Effect of public and private investment on the economy: The case of Timor Leste

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Abstract

This study evaluates the effects of public and private investments on the economy in Timor Leste, using quarterly time series data from 2003–2019, and analysed using Autoregressive Distributed Lag models. Results show that public investment has an insignificant positive effect on gross domestic product and private investment has significant negative effect on it at lag one. Although public investment is positively correlated to gross domestic product insignificantly, its rate of return is negative due to its small marginal productivity; hence, both investments result in a decreasing economic rate of return. Short-run public investment also have a positive effect on private investment; hence, short-run private investment is improved, although it has crowding out effects due to the negative coefficient of private investment. Short-run bank lending interest rates negatively correlate to gross domestic product, and that results in decreasing economic rates of return. Therefore, improving public investment and reducing bank lending interest rates will likely improve the economy in the country.

Keywords: *Gross domestic product, public investment, private investment, Autoregressive Distributed lag model*

1. Introduction

Investment plays an important role for the global economy, although in a small percentage, representing an average of 18.1–33.2 percent of world gross domestic product (GDP) during 1960–1994 (Collins and Bosworth, 1996; IMF, 2007). Specifically, it represented 22.3 percent of GDP in China, 21.1 percent of GDP in East Asia, 18.9 percent of GDP in South Asia, 19 percent of GDP in Sub-Sahara Africa and Middle East, 21.4 percent of GDP in Latin America, and 20.8 percent of GDP in Industrial Countries. In Timor Leste, a combination of private and public investment shares were even higher, representing 35 percent and 44 percent of non-oil GDP in 2018 and 2019 (MoF, 2020), an indication that economic growth in the country was associated with investment.

Besides enhancing economic growth, investment creates jobs for people in the country; the number of people working during 2010–2016 increased by a respective 35.1 percent and 60.6 percent compared to the number of people employed in 2010 and 2013 (SEFOPE *et al.*, 2017). This was comparable with the budget the government allocated to investment, which amounted to $3.87 billion during 2011–2018; this budget financed various investment programs such as road, port, and electricity programs, and it funded the external debt among many other investment programs (OGE, 2018 in BCTL, 2019a).

Government recognized that economic growth was the single most important factor for poverty reduction in the country with strategy being rest on investments by increasing public investment above 30 percent of non-oil GDP during the rest of decades while keep constant current expenditure broadly and improving climate for private investment to drive growth and private investment in later years (IMF, 2007). Since 2008, public investment plays a major role in the economy, while private investment still plays a small role (MoF, 2020). In 2019, 75 percent of the total investment of the country came from public investment, while in 2018 it was only 60 percent of total investment. This raises another question about whether increasing public investment decreased private investment. This study evaluates the effects of public and private investment on the economy as well as evaluates the effect of public investment on private investment and vice versa.

Previous studies have shown that public investment has had two major effects on the economy, both positively and negatively (Afonso and Aubyn, 2008). First, increasing public investment increases demand for more capital for investment. This can be done through raising the tax rate or withdrawing more capital in the market from private sectors. Both have a negative impact on private investment. Raising the tax rate will add an additional cost for private investment and withdrawing more capital in the market from private sectors will reduce capital availability for private investors in the domestic market, thus demotivating private investors to expand their investments, resulting in private sector investment contraction.

Second, public investment creates positive conditions for private investment. For example, construction of vital infrastructure such as roads and bridges can increase productivity of private investments and has the potential to improve private business conditions, and thus, their revenue. However, it does not always bring a positive effect to the economy, as indicated in Afonso and Aubyin (2008), which suggests that public investment has mixed effects. In some countries, it has a positive effect on the economy and in others, it has a negative effect, while private investment mostly contributes positively to economic growth. Of the 17 countries included in that study, only three showed negative rates of return due to smaller marginal productivity of private sector investment (Afonso and Aubyn, 2008). In

addition, Bivens (2017) showed that public investment on infrastructure positively contributes to economy growth in the U.S with estimated average rates of return of 16.7 percent, in addition to creating more than one million jobs in the US.

This study shows that private investment results in short-run significant negative effects on the economy while public investment results in insignificant positive effects, although it can result in a negative rate of return due to small marginal productivity. However, with clear target setting, public investment will likely boost the economy, more so than private investment, as it is positively correlated. The study also shows that public investment positively correlates to private investment; hence, public investment boosts private investment while private investment has mixed effects, improving public investment at lag zero and diminishing it again at lag one.

The rest of this paper is organised as follows: Section 2 presents a literature review on the effect of investment, tax, and interest rate on the economy; section 3 discusses theoretical concepts of the economic rate of return to investments; section 4 discusses the data and method of analysis; and section 5 presents the results and discussions of the study. Lastly, section 6, presents a brief conclusion and policy implications of the study.

2. Literature review

2.1 Effect of investment on the economy

Several studies have investigated the effects of public and private investments on the economy in other parts of the world. Using a cross-sectional sample of 24 countries and the growth model, Khan and Reinhard (1990) in their study on investment and economic growth in developing countries, evaluate the effects of private and public investment on economic growth and find that private investment has a larger direct effect on long-run economic growth than public investment. This indicates that the direct marginal rate of return to private investment is greater than the rate of return to public investment. However, the authors also express that public investment may have an indirect positive effect on the economy, as their study only evaluates the direct effect of private and public investment, especially when private and public investment are complementary.

On a country-specific basis, the study of Rabnawaz and Jafar (2015) in Pakistan shows that public investment positively correlates to GDP in the short-run and has a bi-causal relationship as increases in GDP cause rapid increases in public investment. This is further supported with the results of the Granger causality test, which shows a bi-causal relationship between GDP and public investment when run from GDP to public investment and vice versa. After combining the public and private investment in Pakistan, investment in overall has a positive effect on GDP when evaluating the importance of investment on economic growth using ordinary least square (OLS) model. It shows that a one percent increase in investment will improve GDP by 0.89 percent. Overall investment also has a bi-directional relationship, GDP had Granger causality effect on investment and reversely, investment had a Granger causality effect on GDP.

Using the Granger causality test, Anwer and Sampath (1999) in their study on investment and economic growth in 90 countries also found short-run causality between GDP and investment in 15 countries and long-run causality in 23 countries. More specifically, the study showed that investment and GDP had a bi-directional causality in 10 countries, mostly positive correlation between the two variables, had a unidirectional causality from GDP to investment in 18 countries, of which 10 showed positive correlation and a unidirectional causality from investment to GDP in 10 countries, of which six showed positive correlation. These showed that investments were not always positively correlated to GDP and did not always go in the same directional causality.

Similar to the study of Khan and Reinhard (1990), the study of Chidoko and Sachirarwe (2015) in Zimbabwe found that investment positively affects economic growth. It showed that GDP increased when domestic investment, government investment, and foreign direct investment increased with coefficients of 0.0911, 0.0694, and 0.0488, respectively, indicating that investment—whether public, private, or foreign direct investment—had positive effects on the economy. Using the private sector output as a dependent variable, Pereira (2000) found that aggregate public investment had a positive effect on private output with its elasticity of 0.04253 and marginal productivity of $4.46. It implied that a one dollar increase in public investment leads to a total accumulated increase of $4.46 in private output with its corresponding annual rate of return of 7.8 percent; hence, it had a positive effect on the economy.

Disaggregating the public investment into several sectors, namely 1) highways and streets; 2) electric and gas facilities, transit system, and airfield; 3) sewage and water supply systems; 4) educational building, hospital building, and other buildings such as industrial, general office,

police, and fire stations; and 5) conservation structure, development structure, and civilian equipment, the study of Pereira (2000) further showed that increasing public investment by a dollar on highways and streets will increase private investment output by $1.97 and increasing public investment by a dollar on electric, gas facilities, transit systems, and airfield will increase private output by $19.79. Moreover, it showed that increasing public investment by a dollar on sewage and water supply system will increase private output by $6.36 and increasing public investment by a dollar on education buildings, hospital buildings, and other buildings such as industrial, general office, police, and fire stations will increase private output by $5.53. And lastly, the study showed that increasing public investment by a dollar on conservation structure, development structure, and civilian equipment will increase private output by $4.06. They all indicated that public investment had a positive effect on the economy; hence, resulting in an increased economic rate of return to public investments.

2.2 Effect of income tax on the economy

Lee and Gordon (2005) evaluate tax structure and economic growth using OLS, instrumental variables (IV), and panel models, finding that statutory corporate tax rate significantly and negatively correlates with cross-sectional differences in average economic growth when controlling for various economic growth determinants and other standard tax variables. The findings show that increasing corporate tax rates leads to lower future growth rates within countries and suggests that a 10 percent increase in corporate tax will decrease the annual economic growth by one to two percentage points.

