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Military industry bubbles: are they crowding out utility investments?

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ABSTRACT

The rapid growth in defence expenditure in China raises the concern that investments in the defence sector crowd out investments in social sectors, i.e., the 'guns for butter' argument. This article resorts to the bubble testing method to study the trade-off between defence and utilities sectors in the Chinese capital market. Based upon the generalized sup Augmented Dickey-Fuller (GSADF) test, this paper captures and date stampings explosive behaviors in defence and utilities industries using stock indexes. Empirical results reveal bubbles for defence and utilities sectors in similar time periods, thus indicating that the factors driving explosive movements are alike for both sectors. However, bubbles in a certain sector do not necessarily crowd out investments in the other sector. Through testing bubbles in the ratio of stock indexes of two sectors, we find that the explosive episodes vanish. The results indicate that the crowding-out effect between defence and utilities sectors does not exist in the Chinese capital market. Increases in the military expenditure in China are necessary to safeguard the national security because of frequent geopolitical conflicts and terrorism. However, the defence to utilities ratio is increasing rapidly, implying the possibility that excessive growth in military expenditure may generate the 'guns for butter' problem, which can be detrimental to economic growth.

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1. Introduction

According to the estimates of Stockholm International Peace Research Institute (SIPRI), the military expenditure in China increased at 44.07% per year during 1989 to 2018. During 1989 to 2006, the National Bureau of Standards (NBS) of China disclosed that Chinese utilities expenditure increased at an annual growth rate of 18.32%. After reforming the fiscal expenditure accounts in 2007, the utilities expenditure increased at 13.46% per year. Economic growth is the main reason for the rapid expenditure growth in utilities and military sectors. Comparatively,

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military expenditures in China increased faster than utilities expenditures, appears to agreeing with the 'guns for butter' theory which posits that the increased defence expenditure crowds out social spending. As the representation of military industries (Zhang et al., 2020), is the defence sector of the stock market experiencing asset bubbles? More importantly, are military expenditures crowding out social spending? This paper offers empirical evidence from a new perspective based on the capital market.

The military industry is vital to national security and economic sustainable development because of its cutting-edge technology (e.g., Makštutis, 2005; Meidutė-Kavaliauskienė et al., 2020). The Keynesian multiplier effect argues that an exogenous rise in military expenditure stimulates economic growth through improving utilization, employment, and aggregate demand (Shahbaz et al., 2013). By contrast, military expenditures may shift resources away from the private sector, thus crowding out public and private investments (Hartley & Sandler, 1995). Consequently, both theoretical and empirical relationships between military and social expenditures are inconclusive. For example, Yildirim and Sezgin (2002) find a negative trade-off between defence and health expenditures and a positive trade-off between defence and education expenditures. Murshed and Saleh (2013) report findings that military expenditure crowds out health spending, whereas crowds in education spending. Conversely, Kollias and Paleologou (2011) find two pairs of positive trade-off relationships: defence-education expenditures, and defence-social expenditures. Similarly, Lin et al. (2015) find a positive trade-off between military expenditure and two types of social welfare spending including education and health sectors. Resource gaps in military-industrial capacity and human resources may even lead to wars (Johannesson, 2017). Some studies show that the relationship between military expenditure and social expenditure is mixed. For instance, the causal relationship between defence and education expenditures in eight Asian countries is significant; but has no consistency in the direction (Hirnissa et al., 2009). Günlük-Senesen (2002) and Coutts et al. (2019) find no negative trade-off between security expenditure and spending in other sectors.

There are few studies regarding the 'guns for butter' topic in China, whose rising power has been a grave concern to many policymakers around the world. While Wang (2013) finds a unidirectional crowding-out effect of defence spending on social spending during 1952 to 2006, Zhao et al. (2017) report bidirectional interactions between two sectors. Specifically, past defence spending has negative effects on current social spending, and vice versa. Xu et al. (2018) identify a negative causality from education expenditure to defence spending; but find no causality from defence spending to education expenditure. Therefore, the education expenditure is likely to crowd out military expenditure in China rather than the reverse.

Structural changes in the military industry alter the price of defence products (Golde & Tishler, 2004), and the privatization and financialization of the military industry promote its connection with the capital market. Previous studies use the annual defence spending data disclosed by the national or international statistical departments, which are frequently contradicted with each other. The stock index can be a useful representative of industry indicators (Chen et al., 2015; King, 1966).

Therefore, this paper resorts to the capital market to measure the 'guns versus butter' problem in China, which is believed to be a country specific topic that should be studied within the single-country framework (Wang, 2013).

This paper contributes to the scant literature on the 'guns versus butter' problem in China from the following aspects. First, we measure the bubbles in the military industry and utilities industry using the generalized sup Augmented Dickey-Fuller (GSADF) test to show the capital market's valuation of these industries. The capital market's data enable one to compare investments in different sectors covering both public and private investors. Second, if the military industry crowds out investments in the social sector, we expect to find explosive behaviors in the military index relative to utilities index, and vice versa. Thereby, we test the explosive behaviors of the ratio of the two to identify the trade-off between military and social sectors. Third, many previous studies adopt Granger causality tests, which have an incremental predictability problem, or use the co-integration analysis which is criticized for the endogeneity problem. Through constructing the indicator of ratios of different sectors, we can eliminate common effects of the same factors on both industries such as the pervasive positive effect of economic growth (Su et al., 2020a; Zhang et al., 2020). The GSADF approach allows for time-varying movements of time series and accounts for the nonlinear structure and break mechanisms. Thus, we can analyze the time-varying trade-off between military and social sectors.

