productive and efficient output production, as well as to achieve a sustainable growth. Likewise, Khan et al. (2020) introduced a comprehensive infrastructure composite index which includes more than 30 indicators and their findings discovered that the economic growth of South Asia is positively affected by the infrastructure. Therefore, Khan et al. (2020) suggested that private investment should be encouraged to invest in transportation, energy, information and communication technology (ICT) as well as banking sector by providing them tax rebates and establishing the free economic zones in order to increase the productivity and efficiency.

In contrast, Straub (2008) unveiled that the impact of infrastructure on economic growth was insignificant. The results were poor when applying growth-accounting frameworks and cross-country growth regressions on a sample of 93 emerging economies. In East Asia, Straub et al. (2008) pointed out that the reason for an insignificant nexus between infrastructure, productivity and growth was probably due to infrastructure investments being made to relieve constraints and bottlenecks rather than encourage growth directly.

The findings of Straub (2008) are further confirmed by Tian and Li (2019). Tian and Li (2019) compiled a set of infrastructure data into a comprehensive index, and it was used to study the impacts on economic development in BRI participating countries. Tian and Li (2019) found no significant impact of infrastructure construction on economic growth in developed and emerging developing countries and no significant impact on residents' income distribution in emerging countries. Nonetheless, the

findings of Tian and Li (2019) showed that, particularly for the BRI participating developing countries, the infrastructure construction could promote economic growth and per capita output growth while improving the residents' income distribution along the BRI. The results also demonstrated that a moderate amount of infrastructure would have a catalytic effect on economic growth, whereas an excessive amount of infrastructure can hinder economic growth. The alleviation effect of infrastructure construction on residents' income gap was found. However, it was only applicable at high or initial infrastructure levels (Tian and Li, 2019). Since favourable impacts in implementing the BRI in the BRI participating countries was realised, Tian and Li (2019) suggested that the BRI implementation should continue and focus on deepening interconnections between the countries as a breakthrough.

Arguments regarding the nexus of trade and economic growth are equivocal. Some explanations depict that heightened international competition leads to higher productivity growth since competition raises efficiency. Nonetheless, the infant industry argument delineates that international competition discourages growth. Domestic market players are not ready to compete with other strong international market players. Therefore, it is vital to investigate policies that enable an economy to benefit from trade openness (Rahman, 2006).

The BRI advocates unimpeded trade among the BRI participating countries. Cui and Song (2018) found that the BRI, as a facilitator of unimpeded trade, brings favourable impacts to economic growth in the BRI participating countries and improves the welfare in most regions. In the study of Cui and Song (2018), the BRI was also revealed to significantly improve the economics and trade cooperation between China and the surrounding countries and change Chinese external trade's spatial pattern. However, Cui and Song (2018) emphasised that these effects are specific to the BRI participating countries. Moreover, there

are studies showing the importance of trade in enhancing economic growth of countries that participating in the BRI. For instance, Wang et al. (2020) found that trade has been one of the significant drivers of countries' economic growth in BRI participating countries that located in Central and Eastern Europe region. In studying a single country, namely Nigeria, Çoban et al. (2020) discovered a unit rise in trade openness can lead to an increase of real economic growth by about 0.364 unit. Thus, Çoban et al. (2020) suggested that effort must be made towards expanding the Nigerian export base beyond the current focus on the export of primary commodities while also encouraging large scale domestic investment in order to achieve sustainable growth from trade volumes. Nonetheless, Chaudhry et al. (2019) realised that the trade openness affects economic growth differently in Pakistan when it is decomposed into positive and negative components. Their results showed that an increment in trade openness improves the economic growth while a drop in trade openness deteriorate the economic growth, but the decrease in trade openness has a larger impact on economic growth in the presence of labour, capital, FDI and institutional performance as control variables.

As there has been inconsistency in the findings from previous studies and the majority of the Belt and Road participating countries are from low- and middle-income countries, it has raised the question as to whether the participating BRI countries can enjoy the favourable impacts of economic growth after the BRI has brought them a large amount of infrastructure investment without compromising governance.

