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THE THRESHOLD EFFECT ON MILITARY EXPENDITURE: A PANEL SMOOTH TRANSITION AUTOREGRESSION APPROACH

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ABSTRACT
With the global economic growth, the countries in Asia and Oceania area keep continuing expansion in military expenditure. This paper adopts the panel smooth transition autoregression (PSTAR) models with a GDP growth rate as the transition variables to estimate military expenditure, its persistence and the threshold effect. The model can trace the characteristics of military expenditure in nonlinearity and persistence. Empirical results show that the military expenditure persistence for the nineteen Asia and Oceania countries during 2000-2012 is nonlinear and varies with time and across countries, depending on the GDP growth rate in different regimes. The threshold for GDP growth rate is 5.1745%. A quantitative easing policy would promote economic growth and then decrease military expenditure persistence, which will re-allocate resources and promote a country's financial situation.

KEYWORDS
GDP annual growth rate;Military expenditure; Panel smooth transition autoregression model (PSTAR); Quantitative easing policy.

JEL CLASSIFICATION CODES
C33, E25.

1. INTRODUCTION
With the end of the Cold War and fast development of globalization, whole world economic environment risk tends to relax. Most countries stop their military competition and reduce their military expenditure for enlarging the civil welfare. For recent three decades, many researchers have paid attention to study the relationship between military expenditure and economic growth. According to the report of the Stockholm International Peace Research Institute (SIPRI) in 2013, global military expenditure decreased 1.9% compared to 2012; however, the total military expenditures sill reached to $1,747 billion US dollars (Sam and Carina, 2014). SIPRI also indicated that top 15 military spenders of the world in 2013, five of them (one third) belong to Asian and Oceania countries. [1] Military expenditure annual growth rate in Asia and Oceania regime increased 3.6% in 2013, and the increase value of the military expenditure reached to 407 billion US dollars. This result shows that Asia-Oceania area is the only one area for keeping continues growth in military expenditure of the world. According to the SIPRI data from 2004 to 2013, for the high military expenditure countries, their GDP annual growth rates are also high.

Purpose for countries to increase military expenditure is not only establishing military power mechanism to defense country from the threat, but also considering regional safety and military defense power balance. Most previous studies used linear models to evaluate the relationship between military expenditure and GDP. Although the results of the relationship are divergent, the marginal effects of GDP on military expenditure are permanently constant. However, the relationship may be nonlinear as the transaction cost exists. That is, using linear models to evaluate the relationship between military expenditure and income will lead to a biased estimation result. In view of this, using nonlinear models to examine the relationship between military spending and GDP is required. Our research purpose could be summarized as three aspects. First, we employ a panel smooth transition autoregressive (PSTAR) model to investigate whether the relationship between military expenditure and income is nonlinear. Second, we examine how the persistence of military expenditure varies with GDP growth rate and time. Third, where is the threshold of GDP growth rate for the military expenditure (persistence) to change its increasing or decreasing process. Empirically, we use 19 countries in the Asia-Oceania area during the period 2000 through 2012 as sample objects.

The rest of this paper is organized as follows. Section 2 briefly reviews the literature in terms of military expenditure. Section 3 constructs the military expenditure model of a PSTAR specification, and describes the specification, testing and estimation of the model. Section 4 shows the empirical results, and the final section concludes the paper.

2. LITERATURE REVIEW
Previous researches suggested that the determinants of military expenditure include income, policy attitude, democracy levels and threats (see, for example, Jushua and Reuven, 2006; Vahe, 2011; Christos and Susana-Maria, 2011; Hsu and Lee, 2012; William, John and Bruce, 2012; Ehsan and Junaina, 2013). Economists classify that there are three main components in military expenditure, i.e., personnel expenditure, operation expenditure for communication, investment and infrastructure, and defense spending for military research and development (Partha and Nasser, 2009).

