Asian Economic and Financial Review
ISSN(e): 2222-6737
ISSN(p): 2305-2147
DOI: 10.18488/journal.aefr.2019.910.1124.1135
Vol. 9, No. 10, 1124-1135.

URL: www.aessweb.com

MILITARY SPENDING AND THE SINO-US ARMS RACE: AN ANALYSIS USING BOOTSTRAP ARDL

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Article History
Received: 21 June 2019
Revised: 3 July 2019
Accepted: 9 September 2019
Published: 28 October 2019

Keywords
China military spending
US military spending
Cina gross debt
US gross debt
Cina interest rate
US interest rate.

JEL Classification:
E31; H56; E51; E62.

ABSTRACT

This paper used the newest bootstrap ARDL model to explore a Sino-US arms race and the correlation between military spending and gross debt between China and the United States covering the period from 1995 to 2016. The results showed that military spending positively affected gross debt, while gross debt negatively affected military spending in China and the United States. Furthermore, from the Chinese point of view, when China's economy was prospering, a Sino-US arms race took place by separately using interest rates and gross debt of China and the US as control variables to explore the Sino-US arms race. If logically speaking, there had been a Chinese economic recession, military spending would have been crowded out, and the Sino-US arms race may not have happened. From the perspective of the US, the US is threatened by China's rapid economic growth which triggers the United States to initiate a Sino-US arms competition.

Contribution/ Originality: This study contributes to the existing literature by using the newest bootstrap ARDL model to explore a Sino-US arms race and the correlation between military spending and gross debt between China and the United States covering the period from 1995 to 2016.

1. INTRODUCTION

Since the collapse of Lehman Brothers in 2008, creating more government debt around the world has stimulated the economy, particularly in developed markets in the United States and emerging market leader China, whose government immediately pumped 4 trillion Yuan into the domestic financial market. In the ensuing decade, US debt rose around 60%, while China's debt rose roughly 80%. However, with the economic recovery, rising inflation, and the accompanying rate hikes, these will increase debt service costs and squeeze out other spending, such as military spending increase in the two nations. The trade war between China and the United States has also heated up in recent years. In this paper, we explore how government debt and the Sino-US arms race are related.

There is no consensus among the experts on whether military spending affects debt, but scholars who agree that it does have an impact are in a majority (Brzoska, 1983; Dunne *et al.*, 2004a; Narayan and Smyth, 2008; Shahbaz *et al.*, 2011; Zhang *et al.*, 2016). Some scholars deny that military spending affects debt (Sezgin, 2004) or believe it has no impact (Gülay and Sezgin, 2002; Feridun, 2005). Considering that six financial crises in the 1990s were caused by excessive debt, whether the Sino-US debt has an impact on the Sino-US arms race under debt escalation is a topic worthy of exploration. In addition, no study has used the latest bootstrap ARDL model, proposed in 2016, to explore the causal relationship between the gross debt of China and the United States and their military expenditures, while introducing the interest rate as a control variable to explore the impact of interest rates and debt on the arms race between the two countries.

The literature observes that an increase in defense spending will squeeze out other government consumption and capital expenditures, affecting economic growth. Many scholars have explored this issue (Chester, 1978; Deger and Smith, 1983; Dunne and Vougas, 1999; Karagol, 2005). Although studies have explored the effect of interest on military spending (Calleo, 1981; Chowdhury, 1991; Fordham, 2003) no studies have examined the effect of interest on the arms race between the two countries using their interest rates as a control variable. US monetary policy has spillover effects (Wongswan, 2005; Bauer and Neely, 2013) and China is the largest creditor of the United States. The impact of the interest rates of the two countries on their arms race is one of the matters discussed in this paper.

This article focuses on the relationship between the military spending of China and the US, two powerful countries under debt, a topic on which previous empirical studies are almost non-existent. Second, this article uses the new methodology Bootstrap ARDL test. Most importantly, this article extends the studies by looking at the Sino-US arms competition

The remainder of this study is organized as follows. Section two consists of a brief literature review. Section three describes the methodology. Section four provides the research data and definitions, while Section five presents the empirical results and main discussions. Section six offers conclusions and policy implications.

