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Article

Towards long-term relationship of transport investment and economic growth in Thailand: Implications for public policy in post-COVID-19 investment

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Abstract: COVID-19 has presented considerable challenges to fiscal budget allocations in developing countries, significantly affecting decisions regarding number of investments in the transport sector where precise resource allocation is required. Elucidating the long-term relationship between public transport investment and economic growth might enable policymaker to effectively make a decision in regard to those budget allocation. Our paper then utilizes Thailand as a case study to analyze the effects on economic growth in a developing country context. The study employs Cointegration and Vector Error Correction Model (VECM) techniques to account for long-term correlations among explanatory variables during 1991–2019. The statistical findings reveal a significantly positive correlation between transport investment and economic growth by indicating an increase of 0.937 in economic growth for every one-percent increment in transport investment (S.D. = 0.024, $p < 0.05$). This emphasizes the potential of expanding the transport investment to recover Thailand's economy. Furthermore, in terms of short-term adjustments, our results indicate that transport investment can significantly mitigate the negative impact of external shocks by 0.98 percent ($p < 0.05$). These findings assist policymakers in better managing national budget allocations in the post-Covid-19 period, allowing them to estimate the duration of crowding-out effects induced by shocks more effectively.

Keywords: cointegration; economic development; economic growth; post-Covid-19; Thailand; transport investment; VECM

1. Introduction

The onset of the COVID-19 pandemic sent shockwaves through global economies, communities, and public health systems, forcing societies to adopt unprecedented measures to safeguard lives and mitigate the virus's impact. As the world cautiously transitions into a post-COVID-19 era, many developing countries are confronted with the immense challenge of rebuilding, recovering, and reimagining on their economic development. This pivotal moment calls for a comprehensive reassessment of various aspects of fiscal budget utilizations, and one area that demands a spotlight is public transport investment (Buckle et al., 2020; Earley and Newman, 2021).

Public investments in public transport can serve as a multifaceted tool for economic recovery in the post-COVID-19 landscape. By injecting resources into the development and modernization of transport infrastructure, the investment could stimulate a ripple effect of positive economic outcomes. For example, transport investments have the capacity to swiftly generate employment opportunities, consequently increasing domestic consumption and bolstering domestic production. Yet, the pandemic laid bare the vulnerabilities inherent in developing countries where resources are limited, and competing priorities are numerous.

In Thailand, a nation highly reliant on tourism as a major source of national income, was particularly hard-hit by the pandemic (Klinsrisuk and Pechdin, 2022). With travel restrictions and a decline in international tourism, the economic impact was significant. Despite these challenges, a beacon of hope lies in strategic investments in the transport sector. Recognizing the transformative potential of such investments, Thailand is poised to leverage its transport infrastructure as a crucial tool for economic recovery. However, in the wake of these economic challenges, the Thai government now faces the formidable task of carefully assessing the viability and return on investment for proposed infrastructure projects. While public transport investments hold promise in terms of stimulating economic activity, creating job opportunities, and fostering both local and national economic growth, it is essential to scrutinize how these investments will impact the broader economy in the long term (Tong and Yu, 2018; Yu et al., 2012). Therefore, assessing the long-term economic impact is crucial for ensuring the success of these projects and the efficient allocation of resources (Mohmand et al., 2017).

Although Thailand has undertaken extensive planning for transport investment, there is still a lack of robust evidence confirming its direct impact on economic growth. This observation is not unique to Thailand but is a common pattern observed in many developing countries. The majority of existing literature primarily concentrates on the overall impact of transport investment on economic growth, offering a broad perspective on the subject. Therefore, there is a critical need for more nuanced and context-specific studies that delve into the direct impact of transport investment on economic landscape.

Therefore, this paper we aim to fill such gap by verifying its long-run effects of transport investment on economic growth of Thailand by taking econometric approach into consideration, expecting to help the public policymakers to efficiently allocation the national budget on boosting economic recovery in post-COVID-19 period. The rest of the article is organized as follows; Section II presents literature review. Section III presents methodology and Section IV presents results, followed by the empirical and policy discussion in Section V. Concluding remark was shown as last section.

2. Literature review: Transport investment and economy growth

It has been long discussing how transport investment could contribute to economic growth. Economic development, in its ideal definition, involves the sustainable enhancement of wealth, employment opportunities, tax revenue, and the overall well-being of a state or region. For instance, the increase in employment can positively impact the well-being of individuals and households, while choices that promote upward mobility can enhance individual satisfaction.

As an illustration of this concept, Alotaibi et al. (2021) conducted a study on the influence of transport investment and railway accessibility on regional economic growth across 13 regions in the Kingdom of Saudi Arabia. Their findings suggested that the economic value of transport investment became evident in the year following the investment. Furthermore, Saidi et al. (2020) explored the effects of transport, logistics infrastructure, and foreign direct investment on economic growth in 46 developing countries. Their results indicated a positive relationship between transport, logistic infrastructure, and economic growth. This suggests that a sustainable logistics base, encompassing infrastructure, warehouses, and port logistics, plays a pivotal role in driving the national economy forward.