Saibu (2015), in his study on optimal tax rates and economic growth in Nigeria and South Africa, also find that higher tax rates reduce economic growth after some certain percentages. His study shows growth-maximizing tax rates would be 15 percent of GDP per capita for South Africa and 30 percent for Nigeria. At those tax rates, the economic growth would be 6 percent and 8 percent in contrast to actual growth rates of 2.48 percent and 4.51 percent for South Africa and Nigeria, respectively. The paper concluded that the countries' tax rates at that time were sub-optimal and could hurt the long-term sustainable growth process in the two countries. Similarly, the study of Ferede and Dahlby (2012) entitled 'The impact of tax cut on economic growth in Canada' found that a one percentage point cut in corporate tax rates was related to a 0.1–0.2 percentage points increase in annual growth rates. It further indicated that switching from retail sales tax to a sale tax that was harmonized with the federal value-added sales tax boosted provincial investment and growth in Canada.

2.3 Effect of bank lending interest rate on the economy

Eggertsson *et al.* (2019) evaluate the effect of the negative nominal interest rate policy and bank lending channel in Sweden using aggregate and bank-level data and find that an interest rate of -0.5 percent increases borrowing rates by 15 basis points and reduces bank output by seven basis points. Although bank output declines, reducing the bank lending interest rate will attract many borrowers to borrow money from banks, consequently increasing investments, which improves the economy. Liu, Mian, and Sufi (2019) show that lower interest rates encourage market concentration by raising the industry's leader incentive to gain strategic advantages over followers, and the effect becomes a strength when the interest rates approach zero, although the widening gap of productivity between leaders and followers slows the growth of productivity. This notion is further supported by the study of Al Karaki (2015), which indicates that increasing bank lending rates increases economic growth in Palestine. The coefficient of bank lending rates is 0.31 and significant at the 1 percent level. Bank lending rates also positively correlate with economic growth when separating the bank lending rate into private and public bank lending rates, with respective coefficients of 0.37 and 0.13. However, the author does not include bank lending interest

rate in his study, and so, the effect of bank lending interest rate on the economy remains unclear in this case, or at least does not affect the demand for lending.

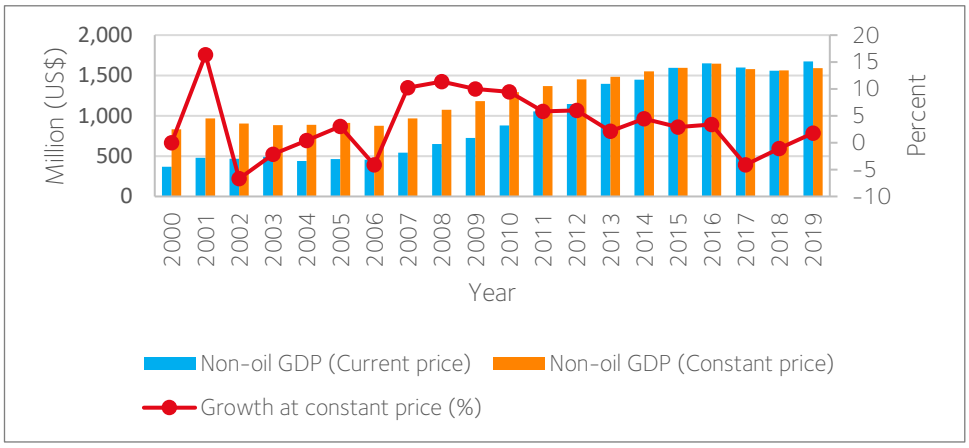
Bank lending rate is not always positively correlated to and the cause of economic growth. In a literature discussion based on 24 references from various countries, Al Karaki (2015) shows that 17 percent of the literature he reviewed showed no causality between bank lending rate and economic growth, while 83 percent showed causality between bank lending rate and economic growth. Of the 83 percent, 41 percent showed unidirectional causality, 21 percent showed negative causality, and another 21 percent showed bi-directional causality, indicating that bank lending rate has mixed effects on economic growth: bank lending rate either contributes positively or negatively, or unidirectionally to economic growth, has no effect at all on economic growth, or bank lending rate and economic growth affect each other.

2.4 Investment, tax rates, bank lending interest rates, and the economy in Timor Leste

Investment and economy

The report of the General Directorate of Statistics (DNE, 2020) of the Ministry of Finance shows that nominal non-oil GDP increased significantly during 2006–2016 before decreasing slightly during 2017–2018, while public investment has decreased since 2012 after it increased during 2006–2011. The report indicates that GDP and investment went in opposite directions between 2011–2019, and almost went perfectly in the same direction between 2002–2008. This led to two phenomena of growth when comparing the growth in 2002–2008 with the growth in 2009–2019. The growth increased at an increasing rate of 3 percent during 2002–2008, while during 2009–2019, it increased at a decreasing rate of -0.9 percent (MoF, 2019b).

Figure 1. Gross domestic product and its growth



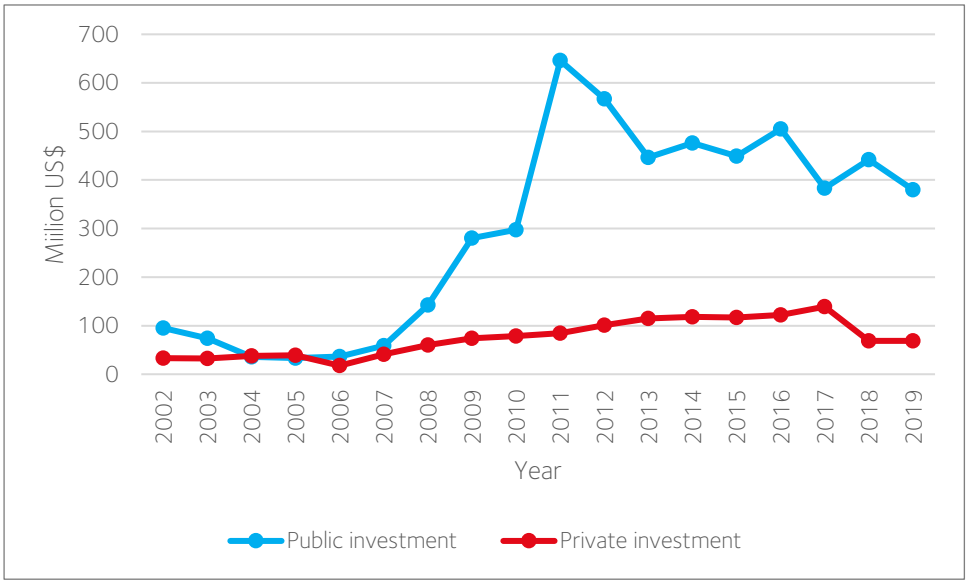
Source: Ministry of Finance

In contrast to public investment, private investment has been increasing slowly during 2006–2017, before it decreased again to 2008–2009 level (Figure 2) and followed the trend of GDP (Figure 1), an indication that private investment and GDP went in the same direction during the same periods. In contrast to private investment, public investment increased by 15.3 percent in 2018, although government expenditure decreased by 2.4 percent from 2017; in 2019, all private and public investment decreased, although government and household final consumption expenditure increased by 3.2 percent and 5.8 percent, respectively, while GDP kept improving during the same period.

Overall, the report of the World Bank in 2020 shows that long-run public investment represented by government capital expenditure positively correlated to GDP with a

coefficient of 0.13 (World Bank, 2020), an indication that increasing public investment increased GDP by 0.13 percent, although lower than capital spent. However, it did not include private investment in its analysis; hence, it ignored the contribution of private investment to the economy. It may also have overestimated the result as expenditure related to public transfer was included in the analysis. This leads us to do further analysis on the effect of public and private investment on the economy, whether they both have a positive effect or not.

Figure 2. Public and private investment



Source: Ministry of Finance

Although it does not specifically show the impact of public and private investment on the economy, the study of Inder and Cornwell (2017) shows that investment in the country has been dominated by public investment since 2008, creating a wider gap between private and public investment. Consequently, the private sector has had a smaller impact on employment. This is also due to the smaller share of private investment (7.6–14.7 percent) to GDP during 2000–2019, taking bank lending rates to private sectors as a proxy to private investment. It is even smaller when deducting the amount of money commercial banks provided to individuals and others for lending, which was mostly used for household consumption. Thus, expanding private sector investment will possibly have a greater impact on the economy.

Political instability is another factor that contributes to investment development and, consequently, to the economy. In 2006, economic growth was negative due to dissatisfaction among the military personnel inside their compound, which spread to racial conflict—namely, the Lorosa'e–Loromonu conflict. This caused domestic unrest due to fighting between the almost 600 outgoing military personnel officers known as petitioners (HRW, 2007) from the western part of Timor Leste and military personnel from the eastern part of the country which also involving police officers and civilians from both parts, disrupted government operations and operation of business activities as usual. In 2017 and 2018, economic growth was negative due to political parties failing to reach concession to form a simple majority coalition in parliament, which caused governments to run on duo decimo regimes as they could not implement all of their programs as planned. The World Bank report also indicates that economic growth in 2017 fell due to lower government expenditure (World Bank, 2018), which can also affect public investment. This also created an unsecured environment for private investors, which caused private investment to decrease by 55 percent, 50 percent, and 1 percent in 2006, 2018, and 2019, respectively. The same situation applied in 2020 but was coupled with the global Covid-19 pandemic. Contraction in 2002 and 2003 was associated with the transition of administration from the United

Nation Transition Administration in East Timor (UNTAET) to the government of Timor Leste's officials to officially lead the government as a nation, which was constrained with budget limitations.