4. Methodology

4.1 Theoretical framework

The main objective of this study was to examine the effect of

infrastructure on economic growth; this study, therefore, used the general production function framework, as follows:

$$Y_t = f(K_t, L_t, I_t) \qquad (1)$$

where Yt is the gross output of a country, while Kt (capital), Lt (labour) and It (infrastructure index) are the inputs that were used. According to economic growth literature, international trade (Grossman and Helpman, 1990; Barro and Sala-I-Martin, 1995) and regulatory quality (Alam et al., 2017) are the key factors that promote economic growth. Therefore, this study modified the general production framework into a more comprehensive form by incorporating both trade and governance effects. This augmented production function framework is expressed as:

$$Y_t = f(K_t, L_t, I_t, T_t, Gov_t) \qquad (2)$$

where Tt is the total trade and GOVt is the indicator of the regulatory quality of governance.

4.2 Data and sources

This study chose the GDP per capita (GDPperC) as the proxy for Yt to capture the effects on the standard of living; gross capital formation (GCF) as the proxy for capital; labour force participation rate (Lf) as the proxy for labour; total trade (RT) as the proxy for the trade variable; and, regulatory quality (Gov) as the proxy for governance. On the other hand, this study employed principal component analysis to construct an infrastructure index (Index) as the proxy for infrastructure. The index included; fixed telephone subscriptions, air transport, the percentage of the population with access to electricity, and the total primary energy

consumption level.

Table 2 Data description

Variable	Name	Description
Dependent	*GDPperC*	GDP per capita (constant 2010 US$)
Independent	*GCF*	Gross capital formation (constant 2010 US$)
	Lf	Labour force participation rate, total (per cent of total population ages 15-64) (modelled ILO estimate)
	RT	Total Trade = Total Exports + Total Imports (constant 2010 US$)
	Gov	Regulatory quality
Infrastructure	*Index*	Infrastructure index:
		• Fixed telephone subscriptions (per 100 people)
		• Air transport, freight (million ton-km)
		• Access to electricity (per cent of population)
		• Total primary energy consumption

This study obtained all of its data from the World Bank's World Development Indicators, except for the regulatory quality and the total level of primary energy consumption, which was obtained from the World Bank's Worldwide Governance Indicators and the Energy Information Administration (EIA), respectively. This study covered a sample period from 2000 to 2017 and examined 22 countries due to data limitation. Of the 11 countries examined from the African region, eight were developing countries and three were classified as least developed countries. The 11 countries examined from the Asian region comprised two developed countries, seven developing countries and two least developed countries. This study constructed the data into balanced panel data. It converted all of the variables except for labour force and

governance into natural logarithm form. Finally, this study estimated the following equation:

$$\ln GDPperC_{it} = \alpha_i + \delta_i t + \beta_{1i} \ln GCF_{it} + \beta_{2i} Lf_{it} + \beta_{3i} \ln RT_{it} + \beta_{4i} Gov_{it} + \beta_{5i} \ln Index_{it} + \varepsilon_{it}$$ (3)

where i denote the cross-sections and t denotes the time-variation.

4.3 Econometric analysis

This study used the Principal component analysis (PCA) method to construct an infrastructure index. The variables' stationarity was checked by applying the Levin, Lin and Chu (LLC); Im, Pesaran and Shin (IPS) and Fisher Augmented Dickey-Fuller (ADF) panel unit root test. The long-run cointegration relationships were tested using the Pedroni (1999, 2004) cointegration test and the Kao (1999) and Engle-Granger-based cointegration tests. Besides, this study employed the panel fully modified ordinary least squares (PFMOLS) and Panel Dynamic Least Squares (DOLS) to obtain the long-run cointegrating coefficients. Lastly, the study examined the short-run relationships by adopting the Granger panel causality test and the Dumitrescu-Hurlin panel causality test.

4.4 Constructing an infrastructure index with PCA

PCA is a multivariate method that reduces the number of variables in a dataset by extracting vital information from a large proportion of the original variables' total variance (Bolch and Huang, 1974). This study employed the PCA method to develop an infrastructure index based on several infrastructure indicators that play essential roles in contributing to economic growth, using a linear weighted combination of the initial

variables. The infrastructure index was defined as:

$$Index_i = W_{i1}X_1 + W_{i2}X_2 + W_{i3}X_3 + W_{i4}X_4 \qquad (4)$$

where Wij was the weight for the ith infrastructure index and the jth initial variable. This study constructed an index from four variables: fixed telephone subscriptions, air transport, the population's percentage with access to electricity, and the total energy consumption level.

