Associate Professor Lin Hung-Pin, PhD
E-mail: lhp0606@stu.edu.tw
Shu-Te University of Taiwan
Assistant Professor Tsung-Li Wang, EdD
E-mail: wsteven@stu.edu.tw
Shu-Te University of Taiwan
Associate Professor Cheng-Lang Yang, PhD
E-mail: chenglang@nhu.edu.tw
Nanhua University of Taiwan

FURTHER CAUSALITY EVIDENCE ON ARMS RACE, INFLATION AND ECONOMIC GROWTH

Abstract. *This paper examines the effects of expanding the ratio of defense spending on long-run inflation and economic growth by constructing an endogenous growth model and employing empirical approaches for China, Japan, South Korea, and Taiwan over the period between 1955 and 2010. By analyzing cointegration test results, it is found that: (1) the increase of the ratio of defense spending leads to a lower long-run inflation rate in China and Japan, but higher inflation rate in Taiwan; (2) the increase of the ratio of defense spending leads to a higher long-run economic growth, supporting the famously Benoit Hypothesis for China, Japan and Taiwan; (3) The results of bidirectional Granger causality test suggests that an arms race exists among the cross-country pairs of China and Japan, China and Taiwan, and the last pair, Japan and South Korea. Based on (1) to (3), as the ratio of defense spending increases, an arms race, higher economic growth and lower inflation coexist in China and Japan. These findings may also be an explanation of why, in view of economic performance, those arms race and disarmament issues have been advocated in recent years.*

Keywords: *Benoit hypothesis; Causality; Defense spending; Economic growth; Inflation rate.*

JEL Classification: C82; H50; O23

1. Introduction

Scholarly debate has been raised for more than two decades about the relationship between defense spending and economic performance. One of these debates builds upon the contention that defense spending may cause inflation and further inhibit economic growth. Other debates argue that defense spending usually takes away enormous economic resources from other economic activities, therefore deterring economic growth. In view of the argument between defense spending and inflation, the affection between defense spending and economic growth is inconclusive. This study tries to fill this gap by constructing an endogenous model to analyze the long-run dynamic interactions and by testing the multivariate co-integration for the long-run relationship between variables as well as the arms race from the direction of causality tests for China, Japan, South Korea, and Taiwan over the period between 1955 and 2010. The reason for choosing these particular countries is that they are major participants in the North-East Asian region relating to potential military threats and conflict positions, and thus endure substantial defense burdens. In addition, long-spanned data is available for these specified countries which allows us to assess the co-integration and causal relationships between the variables examined in this study.

There are three purposes of this study, divided into a theoretical and an empirical component. Firstly, in theoretical part of this study, we construct an endogenous growth model to analyze the relationship among the ratio of defense spending, inflation rate and economic growth as well as clarify the dispute of the *Benoit Hypothesis*. Secondly, in empirical part, we use the ADF test to determine whether there exists a stationarity of variables and examine the long-run relationship between defense spending and inflation rate, and between defense spending and economic growth by conducting co-integration tests for each country. The third objective is to test whether an arms race exists between country pairs using the Granger causality approach.

The remainder of this paper is organized as follows: Section 2 constructs the analytical framework of the theoretical model, while Section 3 describes the empirical approaches. Section 4 reviews the data and empirical results. Finally, Section 5 summarizes the conclusions of this study.

2. Literature Review

Many empirical literature examining the relationship between defense spending, inflation, and economic growth which has been gathered for more than two decades, Brumm (1997), Murdoch et al. (1997), Aynur and Paul (2012), and Muhammad et al (2013) prove there is a positive relation between defense spending and economic growth supporting the famous *Benoit Hypothesis* (Ram ,1995, Sandler and Hartley, 1995). Lipow and Antinori (1995), and Alper and Erman (2014) stress a negative linkage between defense spending and economic growth, while Huang and Mintz (1990, 1991) point out there is no significant effect of defense spending on economic growth. In addition, a third group led by DeRouen (1995), and Landau (1996) tends to give a context-specific explanation that varies from positive to negative effects. Payne (1990) finds no evidence to suggest that defense spending causes inflation by using the Granger causality test. More recently, Fordham (2003) shows that defense spending may lead to a higher inflation rate by investigating data for United States. 0Shieh (2002 a,b) uses an endogenous growth model to demonstrate that there exists an optimal defense spending ratio that maximizes the economic growth and social welfare in an alternative government resource allocation. Finally, Tzeng et al. (2008) sets up a monetary endogenous growth model and explain the undetermined relationship between the defense spending and inflation. They observe that the increase of defense spending will cause unambiguous effects on the inflation and stimulate the economic growth.

Based on the findings revealed by the evidence stated above, there is still no agreement as to the exact nature of the relationship among defense spending, inflation, and economic growth. As a result, constructing an endogenous growth model to explain the empirical findings regarding to the relationship among defense spending, inflation, and economic growth might provide an useful proxy to access the consensus.