Tax rate and economy

Tax in Timor Leste is set to 10 percent of any residence's personal monthly wage income of greater than $500, non-residences for any salary level, sole trader business entrepreneur annual revenue of greater than $6,000, any corporation and unipersonal alike for any annual income level and 0.5 percent of total turnover of business enterprises, totaling 63 percent of the expected domestic revenue in 2020 (MoF, 2019a). Any residence with a monthly income of equal to or smaller than $500, and any annual sale revenue of sole traders equal to or smaller than $6,000, are set to be free of tax. All business enterprises are required to pay tax either monthly or quarterly, depend on their turnover from their previous tax year record. Any business enterprises with annual turnover of greater than $1 million in the previous tax year are required to pay tax on a monthly basis and any business enterprises with annual turnover of $1 million and less are subjected to pay tax on a quarterly basis[1].

Beyond wage income tax, the government also applied withholding tax to various income types applicable to Timor Leste's residences and Timor Leste's permanent establishment of non-residences (Table 1) and identified that taxes are part of national revenue and hence, can possibly positively correlate to national income, although previous studies have shown that taxes negatively correlate to income and investment as it bears cost to private sectors. Other types of tax that the government imposes a levy on include service tax, 5 percent of total revenue, import duties and sale tax, 2.5 percent of customer value of goods and customer value of goods imported to Timor Leste, and excise tax of 10 excisable goods at various rates, depending on the excisable goods. All of these taxes are beyond the tax of the petroleum fund.

Table 1. Sectoral composition of non-oil gross domestic product in percent

Types of taxes	Rate
Royalties	10%
Rent from land and buildings	10%
Income from prizes and lotteries	10%
Income from construction and building activities	2%
Income from construction consulting services including project management, engineering design, and site supervision services	4%
Income from the provision of air or sea transportation services	2.64%
Income from mining and mining support services	4.50%

Source: Ministry of Finance

In 2018, the government collected an amount of $127.7 million; this amount was projected to decrease in 2019 by 0.5 percent to $127.1 million. The decreased amount was mainly contributed to by individual income tax (-2 percent), corporate tax (-2 percent), withholding tax (-22 percent), service tax (-3 percent), and import duties (-23 percent). Higher amounts of tax revenue collected in 2018 were due to the government settling several pending payments to private sectors, due partly to the duo-decimal budgetary constraints in 2017. However, no previous studies evaluate the impact of tax on the economy in the country, as

already done in other parts of the world, and this gap needs to be filled. The report of the World Bank showed that the tax–GDP ratio was 7.5 percent (World Bank, 2020), but it did not show the correlation between tax and GDP itself in its report; hence, further analysis is required.

Bank lending interest rate and the economy

The average bank lending interest rate in Timor Leste were recorded above 12 percent since 2016 (BCTL, 2020) with the margin of bank lending interest rate and deposit interest rate, as well as the margin of bank lending interest rate and saving interest rate, lying between 11.92 percent and 16.36 percent. This could incur a higher cost to borrowers, which can lead to them avoiding borrowing money from banks, hence, demotivating them to expand their investments, which consequently affects the economy. In 2018, companies and households that applied to borrow money from commercial banks decreased by 59 percent and 54 percent, respectively, while the demand for loans for companies decreased by 63 percent (BCTL, 2019b), hence, contracting investments in the country. This is another factor that contributed to economic contraction in the country. On the other hand, low deposits and low saving interest rates also demotivate people to deposit and save their money in banks, hence, less money is available in banks for lending, which demotivates people to invest due to the lack of capital and high lending interest rate.

All in all, the above review of the literature indicates that public and private investment have both positive and negative effects on the economy. In Timor Leste, although report of the World Bank in 2020 show public investment positively correlates to GDP, it does not include private investment in its analysis. Hence, this report ignored the contribution of private investments to the economy, while mostly focusing on private and public investments, tax revenue, bank lending interest rate, and the economy's status during the years. This calls for further analysis to be done to understand the individual effects of these on the economy, considering their level of stationary and cointegration.

3. Theoretical concept of economic rate of return

Economic rate of return refers to return to money that has been spent on an investment. It is also referred to as benefits/losses derived from investments after all costs are subtracted. It indicates how much additional benefit/loss an investor will get when increasing any amount of money from initial capital investments. In project analysis, this refers to internal rate of return (Gittinger, 1982) where economic rate of return to investment becomes zero, which is derived from a combination of low discount factors, difference of low and high discount factors, and their respective present worth of net benefit and losses. Econometrically, it is the coefficient[2] of investment, which is also referred to as elasticity with respect to GDP (Khan and Reinhard, 1990). A positive coefficient indicates an increasing rate of return, while a negative coefficient indicates a decreasing rate of return when increasing the volume of investment.

Afonso and Aubyn (2008) grouped the economic rate of return into four: namely, partial rate of return to public investment[3], rate of return to total investment originated by impulse response to public investment, partial rate of return to private investment, and rate of return to total investment originated from impulse response to private investment. All were derived from marginal productivity[4] of public investment, marginal productivity of private investment, and marginal productivity of total investment after calculating the elasticity of private and public investment as well as the elasticity of total investment to GDP (Perreira, 2000; Pina and Aubyin, 2006; and Afonso and Aubyin, 2008). Elasticity was the accumulation coefficients of private and public investments with respect to GDP; however, this is applicable only to Vector of Autoregression model, and so, for Auto Regressive Distributed Lag model, accumulation only applies for variables with more than one lag.

Marginal productivity of total investment was the sum of marginal productivity of public and private investment. This was extended from the study of Pereira (2000), which evaluated the impact of public investment on private output, private employment, and private investment through including the private investment in order to calculate the effect of total investment. Pereira (2000) shows marginal productivity of total investment was the return to aggregate of public investment, sum of all public investments, but it ignored the private investment; meanwhile, Afonso and Aubyin (2008) find it is the sum of private and public investment marginal productivity, calculated after getting the elasticity of accumulated impulse response function. In this study, total investment was the sum of private and public investment. Gurara, Melina, and Zanna (2019) considered public investment as productive capital; hence, increasing government spending can increase output directly, and that increases the private investment. A public investment increase means more public capital is available, which in turn increases the marginal productivity of private capital, thus, increasing private investment.

Once the above accumulation coefficients of private and public investments with respect to GDP are derived, crowding-in[5] or crowding-out effect of public and private investments can be calculated through applying the equation of Afonso and Aubyn (2008) as used in their study. A positive coefficient indicates a crowding-in effect, and a negative coefficient indicates a crowding-out effect.

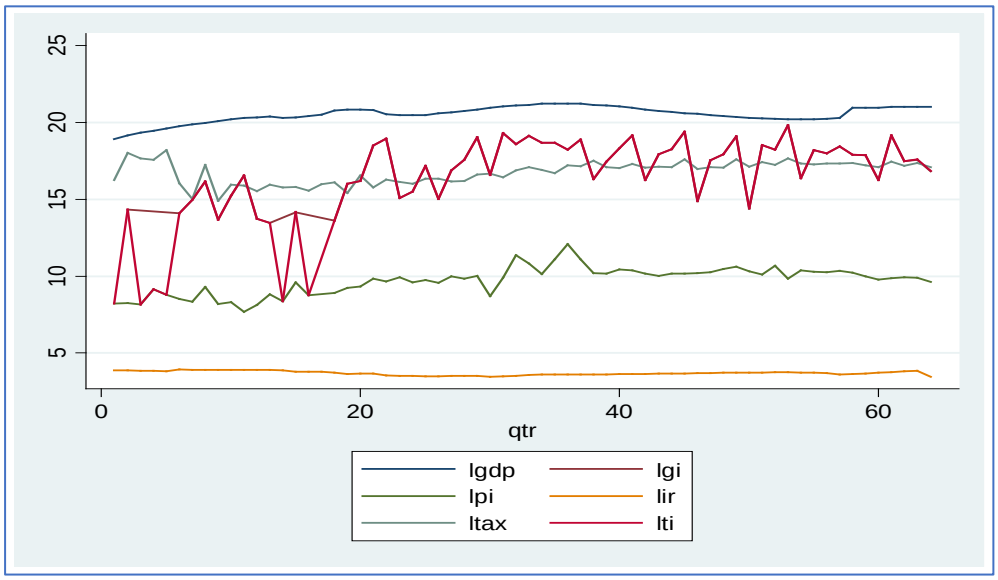
4. Data and methodology

4.1 Data

Data used in this study is from two main sources. Data on GDP, private investment, public investment, and taxes were collated from the Ministry of Finance (MoF), while data on bank lending interest rates were collated from the Central Bank of Timor Leste (BCTL). All data were set on a quarterly basis, 2003q3–2019q3.

