The impacts of public investment on private investment and economic growth
Evidence from Vietnam

Canh Thi Nguyen
Center for Economic and Financial Research, University of Economics and Law, Vietnam National University, Ho Chi Minh City, Vietnam, and
Lua Thi Trinh
Department of Finance, JVN Institute, Vietnam National University-Ho Chi Minh City, Ho Chi Minh City, Vietnam

Abstract

Purpose – The purpose of this paper is to assess both short and long-term influences of public investment on economic growth and test the hypothesis that whether public investment promotes or demotes private investment in Vietnam.

Design/methodology/approach – The authors use the approach of autoregressive distributed lag model and Vietnam's macro data in the period of 1990-2016, to evaluate the short and long-term effects of public investment on economic growth and private investment. The model evaluates the impact of public investment on economic growth and private investment based on the neoclassical theories. The public investment which strongly affects economic growth is also reflected by aggregate supply and demand. Public investment directly impacts aggregate demand as a government expenditure and aggregate supply as a production function (capital factor).

Findings – The results from this research indicate that public investment in Vietnam in the past period does affect economic growth in the pattern of an inverted-U shape as of Barro (1990), with positive effects mostly occurring from the second year and negative effects of constraining long-term growth. Meanwhile, investment from the private sector, state-owned enterprises, and FDI has positive effects on short-term economic growth and state-owned capital stock has positive impacts on economic growth in both the short and long run. The estimated influence of public investment on private investment also shows a similar inverted-U shape in which public investment have crowding-in private investment short-term but crowding-out in the long run.

Practical implications – The empirical findings in this study can be used for conducting a more efficient policy in restructuring the state sector investment in Vietnam.

Originality/value – The main contributions in this study are: to evaluate the impacts of public investment on economic growth and private investment, the authors extracted public investment in infrastructure from aggregate investment of state sector (as previous studies used); the authors also uses state-owned capital stock variable including cumulative public investment and state-owned enterprises investment suggesting that this could control for the different orders of integration between the stock and flow variable and improve the experimental characteristics of the equation to a higher degree.

Keywords Economic growth, Public investment, Private investment

Paper type Research paper

1. Introduction

Vietnam has been making much progress in different fields including economic growth rate during 30 years since "Doi Moi" from 1990 to 2016 ranging around an average of 6.66 percent, inflation rate controlled at an acceptable level and growing exports. One of the key factors in this success is policy renovation in public finance. According to new public investment Vietnam Public Investment Law (2014), public investment consists of the following fields: investment in programs/projects developing social-economic infrastructure; investment in serving activities of governmental organizations, political and social-political organizations, both domestically and abroad; investment in supporting supplies of public services and goods; and investment from public investment capital under shares of government in public private partnership projects. This shows that public investment capital is spread across many economic fields. The question proposed here is how the process of public investment restructuring should be effectively conducted when a medium-term plan is still under implementation. However, along with renovations, policies for public investment and capital of public investment face controversial opinions due to the divergence in assessment and results of analysis of its influence on some economic variables. The research of Khan and Kumar (1997), Ramirez and Nazmi (2003), Bukhari *et al.* (2007) and Haque (2013) showed positive impacts of public investment on economic growth and the research of Cruz and Teixeira (1999), Erden and Holcombe (2005), Gjini and Kukeli (2012) and Dreger and Reimers (2014) also found positive impacts of public investment on private investment. On the contrary, some other studies proved that public investment has no or negative effects on economic growth and creates the situation in which public investment crowds out private investment (Vedder and Gallaway, 1998; Ghani and Din, 2006; Swaby, 2007; Hatano, 2010).

In the scope of this paper, the research objective is to assess both short- and long-term influences of public investment on economic growth and test the hypothesis that whether public investment promotes or demotes private investment in Vietnam. From the research findings, the authors expect to give out proper recommendations for public investment restructuring policy in the future period.

2. Theoretical structure

2.1 Impact of public investment on economic growth

According to Phetsavong and Ichihashi (2012), economic growth models follow two major directions: neo-classical growth model, also known as exogenous growth model, developed by Solow (1956), explaining long-term economic growth by studying capital accumulation or labor, population growth and increase in productivity; new growth model or also called endogenous growth model, pioneered by Romer (1996), Lucas (1988), Barro (1990) and Rebelo (1991). Besides, there are several other models which are widely applied in experimental research such as Aschauer (1989), Haque (2013) and Dreger and Reimers (2014) using Cobb-Douglas production function (1928) to assess impact of labor (L) and investment (K) on total production of manufacturing industry (Y). No matter which model was used, the influence of investment and to be specific, public investment on economic growth is undeniable. Public investment has the wide and deep effect on economic growth under two terms: aggregate demand and aggregate supply. Public investment affects aggregate demand through government spending and aggregate supply through production function (capital element). Public investment also indirectly affects aggregate demand through stimulating private investment and aggregate supply through attracting investment capital from the private sector.

2.2 Impact of public investment on private investment

The relationship between public investment and private investment draws conflicts in macroeconomics for ages. It strongly affects government policy decisions in promoting

economic growth. Some economists believe that public investment can boost private investment, especially when the investment is made in infrastructure development, public goods and services supply, because it creates a secured macro-environment to attract investment capital as well as reducing investment cost for private sector. Besides, the increased demand for goods and services generated by the government will encourage private investment due to better expectation in revenue and profit. Ramirez and Nazmi (2003) and Argimón *et al.* (1997) stated that public investment could encourage private investment when government invested specifically in infrastructure for this economy, for instance, in building the new highway or increasing electricity output by building new power plants.

Thanks to positive and widespread effects generated by public spending, private investment can bloom as total productivity increases. Barro (1990) showed that public investment has a strong impact on margin productivity of private capital and labor. Blejer and Khan (1984) stated that high investment levels are vital for economic growth, especially in developing countries. Besides, Cruz and Teixeira (1999) also supported the point of view of Dixit and Pindyck (1994)[1], believing that government is less risk-adverse than private investors[1] in high profit but risky projects.

On the contrary, many opposite opinions stated that public investment can have crowding-out effect on private investment. The crowding-out effect of public investment on private investment is illustrated in the theory of IS-LM. Provided that unchanged monetary policy is adopted, an increase in government spending can lead to a parallel shift in IS curve and create the phenomenon of raising prices and raising interest rates in the short run, thus negatively affecting private investment (Buiter, 1977; Sundararajan and Thakur, 1980; Ram, 1986). Additionally, public investment sponsored by tax can distort relative price and thus lead to the inappropriate distribution of resources (Atukeren, 2004). An increase in tax also leads to decrease in private investment after tax, providing economic agents with incentives to adjust investment decisions down.