3. Theoretical model

Consider an economy consisting of a government and large number of homogeneous infinite-lived households. Households produce a single composite commodity. They can be consumed, accumulated as capital and be paid as an income tax by households. The government provides defense security and public capital by means of spending on defense capital accumulation and investing in core infrastructure, respectively. Households' utility U comes from consumption C and defense capital S. As indicated by van der Ploeg and Zeeuw (1990), the level of security enters into the Households' utility function due to the fact that it provides security to the public and increases the feeling of national security by a higher level of defense capital (see Zou, 1995; Chang et al.,1996; Shieh et al., 2002a,b; and Tzeng et al., 2008). As a result, the representative household seeks to maximize the discounted sum of instantaneous utilities as given by:

$$\int_0^\infty U(C,S)e^{-\rho t}dt = \int_0^\infty (\ln C + \eta \ln S)e^{-\rho t}dt, \quad \eta > 0, \tag{1}$$

where ρ is the constant rate of time preference and the parameter η measures the impact of the defense capital on household.

Based on the fact that the defense sector and non-defense public sector may have a positive impact on private output reflecting as a spin-off effect which denotes that the defense sector will give a production externality to the private sector such as infrastructure, defense, training, education, and human capital enhancing activities. We assume that output Q is produced with constant returns to scale technology that uses the private capital stock k, public capital stock R, and the defense capital S which these settings are widely used in the endogenous growth literatures such as Barro (1990), Rebelo (1991), and Turnovsky (2000b). That is, the production function is assumed to take a Cobb-Douglas form:

$$Q = Q(k,R,S) = k^{1-\alpha_1-\alpha_2} R^{\alpha_1} S^{\alpha_2}, \quad 0 < \alpha_1, \alpha_2 < 1 \tag{2}$$

Eq.(2) implies that the both of the public capital stock and defense capital are non-excludable and non-rival. The law of motion with real money balances is given by:

$$\frac{\dot{m}}{m} = \mu - \pi \tag{3}$$

where $m(\equiv M/P)$ is the real money balances with nominal money holdings M and price level P; μ is the growth rate of the nominal money stock $(\dot{M}/M)$ and π is the rate of inflation $(\dot{P}/P)$.

Let θ and $1-\theta$ denote the fraction of government spending devoted to defense sector and non-defense sector (core infrastructure of public sector), respectively. The government is assumed to finance its defense spending (θg) by issuing money (μm) and finance its public spending $(1-\theta)g$ (i.e, investment in core infrastructure) by collecting income tax revenue (τQ). Hence the government budget constraint can thus be described as:

$$g = \mu m + \tau Q \tag{4}$$

$$\dot{S} = \theta g = \mu m \tag{5}$$

$$\dot{R} = (1-\theta) g = \tau Q \tag{6}$$

Eq. (4) shows the government's budget constraint and at each instant of time, the government always balances its budget. Eq.(5) describes the linkage between the total stock of defense capital and the flow of defense spending θg financed by issuing money. Eq.(6) describes the linkage between the total stock of public capital and the flow of core public spending $(1-\theta) g$ financed by collecting income tax revenue. Using Eqs.(5) and (6) with $S_0 / R_0 = \theta/(1-\theta)$ initially, we have the following relation such as:

$$\frac{S}{R} = \frac{\theta}{1-\theta} \tag{7}$$

As a result, using Eqs.(2)-(4), the budget constraint of households is given by:

$$\dot{k} + \dot{m} = (1-\tau) k^{1-\alpha_1-\alpha_2} R^{\alpha_1} S^{\alpha_2} - C - \pi m \tag{8}$$

where an overdot denotes the rate of change with respect to time, and τ is a flat-rate income tax. Households choose $\{C, m, k\}_{t=0}^{\infty}$ in order to maximize Eq.(1) subject to Eq.(8). By letting λ be the co-state variable associated with Eq.(8), and the transversality condition, $\lim \lambda m e^{-\rho t} = \lim \lambda k e^{-\rho t}$ given the initial real money balance m_0 and private capital stock k_0. The optimum conditions necessary for the households are:

$$H = \ln C + \eta S + \lambda[(1-\tau) k^{1-\alpha_1-\alpha_2} R^{\alpha_1} S^{\alpha_2} - C - \pi m] \tag{9}$$

$$\frac{1}{C} = \lambda \tag{10a}$$

$$-\lambda \pi = -\dot{\lambda} + \lambda \rho \tag{10b}$$

$$\lambda(1-\tau)(1-\alpha_1-\alpha_2)(R/k)^{\alpha_1}(S/k)^{\alpha_2} = -\dot{\lambda} + \lambda \rho \tag{10c}$$

$$\pi = -(1-\tau)(1-\alpha_1-\alpha_2)(R/k)^{\alpha_1}(S/k)^{\alpha_2} \qquad (10d)$$