This study proceeds as follows. Section 2 explains the theoretical relationship between defence and utilities sector. Section 3 provides methods in testing bubbles in specific sector and the crowding-out effects between two sectors. Section 4 describes the data. Section 5 summarizes and discusses the empirical results, and Section 6 concludes this study.

2. The history of military and utilities sectors in China

In 1990s, China conducted many revolutions in the public utilities sector, such as cuts in subsidies and pricing based on costs. Disadvantages of traditional business models were strengthened with the growth of utilities, which leads to the privatization of public services. The utilities index and returns are highly policy-related in China.

Similarly, China's listed military companies are mainly state-owned, thus indicating that fiscal policies are effective in driving stock prices. Supports of capital and technical innovation research are necessary in the process of military productions. Thereby, Chinese military enterprises prefer financing by listing on the stock market instead of unlisted equity financing. This is different from military companies in the United States, where the main financing strategy is securitization (Wang & Wang, 2020).

Both military and utilities sectors are featured by large capital demand and long return cycle. The lack of external funding will result in a huge capital shortage and thus hinder the development of military and utilities industries. Consequently, a financing competition between these two sectors is possible if the market capital supply is insufficient.

3. Crowding-out effect

The Feder-Ram model is widely used in investigating the relationship between military expenditure and economic growth (Biswas & Ram, 1986; Feder, 1983) in developing and developed countries because it is constructed from a consistent theory structure (Kennedy et al., 2018; Solow, 1988). The basic two-sector version of the Feder-Ram model considers defence (D) and non-defence (N) institutions of a country, both employing homogeneous labor (L) and capital (C) in generating output. The non-defence production benefits from external effects of the military production.

$$D = D(L_D, C_D) \tag{1}$$

$$N = N(L_N, C_N, D) = D^{\theta} n(L_N, C_N) \tag{2}$$

where D^{θ} measures the external effect of defence production on civilian output. Under the factor endowment constraints in Equation (3), the domestic income is determined by Equation (4) considering output values:

$$L = L_D + l_N, K = K_D + K_N \tag{3}$$

$$Y = D + N = P_D Dr(L_D, C_D) + P_N Nr(L_N, C_N, D) \tag{4}$$

where P_D and P_N are the money prices regarding the real output quantities of defence and non-defence sectors, i.e., Dr and Nr, respectively. Thus, the summation of 'guns' and 'butter' constitutes the output of a country. Allowing the values of the marginal products of both labor and capital to differ in two sectors as follows:

$$\frac{D_L}{N_L} = \frac{D_C}{N_C} = 1 + \mu \tag{5}$$

where μ denotes that the marginal productivities of defence and non-defence sectors are different. Thereby, the two sector Feder-Ram model indicates that the economy produces on the efficient frontier of the production possibility set. In other words, the technical efficiency can be achieved when defence output cannot be raised without giving up non-defence production, and vice versa.

4. Bubble detection and crowding-out effect test methodologies

Most studies resort to the Granger-causality model to test the crowding-out effect (e.g., Xu et al., 2018) which is widely used in many other areas to test the linkage between two variables, e.g., Su et al. (2020a, 2020b, 2020c) and Su et al. (2021a, 2021b). To measure the crowding-out effect of the military sector on social sectors, we use the stock index which measures the investment on certain industry. According to Equation (5), allowing for time-varying comparative marginal productivities for defence and social sectors, i.e., μ_t, we expect the ratio of capital investments on two sectors to follow a random walk process. In other words, we propose

the following model to capture the crowding-out effect between defence and social sectors:

$$\frac{SI_{D,t}}{SI_{N,t}} = 1 + \mu_t + \varepsilon_t \tag{6}$$

where $SI_{D,t}$ and $SI_{N,t}$ are stock indexes at time t for defence and non-defnce sectors, ε_t is a white noise residual. If $\varepsilon_t \neq 0$, the investments on defence and non-defence sectors are not driven by the comparative productivity, i.e., there is a crowding-out effect between two sectors.

Also, we analyze the movements of defence and non-defence investments through testing whether there are bubbles in corresponding stock indexes. Following Homm and Breitung (2012) and Chang and Gupta (2014), the stock index for a certain industry can be written as

$$SI_t = F_t + B_t \tag{7}$$

where F_t represents the fundamental value of the stocks that comprises the index, and B_t denotes a 'rational bubble'. If $B_t \neq 0$, the stock index in time t is not entirely driven by fundamentals, i.e., there is a bubble in the stock index.