2. LITERATURE REVIEW

Defense spending may affect government debt in two ways. First, it may increase the need for government borrowing, forcing the government to raise funds domestically or abroad (Narayan and Narayan, 2008). If defense spending cannot be raised due to insufficient domestic financing, money must be borrowed from other countries, resulting in the accumulation of foreign debt (Gülay and Sezgin, 2002).

Second, in some countries, weapons are imported. However, because of the lack of foreign currency, these countries are forced to borrow money abroad, leading to the accumulation of foreign debt (Dunne *et al.*, 2004a). The influence of military spending on foreign debt is different for developing countries and developed countries, because cointegration may occur in developing countries (Fiji and Ethiopia).

Brzoska (1983) observed that the weapons spending of developing countries in 1979 accounted for 20% to 30% of their total foreign debts. He also stressed defense spending as an important part of foreign debt in developing countries. Looney (1989) used a two-stage least squares regression and found that weapons imports were an important factor in foreign debt in third world countries.

Dunne *et al.* (2004a) showed that the military burden (the ratio of defense spending to GDP) positively affected the ratio of foreign debt to GDP. Dunne *et al.* (2004b) used the ARDL model to simulate foreign debt in Argentina, Brazil, and Chile during 1970-2000 as a function of defense spending, GDP, exports, foreign exchange reserves, and the six-month Libor. They found that defense spending had a positive influence on Chile's foreign debt. Narayan and Smyth (2007) studied the relations between defense spending, income, and foreign debt in six Middle East countries (Oman, Syria, Yemen, Bahrain, Iran, Jordan) between 1988 and 2002, finding that increases in defense spending led to rises in foreign debt, and increasing income contributed to repayment of foreign debts by the Middle East countries. Abbas and Wizarat (2018) investigated the impact of military spending on foreign debt in South Asian countries (Pakistan, Bangladesh, India, Nepal, and Sri Lanka) from 1990 to 2015. The results showed that the foreign debt of some South Asian countries was driven by their military spending and had a negative impact on domestic investment activities.

Researchers have paid little attention to the impact of interest rates on military spending and debt. However, central banks in both developed and developing countries target inflation, and respond with interest rate changes, in addition to targeting CPI inflation and domestic reaction output gaps (Caputo and Herrera, 2017). Therefore, both inflation and deflation will be reflected in the central bank's interest rate policy.

Several current studies explore the impact of inflation on defense spending. Deger and Smith (1983) argued that defense spending not only caused inflation, but further inhibited economic growth. This was because inflation led to "forced savings" and higher profits, which further led to higher investment. Chowdhury (1991) performed a Granger Causality Test to investigate the relationship between defense spending and the economy in 55 developing countries, finding that defense spending led to inflation and inhibited economic growth. According to Heo (2009) when the government printed more money to pay for defense spending, inflationary conditions were created.

There are also scholars who contend that war drives inflation, such as Fordham (2003) who explored the correlation between military expenditures, non-military government expenditures, and GDP in the United States from 1941 to 2001, finding that inflation clearly rose during the Second World War, the Korean War, and the Vietnam War, and the inflation rate caused by the military spending was significantly higher than the inflation rate caused by non-military government expenditures. In addition, inflation also has a considerable impact on defense spending, and the negative/positive impact of inflation on the economy is also different. As inflation is specifically manifested in interest rates, loose/tight monetary policies in the US have an impact on defense spending for arms races. The above literature shows that inflation is positively correlated with military spending.

Arms races have traditionally been an important part of the national defense economy, for both external and internal reasons. Internally, investment in defense can be continuously enhanced without having an impact on other defense economic factors.

Externally, the emergence of external threats can lead to arms races (Glaser, 2000). Therefore, external factors are an important driver of arms races. For example, Kollias and Paleologou (2002) found a bidirectional causal relationship in the defense expenditures between Greece and Turkey from 1950 to 1999. Thus, there was an arms race between the two countries. However, Dimitrios *et al.* (2016) have different views on military spending and debt in Turkey and Greece.