4.5 Panel cointegration tests

This study used two types of panel cointegration tests based on the Engle-Granger two-step (residual-based) cointegration test to find the variables' long-run relationships. The first test was the Pedroni (1999, 2004) cointegration test. This test allows for heterogeneous intercepts and trend coefficients across the cross-sections. The Pedroni cointegration test is illustrated below:

$$\ln GDPperC_{it} = \alpha_i + \delta_i t + \beta_{1i} \ln GCF_{it} + \beta_{2i} \ln Lf_{it} + \beta_{3i} \ln RT_{it} + \beta_{4i} Gov_{it} +$$

$$\beta_{5i} \ln Index_{it} + \varepsilon_{it} \qquad (5)$$

where $t = 1, \dots, T; i = 1, \dots, N; \alpha_i$ and δ_i are the parameters for the individual and trend effects. This panel cointegration test assumes that all variables are integrated of order one, I(1). The Pedroni cointegration test's null h ε_{it} thesis is no cointegration (the residual will be I(1)).

The second test was the Kao (1999) cointegration test. This test follows the same basic approach as the Pedroni test but allows specific intercepts and homogeneous coefficients across the cross-section. The Kao

cointegration test is illustrated below:

$$\ln GDPperC_{it} = \alpha_i + \beta_{1i} \ln GCF_{it} + \beta_{2i} \ln Lf_{it} + \beta_{3i} \ln RT_{it} + \beta_{4i} Gov_{it} + \qquad (6)$$

$$\beta_{5i} \ln Index_{it} + \varepsilon_{it}$$

4.6 Panel causality test

This study employed two types of panel causality tests to examine the causal relationship between the GDP per capita and the constructed infrastructure index. The initial panel causality test was the standard Granger causality test which assumes that all coefficients are the same across all cross-sections. On the other hand, the secondary panel causality test, proposed by Dumitrescu-Hurlin (2012), assumes that all coefficients are different across all cross-sections. The Granger causality and the Dumitrescu-Hurlin causality model are constructed, respectively, as follows:

$$\ln GDPperC_{it} = \propto_{0i} + \sum_{k=1}^{K} \propto_{ki} \ln Index_{it-k} + \sum_{k=1}^{K} \beta_{ki} \ln GDPperC_{it-k} + \epsilon_{it} \quad (7a)$$

$$\ln Index_{it} = \propto_{0i} + \sum_{k=1}^{K} \propto_{ki} \ln GDPperC_{it-k} + \sum_{k=1}^{K} \beta_{ki} \ln Index_{it-k} + \epsilon_{it} \quad (7b)$$

where t denotes the panel's time period dimension, i denotes the cross-sectional dimension, and K is the lag order. The null hypothesis of both panel causality tests is that there is no causality between the variables $(\propto_i = 0,$ for all $i = 1, \dots, N)$.

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5. Empirical results and discussion headings

Table 3 Eigenvalues and variance explained by principal components

Principal components	African Region			Asian Region		
	Eigen values	Variance	Cumulative variance	Eigen values	Variance	Cumulative variance
1	2.8250	0.7063	0.7063	2.6261	0.6565	0.6565
2	0.5263	0.1316	0.8378	0.9825	0.2456	0.9022
3	0.4267	0.1067	0.9445	0.2341	0.0585	0.9607
4	0.2220	0.0555	1.0000	0.1572	0.0393	1.0000

Table 3 presents the results of the Eigenvalues, variance and the cumulative variances for all of the variables used to construct the infrastructure index, namely; fixed telephone, air transport, freight, access to electricity and the total level of primary energy consumption, for both the African and Asian regions. Based on the results above, the first factor had the largest Eigenvalues, which explain 70.63 per cent and 65.65 per cent of the total variance for the African and Asian regions. As a result, the first factor was used to generate the composite infrastructure index for both regions, representing the combined variance stemming from the four variables. After generating the infrastructure index, the panel unit root tests were conducted to examine the variables' stationarity for both regions.