2.3 Previous empirical studies

The hypotheses about the impact of public investment on economic growth and private investment are well experienced in countries with different methods and data sets. Aschauer (1989) showed that public nondefense budgets are more important in determining productive capacity than defense or nondefense spending; the defense budget is subject to a small impact from the ability to produce and the infrastructure that has a strong impact on productivity. Barro (1990) showed that the positive and significant effects of public investment on growth. However, he argues that public investment can become a major distortion of the market, so it should not be a lasting solution to a robust economy. Cullison (1993) argued that government spending on education and labor training has a significant impact on future economic growth. Besides, the author argues that spending on education, civilian safety, and labor training directly affects human capital, not physical capital.

Hsieh and Lai (1994) analyzed G7 data in the past by Granger causality tests and the impulse response function in VAR model on Barro's (1990) endogenous growth model. Empirical results showed that the relationship between government spending and growth has changed over time as well as the industrialized countries in the "growth group." Most importantly, there is no clear evidence and no appropriate support for the argument that rejection of government spending could increase GDP per capita. Khan and Kumar (1997) studied empirical results for 95 developing countries over the periods of 1970-1990, 1970-1980 and 1980-1990. The main results of the study are: private investment has a much larger impact than public investment on growth, especially during the 1980s; as shown by an analysis of net returns, higher net returns to private capital only seem to increase over time; and effectiveness of public investment, private investment and growth, and also the rate of return varies in each region. Using cross-country data of nine large Latin American

countries groupings during the period 1983-1993, Ramirez and Nazmi (2003) argued that spending both public and private investment contributes to economic growth. However, all government spending has a negative effect on private investment and growth. Finally, public spending on education and health has a positive and statistically significant impact on the formation of private capital and on long-term economic growth.

Cruz and Teixeira (1999) used the autoregressive distributed lag (ARDL) model to analyze the impact of public investment on private investment for the Brazilian economy during the 1947-1990 period. A number of important conclusions are given: GDP is one of the major determinants of private investment; replacement of private investment with public investment is only recognized in the short term; and the complementarity between private and public investment is represented by the coefficients of the variable in the long-run adjustment.

Using ARDL analysis, Bukhari *et al.* (2007) showed that the crowding-out effect of private investment can reduce or offset growth in East Asian countries in 1971-2000. When investigating the dynamics of public investment, the redistribution of public expenditure can have a positive effect on growth. On the other hand, public investment, private investment and public consumption have long-term impacts on economic growth for all sample countries. Kumo (2012) also employed ARDL model in empirical research in South Africa for the 1960-2009 period. The results of the study demonstrated a causal link between infrastructure investment and GDP growth, and infrastructure reflects a vital long-term direction for economic development in South Africa, while economic development has the negative effect on infrastructure investment.

Haque (2013) found that public investment and private investment have a direct impact on long-term economic development in Bangladesh by using Cobb-Douglas function. The author used the error correction model (ECM) to evaluate in the short run, total factor productivity does not make sense, and capital formation in the private and public sectors provide an impetus for economic growth. In fact, growth can take on as the driving force of investment.

Using the vector error correction model (VECM) for Jamaica to find the relationship between public investment and growth, Swaby (2007) pointed out that although public investment has a positive impact on GDP, this effect is not significant. In addition, the results also show that public investment has crowding-out effect on net private investment as it results in higher private domestic investment, but foreign investment is lower, with the latter impacting well. Evidence from Japan, Hatano (2010) argued that the long-run relationship between private and public investment is not an investment cash flow, but a stock relationship. Estimates are made based on the hoarding equilibrium model that shows the crowding-in effect in long terms.

With a VAR approach, Kollamparambil and Nicolaou (2011) showed that while public investment is not crowding-out or complementary to private investment, it indirectly impacts private investment through acceleration effects in South Africa. Gjini and Kukeli (2012) found that there is no crowding-out effect of public investment on private investments for the period of 1991-2009 in 11 countries in Eastern Europe by using the least square weighted average. The marginal effects of public investment on private investment are positive and tend to decrease as the country moves from underdeveloped to more developed states. Phetsavong and Ichihashi (2012) used Le and Suruga's (2005) economic growth model and fixed-effects model through analysis of data from 15 developing countries in Asia during the 1984-2009 period. The empirical results showed that private investment plays the most important role in contributing to economic growth; the next is FDI, while public expenditure and financing appear to be detrimental to Asian economic growth. Dreger and Reimers (2014, 2016) used the Cobb-Douglas production function and the VAR model, discussed the issues among 12 countries in the Euro area during the period

of 1991-2012. In contrast to previous studies, the long-term implications of public investment and private investment in the Euro area are, in two respects, capital stocks and gross investment flows with a co-integrated relationship of cumulative investment variables, but a relationship is quite "fragile" with net investment variables. According to the analysis of corresponding functions, private investment responds to the effects of public investment on both capital stocks and gross investment flows. On the contrary, public investment seems to be an exogenous variable which means that public investment is a policy variable. Hence, a lack of public investment could lead to restrictions on private investment and GDP growth in the Euro area.

In Vietnam, the studies on the effects of public investment are substantial, but they are mainly in qualitative or theoretical forms and there is not much empirical research. Using VECM to estimate impulse response, To (2011) showed that both private and public investment has a positive effect on yield and is statistically significant. However, the impact of private investment is higher than public investment. In addition, the results suggested that private investment is crowded-out by public investment, negligible impact in the first few years, and "crowding-out" effect reaching its peak in year 5. Tran and Le (2014) used the ARDL model to examine the effect of public investment on Vietnam's economic growth from 1988 to 2012 by approaching the production function from a modern economic point of view. The results of the study indicated that the impact of public investment on short-term economic growth is not statistically significant but has the effect of crowding-in effect in the long term. However, this effect is the lowest compared to private investment and FDI. Diep *et al.* (2015) also used the ARDL model in conjunction with the co-integration for variables through the Pesaran *et al.* (2001) boundary approach. The results suggested that both quality and efficiency of public investment are still limited, although there exist long-term relationships between public investment and economic growth, but there are no grounds to indicate the effectiveness of public investment in short-term investment. The limitation of previous empirical research in Vietnam is that the data used to assess the impact of public investment are state sector investment data (including public investment and state-owned enterprises' investment) collected from published data by the General Statistics Office of Vietnam (GSO). Given the definition of public investment under Vietnam Public Investment Law (2014) in the introduction of this research, public investment is the investment of the state in programs and projects to build socio-economic infrastructure as well as investment in programs and projects to cater for socio-economic development, which do not include investment in production and business activities of state-owned enterprises.