Yakovlev (2007) estimated the military expenditures of China, South Korea, Japan, and the United States using a demand function theoretical model and the nonlinear system model. The results stated that the US and Japan enhanced their military capabilities against China. Kagan *et al.* (2005) believed that the great powers relied on the development and acquisition of sophisticated weapons to fight against weak countries, which in turn may become financially independent due to the acquisition of weapons and pay at cost of market closure. Higher military budgets may thus lead to higher demand for weapons, with economic and political risks. The foregoing discussion demonstrates that arms races are strongly correlated with defense spending.

3. METHODOLOGY

Most empirical studies used panel analysis to test the cointegration and causality between military spending and GDP or normal debt (Lobont *et al.*, 2019). For example, cointegration and error correction have been used to explore this relationship. Pedroni (2004) performed a vertical and horizontal data cointegration test, and identified a long-term relationship between defense spending, income, and external debt. By estimating long-run elasticity, he found that higher defense spending led to higher external debt, and increasing income contributed to repayment of foreign debts by Middle Eastern countries.

Karagol (2005) studied the relationship between defense spending and foreign debt in Turkey from 1955 to 2000 through cointegration and a vector error correction model, finding a positive correlation between the two. Defense spending had a short and long term causal relationship with foreign debts. Narayan and Narayan (2008) found by cointegration check on data from Fiji that foreign debt and domestic debt had long term relationships with income and defense spending. They showed that in the long term, defense spending significantly and positively affected domestic debt and foreign debt. In the short term, the impact of defense spending on debt was not significant. Yemane (2009) explored the impact of Ethiopia's defense spending and income on foreign debts during 1970-2005, and detected a long term positive causal relationship between foreign debt, defense spending, and income. Zhao *et al.* (2017) used cointegration and a VECM model to examine the relationship between defense expenditure, public expenditure, and economic growth in China from 1952 to 2012. Their results revealed the long-term equilibrium relationship between defense expenditure and public expenditure in China and also showed that the impact of defense expenditure on economic growth was negatively monocausal.

However, because of the properties of small samples, the bootstrap method can overcome the small sample size problem. McNown *et al.* (2018) developed a bootstrap methodology based on the Bootstrap ARDL test proposed by Pesaran *et al.* (2001) to allow endogeneity and feedback. The Bootstrap ARDL test can powerfully test short and long term relationships and Granger causality between military spending and normal debt, and, at the same time, incorporate additional control variables for comparison with previous variables for a specific country.

In this paper, a Bootstrap ARDL test was used to explore the relation between military spending and debt in China and the United States. We also further explored whether there will be a future arms race between China and the United States.

To avoid the effects of heteroscedasticity, we used the logarithmic form of the series. Next, following McNown *et al.* (2018) we built the basic equation between military spending and gross debt as:

$$\mathrm{LME} = \alpha + \beta \mathrm{LND} + \epsilon \qquad (1)$$

Where LME and LND in (1) represent military spending and gross debt, respectively, and ε_t is the error term. To further implement the ARDL bounds test, we ensured that the integration orders of the series used did not exceed one, to fit the assumptions of the bounds test. The ARDL bounds test may then be extended as,

$$\Delta ME_t = \alpha + \beta_1 ME_t + \beta_2 ND_t + \sum_{i=1}^{p} \delta_{1,i} ME_{t-1} + \sum_{i=1}^{p} \delta_{2,i} ND_{t-1} \sum_{j=1}^{q} \varphi_j D_{t,j} + \varepsilon_t \qquad (2)$$

$$\Delta ND_t = \gamma + \theta_1 ME_t + \theta_2 ND_t + \sum_{i=1}^{p} \delta_{1,i} ME_{t-1} + \sum_{i=1}^{p} \delta_{2,i} ND_{t-i} + \sum_{k=1}^{q} \gamma_j D_{t,k} + \varepsilon_t \qquad (3)$$