Numerous studies have also endeavored to elucidate the mechanism through which how transport investment contributes to enhancing economic growth. In terms of direct effects, existing research is in consensus that it stipulates the economic growth by job creation (Cigu et al., 2019; Melia, 2018). On the indirect front, economic growth can be impacted by shifts in the prices of transport services which lead to three adjustment mechanisms, namely, changes in consumption patterns, shifts in production dynamics, and the substitution of transport methods.

Firstly, adjustment in fees may influence consumption patterns, resulting in substitutions between transport-intensive goods (e.g., leisure travel, holidays) and other commodities and services (Jara-Díaz, 2007; Wang et al., 2012). When fees associated with transport modes are modified, individuals and households often respond by reallocating their expenditures (Wang et al., 2012). Lower transport costs can render leisure travel and holidays more affordable and attractive options, resulting in increased demand for these transport-intensive goods. Conversely, higher transport fees may lead to a reduction in such travel-related expenditures, prompting consumers to allocate their resources towards alternative goods and services. The elasticity of demand for transport-intensive goods plays a pivotal role in this dynamic (Fouquet, 2016). As fees fluctuate, the degree to which consumers adjust their consumption patterns varies. In the case of high elastic demand for transport-intensive goods, even modest changes in fees can lead to pronounced shifts in consumption away from these goods. Conversely, goods with less elastic demand may exhibit more limited responsiveness to fee adjustments.

Secondly, the adjustment in transport fees may also trigger notable alterations in the production landscape, driven by both an increase in the production of goods and the expansion of production factors, a phenomenon often widespread due to economies of scale (Lakshmanan, 2011; Oosterhaven and Knaap, 2003; Rodrigue, 2020). When transport fees are reduced, firms and businesses often find it more cost-effective to transport raw materials and finished products. This reduction in transport costs can lead to increased production activities, as they take advantage of the more affordable logistics. In particular, industries that rely heavily on the efficient movement of goods, such as manufacturing and agriculture, can experience significant growth in production (Lakshmanan, 2011). Additionally, lower transport fees may incentivize them to expand their operations geographically (Rodrigue, 2020). This impetus aligns with the principle of economies of scale, which assumes a central role in this context. As production volumes surge in response to reduced transport fees, firms and businesses may realize cost reductions per unit of output (Rodrigue, 2020). This heightened cost efficiency, in turn, fosters the expansion of production and fosters economic development. The resultant transformations in the production landscape can trigger a chain reaction of impacts, extending to regional and national economies.

Finally, substitution of transport methods, a primary driver for inducing a consumption shift in transport usage lies in the reduction of fees (Cats et al., 2017; Kwok and Yeh, 2004). The lower fee could influence travel behavior and modal preferences (Salvucci et al., 2018). This impact possess the capacity to instigate a transition in transport choices. This phenomenon follows the fundamental principles of price elasticity of demand in transport economics, where fluctuations in pricing correspond to proportional shifts in the quantity of a particular mode demanded (Cats et al., 2017; Santos et al., 2010). In essence, as fees decrease, the price elasticity of demand indicates that travelers are inclined to switch from higher-cost modes, such as private car usage or air travel, in favor of more cost-effective alternatives, such as public transit, cycling, or walking (Greene, 2011; Salvucci et al., 2018).

While the linkage between transport investment and its influence on economic growth pathways has been identified as mentioned above, a critical research gap exists when it comes to investigate these relationships over the long term. Specifically, as transport investment correlates economic activities such as production, distribution, and the provision of goods and services by various stakeholders, there remains a need to precisely delineate the long-term dynamics and interactions among these factors. Many studies have primarily concentrated on the short-term economic impacts, leaving a substantial void in terms of comprehensive research on the enduring effects of transport investment. Understanding the ramifications of transport infrastructure investments on economic growth over extended timeframes is of paramount importance for shaping well-informed policy decisions. However, the current state of research leaves the ultimate conclusion in this regard somewhat uncertain.