Benoit (1978) suggests that defense expenditure will promote a country's economic growth by increasing military investment. However, a large number of studies suggest that there is an ambiguous effect (positive or negative) in terms of the relationship between economic growth and military expenditure (see, for example, Benoit, 1978; David, 1983; Cuaresma and Reitschuler, 2004; Dunne, et al, 2005). The reason may be that some important variables are omitted or the relationship is non-linear (Joshua and Reuven, 2006).

There is a significant trade-off among military expenditure, education and welfare expenditure, implying that increase in military expenditure will exclude the allocation of other expenditure for a given income (Christos and Susana-Maria, 2011). Chen (1985) suggests that military expenditure is a more important demand factor than any other form of public sector expenditure, and a high ratio of military expenditure to government budget would be harmful for a country's international balance of payment. According to a simple economic theory, military expenditure will cause the reallocation of resource, and less normal resource's distribution might lead to a higher opportunity cost of foreign investment, which negatively influences a country's economic growth. Hence, a constant value of military expenditure in developing countries would not promote the related investment, but the released resource might be frittered away by

[1] The top 6 military spenders include China, Japan, India, Indonesia, Korea and Australia.

non-productive consumption (Saadet, 1986). On the contrary, Mehay and Solnick (1990) argue that the increase of military expenditure in R&D and equipment is a positive factor and significantly affects regional economic growth and employment. In addition, it could be effective to expand the aggregate supply and aggregate demand both for domestic and overseas. Military expenditure increased could offer R&D ability, education, training to commodity industry and create more infrastructures. That is, it could not only offer a multiplier effect in a short run, but also promote economic growth in a long run.

In sum, military expenditure in empirical application and theory belongs to a normal good with unitary elasticity in terms of income. An increase in GDP will cause an expansion of government budget, which allows for more military expenditure (Sonmez, 2013). Military expenditure could influence an economy through security effects, demand effects and supply effects (Dunne, Smith and Willenbockel, 2005). Regarding security effects, increasing military expenditure can offer safety to enterprise and attract assets and innovation accumulation. As to the demand effects, higher military expenditure will promote aggregate demand, resource utilization and cut down unemployment to create a Keynesian Multiplier effect. For the supply effects, if the production from military expenditure cannot offer for the use of civil, then it will have a negative effect to economic growth. Hence, if a country has military training and technology spin-off effects, it will affect the growth rate negatively (Hou and Chen, 2014).

Wall (1996) argued that in investigating the military expenditure issue, there exists the heterogeneous bias in cross-section, which causes a mix (positive or negative) result. Stephen and Frank (2002) suggest that an autoregressive (AR) model is a good methodology to examine the persistence issue of a specific economic variable. Hsu and Lee (2012) also indicate that using the time-series method to estimate expenditure issue is a workable methodology. However, estimation result from the AR(1) model will cause a serious bias, and can be excluded by using specific auxiliary instrument variable (William, John and Bruce, 2012). Some previous studies suggest the positive (or negative) relationship between income and military expenditure. Although Aamer and Suleiman (2008) argue that military expenditure displays a significant structural change between two different regimes, they cannot further describe and capture the non-linear characteristics of military expenditure. For the time series model, using lagged dependent variables as the regressors can measure the persistence of military expenditure. The SIPRI database is famous in the world for its specialization in security and defense expenditure; therefore, this paper adopts this databank for empirical analysis.

Since employing linear autoregressive models to estimate the persistence effect of defense expenditure will cause biased results, it is necessary to replace the linear models with nonlinear models. Some famous nonlinear models have been developed, such as the Markov-switching (MS) model (Hamilton, 1989), the threshold autoregressive (TAR) model (Tsay, 1989), smooth transition autoregression (STAR) model (Luukkonen, 1988) and artificial neural networks (ANN) (Kuan and White, 1994). Regarding the TAR and MS models, the variables under investigation display an abrupt switching process. The shortcomings of the ANN model are its implicit knowledge structure, complicated calculations and lower explanatory power (Teräsvirta et al., 2010). STAR models are broadly applied to asymmetric recycle model (Hall et al., 2001), but they are short of function to overcome the heterogeneity problem (Griliches and Hausman, 1986). PSTR models can resolve the above problem and is a good model to investigate the persistence of a specific variable (van Dijk et al., 2002; González et al., 2005; Wu, et al., 2013).