Obviously, Equations 2 and 3 are unrestricted forms of the ECM model. We also included the dummy variables $D_{t,j}$ and $D_{t,\kappa}$ to deal with structural breaks. To determine the structural breaks, the multiple breakpoint test proposed by Bai and Perron (2003) was employed to find the specific break date. We set the maximum breaks to five. To avoid over-parameterization, we set the lag p to 3, which is adequate for annual data. In order to obtain the long term relation between military spending and gross debt, we made use of the overall F test and t-test, lagged on both the independent and dependent variables. Because of the small sample properties of the data, we used the bootstrap method to enhance the accuracy of the results.[1] The bootstrap method can estimate the restricted residuals for Equation 2 and 3. We then re-scaled and re-centered the residuals by the formula: $\ddot{\varepsilon}_t = \hat{\varepsilon}_t - \frac{1}{(n-p-1)} \sum \hat{\varepsilon}_t$, observation y_t^* and x_t^*. Finally, we estimated the ARDL model and calculated the bootstrap F statistics and t statistics. We next contrasted the bootstrap distribution and determined the critical values from the empirical distribution.

[1] For detailed information about the bootstrap procedure, please refer to McNown, Sam and Goh, (2018).

We could also test the causality between these two variables with the null hypothesis based on the two Equations 2 and 3 respectively.

H_0: $\delta_{2,i}$ =0 for Equation 2 and H_0: $\phi_{1,i}$ =0 for Equation 3

Under the null hypothesis H_0: $\delta_{2,i}$ =0 indicates that LME does not cause LND and H_0: $\phi_{1,i}$ =0 indicates that LME does not cause LND. Here we made use of the Wald test to restrict the coefficients.

We can extend the Equation 1 to a 3-variable case, as in the following model:

$$\Delta y_t = \emptyset y_{t-1} + \gamma x_{t-1} + \varphi z_{t-1} + \sum_{i=1}^{p-1} \lambda_i \Delta y_{t-i} + \sum_{j=1}^{q-1} \delta_j \Delta x_{t-j} + \sum_{k=1}^{r-1} \pi_k z_{t-k} + \sum_{l=1}^{s} \omega_l D_{t,l} + \varepsilon_t \quad (4)$$

In Equation 4, the Granger causality test for x →y should include the lagged differences on x and the lagged level of x: it should test whether γ>0 and δ= 0. For z → y it should include the lagged differences on z and the lagged level of z, and test whether φ>0 and π=0 (under cointegration) in the short term.

The use of all three tests was necessary to distinguish between cases of cointegration, non-cointegration, and degenerate cases as defined by Pesaran *et al.* (2001). Based on McNown *et al.* (2018) we defined the two degenerate cases as follows:

Degenerate case #1occurred when the F-test and the t-test on the lagged independent variable were significant, but the t-test on the lagged dependent variable was not significant.

Degenerate case #2 occurred when the F-test and the t-test on the lagged dependent were significant, but the lagged independent variables were not significant.

Pesaran *et al.* (2001) presented critical values for case #2, but not for case #1. The integration order for the dependent variable must be I(1). However, unit root tests are notorious for having low power (Perron, 1989). The Bootstrap ARDL test addressed this problem through additional tests on the coefficients of the lagged independent variables. The advantage of the Bootstrap ARDL Test is that the evidence shows that when using the asymptotic critical value of Monte Carlo simulation, the endogeneity problem has little effect on the size and power properties of the ARDL test. If the resampling process is properly applied, the performance of the Bootstrap test is superior to that of the asymptotic test in the ARDL Bounds test based on size and power properties. The Bootstrap procedure has the additional advantage of eliminating the possibility of inconclusive inferences.

Finally, McNown *et al.* (2018) also presented an extension of the ARDL testing for the alternative degenerate case, with critical values generated by the Bootstrap procedure. Therefore, the proposed Bootstrap ARDL test provides better insight into the cointegration status of the series in the model.