Eq.(10a) shows that the marginal utility of consumption is equal to the sum of the shadow value of wealth. Eq.(10b) and (10c) indicate the optimal choices of real money balances and private capital stock, respectively. Eq.(10d) states the non-arbitrage condition between real money balances and holding private capital stock. Differentiating Eq.(10a) with respect to time and substituting Eq.(10b) and (10d) into the resulting equation yields:

$$\frac{\dot{C}}{C} = (1-\tau)(1-\alpha_1-\alpha_2)(R/k)^{\alpha_1}(S/k)^{\alpha_2} - \rho \qquad (11)$$

Eq.(11) is Keynes-Ramsey rule, which means that if the net marginal capital production is large (less) than time preference, the representative household will increase (decrease) their consumption in the next period of time. And from Eq.(5) and Eq.(6) , we have the growth rate of the defense capital:

$$\dot{S}/S = \theta g/S = [\theta/(1-\theta)](\tau Q/S) = \tau\theta^{1-\alpha_1}(1-\theta)^{\alpha_1-1}(S/k)^{\alpha_1+\alpha_2-1} \qquad (12)$$

By substituting Eq.(3) and Eqs.(5)-(7) into Eq.(8), we have the economy's resource constraint given as:

$$\dot{k} = [(1-\theta-\tau)/(1-\theta)]k^{1-\alpha_1-\alpha_2} R^{\alpha_1} S^{\alpha_2} - C \qquad (13)$$

In order to solve the balance growth equilibrium, we define the following transformed variables: $x \equiv C/k$ and $y \equiv S/k$ similar to Futagami et al. (1993), Barro and Sala-I-Martin (1995). Combining Eqs.(5)-(7),(10d), and Eqs.(11)-(13), the dynamic system with respect to transformed variables can be itemized by the following equations:

$$\frac{\dot{x}}{x} = \frac{\dot{C}}{C} - \frac{\dot{k}}{k} = \{[(\beta(1-\tau)-1)(1-\theta)+\tau]\}\theta^{-1}(1-\theta)^{\alpha_1-1}y^{1-\beta} + x - \rho \qquad (14)$$

$$\frac{\dot{y}}{y} = \frac{\dot{S}}{S} - \frac{\dot{k}}{k} = \tau\theta^{1-\alpha_1}(1-\theta)^{\alpha_1-1}y^{-\beta} - (1-\theta-\tau)\theta^{-1}(1-\theta)^{\alpha_1-1}y^{1-\beta} + x \qquad (15)$$

where $\beta = 1-\alpha_1-\alpha_2$. At the steady state, the economy is characterized by $\dot{x} = \dot{y} = 0$, and $\hat{x}$, $\hat{y}$ represent their stationary level, respectively.

3.1 Long-run effects and the ratio of defense spending

In this section, we investigate the long run effects of inflation rate and balanced growth rate following a rise in the ratio of defense spending in the steady growth equilibrium. We denote these results as proposition 1 and proposition 2, separately as the following.

Proposition 1: An increase in the ratio of defense spending (θ) will lead to a lower inflation rate $(\hat{\pi})$.

From Eq.(10d), in the steady state, we have

$\hat{\pi}(\theta) = -\beta(1-\tau)\theta^{-\alpha_1}(1-\theta)^{\alpha_1}\ \hat{y}^{1-\beta}(\theta)$, and by using Eq. (14) and Eq.(15) with $\dot{x} = \dot{y} = 0$, we obtain:

$$\frac{\partial \hat{y}}{\partial \theta} = \frac{\hat{y}\left\{(1-\alpha_1)\,\theta\tau + \alpha_1[\beta\,\hat{y}\,(1-\theta)\,(1-\tau)]\right\}}{\beta\,\theta(1-\theta)[(1-\beta)\;(1-\theta)\,(1-\tau)\,\hat{y} + \theta\,\tau]} > 0 \tag{16}$$

Differentiating Eq.(10d) with respect to θ and substituting Eq.(16) into the resulting equation yields:

$$\frac{\partial \hat{\pi}}{\partial \theta} = \frac{-\alpha_2\,\tau(1-\tau)\;\theta^{-\alpha_1}(1-\theta)^{\alpha_1-1}\;\hat{y}^{1-\beta}}{\theta\tau + (1-\beta)(1-\theta)\,(1-\tau)\,\hat{y}} < 0 \tag{17}$$

The results of Eq.(17) infers that once the ratio of defense spending increases, there must be a lower inflation rate. The key factor for this result can be tracked by Eq.(3) because the defense spending is financed by issuing money. To sustain the real money balance in steady state growth, the more money issued to finance the defense spending which implies a lower inflation will occur.

The following proposition we focuses are on the economic growth rate following by an increase in the ratio of defense spending.