3. THE MODEL

This paper constructs a PSTR model to estimate the persistence and non-linear characteristics of military expenditure. Following González et al. (2005), in the case of two extreme regimes and single one transition function, the PSTR model could be written as Eq.(1)

$$y_{it} = \mu_i + \beta_0^{'} x_{it} + \beta_1^{'} x_{it} W(z_{it};\gamma,c) + \varepsilon_{it} \quad (1)$$

where, *i = 1,2,...,N* denotes the number of cross sections and *t = 1,2,...,T* denotes the number of time periods. yit and xit denote the dependent variable and regressor, respectively. µi denotes the individual effect and is time invariant. *W*(•) is the transition function bounded between 0 to 1 and depends on the transition function Zit. γ>0 is the transition parameter, and c is the threshold of the transition function. Transition variable suggested by van Dijk et al. (2002) could be an exogenous variable or a lagged endogenous variable. εit is the residual. PSTR model assumes that parameters under investigation change smoothly between different regimes. Transition functions frequently used in literature is logistic one and can be written as Eq.(2).

$$W(z_{it};\gamma,c) = \left[1+\exp(-\gamma \prod_{j=1}^{m}(z_{i,t}-c))\right]^{-1} \quad (2)$$

where $c_1 \le c_2 \le c_3 \le ... \le c_m$, m denotes the number of location parameters. Following Gonzalez et al. (2005), it is enough to consider m=1 or m=2 from the viewpoint of empirical practice. In addition, it is easy to extend the basic PSTAR model into more general ones as shown in Eq. (3).

$$y_{it} = \mu_i + \beta_0^{'} x_{it} + \sum_{j=1}^{r} \beta_j^{'} x_{it} W_j(z_{it};\gamma_j,c_j) + \varepsilon_{it} \quad (3)$$

where $W_j(z_{it};\gamma_j,c_j),\ j=1,...,r$ is the transition function and r+1 denote the number of regimes.

According to Eq. (1), we can construct the military expenditure of a PSTAR framework:

$$ME_{it} = \mu_i + \sum_{k=1}^{K} \theta_k ME_{it-k} + (\sum_{k=1}^{K} \theta_k^{'} ME_{it-k}) W(z_{it-d};\gamma_j,c_j) + \varepsilon_{it} \quad (4)$$

where ME_{it} and ME_{it-k} denote i country's military expenditure in time *t* and *t-k*, respectively. It is worth mentioning that we use lagged military expenditures instead of endogenous variable as regressors to avoid estimation bias (see Wu et al., 2014).

For a given threshold "*c*", the persistence of military expenditure for country *i* at *t* time is equal to $\sum_{k=1}^{K} \theta_k + (\sum_{k=1}^{K} \theta_k^{'}) W(z_{it-d};\gamma_j,c_j)$. Obviously, the persistence effect varies across countries and with time. In two extreme cases, i.e., $W(z_{it-d};\gamma_j,c_j)=0$ and $W(z_{it-d};\gamma_j,c_j)=1$, the persistence effects are $\sum_{k=1}^{K} \theta_k$ and $\sum_{k=1}^{K} \theta_k + \left(\sum_{k=1}^{K} \theta_k^{'} \right)$, respectively. According to Coelh, De Aguiar and Lopes (2011), persistence coefficient will be limited to less than 1. Besides, military expenditure persistence could be used to predict the change of military expenditure and the impact of current shocks on current military expenditure.

To Estimate Eq.(4), we need to identify the number of transition functions (or the number of transition regimes). Following González et al. (2005), this paper adopts a three-stage approach to proceed estimation of the PSTAR. First, we perform the linearity test to ensure the non-linearity of the estimation model, and then determine the number of transition functions. Finally, after de-meaning the model, we can use the non-linear OLS approach to estimate the parameters of the model.