Therefore, our research will be based on the theoretical base and models of previous domestic and foreign studies with the latest updated data by specialists from GSO (with investment separation between public investment and production and business activities investment of state-owned enterprises). We replace variable "state sector investment" with variable "public investment" according to Vietnam Public Investment Law (2014). In addition, the study also uses state-owned capital stock variable including cumulative public investment and state-owned enterprises investment according to the study of Dreger and Reimers (2014, 2016). Dreger and Reimers (2014, 2016) adopted stock-flow approach, suggesting that this could control for the different orders of integration between the stock and flow variable and improve the experimental characteristics of the equation to a higher degree. Besides that, utilizing capital stocks in a model for gross investment flows improves the co-integration evidence among the other I(1) variables.

3. Methods and data
3.1 Impact of public investment on economic growth
This study investigates the impact of public investment on economic growth based on modeling and adopting some variables suggested by Cullison (1993), Hsieh and Lai (1994),

Khan (1996), Bukhari *et al.* (2007), Phetsavong and Ichihashi (2012) and Haque (2013) and especially capital stock as a variable from Dreger and Reimers's (2014, 2016) study. As stated, to evaluate the impact of public investment, the study will classify investment into five categories: public investment (IG), state-owned enterprise investment (IEG), private investment (IP), foreign direct investment (FDI) and state-owned capital stock. The model is constructed as follows:

$$Y = f(IG, \ IEG, \ IP, \ FDI, \ L, \ CSPUB) \quad (1)$$

where Y is gross domestic product (GDP); L is labor; CSPUB is State-owned capital stock.

3.2 Impact of public investment on private investment

Based on the inheritance of the theories and results from the empirical studies of Cruz and Teixeira (1999) (other empirical studies have performed similar changes, such as Aschauer (1989) and Ferreira (1994)), Kollamparambil and Nicolaou (2011) and especially the variable capital stock from Dreger and Reimers (2014, 2016), this study suggests the model of the impact of public investment on private investment as follows:

$$IP = f(Y, \ IEG, \ IG, \ RR, \ CSPUB) \quad (2)$$

Model 1 based on the neoclassical theories, used to define marginal product and to distinguish allocated efficiency, the defining focus of economics. Cobb-Douglas production function (1928) represents the technological relationship between the amounts of two or more inputs, particularly physical capital (K) and labor (L), and the amount of output (Y) that can be produced by those inputs. Solow (1956) attempted to explain the origin of growth by a different kind of production function that allows analysis of the different causes or origins of growth called the Solow model. The main assumptions of the Solow model relate to the characteristics of the production function and the evolution of the three inputs of product (capital, labor and knowledge) over time.

Model 2 underlines the impact of public investment on private investment so independent variables especially for the Vietnam case are mainly composed of the types of public investment and its relevance (public investment, state-owned enterprises, and state-owned capital stock). The public investment which strongly affects economic growth is also reflected by aggregate supply and demand. Public investment directly impacts aggregate demand as a government expenditure and aggregate supply as a production function (capital factor). First, public investment may increase aggregate output and thus enhance the physical and financial resources in the economy. Second, public spending on infrastructure such as roads, highways, education, sewer and water systems, and power plants often results in a reduction in costs facing the private sector. Such infrastructure investments by the state complement private investment, raising the productivity of private capital. However, there are some cases in which public investment may negatively affect private investment. If the public and private sectors compete for the same resources in the economy, the costs of financing private investment increase while the availability of credit to the private sector declines, which could crowd out investment in the private sector. In the case, if public investment crowds in private investment, it increases total investment and, according to the theory pertaining to Model 1, it will promote economic growth. In the opposite case, if public investment crowds out private investment, this will reduce total investment, which in turn will reduce economic growth (according to Model 1) (Table I).

Logarithm is used for all variables (Y, IP, IG, IEG, FDI, CSPUB, and L) because according to Cruz and Teixeira (1999), the data logarithm will increase stability for variance and optimization of empirical estimates.

Variable	Notation	Data source	Unit
GDP at current prices	Y	GSO; converted at the official exchange rate	Million USD
Private investment	IP	GSO; converted at the official exchange rate	Million USD
State-owned enterprises investment	IEG	GSO; converted at the official exchange rate	Million USD
Public investment	IG	GSO; converted at the official exchange rate	Million USD
Foreign direct investment	FDI	GSO; converted at the official exchange rate	Million USD
State-owned capital stock	CSPUB	IMF	Million USD
Labor	L	WB	Million people
Real interest	RR	WB	%
Source: Author's compilation			

3.3 Research data

Research data are used for the period of 1990-2016 in Vietnam, which collected from the GSO including Y (million VND), public investment (IG), private investment (IP), FDI (million VND), and state-owned enterprises investment (IEG) (million VND) at current prices. Labor (L) (million people) and real interest rate RR (percent) data come from World Bank's World Development Indicators. State-owned capital stock (US$ million) includes cumulative public investment and state-owned enterprises investment collected from the International Monetary Fund (IMF) data. Because of heterogeneous currency data (data from two sources of IMF/WB and GSO), we transferred data from the GSO in the local currency (Vietnam Dong) to the US dollar at the official exchange rate[2] provided by the World Bank data. According to the World Bank, real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator. However, the terms and conditions attached to lending rates differ by country, which limits their comparability. The research data are processed by Microsoft Software 2010 and Eviews 9.5 software including built-in estimation tool for estimating ARDL in the equation estimation object and supporting lagged optimum based on SBC or AIC (minimum value) without having to test lagged results as old Eview versions.

3.4 Research models and estimation techniques

The research techniques in this study built upon co-integrated approach proposed by Pesaran and Shin (1999) is ARDL model, which means standard least squares regressions that include lags of both the dependent variable and explanatory variables as regressors (Greene, 2008). Although ARDL models have been used in econometrics for decades, they have gained popularity in recent years as a method of examining co-integrating relationships between variables through the works of Pesaran and Shin (1998) and Pesaran *et al.* (2001).