3. Methodology

In this study, we delve into the enduring effects of public transport investment on economic growth spanning the years from 1991 to 2019. The methodology consists of four integral steps. First, in Step I, we focus on the identification of the framework, establishing the conceptual basis for our empirical investigation. Following this, in Step II, we proceed with the construction of the empirical model, laying the foundation for subsequent analyses. Step III involves the assessment of the order of integration and long-run dynamics through cointegration, ensuring a comprehensive understanding of the relationships among variables. It is crucial to settle the long-run aspects before delving into Step IV, the Short-Run Analysis utilizing the Vector Error Correction Model (VECM). This sequential approach ensures that the short-run adjustments are made in consideration of the established long-term relationships, allowing for a more nuanced analysis of how variables adapt to their long-term equilibria. Our methodology can be summarized in **Figure 1** as follows:

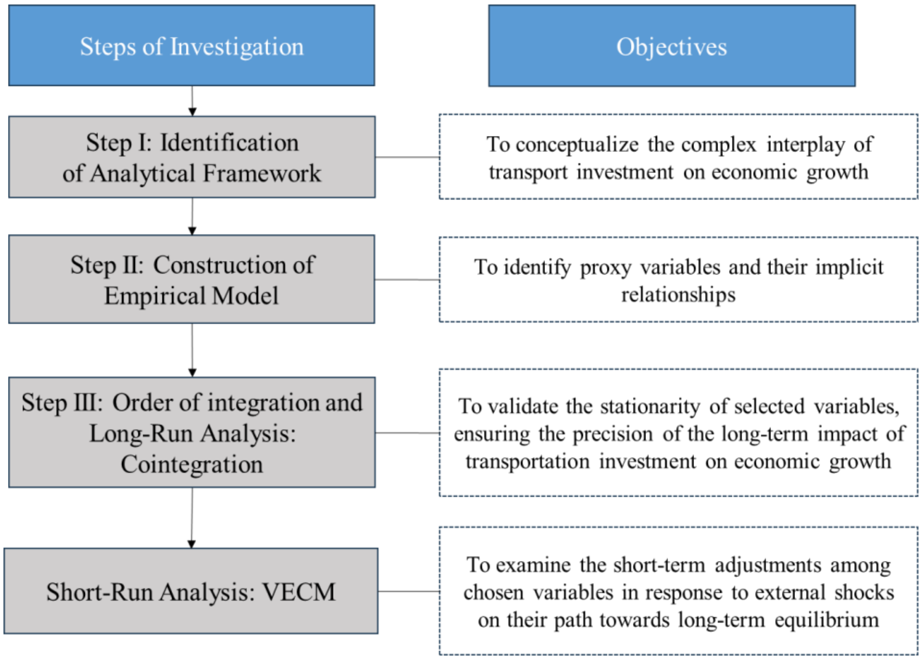


Figure 1. Research methodology.

3.1. Analytical framework

Following the literature review, one may conceptualize the complex interplay of factors, depicted in **Figure 2**. The pathway serves to encapsulate the impact of transport investment on the economy, differentiating between direct and indirect effects. The direct or general effects encompass direct repercussions on the output market. For instance, an increase in transport investment can lead to job creation in the labor market. Consequently, the additional income earned by laborers can stimulate heightened consumption, thereby generating increased demand within the output market. This heightened demand has the potential to drive up price levels and contribute to the overall national income.

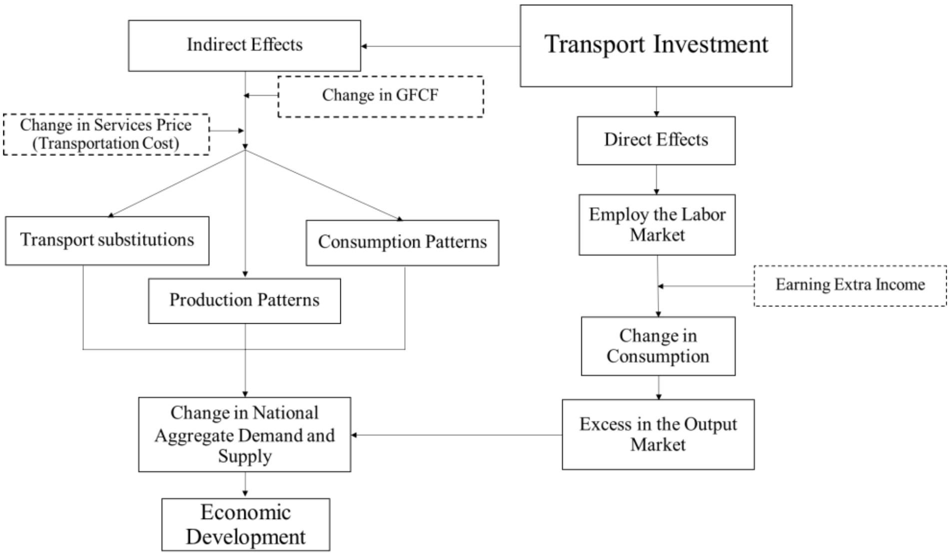


Figure 2. Pathway of transport investment to economic development.