As mentioned above, GDP growth rate will positively or negatively affect military expenditure. Thus, this study selects GDP growth rate as the transition variable to investigate how the military expenditure persistence moves between high and low growth regimes. To perform the linear test from Eq. (4), following Fouquau et al. (2008), we replace the transition function $W(z_{it-d};\gamma,c)$ with its first-order Taylor expansion around $\gamma = 0$. Let *r*=1, we then obtain the following auxiliary equation:

$$ME_{it} = \pi_{0i} + \sum_{k=1}^{K} \pi_k ME_{it-k} + \sum_{k=1}^{K} \pi_k^{'} z_{it-d} ME_{it-k} + \eta_{it} \quad (5)$$

where d=0,1,2,3,4 to allow the transition variable to be current or lagged. Linear test is performed under the assumption of $H_0 : \pi_1^{'} = \pi_2^{'} = ... = \pi_K^{'} = 0$. If the null hypothesis is rejected, then we can use execute no remaining nonlinearity test (see, for example, Wu et al., 2013). If SSR_0 and SSR_1 denote the panel sum of squared residuals under H0 and the panel sum of squared residuals under H1, we can then write the corresponding F statistic as follows:

$$LM_F = [(SSR_0 - SSR_1)/mK]/[SSR_0/(TN-N-mK)] \quad (6)$$

where K denote the number of regressors. Under the null hypothesis, the LMF statistic has an asymptotic $\chi^2(mK)$ distribution and the F-statistic has an approximate $F[mK, TN-N-mK]$ distribution.

To sum up, this paper uses the PSTAR model to estimate the military expenditure and its persistence of the Asia and Oceania countries. First, we construct a linear autoregressive (AR) model and the optimal lag length of military expenditure is decided by the stepwise regression approach. Second, using residuals from the AR model we conduct the linearity test and no remaining nonlinearity test to identify the nonlinearity of military expenditure and the optimal number of transition functions in the PSTAR model. Finally, we adopt the non-linear OLS method to execute the estimation of the PSTAR model.

4. EMPIRICAL RESULTS

The descriptive statistics of the variables used in this paper are shown in Table A1. Before estimating the PSTAR model, we need to perform panel unit root tests for identifying the stationarity of the data (see Wu et al., 2014). Stationary time-series data may be influenced by exogenous variables, but they will finally return to their levels of long run equilibrium. Contrarily, non-stationary time-series data will diverge away from their levels of long run equilibrium. This paper adopts three panel unit root tests, i.e., the LLC, ADF and PP tests. In Table 1, the three panel unit root tests all show that both military expenditure and GDP annual growth rate are stationary. Thus, we can proceed to the following estimation.

TABLE 1: PANEL UNIT ROOT TEST

	Military Expenditure		GDP Annual Growth Rate	
Method	Statistic	Prob.	Statistic	Prob.
LLC	-6.3287	0.0000	-12.3994	0.0000
ADF	82.6347	0.0000	189.393	0.0000
PP	175.488	0.0000	250.152	0.0000

To estimate the PSTAR model, we have to determine the regressors, i.e., the lagged military expenditure. The optimal lag length of military expenditure is selected by the stepwise regression method. Following Brown and Rozeff (1979) and Chen (2013), we allow the lag length up to four periods. According to the regression result in Table 2, the chosen regressors are one- and two-period lagged military expenditures, i.e., ME(-1) and ME(-2).

TABLE 2: STEPWISE REGRESSION RESULT

Variable	Coefficient	Std. Error	Prob.
ME(-1)	0.8311	0.0617	0.0000
ME(-2)	0.2435	0.0789	0.0023

Table 3 shows the testing results of linearity for the PSTAR models with d-period lagged transition variables and different number of location parameters. Following González et al. (2005), this paper allows location parameter m to be 1 or 2. Evidently, except for the case of PSTAR model with d=1 and m=2, the remaining PSTAR models all reject the null hypothesis at the 5% significance level. That is, the models are non-linear. Thus, we can further perform the estimation of the PSTAR models.