Figure 3 illustrates GDP (lgdp), public investment (lgi), private investment (lpi), banking lending interest rate (lir), tax rate (ltax), and total investment (lti) data used in the study. It also shows that data of GI (gi) for six quarters and PI (pi) for a quarter were missing. This resulted in zero data in those quarters. In the analysis, the original data of bank lending interest rate was used as it was already in percentage form, while GDP, income tax, and private and public investment were transformed into logarithm form as shown in Figure 3.

Figure 3. Quarterly data of GDP, private and public investment, interest rate, and tax rate

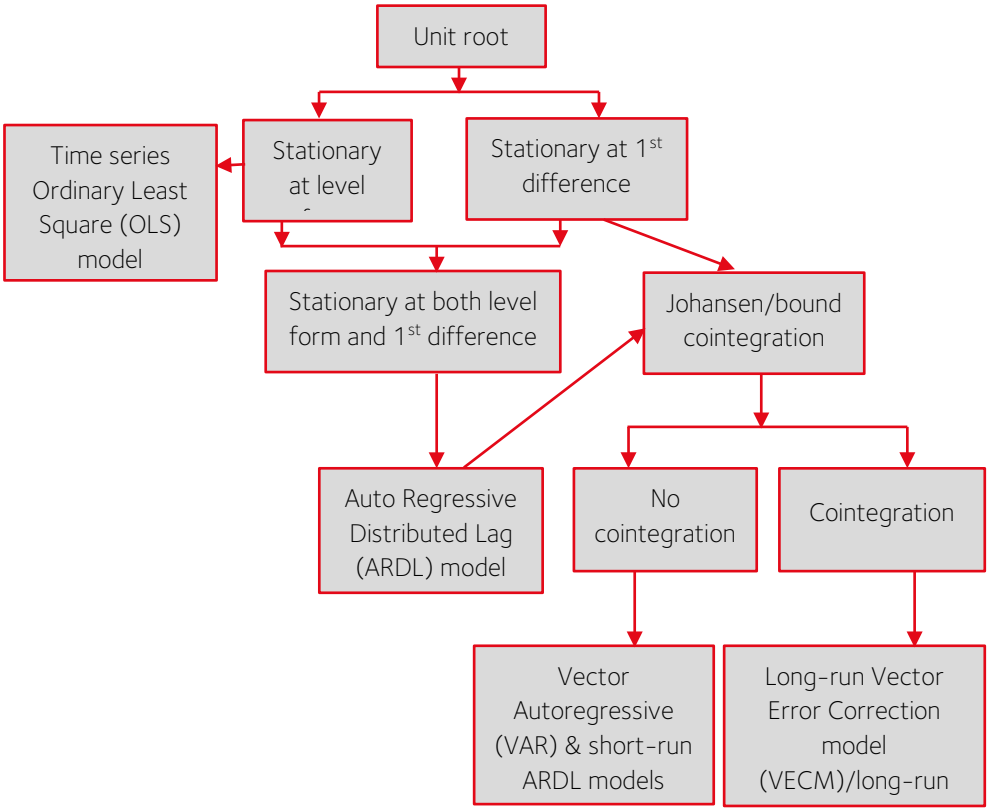


Source: Ministry of Finance and Central Bank of Timor Leste

4.2 Methodology

As was common with time series data, these procedures were followed before selecting a required model (Wei, 2016; Shrestha and Bhatta, 2018): stationary test, determine optimal length of lags, and Johannsen cointegration test. If data were stationary at level form, then time series regression was used to analyze the data, but if data were stationary at first difference, there was need to proceed to the Johansen cointegration test whether cointegration exist or not. If no cointegration, Vector of Auto Regressive (VAR) model was selected, and if there was cointegration, Vector Error Correction Model (VECM) was selected to evaluate the long-run association. However, if data were stationary at both level form and first difference, Autoregressive Distributed Lags (ARDL) model was required, then the same process was followed as for VAR and VECM to evaluate whether there was cointegration or not (Figure 4); in this case, bound cointegration test was performed. If there was no cointegration, short-run ARDL model was selected and if there was cointegration, long-run ARDL model was selected.

Figure 4. Model selection process



Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz's Bayesian Information Criterion (SBIC), and the Hannan and Quinn Information Criterion (HQIC) was considered in determining the optimal length of lags of the required models. Once a required model was selected and data were analysed, a diagnostic test was performed to evaluate the goodness and suitability of the selected model.

5. Results and discussions

5.1. Unit root test

The Augmented Dickey Fuller test showed that most of the selected variables were stationary at level form (Table 2). Bank lending interest rate (IR), GDP, and log of income tax were stationary at first difference. Income tax without log and log of GDP were stationary at level form, while with and without log of total investment, private investment, and public investment were stationary at level form. Therefore, ARDL model was selected. The values of FPE, AIC, HQIC, and SBIC showed optimal length of lags was one for model 2 and 3, and three for model 4 and 5 (Annexure 1). However, ARDL model automatically determined its maximum length of lags when running, and so, the length of lags varies between the selected variables of the selected models.

Table 2. Augmented Dickey Fuller test of selected variables

	t-stat (level form)	Alternative hypothesis
GDP	-1.71^{ns}	-5.62***
LGDP	-2.68*	Not required
TI	-3.93***	Not required
LTI	-2.84**	Not required
GI	-7.01***	Not required
LGI	-2.60*	Not required
PI	-4.35***	Not required
LPI	-3.79***	Not required
IR	-1.60^{ns}	4.99***
TAX	-4.67***	Not required
LTAX	-2.21^{ns}	14.732***

*Notes: 1. ns, *, **, *** = not significant, significant at α =10%, 5%, and 1% level, respectively*
2. t-crit at α = 1% = 3.56, 5% = 2.92 and 10% = 2.60
3. TI = total investment, GDP = gross domestic product, GI = public investment, PI = private investment, IR = bank lending interest rate, TAX = income tax, LGDP = log of GDP, LTI = log of total investment, LGI = log of public investment, LPI = log of private investment, LTAX = log of income tax, and IR = bank lending interest rate

5.2 Bound cointegration test

Since ARDL model was chosen, bound cointegration was applied for detecting the short and/or long-run model that needs to be adopted, and it showed that no cointegrations were detected as a value of F-statistic (3.92, 2.31, 3.92, and 3.92), and the t-statistics (2.36, 2.61, 2.36, and 2.36) of respective models 2, 3, 4, and 5 were smaller than the value of 5 percent critical value of 4.58 and 4.27 (F-critical) and of 3.78 and 3.99 (t-critical). Hence, short-run ARDL model was adopted in this study (Table 3). Therefore, the following general short-run ARDL model was adopted:

$$\Delta Xs_t = \alpha + \varphi \sum_{i=1}^{k-1} \Delta Xs_{t-i} + \varepsilon i_t \qquad (1)$$

Where: Xs_t = dependent and independent variables at time t and t-i, α = intercept, φ = slopes of independent variables, ε_{jt} = residual of the model at time t, Δ = difference, and i = length of lags.

Table 3. Bound cointegration test of the selected models

Dependent variable	Independent variable	F- and t- statistics	F- and t- table	Coint?	Model required
LGDP	LTI, LTAX, IR	F = 3.92 T = 2.36	$F_{1\%}$ = 6.14; $F_{5\%}$ = 4.58; $F_{10\%}$ = 3.92 $T_{1\%}$ = 4.37; $T_{5\%}$ = 3.78; $T_{10\%}$ = 3.46	No	SR-ARDL
LGDP	LGI, LPI, LTAX, IR	F = 2.31 T = 2.61	$F_{1\%}$ = 5.69; $F_{5\%}$ = 4.27; $F_{10\%}$ = 3.68 $T_{1\%}$ = 4.60; $T_{5\%}$ = 3.99; $T_{10\%}$ = 3.66	No	SR-ARDL
LGI	LGDP, LPI, LTAX, IR	F = 3.92 T = 2.36	$F_{1\%}$ = 6.14; $F_{5\%}$ = 4.58; $F_{10\%}$ = 3.92 $T_{1\%}$ = 4.37; $T_{5\%}$ = 3.78; $T_{10\%}$ = 3.46	No	SR-ARDL
LPI	LGDP, LGI, LTAX, IR	F = 3.92 T = 2.36	$F_{1\%}$ = 6.14; $F_{5\%}$ = 4.58; $F_{10\%}$ = 3.92 $T_{1\%}$ = 4.37; $T_{5\%}$ = 3.78; $T_{10\%}$ = 3.46	No	SR-ARDL

Notes: LGDP = log of GDP, LTI = log of total investment, LTAX = log of tax, IR = bank lending interest rate, LGI = log of public investment, LPI = log of private investment, and SR-ARDL = short-run Autoregressive Distributed lags.