Simultaneously, the indirect effects manifest themselves in the context of the pricing dynamics within transport services. Firstly, a reduction in fees has the potential to induce a modal shift in transport usage (Cats et al., 2017; Kwok and Yeh, 2004). Secondly, this adjustment in fees may influence consumption patterns, resulting in substitutions between transport-intensive goods (e.g., leisure travel, holidays) and other commodities and services (Jara-Díaz, 2007; Wang et al., 2012). Finally, alterations in the production landscape may ensue, driven by both an increase in the production of goods and the expansion of production factors, a phenomenon often widespread due to economies of scale (Lakshmanan, 2011; Oosterhaven and Knaap, 2003; Rodrigue, 2020).

Consequently, these two direct and indirect effects collectively contribute to changes in the price level and national income, thereby fulfilling the growing demand for transport services and ultimately fostering economic development.

3.2. Model specification

This study we highlighted one-way correlation between two macro variables, namely, impact of transport investment on economic growth. Typically, economic growth is represented by a change in gross domestic products (GDP) across the period. However, transport investments can take on different forms of representation depending on the context. This variability arises because transport investments often have a long-lasting impact that extends beyond a single year. Roads, bridges, railways, and other infrastructure projects can serve for decades. By considering "transport capital: CST" (i.e., the accumulated value of these assets over time), we can capture the ongoing benefits and contributions of past investments. Consequently, employing the concept of 'capital stock of transport' as a proxy becomes a suitable approach (Khadaroo and Seetanah, 2008; Zhang and Cheng, 2023). This proxy represents the cumulative worth of capital investments in fixed assets made in a given year. Its relationship can be denoted it in term of implicit functional form as Equation (1),

$$GDP_t = f(CST_t) \tag{1}$$

where t is the observation at period t.

Then, it can be rewritten from the functional form to linear relationship as Equation (2) as follows,

$$GDP_t = \beta_0 + \beta_1 CST_t + \varepsilon_t \tag{2}$$

To mitigate potential biases arising from nonlinearity, homoscedasticity, and skewed data, as well as to enhance interpretability (Manning and Mullahy, 2001), we performed a logarithm transformation on Equation (2), resulting in the following log-log function:

$$ln\, G\, DP_t = \beta_0 + \beta_1\, ln\, C\, ST_t + \varepsilon_t \tag{3}$$

where β, ε is parameter and disturbance terms respectively. The variables in Equation (3) were transformed to logarithm variables with the main reason to explain as a percentage change. Considering the relationship between those dependent and independent variables, the sign of TPI is expected to negative as result of the fact that the lower price in transport services can expand the transport activity to raise GDP. Meanwhile, the sign of CST should be positive as the increase in CST means the enlarging investment that affects the activities in consumptions and productions, therefore GDP would be grown up.

3.3. Long-run analysis

As the objective of this study is to verify the long-run effect of transport investment, thereby we would take Equation (3) into account long-run relationship. The general framework used to estimate the coefficient of variable in long-term relationship is a cointegration approach that integrate time series data two or more series with linear combination. While numerous methods exist for examining long-term relationships such as Autoregressive Distributed Lag (ARDL), or Granger Causality test, this study employed the cointegration concept proposed by Johansen and Juselius (1990). As our model features only one independent variable, the use of ARDL, typically employed for examining a combination of lags, may not be essential in this context (Kripfganz and Schneider, 2023). While the Granger causality test highlights the pairwise directionality between variables, it does not offer insights into the relationship between short-run and long-run coefficients (Shojaie and Fox, 2022). By these reasons, Johansen and Juselius concept which allows for the examination of the cointegration relationship across multiple variables in a vector autoregressive (VAR) framework could provide a more comprehensive analysis. This makes it particularly useful for studying systems with more than two variables, providing an extensive understanding of the underlying dynamics and interdependencies among the variables. This method has been previously applied in studies investigating the long-term relationship between transport investment and macroeconomic factors in various developing countries. For instance, it can be observed in the research conducted by Achour and Belloumi (2016) in Tunisia, Ullah et al. (2014) in Pakistan, Jahfer and Inoue (2014) in Sri Lanka, and Hakim and Merkert (2016) in South Asian countries.

The first step in examining the long-run relationship is to detect the order of integration. If the data series has the same order of integration, the investigation of long-run relationship can be applied. Following the Johansen and Juselius method, the beginning step is to find rank of relationship by using Trace Statistics (TS) and Max Eigenvalue Statistics (MES) as shown by Equations (4) and (5). Both TS and MES are evaluated from the Maximum likelihood approach.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \tag{4}$$

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \tag{5}$$

where $\hat{\lambda}_i$ is eigenvalue of observation *i*, *r* is the number of cointegration relationship(s) and T is the amount of data. The null hypothesis of TS (r) and MES (r) is described below:

TS (r); H0: Cointegration at most *r* relationship (s).

MES (r); H0: Cointegration with *r* relationship (s).