To test the bubbles in defence and non-defence sectors and the crowding-out effect between them, we need to test whether $\varepsilon_t \neq 0$ or $B_t \neq 0$. If $\varepsilon_t > 0$, we tend to believe that the defence sector crowds out investments in non-defence sectors. If $B_t > 0$, the stock index of an industry tends to show explosive behaviors. We resort to the right-sided unit root test of Phillips and Yu (2011) which considers the following autoregressive specification by recursive least squares:

$$x_t = \omega + \delta x_{t-1} + \sum\nolimits_{i=1}^{p} \varphi_i \Delta x_{t-i} + \epsilon_t \tag{8}$$

where x_t is the stock indexes of defence or non-defence sectors, or the ratio of them, i.e., $x_t \in \{SI_{D,t},\ SI_{N,t},\ \frac{SI_{D,t}}{SI_{N,t}},\ \frac{SI_{N,t}}{SI_{D,t}}\}$, ω is a constant, p denotes the lag length, and ϵ_t is an error term following independent and normal distributions. The null hypothesis is $H_0:\ \delta = 1$, and the alternative hypothesis is $H_1:\ \delta > 1$ with $\delta = 1 + c/k_n$, where $c > 0$, $k_n \to \infty$, and $k_n/n \to 0$ (Phillips & Yu, 2011). This set allows for mildly explosive bubbles of x_t. Concerning periodically collapsing bubbles instead of one-off exploding speculative bubbles, the supremum of recursively determined Augmented DF (SADF) t-statistic identifies the time period of bubbles. First, estimate Equation (8) for the initial sample which contains $[ns_0]$ observations, where s_0 is the fraction of the entire sample, and $[\cdot]$ denotes the integer part of the argument. Then, extend the initial sample by adding new observations, and re-estimate Equation (8). The ADF t-statistic for the sample size $[ns]$, where $s_0 \leq s \leq 1$, and the SADF statistic are:

$$ADF_s \Rightarrow \frac{\int_0^s BdB}{\left(\int_0^s B^2\right)^{1/2}} \tag{9}$$

$$SADF_s \Longrightarrow \sup_{s\in[s_0,\,1]} \frac{\int_0^s BdB}{\left(\int_0^s B^2\right)^{1/2}} \tag{10}$$

where B denotes the standard Brownian motion.

The SADF fixes the starting point to the first observation of the whole sample. If there are multiple bubbles, the second bubble may be dominated by the first one, thus ignoring the second bubble. Phillips et al. (2015) extend the SADF test to the generalized SADF (GSADF) test which allows the starting sample window to change:

$$GSADF = \sup_{s_w\in[s_0,\,s_1]} \left\{ \sup_{s_1\in[0,\,1-s_w]} ADF_{s_1}^{s_w} \right\} \tag{11}$$

where s_1 fraction of the whole sample becomes the starting point of the test, and s_w denotes the flexible sample window. For Equation (8), the SADF and GSADF statistics converge to the standard normal distribution, and the asymptotic critical values can be determined using Monte-Carlo simulations. The SADF and GSADF approaches have been successfully used to detect bubbles in many financial assets, e.g., exchange rates, stocks, and golds (Zhao et al., 2015).

5. Data

To eliminate the effect of extreme data, we use the five-day average closing prices of stock indexes to test multiple bubbles of defence sector and utilities sector. We measure the bubbles of the ratio of defence sector index to utilities sector index to test whether the defence sector crowds out the utilities sector. Similarly, the measurement of bubbles of the ratio of utilities sector to defence sector can analyze the crowding-out effect of the former to the latter. We consider four different stock indexes regarding the defence sector to improve the robustness of empirical results, including the Defense Index (1 July 2011 to 26 March 2020), Defense Security Index (20 August 2015 to 26 March 2020), and Aviation Industry of China (AVIC) Aerospace & Defence Index (30 August 2011 to 26 March 2020) from the China Securities Index Co., Ltd. (CSI), and the CNI Aerospace & Defense Index (4 November 2009 to 26 March 2020) from Shenzhen Securities Information Co. LTD. For the social sector, we adopt the Utilities Index (4 November 2009 to 26 March 2020) from Shanghai Stock Exchange (SSE), which reflects the prosperity of utilities sector. The sample periods for defence indices cover all available data from the Wind database, and the SSE Utilities Index covers the longest period of the defence sector indices. Table 1 reports the summary statistics of selected indexes.

The mean and median prices vary across four defence indexes because they cover different defence companies. The CNI Aerospace & Defense Index reflects the trend of stock price changes of 50 military industries related to aerospace in Shanghai and Shenzhen stock markets. The CSI AVIC Aerospace & Defence Index covers 51 representative companies that are affiliated to ten military industrial groups in China or with the main business involving military products and services. The CSI Defense Security Index is based on 31 December 2008 which covers 121 listed companies. It selects companies related to national defense and information security as samples.

Table 1. Summary statistics of defence sector and utilities sector indexes.

	CNI Aerospace & Defense Index	CSI AVIC Aerospace & Defence Index	CSI Defense Index	CSI Defense Security Index	SSE Utilities Index
Stocks	50	51	29	121	127
Mean	5861.75	1135.74	5373.41	1240.78	1856.35
Median	5461.34	1056.39	5255.41	1136.81	1846.68
Max.	16125.08	3007.89	8307.03	3269.98	5216.23
Mini.	2607.43	500.92	3346.03	507.59	557.28
Std. Dev.	2125.34	419.39	948.10	472.45	724.36
Skewness	1.44	1.26	0.39	1.12	0.55
Kurtosis	6.18	5.31	3.23	4.80	4.48
J-B	1945.27	1016.90	31.75	732.84	560.18
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Obs.	505	416	425	226	791

Note. Stocks denotes the number of stocks covered by the index. Max. and Mini. are the maximum and minimum values of corresponding stock index. J-B is the Jarque-Bera refers to the empirical statistics of the normality test and probabilities in the parentheses; Std. Dev. is the standard deviation; and Obs. denotes the number of observations covered by the sample period.
Source: Authors' calculation.