Proposition 2: An increase in the ratio of defense spending (θ) ***stimulates the balanced economic growth rate*** $(\hat{\gamma})$ ***.***

Given $\dot{x} = \dot{y} = 0$ implies that $C, m, k, R, S,$ and Q all grow at same rate. Let $\hat{\gamma}$ be the steady-state economic growth rate that:

$$\dot{C}/C = \dot{m}/m = \dot{k}/k = \dot{R}/R = \dot{S}/S = \hat{\gamma} \tag{18}$$

holds in the steady-state growth equilibrium. From Eq.(10a) and (10b), in the steady state, we have $\dot{C}/C = -[\,\hat{\pi}(\theta) + \rho]$, and by using Eq.(17) and (18) we obtain:

$$\frac{\partial \hat{\gamma}}{\partial \theta} = \frac{\partial}{\partial \theta}\left(\frac{\dot{C}}{C}\right) = -\frac{\partial \hat{\pi}}{\partial \theta} = \frac{\alpha_2\;\tau(1-\tau)\;\theta^{-\alpha_1}(1-\theta)^{\alpha_1-1}\;\hat{y}^{1-\beta}}{\theta\tau + (1-\beta)(1-\theta)\,(1-\tau)\,\hat{y}} > 0 \tag{19}$$

Eq.(19) shows that the increase in the ratio of defense spending will stimulate the balanced economic growth rate. This result also implies that the increase in the ratio of public spending will deteriorate the economic growth rate. On the other hand, if the government pursues a higher economic growth rate, expansion on public spending will be in vain.

4. Empirical methodology

4.1 Unit root test - Augmented Dickey Fuller (ADF)

The assumptions of the classical time series model require that both series $\{x_t\}$ and $\{y_t\}$ are stationary and errors have a zero mean and finite variance. Non-stationary variables may result in a spurious regression if the non-stationary properties of the variables are not reflected. Therefore, a unit root test is applied to determine whether variables are stationary individually before conducting causality tests. Unit roots are crucial in examining the stationarity of a time series because a non-stationary regressor can invalidate standard empirical results. The presence of a stochastic trend is determined by testing for the presence of unit roots in time series data. In this study a unit root test is tested by using Augmented Dickey–Fuller (ADF).

The ADF test is referred to the *t* statistic of θ_2 coefficient of the following regression:

$$\Delta x_t = \theta_0 + \theta_1 t + \theta_2 x_{t-1} + \sum_{i=1}^{n} \beta_i \Delta x_{t-1} + \varepsilon_t \qquad (20)$$

where Δ expresses the first differences operator with n lags, ε_t is a stationary random error which adjusts the error of autocorrelation. The null hypothesis is that, x_t is a non-stationary series and rejected when θ_2 is significantly negative ($H_0 : \theta_2 = 0 ; H_\varepsilon : \theta_2 < 0$). This study uses the Akaike Information Criterion (AIC) to determine the optimal lag orders for Eq. (20) by selecting the grid of values for the number of lags (n) and obtaining the value of n at which the AIC attains its minimum.

4.2 Cointegration test

The co-integration test in this study is conducted using the method developed by Johansen and Katarina (1990) which is widely used in many empirical studies such as Fatma and Levent (2010), Pavle and Mirjana (2010), and Timur et. al (2011). Once a unit root test has been confirmed for a data series, the co-integration can be defined as a systematic co-movement economic variables over the long run. The procedure of the Johansen co-integration test is based on a VAR model which employs the likelihood maximum (L-Max) procedure to determine the presence of co-integrating vectors. In this test, the L-Max statistic is:

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) , \qquad (21)$$

where $\hat{\lambda}_{r+1}$ is the estimated smallest eigenvalues, and T denotes the numbers of observed values. The null hypothesis of maximum co-integrating vectors r is tested against the alternative hypothesis of maximum co-integrating vectors $r+1$. Therefore, the null hypothesis of maximum co-integrating vectors $r = 0$ is tested against the alternative $r = 1$. If all the series are integrated of the same order, then the presence of co-integration can be proceed and there must be a constant long run relationship corresponding to the long-run endogenous growth of variables.

4.3 Granger-causality test

The Granger causality test explains the bivariate relationship in variables. Suppose there are two variables, X and Y . They are used to evaluate whether the previous values of X are useful in predicting Y, and Y is considered Granger-caused by X if X helps predict Y, and vice versa. Thus, the bivariate vector autoregression (VAR) model can be executed on the basis of Granger causality test as follows:

$$Y_t = \alpha_1 + \sum_{i=1}^{m} \beta_{1i} X_{t-i} + \sum_{i=1}^{m} \gamma_{1i} Y_{t-i} + \Phi_{1t} \qquad (22)$$

$$X_t = \alpha_2 + \sum_{i=1}^{m} \beta_{2i} X_{t-i} + \sum_{i=1}^{m} \gamma_{2i} Y_{t-i} + \Phi_{2t} \qquad (23)$$

where α_1 and α_2 are intercept terms, β , γ represent the estimate coefficients, and m is the lag order of the model, selected according to the AIC. The null hypothesis supposes that X does not Granger-cause Y in Eq. (22) and Y does not Granger-cause X in Eq. (23), which could be represented as $\beta_{1i} = 0$ and $\gamma_{2i} = 0$ $(i = 1,2,...,m)$, respectively. This study applies the Wald statistics to examine the joint hypothesis of $\beta_{1i} = 0$ and $\gamma_{2i} = 0$. The causality types of arm races among countries are analyzed in the following:

Causality of Arms race between countries (i and j belong to specified country)

·A unidirectional causality running from country i 's defense spending to country j 's defense spending.

·A unidirectional causality running from country j 's defense spending to country i 's defense spending.

·A bidirectional causality between country i 's defense spending and country j 's defense spending.

·No causality between i 's defense spending and country j 's defense spending.

5. Data and empirical findings

5.1 Variables definitions and data

In this empirical study, LGDP stands for the natural logarithm of real GDP, and the LIR denotes the natural logarithm of inflation rate ($\Delta p / p$). In addition, we divide the total government spending into the ratio of defense spending and public spending to GDP expressed in the natural logarithm, LDS and LPS. All of the above annual data are obtained from Taiwan Economic Journal Data Bank (TEJ); AREMOS of Taiwan Economic Data Center; China, Japan, Korea, and Taiwan Statistical Year Book (various issues) over the period 1955 to 2010.

5.2 Results of unit root tests

The ADF unit root test is our first step to confirm the stationarity and the degree of integration of each variable. The ADF test results are presented in Table 1 for the level term and the first difference of each of the variables. As seen in this table, all variables for China, Japan, and Taiwan are non-stationary of the integration of degree one - *I*(1)- in their level term but are stationary in their first difference. As for South Korea, the variables are in different integration orders where $LGDP_{SK}$ and LDS_{SK} are *I*(0), and LPS_{SK} and LIR_{SK} are *I*(1) in their level term, this implies that the co-integration test can not be co-integrated because of the different integration orders of South Korea. Beside this, all variables in China, Japan, and Taiwan are stationary after their first difference.

Table 1: ADF unit roots test r results

Country	Variables	ADF with trend and intercept					
		Level Term			First difference		
		ADF	*m*	LM(4)	ADF	*m*	LM(4)
China	LDS_C	-2.78	3	3.23	-5.08***	0	1.43
	LPS_C	-1.45	1	4.67	-6.42***	1	3.17
	$LGDP_C$	-2.25	6	6.34	-7.21***	0	5.34
	LIR_C	-2.66	1	5.14	-6.56***	0	4.32
Japan	LDS_J	-1.28	1	2.79	-7.72***	0	7.23
	LPS_J	-2.46	0	4.54	-6.46***	0	2.64
	$LGDP_J$	-2.23	2	3.31	-4.25***	1	6.32
	LIR_J	-1.32	1	2.76	-5.07***	1	3.89
South Korea	LDS_{SK}	-4.58 ***	0	2.23	-5.11***	0	6.29
	LPS_{SK}	-2.65	4	6.17	-3.45**	1	2.66
	$LGDP_{SK}$	-3.65*	6	5.30	-5.25***	0	3.31
	LIR_{SK}	-1.45	4	4.41	-6.13***	0	4.33
Taiwan	LDS_T	-2.69	3	2.59	-5.13***	0	2.26
	LPS_T	-2.11	2	3.47	-4.44***	1	5.47
	$LGDP_T$	-1.28	0	6.12	-6.86***	1	7.38
	LIR_T	-2.07	0	5.11	-7.19***	1	6.42

Note: (a) LDS, LPS LGDP, and LIR represent the nature logarithm of ratio of defense spending to government spending, logarithm of ratio of public spending to government spending, the logarithm of real GDP, and the logarithm of inflation rate, respectively. (b)*** and ** represents that the 1% and 5% significance level, respectively. (c) *m* refers to the optimal lag length with a maximum lag length of six allowed. (d) LM(4) is the Lagrange Multiplier residuals test for up to fourth-order serial correlation and followed by the asymptotically distributed $\chi^2_{(4)}$.

5.3 Results of co-integration tests

Table 2 shows the results of Johansen's maximum eigenvalue test (λ_{max}). This co-integration test is a trivariate system which includes the independent variables, LGDP and LIR, and the dependent variables, LDS and LPS. The Johansen's λ_{max} test show that one co-integration relationship between the variables exists for China, Japan, and Taiwan in this trivariate system. The trivariate co-integration results in Table 2 report that the ratio of defense spending affects long-run economic growth positively for China, Japan and Taiwan. The positive outcome is consistent with our theoretical evidence of proposition 2 and supports *Benoit Hypothesis* where the ratio of defense spending is found to stimulate economic growth. This result is also evidenced by the potential military threat among China, Japan, and Taiwan. For example, a country with a higher economic growth rate may expect to enhance its external or internal security by increasing defense spending. Before World War II, South Korea and Taiwan where under Japanese colonial rule until 1945. In Taiwan, security has been the major concern since

Mainland Chinese authorities have claimed that the use of force against Taiwan is one of the possible coercive measures to reunify the territory. Apparently, these results seem to be consistent with our empirical expectations and sustain our theoretical propositions.