4. RESEARCH DATA DEFINITIONS AND SOURCES

In this paper, annual data was used covering the period from 1995 to 2016 for the United States and China. The variables used in this study included the US ten-year-bond rate, the Chinese loan prime rate, military spending, and the gross debt (debt/GDP) of China and US.

The US ten-year-bond rate, denoted US rate herein, is an economic indicator, because it is backed by the guarantee of the US economy. Therefore, higher long-term rates reflect expectations that growth will continue, and vice versa.

The Chinese loan prime rate (LPR) (denoted China rate herein) is defined using a quotation group for the LPR that is composed of ten commercial banks. Panel banks should meet the requirements of financial constraints and macro-prudential policy framework, which has a high systematic importance and a fundamental impact on the market.

Military spending was sourced from the SIPRI for both China and US and was expressed in millions of dollars. Gross Debt prime rates and the US ten-year-bond rate for both China and the US were taken from Datastream.

Table 1 shows the summary statistics for China and the US. The military spending and debt of the US were both greater than China's debt and military spending. The military spending of China showed negative skewness, suggesting that increases come suddenly in large bursts. The dummies in Table 4 for the breakpoints included 1999 and 2007, implying that economic growth in China leads to increased military spending. Kurtosis at 7.6778 in China was obviously larger than for a normal distribution, which indicates that the distribution is a peak distribution.

Table-1. Summary statistics of military spending for China and the US.

	China ND	US_ND	China ME	US_ME	China RATE	US_RATE
Mean	28.94091	74.31876	1.914724	3.654541	6.910455	4.160189
Median	26.40000	64.08931	1.914995	3.622889	6.030000	4.282083
Maximum	44.30000	105.7910	2.185412	4.665615	15.12000	6.580000
Minimum	20.40000	54.61541	1.674801	2.908394	4.750000	1.802500
Std. dev.	7.200110	18.77369	0.141037	0.551848	2.411827	1.529445
Skewness	0.630808	0.633487	-0.056535	0.434031	2.281432	0.004959
Kurtosis	2.243297	1.639897	2.354598	2.182222	7.677887	1.849178
Jarque-Bera	1.983919	3.167176	0.393551	1.303767	39.14382	1.214116

Source: China ND, US_ND, China Rate and US Rate from Data stream, and China ME and US_ME from SIPRI.

Table 2 shows that after performing the ADF, PP, and KPSS tests on the time series, we could not reject the null hypothesis that all the series had a unit root. We found some series were stationary in levels, which suggested that the variables used were all non-stationary in levels, but they became stationary at the first differences for both China and the US Since the Pesaran bounds test allows the modeling of variables with different orders of integration, we proceeded with the estimation of the model for both economies.

Table-2. Univariate unit root tests.

	Level			Level difference		
Conutry	**ADF**	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
China ND	0.8587(1)	0.8344(1)	0.6432(3)**	-6.449(0)***	-6.449(0)***	0.218(1)
MD	-1.954(0)	-1.954(0)	0.1704(3)	-4.5135(0)***	-4.5135(0)***	0.1649(1)
Rate	-6.291(0)***	-6.9958(4)***	0.4353(2)*	-3.7185(0)**	-4.020(7)**	0.366(2)
USA ND	-0.507(1)	0.084(2)	0.5199(3)**	-1.9833(0)	-2.0903(1)	0.3040(2)
MD	-2.8113(1)*	-1.3352(2)	0.2853(3)	-2.3478(1)	-2.066(1)	0.167(2)
Rate	-0.8389(0)	-0.4827(20)	0.646(3)**	-4.7024(0)***	-9.2845(19)***	0.5(20)**

Notes: ***, ** and * indicate the null hypothesis is rejected at the 1%, 5% and 10% levels, respectively. The number in brackets indicates the lag order selected based on Schwarz information criterion. The number in the parenthesis indicates the truncation for the Bartlett Kernel, as suggested by the Newey and West (1987).