The dominance of the ARDL model is expressed in five major aspects: this method allows us to examine short- and long-term relationships between dependent variables and explanatory variables within the multivariate framework; unlike conventional methods for finding long-term relationships, using the ARDL model enables a mere estimation of a single equation (Hamuda *et al.*, 2013); the ARDL model is well suited to co-integration analysis in the case of limited sample size (small sample size) while Johansen co-integration technique requires larger sample size to achieve reliability; the ARDL model can be used even in the case of non-stationary or mixed stationary and non-stationary variables, level I(1) or I(0); and (v) according to Hamuda *et al.* (2013), other co-integration techniques generally require the regressors to have the same lagged period while the ARDL model requires variables to have different and optimal lagged period (according to the AIC or SBC criteria, the study will cover these aspects in the relevant sections).

The ARDL model estimation process is performed with the following steps: bound test determines the co-integration between variables, i.e., the long-term relationship between

variables; the lagged period of variables in the ARDL model is determined using the SBC or AIC benchmark (achieving the smallest value) and run the ARDL model with the defined lagged period to test the long-term relationship between variable in model; model diagnostic test is employed; and short-term impact of variables is assessed by ECM based on the ARDL approach to co-integration. The model used in the study is rewritten according to ARDL model as follows.

Impact of public investment on economic growth:

$$LNY_t = \beta_0 + \sum_{i=1}^{p} \beta_{io}LNY_{t-1} + \sum_{j=0}^{q1} \beta_{j1}LNIG_{t-j} + \sum_{k=0}^{q2} \beta_{k2}LNIP_{t-k}$$

$$+ \sum_{l=0}^{q3} \beta_{l3}LNL_{t-j} + \sum_{m=0}^{q4} \beta_{m4}LNIEG_{t-m} + \sum_{n=0}^{q5} \beta_{n5}LNFDI_{t-n}$$

$$+ \sum_{o=0}^{q6} \beta_{o6}LNCSPUB_{t-o} + \varepsilon_t \tag{3}$$

Impact of public investment on private investment model:

$$LNIP_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{io}LNIP_{t-1} + \sum_{j=0}^{q1} \alpha_{j1}LNIG_{t-j} + \sum_{k=0}^{q2} \alpha_{k2}LNY_{t-k}$$

$$+ \sum_{l=0}^{q3} \alpha_{l3}RR_{t-j} + \sum_{m=0}^{q4} \alpha_{m4}LNIEG_{t-m} + \sum_{n=0}^{q5} \alpha_{n5}LNCSPUB_{t-n} + \varepsilon_t \tag{4}$$

4. Empirical results
4.1 Descriptive statistics
Table II presents descriptive statistics of the variables used in the study. Standard deviation of variables is lower than mean (based on the use of base logarithmic) and have sharpness coefficients and low slope coefficients to ensure normal distribution (except for the variable real interest rate fluctuations with the minimum of −62.6 percent and a maximum of 12.5). This abnormal result mainly comes from before economic renovation in Vietnam in 1986 when turmoil in the domestic economy, scarce commodities, poor macroeconomic policies and budget deficits led to galloping inflation. However, in order to solve the galloping inflation problem, the tools for implementing monetary policy were still experimental. As a result, this problem has not been resolved thoroughly from 1990 to 1995 (especially in 1990 (67.1 percent) and 1991 (67.5 percent)), which makes real interest rate extremely negative in 1990-1991 and mean of real interest rate being negative at −2.897.

	LNY	LNIG	LNIEG	LNL	LNIP	LNFDI	LNCSPUB	RR
Mean	4.655	3.508	3.559	2.320	3.658	3.539	4.899	−2.897
Maximum	5.312	4.035	4.187	4.503	4.436	4.217	5.527	12.577
Minimum	3.841	2.496	2.596	0.266	2.534	2.602	4.284	−62.600
SD	0.440	0.471	0.438	0.775	0.578	0.465	0.405	18.124

Table II.
Statistics descriptive of variables

4.2 Impact of public investment on economic growth
The authors use the Dickey-Fuller test and the extended Dickey-Fuller test to test stationary accreditation of series logarithm and then continue to test stationary accreditation of first difference of the logarithm series. The results of the unit tests showed that LNIP, LNL and RR variables are stationary at I(0) and the LNIP, LNIG, LNIEG LNFDI and LNCSPUR variables are first-order integrals since the primary differences are stationary I(1). According to Pesaran and Shin (1996), Cruz and Teixeira (1999), Bukhari *et al.* (2007), Kumo (2012), Hamuda *et al.* (2013) and Mehrara and Musai (2011), co-integration I(1) or I(0) can be applied to the ARDL procedure most appropriately for empirical research (Table III).

Bound test: a test is performed to determine the co-integration between variables, i.e., to find the long-term relationship between variables according to Pesaran *et al.* (2001), and can be run under the two hypotheses:

H0. There is no co-integration relationship between variables.

H1. There is the co-integration relationship between variables and hypothesis.

If the bound value for the *F*-statistic is greater than the value of the upper bound I(1) at the significance level of 5 percent, then H_0 can be rejected and vice versa. If the *F*-statistic is less than the value of the lower bound I(0) at the significance level of 5 percent, the null hypothesis is accepted. If *F*-statistic is between two bounds, it is not possible to draw conclusions using ECM to determine. If the coefficient of ECM is negative and significant (p-value < 0.05), the conclusion is that the co-integration relationship exists between the variables.

The results of the bound test of Model (3) are shown in Table IV, which reports the existence of a co-integration relationship between variables with *F*-statistic above the value of the upper boundary at the significance level of 5 percent.