Table 4 The panel unit root tests

		GDPperC	GCF	Lf	RT	Gov	Index
African Region							
Levin, Lin	*Level*	0.9	1.4	-1.8**	1.2	-0.8	-2.3**
and Chu	*First diff.*	-2.4*	-2.5*	-2.8*	-3.2*	-4.8*	-3.0*
Im, Pesaran	*Level*	3.4	2.1	1.1	2.4	-1.0	0.2
and Shin	*First diff.*	-2.7*	-2.8*	-0.1	-3.3*	-5.1*	-4.6*
Fisher ADF	*Level*	7.0	20.3	21.5	11.0	25.8	21.2
	First diff.	47.9*	45.5*	37.6**	50.2*	67.1*	60.7*
Asian Region							
Levin, Lin	*Level*	-0.9	-2.7*	-2.0**	0.5	-1.3	0.9
and Chu	*First diff.*	-3.1*	-4.8*	-0.7	-3.7*	-4.7*	-3.2*
Im, Pesaran	*Level*	-0.7	-0.6	1.8	1.8	-1.1	2.8
and Shin	*First diff.*	-4.0*	-4.2*	-1.4***	-3.0*	-5.6*	-3.4*
Fisher ADF	*Level*	26.2	26.0	19.7	10.2	27.7	8.9
	First diff.	52.6*	55.4*	35.1**	42.4*	72.2*	49.1*

Note: *, ** and *** indicate the significance level at 1 per cent, 5 per cent and 10 per cent, respectively.

Table 4 presents the results of panel unit root tests for African region and Asian region, respectively. Based on Table 4, most of the tests indicated that all the variables had unit roots at level but were stationary in the first difference. As such, this study proceeded to carry out Pedroni's panel cointegration test to examine the existence of cointegration among the variables in the long-run.

Table 5 Panel cointegration test

Test	African region	Asian region
Pedroni's Panel Cointegration Test		
Panel v-Statistic	-0.32	6.20*
Panel rho-Statistic	3.11	3.73
Panel PP-Statistic	-5.67*	-0.44
Panel ADF-stat	-4.74*	-0.65
Group rho-Statistic	4.26	4.45
Group PP-Statistic	-8.73*	-6.57*
Group ADF-stat	-2.78*	-0.70
Kao Residual Cointegration Test		
ADF	-4.16*	-4.26*

Note: * indicates the significance level at 1 per cent.

Table 5 presents Pedroni's cointegration and Kao's residual cointegration tests for both the African and Asian regions. For Pedroni's panel cointegration test, both the panel augmented Dickey-Fuller (ADF) and group ADF results were statistically significant at the 1 per cent and 5 per cent levels, respectively, for the African region. Besides, the ADF result under the Kao residual cointegration test was significant at 1 per cent. However, for the Asian region case, the panel ADF result was statistically insignificant. The Kao residual cointegration test was significant at the 1 per cent levels. Since the Kao residual cointegration result is significant for the Asian region, it signifies long-run equilibrium relationships among economic growth, the constructed infrastructure index, gross capital formation, the labour force, total trade and governance quality. Upon confirmation of the existence of long-run

cointegration for the models for the African and Asian regions, this study employed the fully-modified OLS (FMOLS) to derive the coefficients for each dependent variable in the long-run. Dynamic OLS (DOLS) techniques are also applied in this study to compare the results derived from FMOLS. The results of the estimations are reported in Table 6.

Table 6 FMOLS and DOLS Estimated result

Variables	African region	Asian region
	Dependent variables: *GDPperC*	
Panel Fully Modified Least Squares (FMOLS)		
GCF	-1.956 (-43.3)*	1.900 (9.0)*
Lf	-0.059 (-3.6)*	-0.026 (-2.0)**
RT	1.784 (16.9)*	0.076 (0.7)
Gov	0.428 (2.0)**	-0.045 (-0.4)
Index	-0.248 (-1.8)***	-0.119 (-2.2)**
Panel Dynamic Least Squares (DOLS)		
GCF	-1.961 (-39.1)*	1.891 (9.8)*
Lf	-0.063 (-3.5)*	-0.032 (-2.5)**
RT	1.712 (15.2)*	0.046 (0.4)
Gov	0.251 (1.1)	-0.054 (-0.5)
Index	-0.185 (-1.2)	-0.076 (-1.4)

Note: *, ** and *** indicate the significance level at 1 per cent, 5 per cent and 10 per cent, respectively. The t-statistics are reported in parentheses.

Based on the estimated results from FMOLS, the infrastructure index's coefficient was negative and significant at the 5 and 10 per cent significance level for the Africa and Asian region, respectively. The negative impact of infrastructure on economic growth in both regions

might probably have been due to the infrastructure investments made to relieve constraints and bottlenecks instead of directly encouraging growth, as suggested by Straub et al. (2008). Alternatively, due to the dispersion of population among both Africa and Asian countries, the shared infrastructure might negatively impact the economic growth in the region as a whole.