Three kinds of companies are included. The first one includes listed companies that are affiliated to the ten military industry groups with the main business of military industry. The second one covers listed companies in the field of aviation, aerospace, ships, weapons, military electronics and satellites. The last one includes information security software, security integration, network monitoring, network keys, and information security-related listed companies. Similarly, the CSI Defense Index mainly covers listed companies that are affiliated to the ten military industry groups. The remaining sample stocks of the CSI Defense Index are relevant listed companies that provide weapons and equipment to the national armed forces, or have actual equipment sales or contracts with the Chinese military government. The CSI Defense Index covers 29 companies and is based on 30 June 2011. Overall, the four indices reflect the overall performance of the Chinese defence industry which provides investors with the stock price fluctuations for countercyclical industries. The SSE Utilities Index is based on 30 April 1993 and covers 127 public-utility listed companies related to high-speed railway, telecommunication service, automobile and many other industries. The ranges between maximum and minimum prices are wide, particularly for the CNI Aerospace & Defense Index. The volatility of Utilities Index is also large. Prices for five indexes are positively skewed, in line with the observation that the means are larger than the medians. Jarque-Bera tests show that the five indexes are statistically non-normal.

The top curve in Figure 1 denotes the stock index. Observing the movements of defence sector indexes, we find that they show similar trends, despite of different statistical characteristics as reported in Table 1. In early 2015, the overall Shanghai Stock Index (SSI) increased by 13.22% in March and further increased by 18.51% in April for a lot of bull information. For example, the further deepening of the reform and innovation in China, the policy expectation of emerging industries, coupled with the stimulates of 'One Belt and One Road' and the reform of state-owned enterprises. After that, the Chinese stock market enters a period of dramatic fluctuation until the end of 2015. During early 2016 to late 2018, the Chinese stock market maintains a decreasing trend and shows a recovery in 2019. In line with the overall market, significant sharp increases for both defence and utilities indexes appeared in 2015, indicating possible

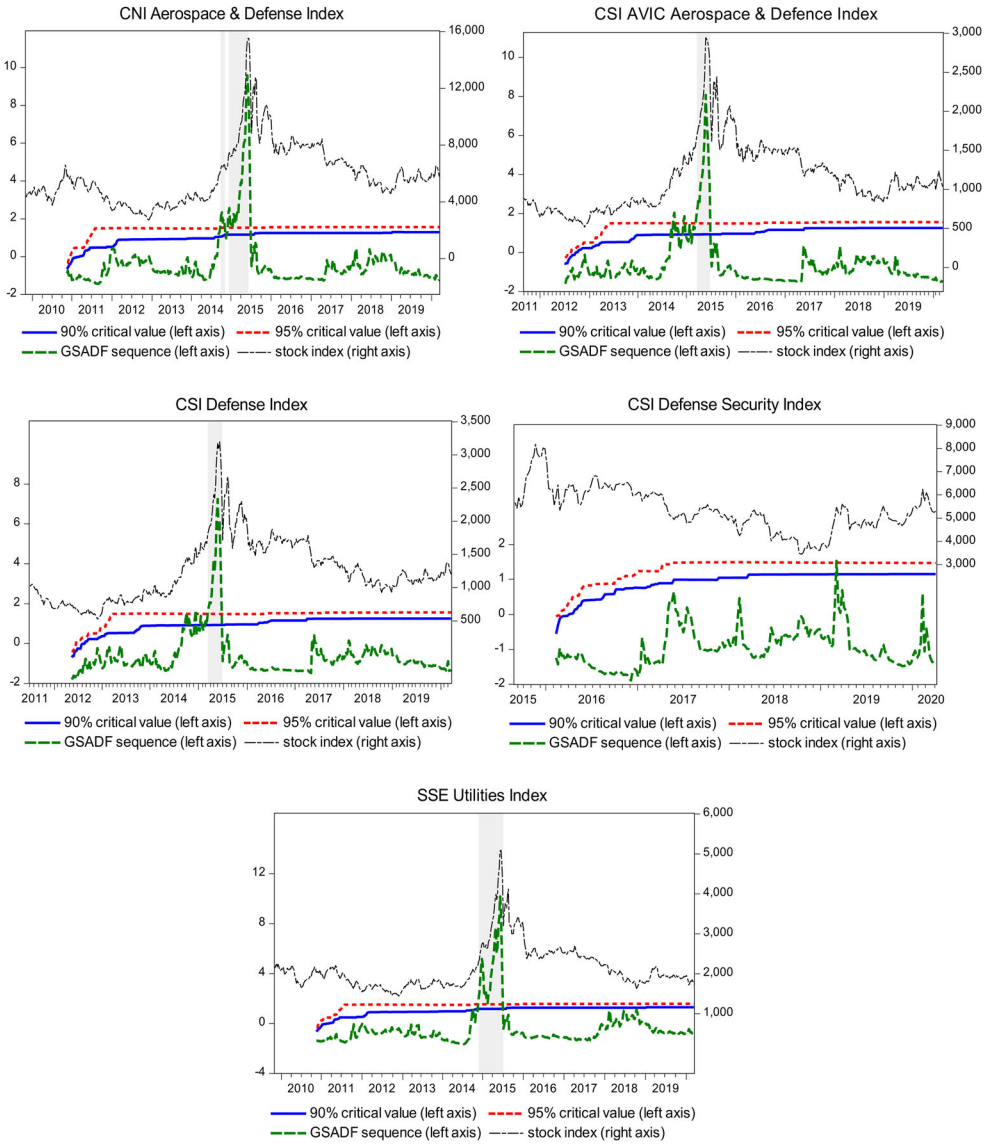

Figure 1. GSADF date-stamping results for stock indexes. Note: The shadows indicate bubble periods.
Source: Authors' calculation.

bubbles during this period. Thereby, the investment boom in the defence sector appears to be more likely induced by the overall market sentiment, thus indicating that the crowding-out effect between defence and utilities sectors may not exist.