We performed the test for cointegration by applying the Bootstrap ARDL test approach for both China and the US, since all variables were integrated at one or zero. The Bootstrap ARDL was selected based on the Schwarz information Criterion (SIC) which was asymptotically consistent for the lag length and was based on a general-to-specific approach and the dropping of all non-significant lags using a 10% decision rule. The F_{pass} statistics of the Bootstrap ARDL approach reported in Table 3 and 4 indicated that a long term cointegrating relationship between military spending and gross debt did not exist in either China or the US.

5. EMPIRICAL RESULTS AND ANALYSIS

First of all, our analysis showed that military spending and debt in both the US and China exhibit bidirectional causality. If military spending increased, debt would also increase (Zhang *et al.*, 2016). but if debt increased, then military spending in both the US and China would decrease (Azam and Feng, 2017) in Table 4 and Figure 1.

Secondly, we also worked on the interaction analysis of the US military spending and debt using the US interest rate as a control variable, and the interactive causality of military spending and debt in both the US did not change as shown in Table 4 and Figure 1. We also put in China's interest rate as a control variable but the result was the same as that for the US.

In sum, our empirical results indicated that both military spending and debt were not affected by the interest rate in the US and China in the short term.

In Table 5 and Figure 2, this paper explored whether there was an arms race between China and the US using the US interest rate, the Chinese interest rate, the US debt and the Chinese debt as control variables respectively.

The results of the linear model indicated that:

(1) The relationship between Sino-US military spending using the US interest rate as a control variable: The US interest rate did not affect Sino-US military spending. However, military spending in both the US and China had a bidirectional positive causal relationship, indicating that an increase in US military spending had a positive influence on China's military spending, and vice versa, showing that an arms race existed between the US and China during the period studied.

(2) When US debt is the control variable for Sino-US military spending, it had a negative correlative causal relationship with Sino-US military spending, while there was a positive causal relationship between US and China military spending, suggesting that an increase in US debt would reduce US military spending, which in turn reduced China's external threats and military spending. Meanwhile, China's military spending had fallen in the wake of rising debt in the US. In sum, whether or not the US interest rate or debt was a control variable, US military spending and the Chinese military spending had a bidirectional positive causal relationship, indicating that there was an arms race between the US and China again for the period under study.

(3) Using China's interest rate as a control variable, we found positive unidirectional causal effects on both US and China's military spending. China's military spending had a positive unidirectional effect on US military spending, yet US military spending had a negative unidirectional effect on China military spending, suggesting that the arms race between the US and China was driven by China's economic situation.

(4) If we took China's debt as a control variable, there was a positive unidirectional causal effect on US military spending from China's debt on US military spending. China's military spending was negatively correlated from China to US military spending, and there was no causal relationship with China's debt, suggesting that US military spending still increased when China's economic situation was unfavorable.

Our empirical results have important policy implications that China's economic growth is affected by the domestic economy, and that with reduced military spending, the United States is threatened by China's rapid economic growth, which triggers the United States to initiate a Sino-US arms competition.

Table-3. Cointegration analysis.

Country	DV |IV	Dummy variable	F^*	F	T*dep	T_{dep}	F^{8}_{indep}	F_{indep}	Result
China	ND|ME	N01 N09 N14	3.5350	3.6234	-2.086	2.5790	2.08800	0.25120	No cointegration
	ND|ME/rate	N01 N09 N14	0.2894	0.2894	0.2894	0.2894	2.9818	0.2894	No cointegration
USA	ND|ME	N09	3.3122	4.3209	-2.2109	0.8930	2.2229	2.7370	No cointegration
	ND|ME/rate	N09	2.5990	3.4866	-1.5000	1.8596	2.7405	4.5472	No cointegration

Country	DV|IV	Dummy variable	F^*	F	T*dep	T_{dep}	F^{8}_{indep}	F_{indep}	Result
China	ME|ND	M99 M07	4.7087	1.9006	-2.6488	-1.8541	-0.0812	-0.2278	No cointegration
	ME|ND/rate	M99 M07	3.7772	4.9890	-2.2628	-1.79158	4.4754	0.8887	No cointegration
USA	ME|ND	M01 M09 M14	5.6792	2.9133	-3.1520	-1.9990	-0.7756	-2.3105	No cointegration
	ME|ND/rate	M01M09 M14	4.4360	2.1417	-2.9150	-2.1671	5.7393	2.7643	No cointegration