The trivariate co-integration results in Table 2 report that the increase of the ratio of defense spending leads to a lower long-run inflation rate in China and Japan, but higher inflation rate in Taiwan. In addition, Table 2 also shows that the increase of the ratio of defense spending leads to a higher long-run economic growth, supporting the famously *Benoit Hypothesis* for China, Japan, and Taiwan.

Table 2: Johansen co-integration test results

Country	Variables	(λ_{max})				(Cointegration equation)
		$r=0$	$r=1$	k	r	
China	$LGDP_C, LDS_C, LPS_C$	37.72***	0.36	1	1	$LGDP = 16.49 + 1.13\,LDS + 11.56\,LPS$
	LIR_C, LDS_C, LPS_C	42.34***	0.26	3	1	$LIR = 14.68 - 1.24\,LDS + 3.01\,LPS$
Japan	$LGDP_J, LDS_J, LPS_J$	17.43**	0.11	1	1	$LGDP = 10.34 + 5.21\,LDS + 17.21\,LPS$
	LIR_J, LDS_J, LPS_J	22.14**	0.22	1	1	$LIR = 11.25 - 3.26\,LDS + 11.21\,LPS$
Taiwan	$LGDP_T, LDS_T, LPS_T$	35.16***	0.25	1	1	$LGDP = 10.19 + 8.24\,LDS + 9.16\,LPS$
	LIR_T, LDS_T, LPS_T	21.68**	0.22	3	1	$LIR = 34.68 + 2.16\,LDS - 3.01\,LPS$

Note: (a) LDS, LGDP, and LIR represent the nature logarithms of ratio of defense spending to nominal GDP, and the nature logarithms of inflation rate, respectively. (b) *** and ** represents that the 1% and 5% significance level, respectively. (c) λ_{max} is the maximum eigenvalue statistic. (d) k is the optimal lag length selected by AIC for the unrestricted VAR model. (e) r is the number of cointegration.

5.4 Results of causality tests

For cross-country studies, the causality test results in Table 3 show that there is an unidirectional causality running from China's (Japan's) defense spending to South Korea's (Taiwan's) defense spending, and no causality between South Korea and Taiwan. These results indicate no arms race between cross-country pairs of China and South Korea, Japan and Taiwan, and the last pair, South Korea and Taiwan.

Table 3 also shows a bidirectional casual relationship between the defense spending of cross-country pairs of China and Japan, China and Taiwan, and the last pair, Japan and South Korea. This result is in line with Kollias and Makrydaskis

(1997), Dunne *et al*. (2001), Chang *et al*. (2001), Dritsakis (2004), and Julide and Nadir, (2006) who report an arms race exists as a bidirectional causal relationship between defense spending of both countries. Apparently, an arms race in such cases of China-Japan, China-Taiwan, and Japan-South Korea are the wider geopolitical instability that has existed during the past few years increases the tensity of foreign security for each country pairs.

Table 3: Granger causality test results of arms race between countries

Country	Causality	Statistic	(Arms race)
China & Japan	$LDS_C \Rightarrow LDS_J$	15.21(0.01) ***	
	$LDS_J \Rightarrow LDS_C$	9.17 (0.05) **	Exist
China & South Korea	$LDS_C \Rightarrow LDS_{SK}$	10.18(0.05) **	
	$LDS_{SK} \Rightarrow LDS_C$	2.31(0.43)	Does not exist
China & Taiwan	$LDS_C \Rightarrow LDS_T$	24.39(0.01) ***	
	$LDS_T \Rightarrow LDS_C$	14.78(0.01) ***	Exist
Japan & Taiwan	$LDS_J \Rightarrow LDS_T$	10.64(0.00) **	
	$LDS_T \Rightarrow LDS_J$	3.19(0.49)	Does not exist
Japan & South Korea	$LDS_J \Rightarrow LDS_{SK}$	26.64(0.00) ***	
	$LDS_{SK} \Rightarrow LDS_J$	13.78(0.01) ***	Exist
South Korea & Taiwan	$LDS_{SK} \Rightarrow LDS_T$	6.79(0.54)	
	$LDS_T \Rightarrow LDS_{SK}$	5.35(0.37)	Does not exist

Note: (a) LDS_C, LDS_J, LDS_{SK}, and LDS_T represent the nature logarithms of ratio of defense spending to nominal GDP for China, Japan, South Korea, and Taiwan, respectively. (b)The number inside the parenthesis is the P-value. (c) *** and ** represents that the 1% and 5% significance level, respectively.