6. Empirical tests

6.1. Bubble detection of defence and utilities sectors

To fully use available data, we test multiple bubbles in defence and utilities sectors covering different time periods as shown in Table 1. Based on SADF and GSADF

Table 2. Results of speculative bubbles in defence and utilities sectors in the full-sample period.

			Critical values		
Indexes	Test statistics		90%	95%	99%
Utilities Index	SADF	9.016***	1.110	1.279	1.408
	GSADF	10.144***	1.835	2.052	2.396
CNI Aerospace & Defense Index	SADF	8.514***	0.904	1.191	1.440
	GSADF	9.567***	2.131	2.364	2.632
CSI AVIC Aerospace & Defence Index	SADF	8.057***	1.099	1.229	1.597
	GSADF	8.057***	1.847	2.049	2.570
CSI Defense Index	SADF	7.234***	1.071	1.304	1.580
	GSADF	7.234***	2.055	2.287	2.806
CSI Defense Security Index	SADF	−0.955	1.106	1.291	1.478
	GSADF	1.528	2.136	2.463	3.135

Notes. *** denotes the rejection of the null hypothesis of no bubble at the 99% significance level. The critical values at different significance levels are generated by Monte Carlo simulations with 2,000 replications. We set the smallest window as 10% of the number of observations for each index.
Source: Authors' calculation.

tests (Phillips et al., 2015; Phillips & Yu, 2011), Table 2 summarizes the results with the null hypothesis that no price bubble exists in corresponding entire sample periods. The critical values for SADF and GSADF are generated by Monte Carlo simulations with 2,000 replications.

According to Table 2, the statistics of SADF and GSADF are larger than the right-tail critical values at the 1% significance level for three out of four indexes of the defence sector, meaning that these indexes reject the null hypothesis that no bubble exists in the full-sample period. The exception is the CSI Defense Security Index. Review Figure 1, the bubble is most likely to appear in the year 2015, whereas the data of CSI Defense Security Index starts from 20 August 2015. It is thus easy to conjecture that the bubbles for the defence sector appear before late 2015. For the Utilities Index, the SADF and GSADF tests also exceed corresponding critical values, showing that the utilities sector has significant explosive sub-periods. Hence, both defence and utilities sectors are likely to have multiple bubbles in the full-sample period.

To locate the number of bubbles for defence and utilities sectors and specify corresponding bubble periods, we figure the GSADF statistic sequences in Figure 1 (the bottom curve in each sub-figure). Similarly, critical values at the 95% and 90% confidence intervals are obtained using Monte Carlo simulations with 2,000 replications (the two curves in the middle in each sub-figure). The shaded areas represent the mild explosive episodes at the 95% confidence intervals. We consider mild explosive episodes that last at least 10 trading days.

In line with the full-sample results in Table 1, the date-stamping of bubble testing suggests that bubbles exist in both defence and utilities sectors in the year 2015. Specifically, two bubbles exist for the CNI Aerospace & Defense Index (25 September 2014 – 6 November 2014 and 11 December 2014 – 2 July 2015), and one bubble exists for the CSI Defense Index (19 March 2015 – 30 June 2015) and the CSI AVIC Aerospace & Defence Index (23 March 2015 – 25 June 2015). The results are similar to Zhang et al. (2020), in which bubbles in the CSI national defence industry index appear in the middle of 2015. The 2008 financial crisis severely dampened the Chinese stock market and the real economy. The following global quantitative easing stimulated the Chinese market for several months; but cannot stop the falling trend

of it. During 2009 to 2012, the overall market was trapped in pessimistic sentiments with decreasing investments and fading prosperities in most sectors, including the defence sector. Until the end of 2012, when the 18th national congress of the communist party of China reveals that the security sector is one of the priorities in the next five-year economic development plan, the defence sector began to rebound mildly. In late 2014, with the stimulation of lower interest rates and the 'One Belt and One Road' initiative, investments in Chinese stock markets increased sharply. Some stock plates, including the defence sector, boomed. Nevertheless, the deleveraging in June 2015 resulted in a collapse in most stocks and the defence sector was not spared. Hence, we find concentrated bubbles during March 2015 to June 2015 for different defence indexes.

The utilities sector encounters a long-lasting bubble during 27 November 2014 to 2 July 2015. Similar with the defence sector, the bubble mainly exists in the year 2015. Comparing the movements of defence and utilities sectors, one can find that they have a similar tendency during 2011 to 2018. After that, a divergence in market trends appears between defence sector and utilities sector. Four defence indexes show similar up-trends in the year 2019, whereas the synchronous utilities sector index decreases mildly.

Overall, both sectors witnessed dramatic rises and falls in the year 2015. Explosive behaviors exist in defence and utilities sectors, appear to be driven by the domestic monetary and politic policies and market sentiments. Consequently, investments in two sectors deviate the fundamental values and generate price bubbles. Considering that such explosive behaviors are likely to be driven by the same macroeconomic factors, the crowding-out effect between defence and utilities sectors may not exist in the Chinese market. Nonetheless, we also note a significant divergence between two sectors during 2019–2020, thus triggering the possibility of crowding-out effects in non-bubble periods.