The results of the ARDL model are estimated based on AIC and SBC with optimal lagged period ARDL (1, 2, 2, 0, 2, 1, 0) in Table V. Estimating the ARDL model with the dependent variable LNY yields R^2 (adjusted) $= 0.9996$, which explains 99.96 percent of the variation in

Variable	*t*-statistics	Result	Order
LNY	−4.667**	Stationary	I(0)
LNL	−3.865**	Stationary	I(0)
LNIP	−2.279	Stationary	I(1)
D(LNIP)	−4.426**	Stationary	I(1)
LNIG	−1.489	Stationary	I(1)
D(LNIG)	−5.513***	Stationary	I(1)
LNIEG	−2.485	Stationary	I(1)
D(LNIEG)	−5.066***	Stationary	I(1)
LNFDI	−2.938	Stationary	I(1)
D(LNFDI)	−3.132**	Stationary	I(1)
RR	−3.723**	Stationary	I(0)
LNCSPUB	0.341	Stationary	I(1)
D(LNCSPUB)	−2.873**	Stationary	I(1)

Notes: D( ) is first-order integral of the variable. *,**,***Significant at 10, 5 and 1 percent levels, respectively

Table III.
Results of the unit root test of stationary of two models

		\ 90%		95%		97.50%		99%	
K	*F*-statistic	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
6	22.746	1.75	2.87	2.04	3.24	2.32	3.59	2.66	4.05

Critical value

Table IV.
Bound test for Model (3)

public investment, state-owned enterprises, private investment, state-owned capital stock and labor. The regression results show that the same effect of public investment and state-owned enterprises investment on economic growth in the two-year lag is at the 5 percent significance level.

The study carried out some tests that yielded model reliability and reliability results through normality test, Lagrange multiplier correlation test, heteroskedasticity test and Ramsey's modeling test. In addition, the testing stability of residuals through cumulative sum of recursive residuals test and cumulative sum of square of recursive residuals test is in the standard range of 5 percent, so it is possible to conclude that the residuals of the model are stable and the model is suitable. Model test results are reported in Table VI (see Figure A1).

Estimation of the long-term coefficient of the ARDL model with lags (1, 2, 2, 0, 2, 1, 0) is shown in Table VII. Long-term equilibrium solution for the Vietnamese economy in the 1990-2016 period indicates that public investment has the opposite effect on long-term economic growth and low impact factor (−0.367) at 10 percent significance while state-owned capital stock has a positive growth effect at 5 percent significance level. In addition, private investment and FDI do not affect long-term economic growth.

The study estimates the short-term coefficients from ECM based on the ARDL approach with latency (1, 2, 2, 0, 2, 1, 0). After recognizing the co-integration of the variable through the bound test, the study estimates model again to adjust model to different differences, including ECM. As expected, the coefficient of ECM is negative (−0.352) and significant at 1 percent indicates a pattern correction toward long-term equilibrium. The results show that public investment in short-term economic growth is negative with a weak impact coefficient.

Selected model: ARDL(1, 2, 2, 0. 2, 1, 0)

Variable	Coefficient	SE	Prob.
LNY(−1)	1.356	0.183	0.000
LNIG	−0.074	0.056	0.211
LNIG(−1)	0.009	0.069	0.903
LNIG(−2)	0.196	0.079	0.030
LNIEG	−0.343	0.103	0.007
LNIEG(−1)	−0.257	0.081	0.009
LNIEG(−2)	0.189	0.053	0.005
LNL	0.002	0.004	0.635
LNIP	0.097	0.055	0.106
LNIP(−1)	0.037	0.067	0.592
LNIP(−2)	−0.221	0.068	0.008
LNFDI	0.054	0.043	0.240
LNFDI(−1)	−0.095	0.057	0.120
LNCSPUB	−0.023	0.099	0.823

Note: Number of models evaluated: 1,458

Table V.
Estimating ARDL model with dependent variable LNY (Model (3))

No.	Test	Result	Inference
1	Normality test	Jarque-Bera = 0.0012, p-value = 0.999	The residuals have a standard distribution
2	Breusch-Godfrey serial correlation LM test	$N \times R^2$ = 0.0928, p-value = 0.7605	No autocorrelation
3	Heteroskedasticity test: Breusch-Pagan-Godfrey	$N \times R^2$ = 13.956, p-value = 0.4530	No heteroskedasticity
4	Ramsey RESET test	F-statistic = 0.1108, p-value = 0.7461	Model is standard

Table VI.
Test model results for Model (3)

Meanwhile, private investment, state-owned enterprises investment, state-owned capital investment and foreign direct investment FDI have had a positive impact on economic growth in the short term at the significance level 5 percent (Table VIII).

The findings of estimating the impact of public investment on economic growth in Vietnam in the period of 1990-2016 show that: public investment has negative impact (weak effect) on economic growth in short term, while private investment, state-owned enterprises investment, state-owned capital stock, and FDI have a positive impact in the short run; public investment and state-owned enterprises investment impact positively on economic growth from the second year; and public investment has negative effect (weak impact coefficients) and state-owned capital stock has positively impact (strong impact coefficients) on economic growth. The impact of public investment on economic growth is quite consistent with Barro's (1990) study. Barro (1990) argued that the relationship between public investment and economic growth is non-linear, represented by inverted-U. According to that first stage of development, public investment increased with the total output. This is due to an increase in government investment that increases the marginal productivity of capital. This increase is superior to the negative impact of tax burdens. However, to some extent (the optimal level of public investment according to Barro), the effects will occur in the opposite direction. As a result, public investment will slow down the pace of economic growth.

4.3 Impact of public investment on private investment

Likewise, the study has regression model by the ARDL model with model to investigate the impact of public investment on private investment. The results of the bound test of Model (4) are shown in Table IX, showing the existence of a co-integration relationship between variables with F-statistic above the value of the upper boundary at the 5 percent significance level.

Estimating the ARDL model, the long-term coefficients of the ARDL model with lags (2, 2, 2, 3, 3, 3) and the short-term coefficients of the ARDL model is shown in Table X.

| Variable | Long-run coefficients | | |
	Coefficient	SE	Prob.
LNIG	−0.367	0.194	0.085
LNIEG	0.063	0.246	0.802
LNL	−0.006	0.013	0.649
LNIP	0.245	0.146	0.121
LNFDI	0.116	0.112	0.322
LNCSPUB	1.154	0.375	0.011

Table VII.
Estimating long-term coefficients of ARDL model with lags (1, 2, 2, 0, 2, 1, 0)

| Variable | Co-integrating form | | |
	Coefficient	SE	Prob.
D(LNIG)	−0.073	0.036	0.066
D(LNIG(−1))	−0.204	0.041	0.000
D(LNIEG)	−0.329	0.062	0.000
D(LNIEG(−1))	−0.190	0.029	0.000
LNL	0.001	0.002	0.687
D(LNIP)	0.090	0.035	0.026
D(LNIP(−1))	0.223	0.038	0.000
D(LNFDI)	0.060	0.025	0.039
LNCSPUB	−0.001	0.001	0.636
CointEq(−l)	−0.352	0.032	0.000