TABLE 3: LINEARITY TEST

Number of location parameters (*m*)		*m=1*		*m=2*	
Lagged transition variable (GDP%)	*d=0*	3.146	[0.026]	2.515	[0.022]
	d=1	2.948	[0.034]	1.836	[0.088]
	d=2	6.708	[0.000]	4.062	[0.001]
	d=3	3.727	[0.012]	2.871	[0.010]
	d=4	5.349	[0.001]	4.010	[0.001]

1. The degits in table and brackets are the statistics of the Fisher test (LMF) and p-value, respectively.
2. H0: linear model against H1: PSTAR model with at least one transition function.

Table 4 shows the result of the no remaining nonlinearity test. At the 1% significance level, most PSTAR models have single one transition function. In th cases of m=2 and d=0 and m=2 and d=4, the estimated thresholds are over the range of the sample data; therefore, we ignore their estimation results.

TABLE 4: NO REMAINING NONLINEARITY TEST

(m)	*m=1*	*m=2*
	LMF	LMF
d=0	3.865	4.367
	(0.022)	(0.002)
d=1	1.312	0.920
	(0.271)	(0.453)
d=2	1.670	2.664
	(0.332)	(0.033)
d=3	2.986	0.956
	(0.053)	(0.433)
d=4	0.840	6.333
	(0.433)	(0.000)

Notes: H0:PSTR with r=1 against H1:PSTR with at least r=2. The digits in brackets are the p-values. The significance level is 1%.

In Table 5, the model that has minimum AIC and BIC is the one with one transition function (r=1), one location parameter (m=1) and one-period lagged GDP annual growth rate as transition variable. That is, this model is the optimal one to estimate the military expenditure and its persistence. In this model, the estimated threshold c and smooth parameter γ are 5.1745 (i.e. 5.1745%) and 1.7715, respectively.

The persistence for military expenditure is permanently positive, i.e., $0.4005 + 0.2077 * W(ME_{it-1}, 1.7715, 5.1745) > 0$, depending on one-period lagged GDP annual growth rate. Since the GDP annual growth rate varies across countries and with time, the persistence effect is time- and country-varying. In two extreme cases, $W(ME_{it-1}; 1.7715, 5.1745) = 0 \text{ and } 1$, the persistence effect are 0.6704 and 0.6082, respectively. Obviously, in these two extreme cases, exogenous impacts on current military expenditure are 0.3296 and 0.3918. When one-period lagged GDP growth rate is above the threshold (5.1745%), the military expenditure will have lower persistence and higher exogenous impact. Contrarily, as the GDP growth rate is below the threshold, the military expenditure persistence increases and the exogenous shock decreases. Again, the persistence effect is permanently positive and varies with time and across countries.

TABLE 5: ESTIMATION RESULT OF MILITARY EXPENDITURE (PERSISTENCE): THE PSTAR SPECIFICATION

	d=0	d=1#	d=2	d=3	d=4
	r=m=1	r=m=1	r=m=1	r=m=1	r=m=1
γ	660.9172	1.7715	3.4006	1.6355	522.0195
c	3.9071	5.1745	4.7330	6.1474	7.4324
θ_1	0.3395 (2.2515)**	0.7058 (3.9224) ***	0.4350 (2.4730) **	0.3125 (2.4323) **	0.4860 (3.1163) ***
θ'_1	0.3687 (1.8341) *	-0.3053 (-1.3786)	0.1614 (0.7570)	0.6473 (2.2114) **	0.1209 (0.5559)
θ_2	0.2025 (1.3890)	-0.0354 (-0.1923)	0.2425 (1.3614)	0.3412 (2.7394) ***	0.0622 (0.4399)
θ'_2	-0.2919 (-1.4686)	0.2431 (1.1266)	-0.2524 (-1.2467)	-0.662 (-2.5131) ***	-0.2331 (-1.1872)
AIC	0.5300	0.4898	0.5620	0.5122	0.4927
BIC	0.6153	0.5751	0.6473	0.5975	0.5780

Notes: # denotes the PSTAR model with minimum AIC and BIC. *d, r,* and *m* denote lag length of transition variable, the number of transition function and the number of location parameter, respectively. The digits in brackets are the t-statistics.