Since model 1 was too general, specifically, the following models were applied:

Total investment:

$$\Delta LGDP_t = \alpha + \beta_1 \sum_{i=1}^{k-1} \Delta LGDP_{t-i} \beta_2 \sum_{i=1}^{k-1} \Delta LTI_{t-i} + \beta_3 \sum_{i=1}^{k-1} \Delta IR_{t-i} + \beta_4 \sum_{i=1}^{k-1} \Delta LTAX_{t-i} + \varepsilon i_t \quad (2)$$

Public and private investment:

$$\Delta LGDP_t = \alpha + \beta_1 \sum_{i=1}^{k-1} \Delta LGD_{t-i} + \beta_2 \sum_{i=1}^{k-1} \Delta LGI_{t-i} + \beta_3 \sum_{i=1}^{k-1} \Delta LPI_{t-i} + \beta_4 \sum_{i=1}^{k-1} \Delta IR_{t-i} + \beta_5 \sum_{i=1}^{k-1} \Delta LTAX_{t-i} + +\varepsilon i_t \quad (3)$$

$$\Delta LGI_t = \alpha + \beta_1 \sum_{i=1}^{k-1} \Delta LGDP_{t-i} + \beta_2 \sum_{i=1}^{k-1} \Delta LGI_{t-\mathrm{i}} + \beta_3 \sum_{i=1}^{k-1} \Delta LPI_{t-\mathrm{i}} + \beta_4 \sum_{i=1}^{k-1} \Delta IR_{t-\mathrm{i}} + \beta_5 \sum_{i=1}^{k-1} \Delta LTAX_{t-\mathrm{i}} + +\varepsilon i_t \quad (4)$$

$$\Delta LPI_t = \alpha + \beta_1 \sum_{i=1}^{k-1} \Delta LGDP_{t-i} + \beta_2 \sum_{i=1}^{k-1} \Delta LGI_{t-\mathrm{i}} + \beta_3 \sum_{i=1}^{k-1} \Delta LPI_{t-\mathrm{i}} + \beta_4 \sum_{i=1}^{k-1} \Delta IR_{t-\mathrm{i}} + \beta_5 \sum_{i=1}^{k-1} \Delta LTAX_{t-\mathrm{i}} + +\varepsilon i_t \quad (5)$$

Where: LGDP = log of gross domestic product, LTI = log of total investment, LGI = log of public investment, LPI = log of private investment, LTAX = log of tax rate, and IR = bank lending interest rates, Δ = difference (in the results D was used), and i = length of lags.

The results of the diagnostic test showed that the above models had no issues with autocorrelation and heteroscedasticity, and the model fulfils the stability condition (Annexure 2, 3, 4, and 5). Hence, the models were free of autocorrelation and heteroscedasticity and had stable coefficients. Only model five had issues with heteroscedasticity, as the probability value of white's test was smaller than α = 5 percent level, but this was the best one as error become larger at lag one, two and four. Model five also had no issue with heteroscedasticity when original data were used, but standard error of regression was huge, and so, model five was the best outcome. The values of mean variance inflation factor (VIF), which were smaller than 10 (Annexure 5), indicated a manifestation of no multicollinearity. This was because no perfect correlation was detected between the selected variables in the study (Annexure 6).

5.3 Empirical results and analysis

The result of the study showed that total investment DLTI (t-0) and DLTI (t-1) had no short-run effect on the economy as prob. = 0.675 and 0.984 (Table 4), which was all greater than α = 5 percent, and indicated that GDP was not significantly influenced by total investment. However, the signs of the coefficients showed mixed effects: positive correlation to GDP at lag zero, and negative correlation at lag one, which indicated that overall, investment will improve the economy at lag zero and will reduce it again at lag one insignificantly.

GDP and investment growth fluctuation over the years also led to the insignificancy. Over 19 years, GDP contracted for five years while investment contracted for nine years. Overall investment growth during 2001–2019 was 11.3 percent, while overall economic growth was 3.8 percent, a ratio of 0.3 percent, indicating that a 1 percent increase in total investment resulted in a marginal rate of return of 0.3 percent.

Table 4. Effects of total investment on the economy

Variable	Coefficient	Std. Err.	t-Stat
DLGDP (t-1)	1.100***	0.132	8.338
DLGDP (t-2)	-0.000ns	0.198	-0.001
DLGDP (t-3)	-0.204ns	0.123	-1.651
DLTI (t-0)	0.002ns	0.006	0.422
DLTI (t-1)	-0.007ns	0.005	-1.290
DLTAX (t-0)	0.0004ns	0.022	0.020
DIR (t-0)	-0.002ns	0.002	-1.527
C	1.054	0.450	2.344
R-squared	0.940	Mean dependent var	8.950
Adjusted R-squared	0.932	S.D. dependent var	0.184
S.E. of regression	0.048	Akaike info criterion	-3.119
Sum squared residual	0.121	Schwarz criterion	-2.842
Log likelihood	103.123	Hannan-Quinn criterion	-3.010
F-statistic	118.475	Durbin-Watson stat	2.073
Prob(F-statistic)	0.000		

*Notes: ns, *, **. *** = not significant, significant at 10%, 5%, and 1% levels, respectively. DLGDP = difference of log GDP, DLTI = difference of log total investment, DLTAX = difference of log of income tax, DIR = difference of bank lending interest rate and t-0...t-3 = number of lags.*

Although overall investment had no significant effect on GDP, it possibly had a significant positive effect on labour force adoption. It was reported in 2017 that the total number of people employed increased from 139,100 people in 2010 to 189,300 people in 2013 and increased again to 304,000 people in 2016 (SEFOPE *at al.*, 2017). However, population growth also needs to be considered as unemployment rates were also increasing during the same period. The unemployment rate increased by 98 percent and 51 percent from 11,800 people and 23,400 people in 2010 and 2013, respectively, to 35,400 people in 2016, which were higher than the labour force absorption percentage in the same period. Another reason for the increase in unemployment rate was that a higher number of young people entered the labour force market during 2013 and 2016 (DNE, 2015). In 2015, 41 percent of the population in Timor Leste was grouped under ages of 10–14 years old and 0–9 years old.

Tax rate (DLTAX (t-0)) did not have significant effect on GDP, but its sign was not as expected as it positively correlated to GDP, indicating that increasing tax rates will improve the economy although insignificantly. This was possibly due to national income depending on income tax, as income increased tax rate increases as well, and consequently increased national income. Hence, when more people earn an income of greater than $500 per month and more businesses earn an annual revenue of greater than $6,000, this will contribute positively to national income as they will contribute 10 percent of additional revenue from what they earn beyond the threshold of $500 per month and $6,000 per year.

Bank lending interest rates (DIR (t-0)) did not significantly affect GDP but were negatively correlated. This showed that every additional increase in bank lending interest rate will diminish GDP, although not significantly (Table 4). Hence, increasing bank lending interest rate will contribute negatively to the economy in the country. GDP was also influenced by its values in the previous seasons (DLGDP (t-1)). It was significant and positively correlated at lag one (prob. = 0.000) with a coefficient of 1.1, which indicated that previous seasons' GDP will increase current GDP by 1.1 percent.

Separating investment into public and private investment (Table 5), the study showed that public investment (DLGI (t-0)) had no significant effect on GDP but is positively correlated, indicating that increasing public investment will improve the economy although not significantly. The coefficient of 0.002 indicates public investment will improve the economy by at least 0.002 percent. In contrast, private investment (DLPI (t-1)) negatively correlated to GDP and significant at the α=10 percent level at lag one with a probability value of 0.078 indicates that increasing private investment will contribute negatively to the economy. The coefficient of -0.02 of private investment indicates that increasing private investment by a percent will diminish the economy by 0.02 percent at lag one.

Table 5. Effects of private and public investment on economy

Variable	Coefficient	Std. Err.	t-Stat
DLGDP (t-1)	1.091***	0.131	8.303
DLGDP (t-2)	-0.013ns	0.197	-0.067
DLGDP (t-3)	-0.191ns	0.123	-1.552
DLGI (t-0)	0.002ns	0.004	0.553
DLPI (t-0)	-0.006ns	0.013	-0.463
DLPI (t-1)	-0.020*	0.011	-1.797
DLTAX (t-0)	0.013ns	0.023	0.546
DIR (t-0)	-0.003*	0.002	-1.684
C	1.125	0.443	2.542
R-squared	0.942	Mean dependent var	8.950
Adjusted R-squared	0.933	S.D. dependent var	0.184
S.E. of regression	0.047	Akaike info criterion	-3.122
Sum squared residual	0.117	Schwarz criterion	-2.811
Log likelihood	104.229	Hannan-Quinn criterion	-3.000
F-statistic	105.705	Durbin-Watson stat	2.085
Prob (F-statistic)	0.000		

*Notes: ns, *, **, *** = not significant, significant at 10%, 5%, and 1% level, respectively; DLGDP = difference of log GDP, DLGI = log of public investment, DLPI = difference of log private investment, DLTAX = difference of log of income tax, DIR = difference of bank lending interest rate, and t-0...t-3 = number of lags.*

With the coefficient of public investment (0.002) and accumulation of private investment coefficients (-0.026), the marginal productivity of private investment, public investment, and total investment were derived as -$1.02, $0.03, and -$0.99, respectively, with an economic rate of return of public investment of -19.85 percent over 16 years of investment. Since marginal productivity of private and total investment was negative due to negative elasticity of private investment, their economic rate of return was not applicable to calculate.