Notes: Cointeq = LNY − (−0.3667 × LNIG + 1.1540 × LNIEG − 0.0061 × LNL + 0.2447 × LNIP + 0.1160 × LNFDI + 0.0634 × LNCSPUB)

Table VIII.
Estimating short-term impact using ECM based on ARDL approach (1, 2, 2, 0, 2, 1, 0)

Private investment is in the nature of inertia and past investment has the positive impact on next period. Public investment and state-owned enterprises investment with two periods of lag have positive effects, while at t and $(t-1)$ periods, these ones have negative effects on private investment. State-owned capital stock accrues cyclical effects to current private investment, and mainly impact from the second and third years. In addition, real interest rates also affect private investment with different lags with low coefficients, which corresponds to the findings of Cruz and Teixeira (1999) and Erden and Holcombe (2006).

Similar to Model (3), diagnostic tests do not give the wrong results, indicating that this is an econometric model that meets expectations. The results of Model (4) testing are shown in Table XI (see Figure A2).

		Critical value							
		90%		95%		97.50%		99%	
K	F-statistic	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
5	20.669	1.81	2.93	2.14	3.34	2.44	3.71	2.82	4.21

Source: Author's compilation

Table IX.
Bound test for
Model (4)

	Selected model: ARDL(2, 2, 2, 3, 3, 3)		
Variable	Coefficient	SE	Prob.
LNIP(-1)	0.479	0.114	0.014
LNIP(-2)	0.861	0.209	0.015
LNIEG	-0.189	0.341	0.609
LNIEG(-1)	-0.178	0.297	0.580
LNIEG(-2)	1.000	0.240	0.014
LNIG	-1.533	0.298	0.007
LNIG(-1)	-0.584	0.236	0.069
LNIG(-2)	0.720	0.288	0.067
RR	0.007	0.003	0.083
RR(-1)	0.005	0.003	0.095
RR(-2)	-0.001	0.001	0.675
RR(-3)	0.001	0.001	0.310
LNY	0.107	0.691	0.884
LNY(-1)	2.953	1.214	0.072
LNY(-2)	-3.784	1.009	0.020
LNY(-3)	-0.948	0.542	0.155
LNCSPUB	3.065	1.703	0.146
LNCSPUB(-1)	0.354	2.200	0.880
LNCSPUB(-2)	-3.978	1.675	0.076
LNCSPUB(-3)	2.417	0.883	0.052

Table X.
Estimating the ARDL
model with dependent
variable LNIP
(Model 4)

No.	Test	Result	Inference
1	Normality test	Jarque-Bera $= 0.3042$, p-value $= 0.8588$	The residuals have a standard distribution
2	Breusch-Godfrey serial correlation LM test	$N \times R^2 = 0.8285$, p-value $= 0.3627$	No autocorrelation
3	Heteroskedasticity test: Breusch-Pagan-Godfrey	$N \times R^2 = 22.673$, p-value $= 0.3051$	No heteroskedasticity
4	Ramsey RESET test	F-statistic $= 1.771$, p-value $= 0.2753$	Model is standard

Table XI.
Test model results
for Model (4)

Estimation of long-term coefficients of the ARDL model with lags (2, 2, 2, 3, 3, 3) is shown in Table XII. In the long run, public investment, state-owned capital stock, and real interest rates have a negative impact on private investment. In contrast, in the long run, real economic growth has a strong impact and attracted private investment growth.

The results of estimating the impact of public investment on private investment in the short term by the ECM are based on the ARDL approach with lags (2, 2, 2, 3, 3, 3) showed in Table XIII. The coefficient of ECM (Cointeg (−1)) is statistically significant at 1 percent significance level and negative coefficient (−0.34) assures co-integration unified in the bound test under Pesaran *et al.* (2001). Public investment and growth have a positive impact on private investment while real interest rate, state-owned enterprises investment and state-owned capital stock have a negative impact on private investment in ECM.

The findings of estimating the impact of public investment on private investment in Vietnam during the period from 1990 to 2016 suggest that: estimation using ECM indicates that public investment and growth have a positive impact on private investment; in contrast, real interest rates, state-owned enterprises investment, and state-owned capital stock have a negative impact on private investment in the short run; public investment and state-owned enterprises investment have had a positive impact on private investment with two periods of lag, while state-owned capital stock accrues cyclical effects on current private investment and primarily at the second and third year; and in the long run, economic growth has had a positive and dramatic effect on attracting private investment while rising interest rates have increased costs

	Long-run coefficients		
Variable	Coefficient	SE	Prob.
LNIEG	−1.861	1.378	0.248
LNIG	−4.108	1.405	0.043
RR	−0.039	0.018	0.094
LNY	4.916	2.112	0.081
LNCSPUB	−5.464	2.483	0.093

Table XII.
Estimation of long-term coefficients of the ARDL model with latencies (2, 2, 2, 3, 3, 3)

	Co-integrating form		
Variable	Coefficient	SE	Prob.
D(LNIP(−1))	−0.861	0.082	0.001
D(LNIEG)	−0.189	0.109	0.159
D(LNIEG(−1))	−1.000	0.122	0.001
D(LNIG)	−1.533	0.110	0.000
D(LNIG(−1))	−0.720	0.089	0.001
D(RR)	0.007	0.001	0.002
D(RR(−1))	−0.001	0.000	0.221
D(RR(−2))	−0.001	0.000	0.040
D(LNY)	0.107	0.215	0.645
D(LNY(−1))	4.731	0.397	0.000
D(LNY(−2))	0.948	0.293	0.032
D(LNCSPUB)	3.065	0.552	0.005
D(LNCSPUB(−1))	1.561	0.541	0.045
D(LNCSPUB(−2))	−2.417	0.397	0.004
CointEq(−l)	−0.340	0.020	0.000
Notes: Cointeq = LNIP − (− 1.8606 × LNIEG + 4.1076 × LNIG − 0.0387 × RR + 4.9160 × LNY−5.4635 × LNCSPUB)			

Table XIII.
Estimation of short-term effects using ECM based on the ARDL approach (2, 2, 2, 3, 3, 3)

borrowing and thus have the negative impact on private investment. In addition, public investment and state-owned capital stock have "crowded out" private investment in the long run. The results are consistent with the findings of Vedder and Gallaway (1998), Phetsavong and Ichihashi (2012), Dreger and Reimers (2014), Hatano (2010), and Phetsavong and Ichihashi (2012). Initially, by providing the legal system, monetary system, security, defense, infrastructure, education, etc., the government provided the framework for effective market operation, thereby stimulating economic and other economic sectors, such as private investment and foreign investment. However, if the expansion of public investment continues, these expenditures will increasingly shift to less productive activities. The more inappropriate the investment activities (especially commodities) in the private sector, the lower the return on capital, and the more the economic growth and other economic sectors slow down.