According to the estimation result in Table 5, we can depict the processes of GDP growth rate, threshold and military expenditure in Figure 1A. Evidently, if a country's economic growth in a relatively high stage, the military expenditure persistence will decrease. That is, a higher current economic growth will cause a bigger exogenous shock on current military expenditure, which leads to a lower military expenditure persistence. This result may come from the fact that the increase of total government expenditure is higher than military expenditure in a higher economic growth stage. On the contrary, lower economic growth will rapidly promote military expenditure persistence. The probable reason is that during the periods of economic growth, government decreases the ratio of military expenditure to GDP for promoting economic modernization and organization efficiency (Saadet, 1986). However, during the periods of lower economic growth (i.e. the growth rate is below the threshold), government loses some support from people, and then expanding military expenditure relative to GDP for keeping military "happy" (Vahe, 2011)

5. CONCLUSION

This paper investigates military expenditure persistence by employing the PSTAR model. To estimate the model, we select economic growth rate (GDP growth rate) as the transition variable. The advantages of the PSTAR model include that it can control the bias originated from the choice of fundamentals and can potentially explain the heterogeneity of the military expenditure persistence.

Empirical results can be summarized as follows. First, military expenditure persistence is nonlinear and varies with time and across countries, depending on one-period lagged GDP growth rate. This result is quite different to those derived from linear models. Second, in the periods of relatively low economic growth, the government would increase the ratio of military expenditure to GDP for stimulating economic growth, which causes a higher military expenditure persistence. However, as a country is in economic booming stage and the growth rate is higher than the threshold, the military expenditure persistence would decrease. Third, if a quantitative easing policy is adopted to stimulate economic growth, the country's military expenditure will decrease.

This paper provides two policy propositions. First, a high economic growth in the Asia and Oceania countries is helpful for the governments to reduce the ratio of military expenditure to GDP and to attract more foreign direct investment. Second, higher level of economic growth in these countries is harmful for maintaining the stability of military expenditure persistence. Thus, the governments need to monitor the impact of current shocks on current military expenditure.

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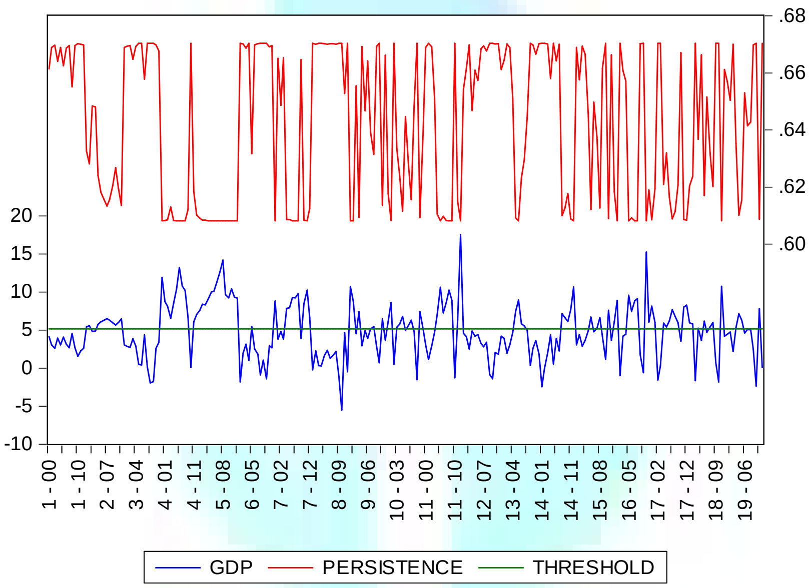
APPENDIX

TABLE 1A: DESCRIPTIVE STATISTICS OF VARIABLE

	Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis	Jarque-Bela	Obs.
ME	0.0931	0.3515	0.0163	0.0637	1.6605	6.2079	219.42	247
GDP annual growth rate	4.7650	17.514	-5.527	3.5087	0.2333	3.4381	4.2161	247

FIG. 1A: MILITARY EXPENDITURE PERSISTENCE



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