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The Co-movements Analysis of Military Expenditure Based on Complex Network Approach

Yingli Wang¹, Muzhi Li¹, Wei Feng¹, Jinjun Liu¹, Yong Guan^{1*}

1. Consulting Center for Strategic Assessment, Academy of Military Science, Beijing 100091

*Corresponding author: 18910813063@189.cn

Abstract

In the paper, we develop co-movement network of international military expenditure with the empirical mode decomposition method and Granger causality test. The results demonstrate that the most influential nations on different time scales are similar despite that the short-term components are disturbed. As the time scale increases, the pattern tends to be more clarified that the nations with developed economy or powerful military force, e.g., UK and USA are the most influential countries in co-movement of military expenditure. our paper provides a novel network approach to study the co-movement military expenditure path among nations from short- and long-term time-scale, where affectees and influencers are distinctive.

Fig. 1 shows (1) As the time scale increases, overall centrality of each node increases as well. (2) For a specific node, larger the out-degree, smaller the out-degree, that is, if a nation has a strong effect upon others, and it would show a low probability to be influenced by other nations. (3) From the perspective of out-degree, nations with strong military power, such as USA and UK, have strong effect upon others, regardless of short or long-time scales.

Data and Methodology

In our paper, we collect the yearly military expenditure from SIPRI dataset. We have 44 nations left. Due to the lack of military expense from 1949 to 1955, China is not included in these 44 nations.

The key feature of EMD is to decompose a signal into intrinsic mode functions (IMF) of different frequencies, from high to low. Thus, the signal is decomposed into sums of IMFs and the residual.

$$x(t) = \sum_{i=1}^n imf_i(t) + r(t) \quad (1)$$

We divide all IMFs for each industry into 2 subgroups according to their frequency or cycle length. IMFs with less than 5 years compose short-term fluctuation. And the remained ones as well as the residual compose the long-term trend.

$$I_1(t) = \sum_{T/N_i \leq 5} IMF_i(t)$$

$$I_2(t) = \sum_{5 < T/N_i} IMF_i(t) + r(t)$$

Robustness Check

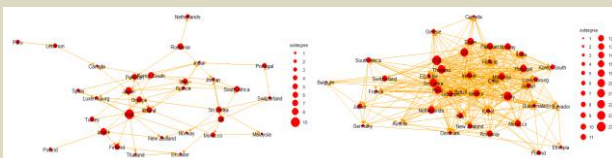
We explore the robustness of our results. In the earlier parts, the threshold of short- and long-time scale is 5 years. Considering there are different threshold to discriminate short- and long-term, here we adopt 3 years as the threshold to do robustness check (Table 1). Additionally, we choose per capita military expenditures to replace the total military expenditure as a military spending measure to do another robustness check. These results are consistent with the previous results, which support that our conclusions are robust.

Table 1: Centrality of national military expenditure among the Granger causality network with threshold of 3 years

Ranking	S_Out	S_In	Ranking	L_Out	L_In
USA	11	0	USA	22	0
UK	10	0	UK	20	1
Spain	9	0	Turkey	18	2
Japan	8	3	Spain	17	3
Greece	7	6	Thailand	17	3
South Africa	7	0	Sri Lanka	15	4
Italy	6	2	Netherlands	15	1
New Zealand	5	3	Peru	15	6
Finland	5	7	Portugal	15	5
Korea South	5	1	Norway	13	6
Israel	5	5	Ireland	11	14
Malaysia	4	1	Malaysia	10	8
Luxembourg	4	4	Morocco	10	8

Empirical Results

We do an analysis of EMD to time series of 44 nations' military expenditure with the division of IMFs into different groups based on their cycles. Then we do Granger causality test pairwise and thus generating the directed causality network based on the 5% significant Granger causality.



Figures1: Short / Long co-movement of international military expenditure

Conclusions

We decompose the time series of national military expenditure in fluctuations with different time-scales. Then, we develop networks of different time-scales with test of Granger causality. We explore the co-movement effect with different time scales between the national military expenditure via investigating nodes centrality in the networks and get the conclusions. First, in component of short-term, the fluctuation is mixed with more noise and less causality. Second, the co-movement path among nations is clear directed, and influencers and affectees are distinctive. The nations with strong economy and military power are the most influential nations in military expenditure co-movement. Last, our paper provides a network method with EMD model and Granger causality to study the co-movement path between global military expenditure from short- and long-term time-scale.