5. Conclusion and recommendation
This research studies the effects of public investment on Vietnam's economic growth and private investment in both short and long terms during the period of 1990-2016 by a ARDL model. The findings indicate that public investment in Vietnam in the past period does affect economic growth in an inverted-U shape effect as of Barro (1990), with positive effects mostly occurring from the second year and negative effects in the long run. Similarly, public investment also has a similar influence pattern on private investment, boosting in the short term but crowding-out in the long term. This implies that when the economy needs investment environment to attract private investment, public investment plays an important role; however, in the long term, the role of public investment is reduced due to the coefficient of negative impact. Therefore, it is significantly necessary to have a reasonable threshold of the public investment to achieve the best balance. From the findings of public investment's influences on economic growth and private investment in Vietnam, this paper attempts to make some recommendations to improve Vietnam's current public investment in the context of medium-term policy of 2016-2020 which is being implemented.

First, public investment comes from government budget but that investment is sometimes inefficient and unfocused, and even spread investment leads to budget overspending. Thus, investment spending needs restructuring to guarantee efficiency.

Second, enhance transparency and comprehension in using public investment capital by means of integrity in data, the audit of investment project or of state-owned enterprises; strengthened accountability at every investment management level, reporting investment performance progress of every single project or enterprise; public finance renewal along with establishing a clean and sustainable management system.

Third, low efficiency on public investment leads to little-improved quality of human resources. Hence, the quality and productivity of labor force in private sector are not significantly strengthened. Therefore, Vietnam Government must establish more initiatives to invest in human development, labor productivity improvement, and technology innovation.

Fourth, low efficiency and inadequate management in public investment together with improperly spread investment portfolio lead to the situations of capital shortage, prolonged projects, and increases in costs. Therefore, the critical issue in improving the efficiency of public investment is to assure appropriateness in project evaluation and selection. To make a right choice, preventing imperfections throughout the process of the project proposal, project approval in central government and local authority by checking and developing a well-tailored procedure of project proposal, project selection, and public investment capital distribution, avoiding overlapping situations, is highly required.

Fifth, continue to privatize public investment projects where appropriate and equitize non-core state-owned enterprises. Accordingly, reducing government intervention in the production business sector, promoting equitization, divesting state-owned enterprises from

equitized SOEs, for increasing investment in infrastructure to reduce public debt, to create an investment environment that attracts domestic private investment and FDI capital, ultimately boosting economic growth.

Notes

1. In developing economies, large and long-term capital intensive sectors for the first time are considered to be high risk (Dixit and Pindyck, 1994).

2. "Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the US dollar)", according to World Bank's statement.

References

Argimón, I., González-Páramo, J.M. and Roldán, J.M. (1997), "Evidence of public spending crowding-out from a panel of OECD countries", *Journal of Applied Economics*, Vol. 29 No. 8, pp. 1001-1010.

Aschauer, D. (1989), "Is public expenditure productive?", *Journal of Monetary Economics*, Vol. 23, pp. 177-200.

Atukeren, E. (2004), *Intrection between Public and Private Investment Evidence from Developing Countries*, Kyklos.

Barro, R.J. (1990), "Government spending in a simple model of endogeneous growth", *The Journal of Political Economy*, Vol. 98 No. 5, pp. 103-125.

Blejer, M.I. and Khan, M.S. (1984), "Private investment in developing countries", *Finance and Development*, pp. 26-29.

Buiter, W. (1977), "Crowding out and the effectiveness of fiscal policy", *Journal of Public Economics*, Vol. 7 No. 3, pp. 309-328.

Bukhari, S., Ali, L. and Saddaqat, M. (2007), "Public investment and economic growth in the three little dragons: evidence from heterogeneous dynamic panel data", *International Journal of Business and Information*, Vol. 2 No. 1, pp. 57-79.

Cruz, B.O. and Teixeira, R.J. (1999), "The impact of public investment on private investment in Brazil 1947-1990", *Cepal Review*, Vol. 67, pp. 75-84.

Cullison, E.W. (1993), "Public investment and economic growth", *Federal Reserve Bank of Richmond Economic Quarterly*, Vols 79/4, pp. 19-33.

Diep, G.L., Dang, V.C. and Bui, D.T. (2015), "Enhancing quality and efficiency of public investment in Vietnam up to 2020", *Journal of Economic Development*, Vol. 23 No. 1, pp. 2-24.

Dixit, A.K. and Pindyck, R.S. (1994), *Investment Under Uncertainty*, Princeton University Press, Princeton, NJ.

Dreger, C. and Reimers, H. (2014), "On the relationship between public and private investment in the Euro area", discussion papers, DIW Berlin, German Institute for Economic Research, Berlin.

Erden, L. and Holcombe, R. (2005), "The effects of public investment on private investment in developing economies", *Public Finance Review*, Vol. 33 No. 5, pp. 575-602.

Erden, L. and Holcombe, R. (2006), "The linkage between public and private investment: a co-integration analysis of a panel of developing countries", *Eastern Economic Journal*, Vol. 32 No. 3, pp. 479-492.

Ferreira (1994), "Public versus private provision of infrastructure in a neoclassical growth model", Graduate School of Economics Fundação Getulio Vargas.

Ghani, E. and Din, M. (2006), "The impact of public investment on economic growth in Pakistan", *The Pakistan Development Review*, Vol. 45 No. 1, pp. 87-98.

Gjini, A. and Kukeli, A. (2012), "Crowding-out effect of public investment on private investment: an empirical investigation", *Journal of Business & Economics Research*, Vol. 10 No. 5, pp. 269-276.

Greene, W.H. (2008), *Econometric Analysis*, 6th ed., Prentice-Hall, Upper Saddle River, NJ.