6.2. The crowding-out effect based upon the bubble detection method

The annual growth rate of the CNI Aerospace & Defense Index during 4 November 2009 to 26 March 2020 is 2.99%, whereas the growth rate of the Utilities Index in this period is −1.87%. It appears that the increase of investment in the defence sector is accompanied with decreases in the utilities investment. If the defence sector crowds out investments in the utilities sector, the ratio between indexes of two sectors should not be determined by fundamentals. In other words, the ratio between stock indexes of defence and utilities sectors should display explosive behaviors. By contrast, if the utilities sector crowds out the defence sector, the ratio between the former to the latter should have bubbles. Hence, we apply the GSADF approach to test the ratios between stock indexes of defence and utilities sectors. The sample periods are in line with Table 1. Table 3 reports the testing results under the null hypothesis that no bubble exists in the sample periods. Specifically, Panel A tests the crowding-out effect of the defence sector to the utilities sector, and Panel B tests whether the utilities sector crowds out the defence sector. In line with Table 2, the critical values for SADF

Table 3. Results of the full-sample crowding-out effect between defence and utilities sectors.

Index		Test statistics	Critical values 90%	95%	99%
Panel A: The crowding-out effect of defence sector on utilities sector					
CNI Aerospace & Defense Index/Utilities index	SADF	−0.354	1.110	1.279	1.408
	GSADF	1.414	1.835	2.052	2.396
CSI AVIC Aerospace & Defence Index/Utilities Index	SADF	0.240	1.099	1.229	1.597
	GSADF	0.992	1.847	2.049	2.570
CSI Defense Index/Utilities Index	SADF	0.510	1.071	1.304	1.580
	GSADF	1.227	2.055	2.287	2.806
CSI Defense Security Index/Utilities Index	SADF	−0.369	1.106	1.291	1.478
	GSADF	2.157*	2.136	2.463	3.135
Panel B: The crowding-out effect of utilities sector on defence sector					
Utilities Index/CNI Aerospace & Defense Index	SADF	−0.428	1.100	1.191	1.388
	GSADF	1.122	1.786	2.052	2.387
Utilities Index/CSI AVIC Aerospace & Defence Index	SADF	−0.157	1.083	1.222	1.409
	GSADF	1.020	1.838	2.048	2.570
Utilities Index/CSI Defense Index	SADF	−0.116	1.112	1.274	1.411
	GSADF	2.095**	1.838	2.049	2.436
Utilities Index/CSI Defense Security Index	SADF	−1.006	1.123	1.272	1.425
	GSADF	1.373	2.136	2.457	3.135

Notes. ** and * denote the rejection of the null hypothesis of no bubble at the 95% and 90% significance levels. The critical values at different significance levels are generated by Monte Carlo simulations with 2,000 replications. We set the smallest window as 10% of the number of observations for each index.
Source: Authors' calculation.

and GSDF at various confidence intervals are generated by Monte Carlo simulations with 2,000 replications.

Unsurprisingly, the full-sample results indicate no pervasive evidence supporting the 'guns for butter' argument. For three out of four indexes of the defence sector, results of SADF and GSADF cannot reject the null hypothesis, meaning that no bubble exists in the ratio of defence index to utilities index. The only exception is the CSI Defense Security Index, the GSADF statistic exceeds the critical value at the 90% confidence interval. Thus, the CSI Defense Security Index may crowd out the utilities index at certain periods. For the crowding-out effect of utilities sector on defence sector, only the GSADF statistic for the CSI Defense Index exceeds the critical value at the 95% confidence interval, meaning that there are bubbles for the ratio of Utilities Index to the CSI Defense Index. For the other three indexes, no evidence shows crowding-out effect of utilities sector on defence sector.

Similarly, we figure the GSADF statistic sequences with critical values in Figures 2 and 3 to locate the number of bubbles for the ratio between defence and utilities sectors and specific bubble periods. In both figures, the top curve is the ratio sequence, the middle two curves are critical values at the 95% and 90% confidence intervals, and the bottom curve denotes the GSADF sequence. The shaded areas represent the mild explosive episodes at the 90% confidence intervals. In line with Figure 1, mild explosive episodes that last at least 10 trading days are considered.

According to Figure 2, the ratios of defence sector indices to Utilities Index generally follow the same trend, increasing during 2012 to 2014 (except that the CSI Defence Security Index has no data), maintaining fluctuating during 2015 to 2018, and increasing during 2019 to 2020. The data-stamping of bubble testing is