6. Conclusion

Issues regarding economic performance and military stability in China, Japan, South Korea, and Taiwan have gone through decades of competitiveness, peaceful co-existence, and conflicts. The efficiency of a government spending allocation on economic performance has been a long controversial issue, and understanding the time series dynamics between defense spending and economic growth as well as between the military expenditures of rival states has drawn much attention in recent literature. For the internal aspect, allocating government spending from public spending to defense spending may achieve a higher economy growth and a lower inflation; however, an arms race between countries may explain why the expansion of defense spending has stirred the dispute of armament and disarmament during recent years. For the external aspect, defense spending is a representative indicator of historical fluctuations and armament factors, not only a ratio of government expenditure but also an indicator of military deterrence capability.

This study attempts to make some contributions to this line of research using theoretical and empirical components. In the theoretical part of this study, we construct an endogenous growth model to examine both the long-run inflation rate and economic growth when defense spending arises. In the empirical part of this study, we divide the government spending into defense spending and public spending and then test for the theoretical propositions by using Johansen co-integration and Granger causality test within a trivariate framework in the following steps. First, ADF test is used to confirm the stationarity of variables, and second, the Johansen co-integration is employed to analyze the long-run relationship between inflation rate and economic growth when the ratio of defense spending increases. Finally, the Granger causality test is applied to determine whether an arms race exists. It is found that there is a co-integration relationship among China, Japan, and Taiwan, but not in South Korea. The trivariate co-integration results also help to predict the long-run relationship between variables and show that (1) the increase of the ratio of defense spending leads to a lower long-run inflation rate in China and Japan, but higher inflation rate in Taiwan; (2) the increase of the ratio of defense spending leads to higher long-run economic growth in China, Japan and Taiwan. Therefore, based on (1) and (2), we see that in China and Japan, this trivariate framework is consistent with our theoretical evidences of proposition 1 and proposition 2, and supports the famously *Benoit Hypothesis* because the expansion of defense spending benefits the economic growth and decreases the inflation rate.

The results of bidirectional Granger causality test suggest that an arms race exists among the cross-country pairs of China and Japan, China and Taiwan, and the last pair, Japan and South Korea. Comparing the co-integration results, as the ratio of defense spending increases, an arms race, higher economic growth and lower inflation coexist in China and Japan. These findings may also be an explanation of why in view of economic performance, those arms race and disarmament issues are advocated in recent years. From a methodological perspective, the endogenous model and empirical method of this can be extended to a more generalized multivariate application, where inflation rate, economic growth, and defense spending are explicitly influenced by other economic factors such as net capital flow, exchange rate, employment status, and other non-economic factors such as military deterrence, government types, geographical distribution, etc. Future studies, in conjunction with these factors and other economic ones, may be needed in this perspective.

REFERENCES

[1] **Alper, O. And Erman, E. (2014), *Further Evidence on Defence Spending and Economic Growth in NATO Countries*.** *Economic Computation and Economic Cybernetics Studies and Research*, 48(2), 1-12;
[2] **Aynur A. and Paul, L. (2012), *Military Expenditure and Economic Growth: A Meta-Analysis.*** *European Journal of Political Economy* 28(4), 636-650;
[3] **Barro, R. Jr. (1990), *Government Spending in a Simple Model of Endogenous Growth.*** *Journal of Political Economy* 98(5), 103-125;
[4] **Barro, R. Jr. and Sala I. M. (1995)., *Economic Growth.*** *McGraw-Hill*, New York;
[5] **Brumm, H**. **(1997)**, ***Military Spending, Government Disarray and Economic Growth: A Cross-Country Empirical Analysis.*** *Journal of Macroeconomics* 19(4), 827-838;
[6] **Chang, T. Y., Fang, W. S. and Liu, C. C. (2001), *Defense Spending, Economic Growth and Temporal Causality: Evidence from Taiwan and China, 1952-1995.*** *Applied Economics* 33(10), 1289-1299;
[7] **DeRouen, K. Jr. (1995), *Arab-Israeli Defense Spending and Economic Growth.*** *Conflict Management and Peace Science* 14(1), 25-47;
[8] **Dritsakis, N. (2004), *Defense Spending and Economic Growth: An Empirical Investigation for Greece and Turkey.*** *Journal of Policy Modeling* 26(2), 249-264;
[9] **Dunne, P., Nikolaidou E. and Vougas, D. (2001), *Defense Spending and Economic Growth: A Causal Analysis for Greece and Turkey, 1960-1996.*** *Defense and Peace Economics* 12(1), 5-26;
[10] **Fatma Z. and Levent, K. (2010), *A Cost-based Empirical Model of the Aggregate Price Determination for the Turkish Economy: A Multivariate Cointegration Approach.*** *Panoeconomicus* 57(2), 173-188;
[11] **Fordham, B. (2003), *The Political and Economic Sources of Inflation in the American Military Budget.*** *Journal of Conflict Resolution* 47(5), 574-593;
[12] **Futagami, K., Morita, Y. and Shibita, A. (1993), *Dynamic Analysis of an Endogenous Growth Model with Public Capital.*** *Scandinavian Journal of Economics* 95(4), 607-625;
[13] **Huang, C. and Mintz, A. (1990), *Ridge Regression Analysis of the Defense-Growth Tradeoff on the United States.*** *Defense Economics* 2(1), 9-37;
[14] **Huang, C. and Mintz, A. (1991), *Defense Expenditures and Economic Growth: The Externality Effect.*** *Defense Economics* 3(1), 35-40;
[15] **Johansen, S. and Katarina, J. (1990), *Max imum Likelihood Estimation and Inference on Cointegration – with Applications to the Demand for Money.*** Oxford Bulletin of Economics and Statistics 52(2), 169-210;
[16] **Julide,Y. and Nadir, O. (2006), *Arms Race and Economic Growth: The Case of India and Pakistan.*** *Defense and Peace Economics* 17(1), 37-45;