3.4. Short-run analysis

After long-run relationship is verified, we can consider in term of short-run adjustment by Vector Error Correction Model (VECM) which explains short run changes in variables and deviations from equilibrium (Sargan, 1964), as indicated by Equation (6).

$$\Delta \ln GDP_t = \alpha_0 + \theta COINT_{t-1} + \lambda DM_t + \sum_{i=1}^{n} \varphi_i \Delta \ln CST_{t-1} \quad (6)$$

According to the Equation (6), during the study period, economic shock is concerned, therefore the dummy variables (DM) as exogenous variable to express its effects is proceeded. We added two economic shocks, namely, Asian Financial Crisis in 1997 (DM_1) and Global Financial Crisis or Subprime Crisis in 2008 (DM_2). These two economic shocks exerted substantial impacts not only on Thailand but also on global economic activities, particularly disrupting consumption and production activities. Furthermore, these shocking events exhibited parallels with the circumstances surrounding the COVID-19 pandemic, where investment opportunities were constrained, necessitating a profound consideration of strategies to facilitate economic recovery.

In line with the VECM model, the coefficient of long-run relationship (θ) is considered. The θ represents the speed of adjustment of cointegrated vector towards long-run equilibrium which is significantly to observe short-term adjustment. Such its interpretation, when the economic growth in this period is affected by other exogenous factors which lead the value below or above the long-run equilibrium, the economic growth would tend to its equilibrium with speed θ in the next period.

More importantly, to ensure that the model is reliable, the concept of stationary was employed prior to the Cointegration test. This concept has a necessary condition for time series data as the most characteristic of time series data is contained random process. Using these data to run regression without non-stationary assumption, it would be caught up the problem "Spurious" regression which affects to high R-Square from the autocorrelation among disturbance term in each period (Anderson et al., 2001; Granger et al., 2001). The Augmented Dickey Fuller (ADF) method is mostly used to investigate this problem. The null hypothesis (H0) is data non-stationary, if the result show as a non-stationary data—Accept null hypothesis- a conventional approach to solve this problem is "First Difference". At the first difference level, if the variables reject the null hypothesis, it is confirmed that the data are stationary.

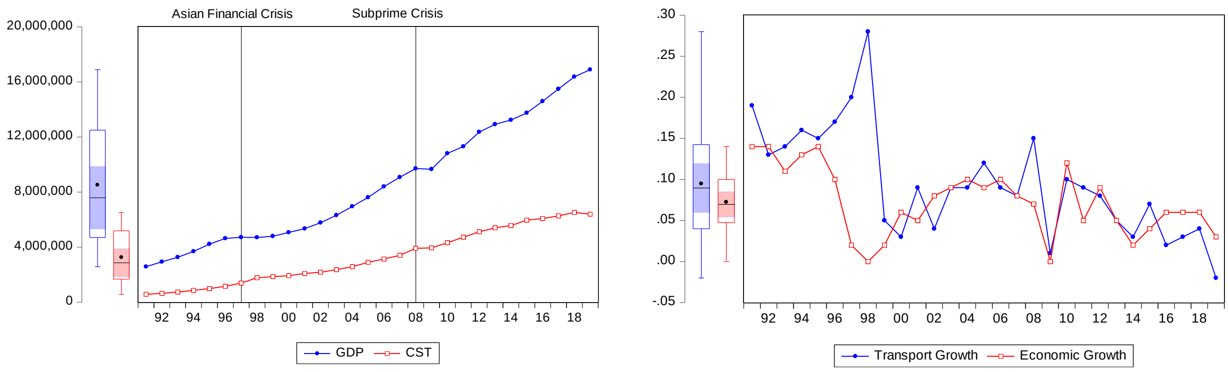
Moreover, another important step is to select optimal lag length. This step is vital for the time-series model as it reveals how many periods back could well understand the current condition. Commonly, traditional criteria used to select are Akaike (AIC), Schwarz (SC) and Hannan-Quinn (HQ). The study emphasizes the selection based on Ivanov and Kilian (2005), suggest that the sample be less than 120 observations, the AIC would give the optimal estimation.

Model and all testing hypotheses for this study is calculated by E-view 9.5 product.

3.5. Data

This study applied the yearly data to estimate the result covering years 1991–2019 (29 years). Data at national level, namely GDP and CST were compiled from the report of national account of selected years, produced by Office of the National Economic and Social Development Council of Thailand.