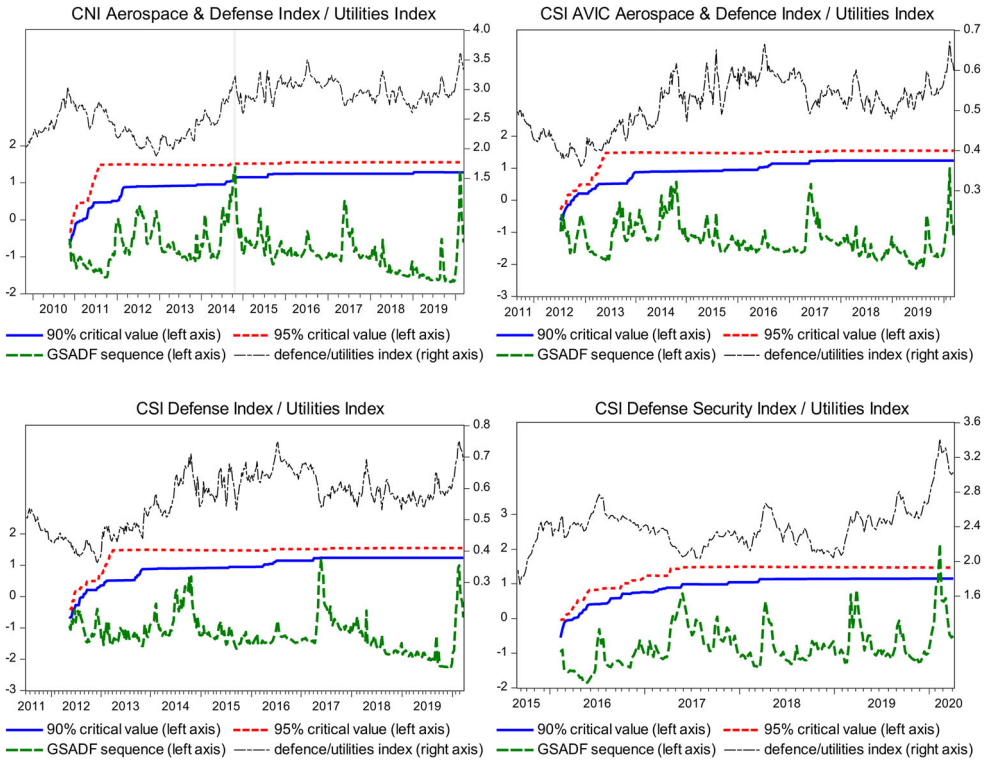

Figure 2. The crowding-out effect of defence sector on utilities sector.
Source: Authors' calculation.

moderately different from Table 2. One bubble that lasts more than 10 trading days exists in the ratio of CNI Aerospace & Defense Index to Utilities Index during 16 October 2014 to 30 October 2014. For other indexes of the defence sector, no bubble exists. For the CSI Defense Security Index, the GSADF statistic exceeds the critical value at the 90% confidence level at the time point of 21 February 2020; but lasts only 5 trading days. The bubble for the ratio of CNI Aerospace & Defense Index to Utilities Index shows that the defence sector crowds out the investment on the utilities sector. However, such effect is short-lasting and not pervasive. By contrast, we find that on 21 February 2020, where the GSADF statistic of the ratio of CSI Defense Security Index to utilities index exceeds the critical values at the 90% and 95% confidence intervals, the GSADF statistics of the other three defence sector indexes also approach to the critical values. Such finding is in line with the observation of Figure 1 that the defence sector indexes have an upward trend, whereas the utilities index shows a downward trend.

Considering the crowding-out effect of the utilities sector on the defence sector, Figure 3 identifies with Table 2. The only bubble appears during 12 May 2017 to 26 May 2017 for the ratio of utility index to CSI Defense Index. While no bubble exists for the other three ratios, the GSADF statistics of them are close to the critical values at the 90% confidence intervals. Hence, the crowding-out effect of the utilities sector on the defence sector is likely to exist during 12 May 2017 to 26 May 2017.

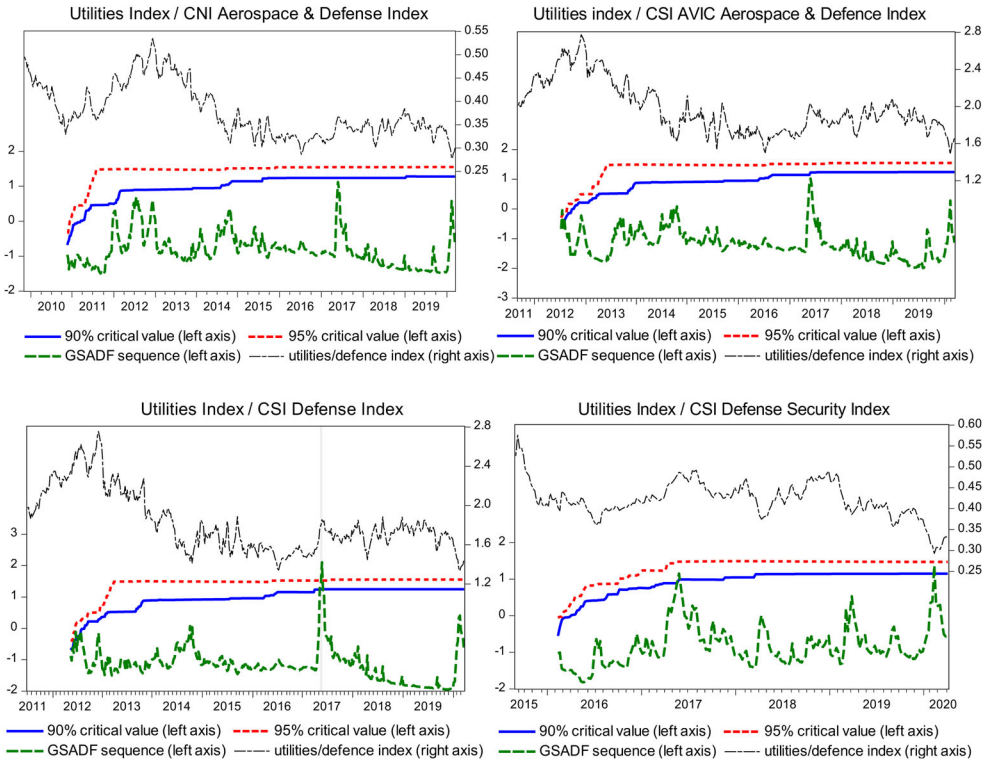

Figure 3. The crowding-out effect of utilities sector on defence sector.
Source: Authors' calculation.