The estimated results showed that the labour force (Lf) imposed a negative and significant impact on economic growth for both the African and Asian regions. The variable was significant at the 1 per cent and 5 per cent significance levels in respective regions. These results suggest the BRI participating countries should shift away from the focus on labour-intensive industries to capital-intensive or services industries to stimulate economic growth. The estimated results showed that capital (GCF) imposed a positive and significant impact on economic growth for the Asian region. The result supported the production function framework, the neoclassical growth theory and the Keynesian economic growth model. Besides, it was compatible with part of the findings of a previous study, such as Mihaela et al. (2017), and Awolusi and Adeyeye (2016). The empirical result revealed that capital was the cardinal to the economic growth of a country.

On the contrary, the estimated results depicted the negative and significant impact of capital formation on Africa's economic growth at the 1 per cent significant level. This result might be because capital formation will negatively impact economic growth if proper infrastructure is not ready in the African region as the lack of complete and advanced infrastructure. The countries will incur a higher cost with capital formation instead of stimulating their economic growth.

The empirical results revealed that total trade (RT) imposed a positive and significant impact on the African region's economic growth at the 1 per cent significant level. The result was consistent with the

trade-led growth theory as the theory reveals that trade is crucial for a country's economic growth. Trade can enhance productivity due to competition, and according to Grossman and Helpman (1991) and Rahman and Shahbaz (2013), it can facilitate the technology transfer from the trading partners. This finding is similar to the findings of Wang et al. (2020) and Çoban et al. (2020). However, the empirical results showed that the total trade's coefficient was not significant in promoting economic growth in the Asian region. Therefore, the trade-led growth hypothesis was not valid in this region. This result may have been because most of the BRI-participating countries in the Asian region were developing or less-developed and had a very diverse economic growth level. Hence, many of the countries in the Asian region, in particular the least developed countries, had yet to tap into the China-led global production fragmentation chain. As suggested by Were (2015), trade is statistically insignificant to economic growth in the least developed countries. The author believed that the exportable products of less-developed countries were less diversified and had lower value-added.

Nevertheless, the estimated results revealed that governance quality imposed positive and significant impact on African region. This result support the findings of past studies such as Alshammari et al. (2019) as well as Hall and Jones (1999) as good governance would mostly improve economic growth. On the contrary, the governance quality had no significant impact on Asian region. These results were consistent with Quibria (2006) findings and Kurtz and Schrank (2007). Based on these authors, the evidence from the empirical literature has not always supported the hypothesis of good governance stimulating economic growth. Besides, Acemoglu and Robinson (2008) mentioned that the notion of good governance leading to economic growth is not guaranteed.

Besides that, the estimated results from DOLS exhibit that the

direction of all independent variables are consistent with that of FMOLS even though the significance level for some independent variables is slightly different from that of FMOLS. As such, it signifies that the results estimated from FMOLS are valid and robust.

Since the impact of the role of infrastructure on economic growth in both the African and Asian regions was the focal point of this study, the panel Granger causality tests were conducted between economic growth and the infrastructure index to identify the short-run relationship between the two variables, for both the African and Asian regions. The panel Granger causality tests consist of two tests: the pairwise Granger causality test and the pairwise Dumitrescu-Hurlin panel causality tests.

Table 7 Panel Granger causality between the GDP per capita and the infrastructure index

	African region			Asian region		
	Granger Causality Tests (F-Stat.)					
	K = 1	*K = 2*	*K = 3*	*K = 1*	*K = 2*	*K = 3*
Causality from *Index* to GDPperC	3.598***	2.808***	5.359*	0.665	0.200	0.017
Causality from GDPperC to *Index*	0.168	0.413	0.638	5.329**	3.112**	1.690
	Dumitrescu Hurlin Panel Causality Tests (W-Stat.)					
	K = 1	*K = 2*	*K = 3*	*K = 1*	*K = 2*	*K = 3*
Causality from *Index* to GDPperC	2.663*	4.249***	8.129*	2.816*	4.570**	7.539**
Causality from GDPperC to *Index*	1.380	5.821*	6.861***	2.870*	2.561	6.436***

Note: *, ** and *** indicate the significance levels at 1 per cent, 5 per cent and 10 per cent, respectively. K denotes lag order.