Similarly, with the same coefficient of 0.002 and -0.026, this study calculates the crowding-in effect of public investment on private investment and vice versa; the results of the study show that public investment had a crowding-out effect on private investment (-0.03) and similarly, private investment had a crowding-out effect on public investment (-35.20); hence, increasing public investment will crowd out private investment, and hence, they were substituting for each other instead of complementing each other. This was due to negative overall coefficient of private investment, as public investment positively correlated to the economy.

The tax rate consistently had no significant effect on the economy and positively correlated (DLTX (t-0)), which indicated that increasing the tax rate will improve the economy insignificantly, while bank lending interest rate (DIR (t-0)) consistently had a negative correlation to GDP and was significant at the 10 percent level. The coefficient of -0.003 of the interest rate indicated that increasing the bank lending interest rate will diminish the economy by 0.003 percent (Table 5). Therefore, it is clear that increasing the bank lending interest rate will contribute negatively to the economy.

Table 6. Effects of private investment and GDP on public investment

Variable	Coefficient	Std. Err.	t-Stat
DLGI (t-1)	0.151^{ns}	0.117	1.290
DLGI (t-2)	0.530***	0.108	4.911
DLGI (t-3)	-0.542***	0.106	-5.128
DLGI (t-4)	0.186**	0.086	2.176
DLGDP (t-0)	-0.613^{ns}	1.193	-0.514
DLPI (t-0)	2.064***	0.342	6.030
DLPI (t-1)	-1.367***	0.361	-3.787
DIR (t-0)	-0.038^{ns}	0.065	-0.587
DIR (t-1)	0.251**	0.119	2.100
DIR (t-2)	-0.293***	0.106	-2.756
DLTAX (t-0)	-0.755^{ns}	0.675	-1.118
DLTAX (t-1)	1.291*	0.675	1.913
C	6.665	12.681	0.526
R-squared	0.750	Mean dependent var	6.930
Adjusted R-squared	0.686	S.D. dependent var	2.009
S.E. of regression	1.126	Akaike info criterion	3.264
Sum squared resid	59.586	Schwarz criterion	3.718
Log likelihood	-84.929	Hannan-Quinn criter.	3.442
F-statistic	11.743	Durbin-Watson stat	2.057
Prob (F-statistic)	0.000		

*Notes: ns, *, **. *** = not significant, significant at 10%, 5%, and 1% level, respectively; DLGDP = difference of log GDP, DLTI = difference of log total investment, DLTAX = difference of log of income tax, IR = bank lending interest rate, and t-0…t-3 = number of lags.*

Many factors other than interest rate in Timor Leste still need to be solved. Hor (2019) shows that political instability, as discussed previously, corruption, and access to finance are constraints still faced by 15–45 percent of firms in the country. License and permit, crime, theft and disorder, court, custom and trade regulation, electricity, access to land, poorly educated workers, tax administration, labor regulation, and transport are also still faced today by 1–8 percent of the firms. Although some progress had been made in electricity, access to land, custom and trade regulations, poorly educated workers, transport and crime, theft, and disorder during 2009–2015, the government still needs to solve these problems in order to expand private sector investments in the country.

Considering public investment as a dependent variable (Table 6), the study revealed that private investment had mixed effects on public investment. Private investment had a significant positive effect on public investment at lag zero (DLPI (t-0)) but had a negative effect at lag one (DLPI (t-1)), which indicated that increasing private investment will diminish public investment at lag one. This is understandable as in some cases the government subsidized private sectors to invest to help them survive from some kinds of crisis or unfavourable policies. The government's provision of more subsidies to private sectors will reduce the capital availability for public investment as more capital went to private sectors. However, accumulation of private investment coefficients at lag zero and one indicate a positive effect on public investment; hence, overall, this has contributed positively to public investment.

Table 7. Effect of public investment and GDP on private investment

Variable	Coefficient	Std. Err.	t-Stat
DLPI (t-1)	-0.024^{ns}	0.132	-0.185
DLPI (t-2)	-0.210^{ns}	0.126	-1.659
DLPI (t-3)	-0.254**	0.123	-2.070
DLGDP (t-0)	-0.561^{ns}	0.435	-1.290
DLGI (t-0)	0.102***	0.038	2.684
DLGI (t-1)	0.053^{ns}	0.043	1.237
DLGI (t-2)	-0.065^{ns}	0.039	-1.665
DLGI (t-3)	0.141***	0.038	3.692
DIR (t-0)	0.006^{ns}	0.024	0.248
DIR (t-1)	-0.068^{ns}	0.046	-1.486
DIR (t-2)	0.138**	0.059	2.351
DIR (t-3)	-0.111**	0.045	-2.458
DLTAX (t-0)	0.149^{ns}	0.301	0.494
DLTAX (t-1)	0.273^{ns}	0.258	1.058
DLTAX (t-2)	0.475*	0.280	1.696
C	4.596	4.929	0.933
R-squared	0.699	Mean dependent var	4.183
Adjusted R-squared	0.599	S.D. dependent var	0.655
S.E. of regression	0.415	Akaike info criterion	1.298
Sum squared resid	7.741	Schwarz criterion	1.852
Log likelihood	-23.592	Hannan-Quinn criter.	1.515
F-statistic	6.983	Durbin-Watson stat	1.788
Prob (F-statistic)	0.000		

*Notes: ns, *, **. *** = not significant, significant at 10%, 5%, and 1% level, respectively; DLOGDP = difference of log GDP, DLOTI = difference of log total investment, DLOTAX = difference of log of income tax, IR = bank lending interest rate, and t-0…t-3 = number of lags.*

Bank lending interest rate also had a mixed effect on public investment, showing that increasing bank lending interest rate will increase public investment at lag one (DIR (t-1)) but will diminish it at lag two (DIR (t-2)). However, overall, bank lending interest rates negatively correlated to public investment (DIR (t-0)) although not significantly, indicated that increasing bank lending interest rate will diminish public investment. In contrast, income tax had a significant positive effect on public investment at lag one (DLTAX (t-1)), indicating that increasing income tax will increase public investment at lag one by 1.3 percent. Although negatively correlated to public investment at lag zero, overall, accumulation coefficient of income tax at lag zero and one had a positive correlation to public investment.

Income tax also positively correlates to private investment at lag zero (DLTAX (t-0)), lag one (DLTAX (t-1)) although insignificantly, and significant at lag two (DLTAX (t-0)) at 10 percent significant level (Table 7). This indicates that increasing income tax by a percentage point will improve private investment at lag two by 0.48 percent, hence, still contributing positively to private investment. This also indicates that current income tax rates are still fallen within the profit maximizing tax rates or at least the current tax rates are not optimal yet. Another reason that caused tax contributed positively to private investment was that private investors received some amount of money from government as grants which also coming from domestic tax revenue. The study further shows that public investment is also influenced by its lags, past value of public investment increases the current value of public investment at lag two (DLGI (t-2)), diminishes it at lag three (DLGI (t-3)) and increases it again at lag four (DLGI (t-4)) while GDP did not have a significant effect on public investment although is negatively correlated, which indicates that increased in GDP does not automatically increase public investment (Table 6). The government needs to keep invest although economic growth is not as expected, this is another reason why GDP does not have significant effect on public investment and even negatively correlated.

Similarly, when considering private investment as a dependent variable (Table 7), the study showed that private investment is influenced by its own lags as well. Past value of private investment in the previous years had a negative effect on private investment at lag three (DLPI (t-3)) and significant at $\alpha = 5$ percent significant level. It decreases the current value of private investment at lag three (DLPI (-3)) by 0.25 percent while public investment has a positive effect on private investment; it increases private investment at lag zero (DLGI (t-0)) and three (DLGI (t-3)) by 0.10 percent and 0.14 percent, respectively, indicating that public investment improves private investment.

Bank lending interest rates have mixed effects on private investment. They have a positive effect on private investment at lag two (DIR (t-2)) but a negative effect at lag three (DIR (t-3)). Sometimes, bank lending interest rates increase private investment and sometimes it decreases private investment. This is associated with demand for credit in banks, as demand for credit increases in some seasons due to an increase in income, which caused an increase in bank lending interest rates. GDP also does not have a significant effect on private investment and is negatively correlated, indicating that an increase in income does not automatically increase private investment. Investors may reduce their investment if they see their planned investment is not viable although they have enough capital.

5.4 Granger Causality test

The Granger Causality test was performed to evaluate whether the selected variables have a causality relationship or not and if they have, if it is a unidirectional or bi-directional causality relationship. This approach helps us understand the causal relationship between variables, especially when most variables of the selected models are not significant. The results of the test show that GDP had the Granger causality effect on total investment, private investment, and bank lending interest rate, but there was no Granger causality effect on GDP. Similarly,

private investment had a Granger causality relationship with public investment, bank lending interest rate, and income tax, but they did not have the Granger causality effect on private investment. They all indicated a unidirectional causality relationship, with all significant at α = 1 percent, 5 percent, and 10 percent level (Table 8).