6.3. Discussions

By comparing the explosive behaviors in defence and utilities sectors, we find that the bubbles of two sectors locate in similar periods, indicating that the underlying factors that contribute to the bubbles in the defence sector also works in the utilities sector. We account for the same driving factors behind the movements of defence and utilities stock indexes through calculating the ratios of stock indexes of two sectors. The GSADF testing suggests that the numbers and periods of bubbles for the ratios of two sectors are different from individual indexes. In the year 2015, when bubbles pervasively exist in individual sectors, no explosive behavior in the ratios of two sectors appears. Thereby, the blooming in two sectors is likely to be stimulated by the boom in the overall capital market, rather than by crowding-out investments in the other sector. The results are robust to four defence sector indices. One the one hand, these four defence sector indices which cover different constituent stocks show similar bubble movements, thus indicating that all of them are representative enough. On the other hand, these four defence sector indices cover different time periods. Hence, the consistent performances of four indices suggest that changes in time periods have no essential effect on the results. For example, for the results during 2016–2020, covering the 2011 European sovereign debt crisis or not leaves no significant difference to the CSI Defense Security Index and CSI Defense Index which have similar constituent stocks.

Since the programme of military modernization in the 1970s, China makes many reforms in the defence sector, which has restructured corresponding investments. For example, the civilianization of military products and restructuring of the defence industry since 2005 and the reform of defence scientific research institutions in 2014, etc. Consequently, the investment in Chinese military industry maintains increasing with the annual growth rate of 44.07% according to the estimation of the SIPRI. The six large-scale disarmaments in the past 40 years did not slow down the rise in military expenditures, thus raising the concern of 'guns for butter' problem which may hinder the economy. However, further analyze the estimation of SIPRI, one can find that the military expenditure as a share of GDP in China maintained in the range of 1.8%–1.9% during 2010 to 2018. In other words, China is expanding the defence spending at a pace mirroring the economic growth. The military expenditure as a share of government spending even decreased from 7.64% in 2010 to 5.5% in 2018. Consequently, it is not surprising to find bubbles in individual sectors when no crowding-out effect exists between defence and utilities sectors.

In line with the finding of Xu et al. (2018), in which the casualties between defence expenditure and education spending in China are measured, the public spending appears not to be diverted from social programs to military purposes. Thus, the 'guns for butter' cannot explain the relationship between investments in defence and utilities sectors in current China. The increase in military expenditure is not at the expense of social welfare. Chinese army owns more than 50 educational institutions and 100 hospitals. These utilities institutions are unlisted, but they strength capital attractions to such organizations when massive public investments are injected into the defence sector. Particularly, in recent years, the optimization of military expenditure structure in China concentrates on the mechanization and informatization construction, which has significant spill-over effects in other sectors, including the utilities sector. China is the world's second-largest country in defence spending (Furuoka et al., 2016; Robertson & Sin, 2017). However, the overall asset securitization rate of the military industrial is low compared with developed economies. With the acceleration of the securitization, the relationship between investments in defence and utilities sectors in the capital market may change.

Territorial conflicts and other security challenges are rising for China, requiring the use of military power. Considering that the crowding-out effect of defence sector to utilities sector is not a threat to current Chinese market, maintaining a proper increase in military expenditure will not hinder social welfare. Nevertheless, the high GSADF statistic of the ratio of defene sector to utilities sector in the early 2020 indicates the possibility of bubbles. Hence, excessive growth in investments in the military industry crowds out investments in the utilities sector is still possible as indicated in Figure 2.

7. Conclusion

This paper analyzes the explosive behaviors in defence and utilities sectors and the crowding-out effect between two sectors concerning investments in the capital market. Based on the GSADF approach which captures multiple bubbles of underlying

financial series, we detect bubbles in both defence and utilities sectors in the year 2015. These bubbles are generally long-lasting. However, after accounting for the same factors affecting stock indexes of both sectors by calculating the ratios between them, we find that the mild explosive episodes disappear. One short-lasting bubble exists for the ratio of defence sector to utilities sector in October 2014, and one short-lasting bubbles appears for the ratio of utilities sector to defence sector in May 2017. Thus, the crowding-out effect between two sectors is unconvincing. The 'guns for butter' argument thus cannot explain the relationship between defence sector and utilities sector from the perspective of capital market. The explosive behaviors in investments in the defence sector is likely to be stimulated by the economic growth, in line with the finding in the literature (Zhang et al., 2020).

China is conducting a great reform in the military industry which concentrates on the optimization of military expenditure and modernization of the army. The empirical results in this paper implicate that reasonable increases in military expenditures will not hinder social welfare for now. By contrast, the spill-over effect of advanced military technology may benefit the economic growth. Nonetheless, the increases in the ratio of stock indexes of defence sector to utilities sector also trigger the concern that excessive investments in defence sector may crowd out investments in utilities sectors.

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