Note: is optimal lag order based on Schwarz Bayesian Criterion (SBC). F is the F-statistic for the coefficients of yt−1, x t−1; Tdep denotes the t-statistics for the dependent variable, Findep denotes the F-statistics for the independent variable. F*, Tdep* and Tindep* are the critical values at 10% significance level, generated from the bootstrap program. Dummy variables are to capture any economics shocks. D02 means 1 for year 2012, other years are 0.

Table-4. Granger-causality analysis based on bootstrap ARDL models.

Country		ΔUME equation	ΔUND equation
		F or t statistic (p value)	F or t statistic (p value)
USA	$\Delta\ ume_t$, ume_{t-1}	n/a	3.1936** *(0.006) (+)
	$\Delta\ und_t$, und_{t-1}	29.491*** (0.000)(-)	n/a
	$\Delta\ ume_t$, ume_{t-1}	n/a	4.8613**(0.047)(+)
	$\Delta\ und_t$, und_{t-1}	4.7408*(0.054) (-)	n/a
	$\Delta rate_t$, $rate_{t-1}$	0.4681 (0.568) (-)	0.2186 (0.684(-)
Country		ΔCME equation	ΔCND equation
		F or t statistic (p value)	F or t statistic (p value)
China	$\Delta\ cme_t$, cme_{t-1}	n/a	6.4784***(0.000) (+)
	$\Delta\ cnd_t$, cnd_{t-1}	5.6111**(0.034)(-)	n/a
	$\Delta\ cme_t$, cme_{t-1}	n/a	7.5107**(0.020)(+)
	$\Delta\ cnd_t$, cnd_{t-1}	14.4734***(0.002) (-)	n/a
	$\Delta\ rate_t$, $rate_{t-1}$	0.2821(0.605) (-)	0.0960(0.763)(-)

Note: Values in bold refer to the case of cointegration and the causality test involved both lagged level and lagged differenced variables. Those values not in bold refer to the case of no-cointegration where the causality test involved only lagged differences.

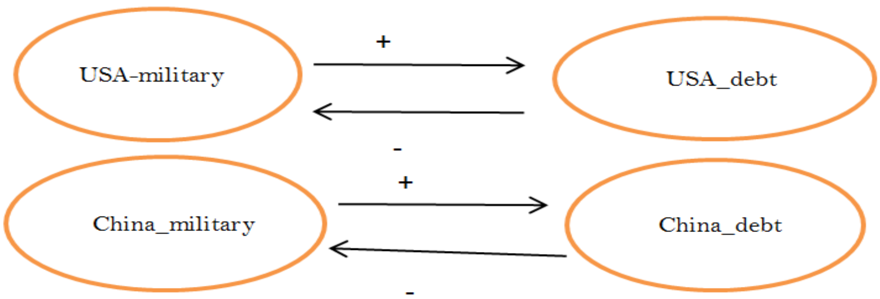

Figure-1. USA_military/ USA_debt and China_military/ China_debt granger-causality relationship.
Source: China debt, USA debt from Data stream, and China military and US military from SIPRI.

Table-5. Granger-causality analysis based on bootstrap ARDL models.