The estimated results are shown in Table 7. As the panel Granger causality test and the Dumitrescu-Hurlin panel causality test show different results, this study focused on the latter test results. Considering the countries' heterogeneity properties, the Dumitrescu-Hurlin panel causality test assumes that all of the coefficients are different across cross-sections and were deemed more suitable for this study identifying the Granger causality relationship. Based on the estimated results from the pairwise Dumitrescu-Hurlin panel causality tests, economic growth Granger caused infrastructure in both Africa and Asian regions in the short run as the majority of the lags are significant. Therefore, the results implied that African and Asian' BRI participating needs to achieve specific economic growth levels before enjoying the positive economic growth brought about by infrastructure investment under the BRI umbrella. Like the long-run findings, the estimated results also revealed that infrastructure development Granger caused economic promotions in the short run. As such, the pairwise Dumitrescu-Hurlin panel causality tests signified a bidirectional causality between infrastructure and economic growth in the short run in both African and Asian regions. These findings were in line with the findings by Sahoo and Dash (2012), and illustrated the importance of infrastructure development in the African and Asian countries participating in the BRI.

6. Conclusion and policy implication

One of the main focuses of the BRI is to accelerate infrastructure investment to participating countries to enable them to enjoy joint prosperity via trade links. This study's main objective was to investigate and compare the impact of infrastructure on the level of economic growth in the African and Asian regions from 2000 to 2017. The African and Asian regions were selected for this study because they share

common features, in that most of their BRI-participating countries were developing and least developed countries. To cover all of the essential types of physical infrastructure, namely, fixed telephone subscriptions, air transport, access to electricity and the total level of primary energy consumption, this study constructed a composite infrastructure index for the African and Asian regions, using the PCA method. Thereafter, this study adopted Pedroni's (1999, 2004) cointegration test to examine the existence of long-run equilibrium among the variables: economic growth, infrastructure index, gross capital formation, labour force, and governance quality. The panel fully modified ordinary least squares, dynamic ordinary least squares and the Granger causality panel data test were then employed to identify the long-run cointegrating coefficients and the short-run relationships, respectively.

The empirical results revealed that infrastructure development negatively impacted economic growth in both African and Asian region in the long-run which is mostly different from the previous study except for Straub et al. (2008). One of the possible reasons might be contributed by the dispersion of population and large income gap among the countries. Thus, the infrastructure that linked to various countries might negatively impact the economic growth in the region as a whole owing to different priority among the countries. On the contrary, the pairwise Dumitrescu-Hurlin panel causality tests revealed a bidirectional Granger causality between economic growth and infrastructure development in both African and Asian regions in the short run. As such, the result suggested that both regions need to enhance their economic growth, to a certain extent, before enjoying joint prosperity stemming from infrastructure development. Besides, there is evidence that capital accumulation played a positive and significant role in Asia region's economic growth. As per the production function framework, the accumulation of capital will increase the productivity of a country

directly and economic growth indirectly. These findings were consistent with the endogenous growth theory and the neoclassical growth theory, respectively.

This study found that capital formation imposed a negative impact on the African region but positive on Asian region. In addition, the labour force imposed a negative impact on both African and Asian regions, which implied an urgent need for the regions to shift the focus from labour-intensive industries to capital-intensive industries or services industries. Besides, this study found that total trade was positive and significant toward economic growth in the African region. However, it was not significant in accelerating economic growth in the Asian region. This might have been attributable to the diverse composition of the countries participating in the BRI from the Asian region. As most of the BRI-participating countries from the Asian region were developing and least developed countries, they had yet to play an essential part in the China-led global supply chain due to their exports being relatively low value-added products. It is believed that these countries are still focusing on the export-led growth hypothesis rather than the trade-led growth hypothesis. Lastly, based on the findings, governance quality did not significantly impact the economic growth of the Asian region even though it plays an essential role in the economic growth of the Africa region. Acemoglu and Robinson (2008) pointed out that good governance leading to economic growth is not guaranteed.

The conclusion above indicates that the impact of infrastructure on economic growth is similar between the African and Asian regions. As such, policymakers from both regions could exchange ideas on spurring economic growth in respective regions. The policymakers from both regions are advised to prioritise cooperation among the countries in the respective regions to reduce the development gap before enjoying the benefits stemming from BRI infrastructure projects. Simultaneously, the

African region's policymakers should develop trade policies to spur international trade, such as reducing trade barriers and offering unique benefits for exporters. It is evident that trade stimulates economic growth in the African region in the long-run. On the contrary, the policymakers of the Asian region should focus on accumulating foreign capital by formulating attractive foreign direct investment policies, such as reducing corporate taxes for foreign companies to enhance capital inflow.

Notes

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