Table 8. Granger Causality test

Indep var	Dep var	Chi2	Indep var	Dep var	Chi2
LGI	LGDP	2.026^{ns}	LGDP	LTAX	0.013^{ns}
LGDP	LGI	0.158^{ns}	IR	LGI	0.045^{ns}
LPI	LGDP	0.010^{ns}	LGI	IR	2.384^{ns}
LGDP	LPI	4.310**	IR	LPI	0.439^{ns}
LGI	LPI	0.565^{ns}	LPI	IR	3.828**
LPI	LGI	11.466***	LTAX	LGI	0.201^{ns}
IR	LGDP	1.555^{ns}	LGI	LTAX	0.044^{ns}

*Notes: ns, *, **. *** = not significant, significant one present, significant at 10%, 5%, and 1% level, respectively; LGDP = log of GDP, LGI = log of public investment, LPI = log of private investment, LTAX = log of income tax, IR = bank lending interest rate, Ind. var = independent variable, and Dep. var = dependent variable.*

The above results also suggest that past values of GDP can be used to predict overall investment, private investment, and bank lending interest rate more accurately than only using the past values of overall investment, private investment, and interest rate. Similarly, the past value of private investment can be used to predict public investment, tax rate, and bank lending interest rate more accurately than only using the past values of public investment, tax rate, and bank lending interest rate. The test also shows that public investment and tax rate do not have Granger causality effect on GDP.

6. Conclusion and policy implications

6.1. Conclusion

This study explores the effects of public and private investment on the economy using quarterly time series data of 2003–2019, analysed using ARDL models. The results of the study support previous studies that indicated private and public investments resulted in decreasing economic rate of return.

No significant short-run effect of public investment on GDP was found, but private investment significantly and negatively correlated to GDP; hence, it did not contribute positively to the economy. Although public investment had a positive effect on GDP, its marginal productivity was very small ($0.03), resulting in a negative economic rate of return (-19.85 percent); hence, both private and public investments resulted in a decreasing economic rate of return. The study also shows that public investment is positively correlated to private investment, which improves private investment, while private investment has mixed effects on public investment, improving public investment at lag zero but diminishing it at lag one. However, since the accumulation coefficient of private investment on the economy was negative, increasing public investment or private investment will result in crowding-out effect.

Tax rates positively correlated to short-run GDP while bank lending interest rates negatively correlated to short-run GDP; hence, interest rates had a negative effect on the economy. This could indicate that current income tax rates are still within the optimal rate of return to investment or at least that the current income tax rates are still not optimal yet. Tax also plays an important role in the economy as the public sector depends on tax revenue for funding public consumption and public investment, and so, improving tax revenue will partially contribute positively to the economy, although it may negatively affect private sectors. The Granger causality test showed that interest rate, tax rate, total investment, and public investment increases were associated with increases in GDP and private investment, while private investment increases were associated with GDP.

6.2 Policy implications

Since bank lending interest rate is negatively correlated to GDP, and public investment and private investment at lag one and three, respectively, it is recommended to minimize the current bank lending interest rate in order to promote economic growth as well as to improve private investment, as private investment is still negatively correlated to economy, and hence can help to improve the overall economy.

It is also recommended to increase public investment with clear targets that need to be achieved in certain periods that can result in a high return; this can improve the economy in the country as private investment currently still plays a minor role for the economy. Despite having a negative rate of return due to small marginal productivity, public investment is still positively correlated to the economy; hence, increasing public investment will still improve the economy in the country. Increasing public investment will also improve private investment as it is significantly and positively correlated to private investment.

Finally, the gap between public and private investment has been kept wide since 2008 as the value of private investment is far below the value of public investment. It is important to push private investment through clearing all or some of the obstacles defined by Hor (2019), so that private investment can contribute maximally to the economy through tax payment, production, consumption, and labour absorption.

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Notes

1 https://www.mof.gov.tl/taxation/income-tax/income-tax-installments/?lang=en

2 εGIPI =∂y/∂GIPI; where: εGIPI = elasticity of public and private investments with respect to GDP, ∂y = changing in income (GDP) and ∂GIPI = changing in public and private investments

3 (1+r) t=MP; where: r = rate of return, t = lifespan of investment and MP = marginal productivity

4 MP = εGIPI.(Y/GIPI); where: Y = GDP and GIPI = public and private investment

5 $\frac{\partial PI}{\partial GI} = \frac{\varepsilon_{GI}}{\varepsilon_{PI}} \frac{PI}{GI}$ where: εGI = elasticity of public investment, εPI = elasticity of private investment and PI and GI = private and public investment, respectively

Annexures

Annexure 1. Optimal length of lag

Lag	LL	LR	df	P	FPE	AIC	HQIC	SBIC
Model 2								
0	-3687.38				3.20E+48	123.046	123.101	123.186
1	**-3561.36**	**252.03**	**16**	**0.000**	**8.2e+46***	**119.379***	**119.652***	**120.077***
2	-3550.07	22.592	16	0.125	9.70E+46	119.536	120.027	120.792
3	-3533.27	33.601	16	0.006	9.60E+46	119.509	120.219	121.324
4	-3515.64	35.263*	16	0.004	9.50E+46	119.455	120.383	121.828
n	60							
Model 3								
0	-4370.99				1.50E+57	145.866	145.935	146.041
1	**-4237.39**	**267.19**	**25**	**0.000**	**4.1e+55***	**142.246***	**142.656***	**143.294***
2	-4221.48	31.817	25	0.163	5.70E+55	142.549	143.3	144.469
3	-4195.15	52.66	25	0.001	5.70E+55	142.505	143.597	145.298
4	-4170.45	49.414*	25	0.003	6.30E+55	142.515	143.949	146.18
n	60							
Model 4								
0	-321.688				0.036892	10.8896	10.9579	11.0641
1	-177.813	287.75	25	0	0.000704	6.92709	7.33669	7.97426*
2	-147.997	59.631	25	0	0.00061	6.76657	7.51751	8.68638
3	**-103.489**	**89.016**	**25**	**0**	**.000333***	**6.1163***	**7.20859***	**8.90876**
4	-81.3847	44.209*	25	0.01	0.000401	6.21282	7.64645	9.87793
n	60							
Model 5								
0	-321.688				0.036892	10.8896	10.9579	11.0641
1	-177.813	287.75	25	0.000	0.000704	6.92709	7.33669	7.97426*
2	-147.997	59.631	25	0.000	0.00061	6.76657	7.51751	8.68638
3	**-103.489**	**89.016**	**25**	**0.000**	**.000333***	**6.1163***	**7.20859***	**8.90876**
4	-81.3847	44.209*	25	0.010	0.000401	6.21282	7.64645	9.87793
n	60							

Note: Values marked with asterisks indicate the optimal length of lag.

Annexure 2. Test of residual autocorrelation

Model 2			
F-statistic	0.248401	Prob. F (4,49)	0.9093
Obs*R-squared	1.21235	Prob. Chi-Square (4)	0.8761
Model 3			
F-statistic	0.329592	Prob. F (4,48)	0.8567
Obs*R-squared	1.63064	Prob. Chi-Square (4)	0.8033
Model 4			
F-statistic	0.226437	Prob. F (3,49)	0.9221
Obs*R-squared	1.237764	Prob. Chi-Square (3)	0.8718
Model 5			
F-statistic	0.555188	Prob. F (3,49)	0.6475
Obs*R-squared	2.3266761	Prob. Chi-Square (3)	0.5074

Note: Value of Prob>chi2 showed all models have no autocorrelation.

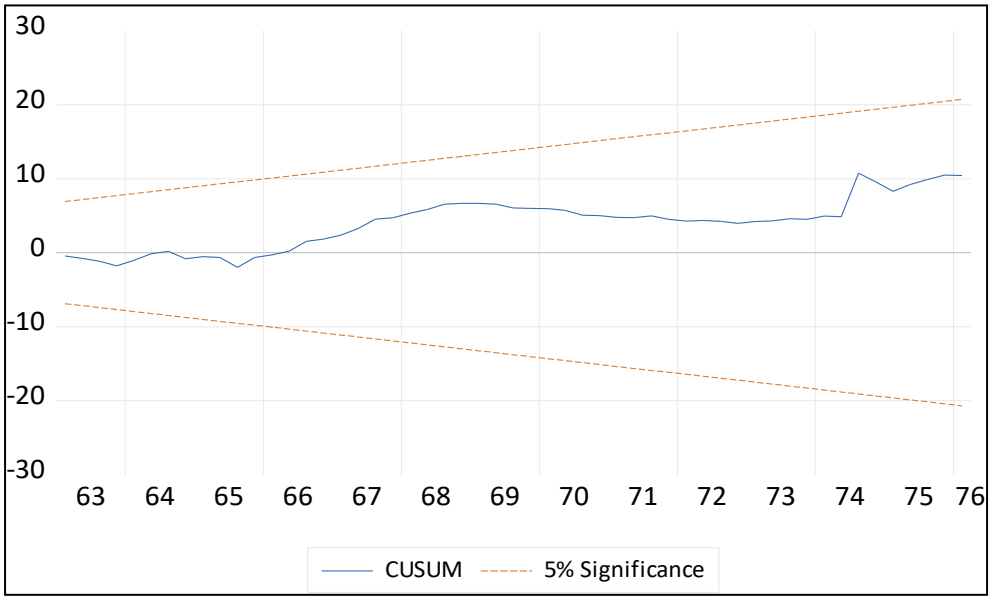
Annexure 3. Test of normality distributed disturbances