Country		ΔUME equation	ΔCME equation
Contral variable		F or t statistic (p value)	F or t statistic (p value)
USA$_{rate}$	$\Delta\ ume_t$, ume_{t-1}	n/a	3.4845*(0.089) (+)
	$\Delta\ cme_t$, cme_{t-1}	3.7369* (0.088)(+)	n/a
	$\Delta\ rate_t$, $urate_{t-1}$	0.5780(0.589)(+)	0.5888 (0.580) (-)
USA$_{debt}$	$\Delta\ ume_t$, ume_{t-1}	n/a	17.5540***(0.001)(+)
	$\Delta\ cme_t$, cme_{t-1}	3.8605*(0.083) (+)	n/a
	$\Delta\ und_t$, und_{t-1}	5.6765**(0.041)(-)	24.4700*** (0.000)(-)
China$_{rate}$	$\Delta\ ume_t$, ume_{t-1}	n/a	19.6185***(0.001) (-)
	$\Delta\ cme_t$, cme_{t-1}	20.3679***(0.002)(+)	n/a
	Δ $crate_t$, $crate_{t-1}$	68.0739***(0.005)(+)	7.3071**(0.019)(+)
China$_{debt}$	$\Delta\ cme_t$, cme_{t-1}	3.8414*(0.097) (-)	n/a
	$\Delta\ cnd_t$, cnd_{t-1}	17.9642***(0.005)(+)	1.3072(0.329)(+)

Source: USA rate, USA debt, China rate and China debt from data stream.

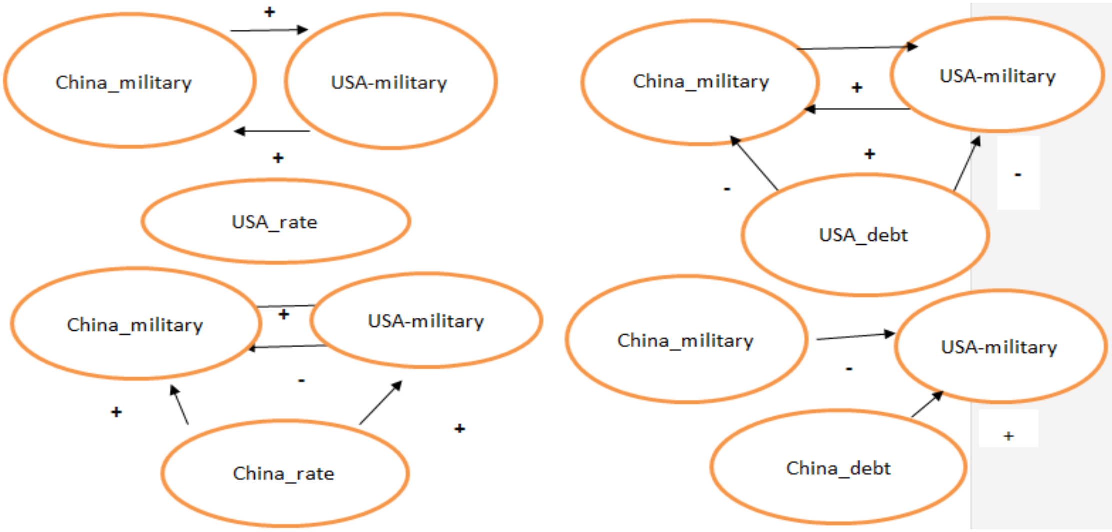

Figure-2. USA military and China military granger-causality relationship.
Source: China debt, US debt, China rate and US rate from Data stream, and China military and US military from SIPRI.

6. CONCLUSION

This study uses a new methodology, the bootstrap ARDL model, to explore three aspects: (i) whether debt affects military spending in China and the United States (ii) whether interest rates have no effect on Chinese or U.S. military spending or debt and (iii) whether the arms race between China and the United States is affected by interest rates and debt. The paper found that as gross debt increases, military spending in both the US and China fell because the gross debt had a negative effect on the military expenditure of the US and China, and the military expenditure in both China and the US had positive effects on the gross debt.

We used the interest rate and the debt of the US and China as control variables to explore the Sino-US arms race. When China's economy was strong, the US may begin an arms race. However, if China's economy was declining, its military spending would be affected. Therefore, this paper's primary contribution was through using new bootstrap ARDL model and finding that the Sino-US arms race existed during the period under study because the US is threatened by China's economic growth, and the US and Chinese military expenditure was affected by gross debt increases.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Contributors/Acknowledgement: Both authors contributed equally to the conception and design of the study.

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