Hamuda, A.M. *et al.* (2013), "Ardl investment model of Tunisia", *Theoretical and Applied Economics*, Vol. 20 No. 2, pp. 57-68.

Haque, S. (2013), "Effect of public and private investment on economic growth in Bangladesh: an econometric analysis", Research Study Series No-FDRS 05/2013, pp. 105-136.

Hatano, T. (2010), "Crowding-in effect of public investment on private investment", *Public Policy Review*, Vol. 6 No. 1, pp. 105-120.

Hsieh, E. and Lai, K.N. (1994), "Government spending and economic growth: the G-7 experience", *Review of Applied Economics*, Vol. 26, pp. 535-542.

Khan, M. (1996), "Government investment and economic growth in the developing world", *The Pakistan Development Review*, Vol. 35 No. 4, pp. 419-439.

Khan, M. and Kumar, M. (1997), "Public and private investment and the growth process in developing countries", *Oxford Bulletin of Economics and Statistics*, Vol. 59 No. 1, pp. 305-9049.

Kollamparambil, U. and Nicolaou, M. (2011), "Nature and association of public and private investment: public policy implications for South Africa", *Journal of Economics and International Finance*, Vol. 3 No. 2, pp. 98-108.

Kumo, W. (2012), "Infrastructure investment and economic growth in South Africa: a granger causality analysis", Working Paper Series No. 160, African Development Bank, Tunis.

Le and Suruga (2005), "The effects of FDI and public expenditure on economic growth: from theoretical model to empirical evidence", GSICS Working Paper Series No. 2, November.

Lucas (1988), "On the mechanics of economic development", *Journal of Monetary Economics*, Vol. 22, pp. 3-42.

Mehrara and Musai (2011), "Granger causality between economic growth in oil exporting countries", *Interdisciplinary Journal of Research in Business*, Vol. 1 No. 8, pp. 103-108.

Pesaran, M.H. and Shin, Y. (1996), "Cointegration and speed of convergence to equilibrium", *Journal of Econometrics*, Vol. 71 Nos 1-2, pp. 117-143.

Pesaran, M.H. and Shin, Y. (1998), "Generalized impulse response analysis in linear multivariate models", *Economics Letters*, Vol. 58 No. 1, pp. 17-29.

Pesaran, M.H. and Shin, Y. (1999), "An autoregressive distributed lag modelling approach to cointegration analysis", in Strom, S. (Ed.), *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*, Cambridge University Press.

Pesaran, M.H., Shin, Y. and Smith, R. (2001), "Bounds testing approaches to the analysis of level relationships", *Journal of Applied Econometrics*, Vol. 16, pp. 289-326.

Phetsavong, K. and Ichihashi, M. (2012), "The impact of public and private investment on economic growth: evidence from developing Asian countries", IDEC discussion paper, Hiroshima University, Higashi Hiroshima.

Ram (1986), "Government size and economic growth: a new framework and some evidence from cross-section and time-series data", *The American Economic Review*, Vol. 76 No. 1, pp. 191-203.

Ramirez, M.D. and Nazmi, N. (2003), "Public investment and economic growth in Latin America: an empirical test", *Review of Development Economics*, Vol. 7 No. 1, pp. 115-126.

Rebelo, S. (1991), "Long-run policy analysis and long-run growth", *Journal of Political Economy*, Vol. 99 No. 3, pp. 500-521.

Romer, D. (1996), "The solow growth model", *Advanced Macroeconomics*, McGraw-Hill, pp. 5-140.

Solow, R. (1956), "A contribution to the theory of economic growth", *The Quarterly Journal of Economics*, Vol. 70 No. 1, pp. 65-94.

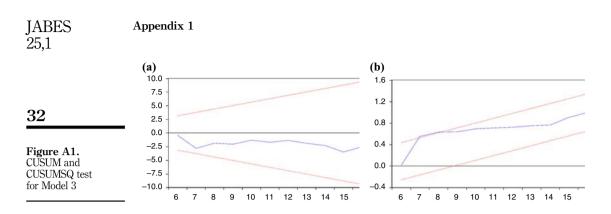Sundararajan, V. and Thakur, S. (1980), "Public investment, crowding out and growth: a dynamic model applied to India and Korea", staff papers, International Monetary Fund, Washington, DC.

Swaby, R. (2007), "Public investment and growth in Jamaica", Fiscal and Economic Programme Monitoring Department, Bank of Jamaica.

To, T.T. (2011), "Public investment 'crowds out' private investment? A look from experimental model of VECM", *Magazine of Finance*, Vol. 6 No. 560, pp. 49-62.

Tran, N.N.A. and Le, H.P. (2014), "Impact of public investment on economic growth in Vietnam: an experimental look of ARDL model", *Development and Integration*, Vol. 19, pp. 3-10.

Vedder, R.K. and Gallaway, L.E. (1998), "Government size and economic growth", paper prepared for the Joint Economic Committee of the US Congress, p. 1.

Vietnam Public Investment Law (2014), available at: www.moj.gov.vn/pages/vbpq.aspx

Further reading

Gregoriou, A. and Ghosh, S. (2009), "The impact of government expenditure on growth: empirical evidence from a heterogeneous panel", *Bulletin of Economic Research*, Vol. 61 No. 1, pp. 95-102.

Kneller, R., Bleaney, M. and Gemmell, N. (1999), "Fiscal policy and growth: evidence from OECD", *Journal of Public Economics*, Vol. 74, pp. 171-190.

Vu, S.C., Pham, T.A., Nguyen, T.D., Le, D.B. and To, T.T. (2014), "Mechanism of public investment capital distribution: current state and institutional solutions", The project "Support to improve macroeconomic policy advisory, monitoring and overseeing capabilities" of the Economic Commission (in Vietnamese).
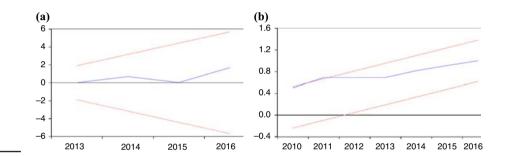
(The Appendix follows overleaf.)

Appendix 1

Figure A1.
CUSUM and
CUSUMSQ test
for Model 3

(a)

(b)

Appendix 2

Figure A2.
CUSUM AND
CUSUMSQ test
for Model 4

(a)

(b)

Corresponding author
Canh Thi Nguyen can be contacted at: canhnt@uel.edu.vn