Figure 3 illustrated the trend in public transport investment growth during two distinct economic crises: the Asian Financial Crisis in 1997 and the Global Financial Crisis (also known as the Subprime Crisis) in 2008. The values on the vertical axis represent the growth rate of transport investment, while the horizontal axis likely represents time, with data points corresponding to the respective crisis periods. At the outset of the Asian Financial Crisis in 1997, the graph shows that the growth rate of transport investment was relatively high, starting at 0.28. This indicates that there was a significant level of investment and development in the transport sector before the crisis hit. As the crisis unfolded, the growth rate of transport investment began to decline sharply, eventually reaching 0.05. This substantial decrease implies that during the Asian Financial Crisis, investments in transport infrastructure and related projects experienced a severe contraction. Economic uncertainty, reduced access to financing, and other factors likely contributed to this decline. While considering the Global Financial Crisis, before 2008, the graph indicates that the growth rate of transport investment was at a lower level, starting at 0.08. This suggests that the transport sector was not experiencing as robust growth compared to the pre-Asian Financial Crisis period. When the Global Financial Crisis struck, the growth rate of transport investment plummeted further, reaching a mere - 0.05. This decline was even more pronounced than during the Asian Financial Crisis, indicating not only a slowdown but an actual contraction in transport investment during this crisis. Similar factors such as economic downturn, reduced investor confidence, and fiscal constraints likely played a role in this sharp decline.



(a) Value of Transport Capital and GDP (THB). **(b)** Growth of Transport Capital and GDP (%).

Figure 3. Relationship between Transport's Capital Stock and GDP.

4. Results

The results begin with **Table 1**. All variables were statistically accepted Null Hypothesis. Hence, the data was non-stationary at level which probably contained a random process with trend and drift. Then, this problem was solved by using First Difference and test all variables again. The results at First Difference indicated those variables were stationary (Rejected Null Hypothesis) thereby it concluding all variables had the same order of integration. The cointegration test would be applied.

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

Table 1. Summary of Augmented Dickey-Fuller (ADF) unit root test.

Variable	P-Value		Result
	With Trend	With Trend and Drift	
At level			
lnGDP	0.0320	0.1007	Non-Stationary
lnCST	0.8858	0.4612	Non-Stationary
At First Difference			
lnGDP	0.0141*	0.0184*	Stationary
lnCST	0.0001*	0.0004*	Stationary

* Statistically significant at level 0.05.

When considering the optimal lag length, **Table 2** shown criteria for selection. In this study, we selected the lag based on AIC criterion that found lag two was optimal lag likewise SH and HQ criterion. In fact, lag two was reasonable as the effects of investment should clearly impact in the second period, it could not suddenly affect at period that investment because of sticky economic activity and imperfect information. Additionally, the optimal lag could not be over two periods due to that the effects of information and economic activity are too slowly explicit, in line with the study by Tong and Yu (2018).

Table 2. Optimal lag length criteria.

Lag	AIC	SH	HQ
0	0.145501	0.242277	0.173369
1	−7.096435	−6.806105*	−7.012831
2	−7.215472*	−6.731588	−7.076131*
3	−7.103878	−6.426441	−6.908801

* Optimal lag order selection for each criterion.

Finally, the study tested cointegration by using Johansen method, the results were shown at **Table 3**. Both Trace test and Maximal Eigen Value Statistic significantly rejected null hypothesis at $r = 0$ that indicating all variables were cointegrated with one long-run relationship. Then, the cointegration coefficients were normalized into Equation (7),

Table 3. Johansen cointegration test.

Trace Test				Maximal Eigen Value Statistic			
H0	H1	Test	Critical	H0	H1	Test	Critical
$r = 0$*	$r > 1$	20.837	15.495	$r = 0$*	$r = 1$	20.071	14.265
$r \leq 1$	$r > 2$	0.765	3.8414	$r = 1$	$r = 2$	0.766	3.841

* Statistically significant at level 0.05.

Long-Run Relationship:

$$\ln GDP_t = \underset{(0.077)}{0.194} + \underset{(0.204)}{0.937}\ln CST_t^* \tag{7}$$

Short-Run Adjustment:

$$\Delta GDP_t = 0.180\text{-}0.198\ (1.94 + 0.937 \ln CST_t)^* \text{ - } 0.120DM_1^* \text{ - } 0.035DM_2^* \\ +0.105\Delta \ln GDP_{t-1} + 0.319\ln\Delta GDP_{t-2} \text{ - } 0.284\Delta CST_{t-1} \\ +0.011\Delta CST_{t-2} \tag{8}$$

* Statistically significant at level 0.05.

The results accorded to expected sign. If capital stock of transport is increased one percent that pushing the gross domestic product statistically expands 0.937 percent. Furthermore, the short-run adjustment was shown at Equation (8). The speed of adjustment was significantly at level 0.05. This indicated that if the shock happens in the economy, the effect would be reduced with 0.13 percent in the next period. This reduction implied that the transport investment had a dampening or mitigating effect on the subsequent economic outcome, reducing its severity to some extent.

5. Discussion

Our empirical results existed that the transport investment was importance role for boosting the Thailand economic growth. Nevertheless, our findings indicated distinctions in the effects of short-term and long-term impacts on the trajectory of economic growth.