[17] **Kollias, C. and Makrydakis, S. (1997),** ***Defense Spending and Growth in Turkey 1954- 1993: A Causal Analysis.*** *Defense and Peace Economics* 8(2), 189-204;
[18] **Murdoch, J. C., Pi,C. R. and Todd, S. (1997),** ***The Impact of Defense and Non-Defense Public Spending on Growth in Asia and Latin America.*** *Defence and Peace Economics* 8(2), 205-224;
[19] **Landau, D. (1996),** ***Is One of the Peace Dividend Negative: Military Expenditure and Economic Growth in the Wealthy OECD Countries.*** *Quarterly Review of Economics and Finance* 36(2), 183-96;
[20] **Lipow, J. and Antinori, M. C. (1995),** ***External Security Threats, Defense Expenditures, and the Economic Growth of Less-Developed Countries.*** *Journal of Policy Modeling*, 17(6), 579-595;
[21] **Muhammad, S., Nuno, C. L., Gazi, S. U., Mohamed, A., Frédéric, T. (2013),** ***Should Portuguese Economy Invest in Defense Spending? A Revisit;*** *Economic Modelling* 35(2), 805-815;
[22] **Pavle, P. and Mirjana, G. (2010),** ***Exchange Rate and Trade Balance: J-curve Effect.*** *Panoeconomicus* 1(2), 23-41;
[23] **Payne, J. E. (1990),** ***Granger Causality between Inflation and Defense Spending: An Empirical Note.*** *Kentucky Journal of Economics and Business* 10(4), 38-41;
[24] **Ram, R. (1995),** ***Defense Expenditure and Economic Growth in Handbook of Defense Economics, edited by K. Hartley and T. Sandler.*** *Amsterdam*: *Elsevier*: 251-273;
[25] **Rebelo, S. (1991),** ***Long-Run Policy Analysis and Long-run Growth.*** *Journal of Political Economy* 99(3), 500-521;
[26] **Sandler, T. and Hartley, K. (1995),** ***The Economics of Defense***. *Cambridge:* Cambridge University Press;
[27] **Shieh, J. Y., Lai, C. C. and Chang, W. Y.. (2002a),** ***The Impact of Military Burden on Long-Run Growth and Welfare.*** *Journal of Development Economics* 68(2), 443-454;
[28] **Shieh, J.Y., Lai, C.C. and Chang, W, Y. (2002b),** ***Endogenous Growth and Defense Expenditures: A New Explanation of the Benoit Hypothesis***. *Defense and Peace Economics* 13(3), 179-186;
[29] **Timur, H. G., Lutfi, E. and Ibrahim, O. (2011),** ***An Empirical Investigation on the Determinants of the Saving- Investment Interaction***. *Panoeconomicus* 58(3), 343-353;
[30] **Turnovsky, S. (2000b),** ***Fiscal Policy, Elastic Labor Supply and Endogenous Growth.*** *Journal of Monetary Economics* 45(1), 185-210;
[31] **Tzeng, S. J., Lai, C.C. and Huang, C.C. (2008),** ***Does Military*** **Expenditure Matter for Inflation and** ***Economic Growth*****?** *Defense and Peace Economics* 19(6), 471-478;
[32] **Van der Ploeg, F. and Zeeuw, D. (1990),** ***Perfect Equilibrium in a Model of Competitive Arms Accumulation.*** *International Economic Review* 31(1), 131-146;

[33]**Zou, H. F. (1995),** ***A Dynamic Model of Capital and Arms Accumulation.*** *Journal of Economic Dynamics and Control* 19(1), 371-393.