Model 2			
F-statistic	0.380132	Prob. F (7,53)	0.9099
Obs*R-squared	2.916162	Prob. Chi-Square (7)	0.8926
Scaled explained SS	25.86981	Prob. Chi-Square (7)	0.0005
Model 3			
F-statistic	0.300326	Prob. F (8,52)	0.9626
Obs*R-squared	2.693974	Prob. Chi-Square (8)	0.9521
Scaled explained SS	23.33991	Prob. Chi-Square (8)	0.003
Model 4			
F-statistic	1.100225	Prob. F (12,47)	0.3822
Obs*R-squared	13.15824	Prob. Chi-Square (12)	0.3576
Scaled explained SS	37.11038	Prob. Chi-Square (12)	0.0002
Model 5			
F-statistic	10.88405	Prob. F (15,45)	0.0000
Obs*R-squared	47.81941	Prob. Chi-Square (15)	0.0000
Scaled explained SS	75.35915	Prob. Chi-Square (15)	0.0000

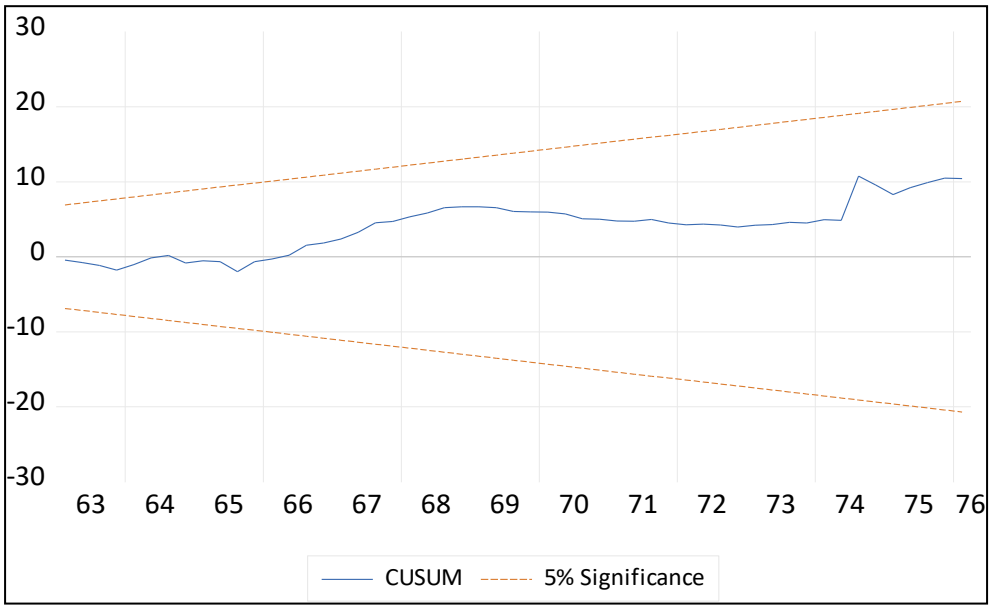
Note: Model 5 has an issue with error distribution. Errors are not normally distributed.

Annexure 4. Test of stability condition

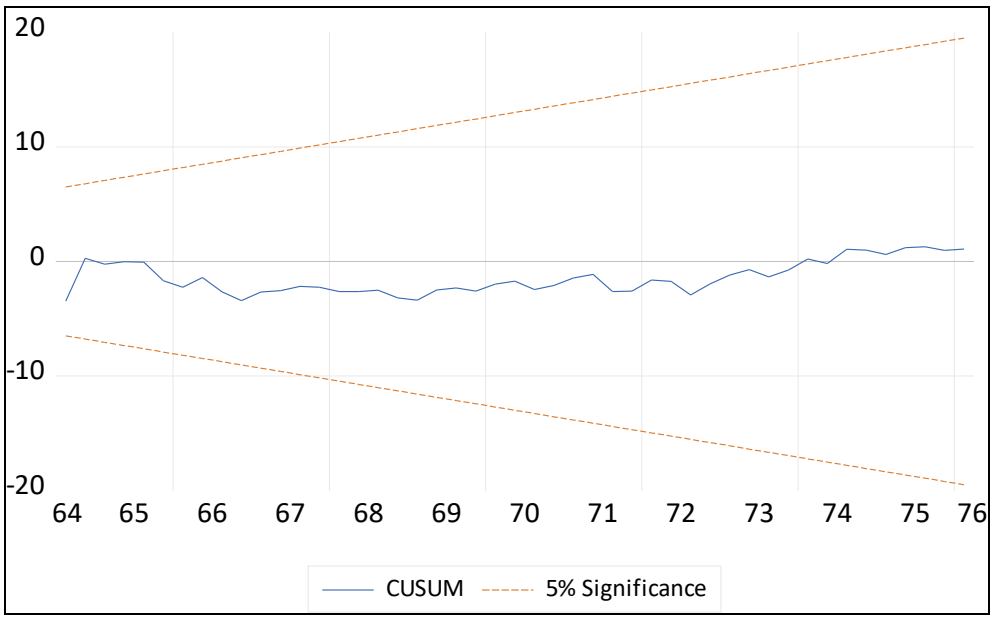
Model 2 CUSUM



Model 3 CUSUM

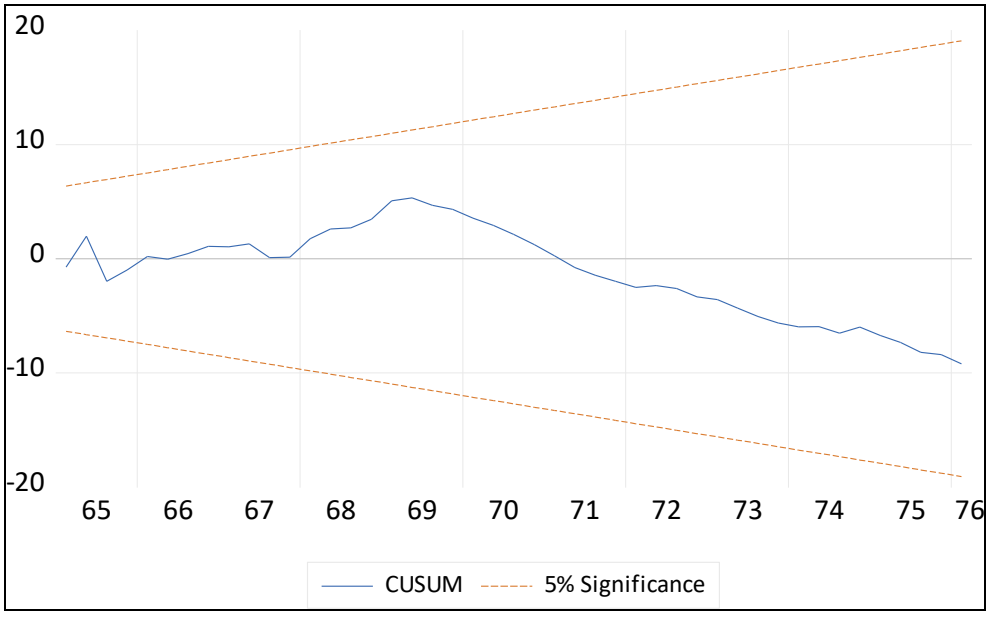


Model 4 CUSUM



Note: The coefficients of the model are stable as all values lying between the 95% of confidential level.

Model 5 CUSUM



Note: The coefficients of the model are stable as all values lying between the 95% of confidential level.

Annexure 5. Multicollinearity test

Variable	VIF	1/VIF
	Model 2	
LTI	1.4	0.713196
IR	1.32	0.759441
LTAX	1.09	0.920655
Mean VIF	1.27	
	Model 3	
LPI	1.88	0.530682
LGI	1.72	0.581439
IR	1.35	0.73896
LTAX	1.18	0.845945
Mean VIF	1.53	
	Model 4	
IR	1.84	0.543307
LGDP	1.76	0.569396
LPI	1.47	0.678913
LTAX	1.2	0.831578
Mean VIF	1.57	
	Mode 5	
LGDP	2.12	0.470926
IR	1.76	0.567866
LGI	1.63	0.615208
LTAX	1.06	0.943499
Mean VIF	1.64	

Note: The coefficients of the models indicate no multicolinearity as values of VIF were smaller than 10.

Annexure 6. Correlation matrix of selected variables

	LGDP	LGI	LPI	IR	LTAX
LTAX	1				
LGI	0.5932	1			
LPI	0.3682	0.6004	1		
IR	-0.6439	-0.469	-0.4316	1	
LTAX	0.0221	0.1635	0.3826	-0.1494	1

Note: One (1) indicates perfect correlation and zero (0) indicates no correlation between variables.

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