In our long-term analysis at the national level (Equation (7)), our study compellingly revealed that even a modest one-percent augmentation in transport capital exerted a profoundly positive impact on GDP, propelling it upward by a remarkable 0.937 percent, with a standard deviation (S.D.) of 0.204. This empirically derived insights not only underscored the pronounced significance of persistent investments in transport infrastructure but also provided concrete evidence of its role as a potent catalyst for the sustainable economic growth of Thailand. This observation prompted consideration of a hypothesis: Thailand may exhibit a strong multiplier effect emanating from the transport sector on its overall economy. Over the period spanning from 1991 to 2019, instances of government investments in transport projects have resulted in multifaceted economic consequences. Principally, such investments have generated employment opportunities, elevated the demand for goods and services, and invigorated diverse sectors of the economy. These ripple effects were as a result of changing patterns on consumption (Jara-Díaz, 2007; Wang et al., 2012), production (Lakshmanan, 2011; Oosterhaven and Knaap, 2003; Rodrigue, 2020), and transport substitutions (Cats et al., 2017; Kwok and Yeh, 2004). This hypothesis aligned with the broader academic literature, which posited that robust investments in transport infrastructure can yield far-reaching economic benefits (Berechman, 2001; Seidu et al., 2020). Furthermore, it underlined the pragmatic policy implications of sustained and strategic investments in transport infrastructure as a means to foster economic resilience and growth, a perspective echoed in the development policies of various nations (Kemmerling and Stephan, 2002; Lee, 2021).

In the short run following the VECM (Equation (8)), a significant association was identified between the GDP and transport investment in Thailand. Our analysis yielded an estimated speed of adjustment of 0.198, signifying that a one-percentage increment in transport investment corresponded to a reduction of 0.198 percent in the adverse effects of external shocks on GDP or economic growth. This observation showed the remarkable swiftness with which Thailand's transport investment reacted to economic shocks, potentially assuming a role as a mitigating influence on economic activity. This proved instrumental in facilitating the recovery of the Thai economy during the period from 1991 to 2019, in stark contrast to the average loss rates experienced during the Asian Financial Crisis (D1) and the Global Crisis (D2), which inflicted damages on the Thai economy to the extents of 0.120% and 0.035%, respectively. This phenomenon can be principally attributed to the catalytic impacts of transport investment in stimulating consumption and production activities within the economic system, as established by prior research (Jara-Díaz, 2007; Kwok and Yeh, 2004; Wang et al., 2012). As consumption patterns changed and production activities developed transformations in response to developments in transport infrastructure, these adaptations fostered a resilient economic environment. Consequently, the speed of adjustment within the VECM framework emphasized the dynamic role played by transport investment in Thailand during times of crisis (D1, D2), highlighting its capacity not only to react to but also to actively shape the trajectory of the country's economic recovery (denoted by the sign "-").

6. Policy implications: Public investment in post COVID-19

In light of the ongoing challenges posed by the COVID-19 pandemic, it is imperative for the government of developing countries to adopt a comprehensive policy framework that addresses not only immediate healthcare concerns but also promotes sustainable economic growth. To this end, one critical policy implication from our analysis could suggest the integration of transport investment within broader economic recovery efforts.

The importance of this integration is underscored by ample prior research highlighting the impediments to transport achievement, particularly the bottleneck problems that directly hinder economic growth (Bronzini and Piselli, 2009; Jiwattanakulpaisarn et al., 2010; Kim, 2002). As discussed in the previous section, prioritizing investments in improving and expanding transport networks is important and necessary. Smart mobility, for example, could increase an investment in public transport system and uplift wellbeing of citizens by integrating digital technology for an effective city management. Investment in technological development to be intelligent transport system (ITS) that connects diverse IT and modalities is required. In addition, smart mobility would provide significant transport data to all parties – central government, local government, private sector and public sector. Governments would gain benefits in terms of effective and sustainable city management. Businesses in different segments would be interconnected. Competition among investors in this field would be intense to produce innovation for transport and related areas. An obvious example is public transport businesses, Uber, Grab, Line Taxi, and Robinhood, that shift consumers to be prosumers. In terms of citizens' quality of life, apart from convenience, ITS also improves transport security, which would reduce mortality rate and a certain public health issues such as budget for disability and long term care.

However, investment in transport system not only enhances accessibility for citizens but also facilitates the movement of goods and services, thereby stimulating economic activity (Zhang and Graham, 2020). By taking investment allocations into consideration, the governments must consider policies that foster economic diversification away from urban centers. The prevailing concentration of economic activity in urban areas has been a trend for some time. However, the COVID-19 crisis has exposed vulnerabilities associated with such concentration, especially when transport blockage from city lockdown (Klinsrisuk and Pechdin, 2022). To address these challenges and bolster the resilience of the economic environment, it is advisable to explore investment opportunities aimed at enhancing accessibility and infrastructure in sparsely populated regions, with a particular focus on potential rural areas.

As a matter of fact, the improvement of rural connectivity has become more and more important. The pandemic has brought to light the importance of resilient local economies, and rural areas represent a largely untapped reservoir of economic potential (Vitale Brovarone and Cotella, 2020). By investing in better road, rail, and digital infrastructure to connect these rural regions, governments can facilitate the flow of goods, services, and labor (Cascetta et al., 2020; Vitale Brovarone and Cotella, 2020). This, in turn, can spur economic growth by enabling farmers and businesses in rural areas to access larger markets for their products. One particularly direct impact of improved rural connectivity is the reduction in migration pressure on cities (Coscia et al., 2020; Marta et al., 2020). In many developing countries, rural-to-urban migration has strained urban infrastructure and social services, leading to overcrowding and unsustainable living conditions in cities (Marta et al., 2020). By offering better economic prospects and opportunities in rural areas, the pull factors drawing people to urban centers can be diminished. Furthermore, the economic benefits of enhanced rural connectivity extend beyond agriculture (Surya et al., 2021; Yaacoub and Alouini, 2020). These improvements can stimulate diverse industries such as agribusiness, manufacturing, and tourism, creating jobs and income streams that contribute to overall economic recovery.

By bridging the rural-urban divide, in the context of constrained government budgets which are commonly found in developing countries, it is essential to allocate investments judiciously, giving priority to projects that align with these policy goals (Rouhani et al., 2016). Private Sector Partnerships are instrumental in driving economic recovery after the COVID-19 pandemic. Collaborating with the private sector to finance and manage transport infrastructure projects can be a game-changer in revitalizing economies (Guo et al., 2022). Public-private partnerships (PPPs) are a strategic approach that allows governments to harness the resources, innovation, and expertise of private enterprises while jointly shouldering risks (Galilea and Medda, 2010; Guo et al., 2022). In the wake of the economic challenges posed by the pandemic, PPPs can provide an infusion of much-needed capital, expediting the development and improvement of critical transport infrastructure. These partnerships enable governments to tap into private investment, which is essential when public budgets are strained. Private sector entities can inject substantial capital into projects, accelerating their implementation. Moreover, the involvement of private companies often results in more efficient project management, cost-effectiveness, and innovation in design and execution (Le et al., 2022). PPPs also foster a sense of shared responsibility. Private partners have a vested interest in the success of these projects, ensuring that they are completed on time and within budget. This can mitigate delays and cost overruns that frequently plague public infrastructure projects.

In conclusion, the pivotal role of public investment in transport as an engine of economic growth in developing countries has been underscored, particularly in the context of the post-COVID-19 era. These outlined strategies, when tactically executed in harmony with comprehensive economic policies, hold the potential to empower these nations in constructing robust and effective transport networks, thereby fostering economic development and enhancing the well-being of their populations.

7. Conclusion

We undertook a thorough examination of the long-term relationship of transport investment on economic growth. Our findings revealed a notably positive correlation between transport investment and economic growth, indicating an increase of 0.937 in economic growth for every one-percent increment in transport investment (S.D. = 0.024, $p < 0.05$). This highlighted the potential for expanding the transport investment as a means to fortify Thailand's economy in the long term. Additionally, in terms of short-term adjustments, our results indicated that transport investment can significantly mitigate the negative impact of external shocks by 0.98 percent ($p < 0.05$). Consequently, the findings extracted from this study could reconfirm the crucial significance of optimizing the allocation of transport resources, taking into account the trajectory from transport investment to comprehensive economic development. Especially in the post-COVID-19 era, this period presents an exceptionally challenging environment, with numerous countries contending with constrained national budgets and an immediate requirement for measures to kickstart economic recovery. In this context, strategies that concentrate on improving urban-rural connectivity and harnessing the benefits of public-private partnerships (PPPs) that we have been discussed can have the potential to yield positive results for governments grappling with these difficult circumstances.

More to the point, given our research constraints, a significant drawback of the Johansen cointegration test in the realm of transport investment analysis is its assumption of a linear relationship between variables. This simplification, while facilitating a quick overview of the general effects of transport investment on economic growth, may potentially neglect more complex and non-linear dynamics inherent in transport investment scenarios. To address this limitation, future research in transport investment analysis should explore the incorporation of non-linear modelling techniques. Employing advanced econometric methods, including non-linear cointegration tests, could unveil distinct patterns that linear models might overlook. Computable general equilibrium approach might be considered for investigating sectoral effects from transport linkage. Additionally, enhancing accuracy in analysis could involve considering time-varying parameters or accounting for the impact of structural breaks in the data. These methodological advancements would contribute to a more comprehensive understanding of the multifaceted relationships between variables in the context of transport investment.

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