# A causality analysis. Military expenditures and economic growth in USA and China.

Gentilucci, Eleonora

December 2020

# A causality analysis. Military expenditures and economic growth in USA and China.

*Eleonora Gentilucci*
elef1@ymail.com

**Abstract**

Recent literature on military expenditures in the economic system has pointed out in recent years that China's role as not only economic but also military power, is becoming increasingly important, leading to China's emergence as a world military power capable of undermining the United States supremacy.

The analysis undertaken tests the hypothesis that, in China, unlike the US, the increase in military spending is essentially due to the increase in GDP made available by Chinese economic boom. On the other hand, in US, the high military expenditures and its trend is the result of a strategic decision determined only partially and to a limited extent by GDP trends. Hypotheses validation implies that increase in Chinese military expenditure is fully explained by increase in GDP. On the other hand, in the United States, the variation in GDP explains only a part of variation in military spending, suggesting the possibility of investigating other factors determining their variation. The empirical analysis is performed through an econometric analysis accomplished using Toda-Yamamoto approach to Granger causality, impulse response function and variance decomposition analysis.

Keywords: China, USA, military expenditures, GDP, causal relationship, Toda-Yamamoto Granger causality test, IRF, FEVD.

Declarations of interest: none

# 1 Introduction

The role of military expenditure within the economic system is controversial, "It is crucial to suppress the economic imbalances or inequities to have a sustainable peace. Here, economic analysis can help decision-makers re-allocate public spending to focus on the most relevant issues, not on those which seem to have the most immediate results."[1]

"The political economy of defense spending is enormously important given its magnitude and its global implication" (Gentilucci, 2019).

A lot of studies deal with the rising role and power of Chinese economy relative to that of United States (Malkin, 2020), but not many studies deal with the increasing size and role of the military in China relative to United States. Beckley (2012) point out that an analysis of the hegemony between the two countries must be did analysing also the military capabilities of the two countries. Schwartz (2019, p.507) emphasizes the US military superiority "over the geo-political rivals", in this case the military power is seen as an "infrastructural power".

The aim of this paper is to contribute to the debate on the role and evolution of global military spending in the economic system. In the literature often military expenditures are considered as a proxy of military power, Arvanitidis and Kollias (2016, p. 41) claim that "military expenditures are essentially the costs of producing military power". Some other scholars point out that "military force is a convenient tool to fulfil a

[1] Fanny Coulomb, Keith Hartley, Michael Intriligator. Pacifism in Economic Analysis: A Historical Perspective. Defence and Peace Economics, Taylor & Francis (Routledge), 2008, War and Peace Issues in the History of Economic Thought, 19 (5), pp.373-386. 10.1080/10242690802354378. hal-02051640

state's national interests of value expansion, prestige augmentation, and security assurance"(Lee, 2008, p. 529).
The analysis will be carried out through a comparison between China and the United States. In particular, the growth of Chinese military spending is increasingly part of the current debate (Zhong et al. 2017; Dimitraki and Menla Ali, 2013; Menla Ali and Dimitraki, 2014) and results are not unambiguous. The research will take into account the evolution of these expenditures within the national economic system, comparing them to those of the leading country in the sector, the United States. Recent literature on military spending places a very strong emphasis on the strategic link between the increase in military spending and the increasingly militaristic character of Chinese growth in the global context. In these last years, some scholars (Chen and Feffer, 2009; Arvanitidis and Kollias, 2016, etc. ) of military expenditures in the economic system have pointed out that China's role as not only economic but also military power, is becoming increasingly important, leading to China's emergence as a world military power capable of undermining United States in their supremacy. One may wonder if and to what extent this constitutes a new and deliberate strategy[2] of China.
The hypothesis that will be tested with empirical analysis, brings a new light on the role of the link between military and GDP in Chinese and American economy. In particular, the study will try to highlight whether the increase in military spending is really a deliberate political choice or rather the result of China's extraordinary economic expansion. To try to answer this question it seems pertinent to assess the evolution of military spending and gross domestic product in the two countries.
A first intuitive hypothesis that would make it possible to explain the huge increase in the level of Chinese military expenditures is certainly linked to the possible correlation between these types of expenditure and the trend of the country's Gross Domestic Product. Particularly, the analysis that will be carried out will test the hypothesis that, in China, unlike the United States, the increase in military spending is essentially due to the increase in GDP made available by Chinese economic boom. On the other hand, in the United States, the high military expenditures and its trend is the result of a strategic decision determined only partially and to a limited extent by GDP trends. If this were verified, it would suggest that other factors affect the evolution of military expenditures in the economic system. In particular it could support the thesis that the level and trend of military expenditure is the result of power interpenetrations, spanning from military spending to economic growth (or GDP) and/or from economic growth (or GDP) to military spending.
So, in order to test these hypothesis I think that the tool of causality is appropriate, so this study will perform an econometric analysis using the Toda-Yamamoto approach to Granger causality, the impulse response function and the variance decomposition analysis.
To the best of my knowledge, not many are studies have tried to apply the Toda-Yamamoto approach to Granger causality test in the field of military expenditures and economic growth. Moreover, I'm not aware of studies that jointly apply Toda-Yamamoto's analysis, impulse response function and variance decomposition analysis.
This study is organized as follows: Section 2 shows an overview of the evolution of Chinese and American military expenditures; section 3 presents the literature review; section 4 describes the methodology, in particular the empirical model and data. ; section 5 shows the results of econometric analysis. Section 6 presents the principal stylized facts and conclusions of this study.

# 2 An overview on Chinese and American evolution of military expenditures and GDP

On the basis of the data of Sipri Yearbook 2019, this study shows the principal trends of military expenditures at constant US dollars, of military expenditures as a percentage of GDP and of military expenditures as a percentage of central government expenditures, during the period 1989-2018.

[2] While fully recognizing that the strategy of a nation must be analyzed through a complex analysis of a set of political, economic, geographical factors etc., in this context, and in order to be integrated into the current debate on the military power of the two states (China and USA), the deliberate strategy is analyzed through the exclusive analysis of two macroeconomic variables: military spending and GDP.

Data show that although Chinese military expenditures have never stopped increasing for thirty years, they have not yet reached the level of American military expenditures and remain much lower (Figure 1). In 2018, it stood at a constant 239 223 million of constant dollars in China, while it reached the level of 633 565 million of constant dollars in the United States. Consequently, Chinese military expenditures in 2018 represent just under one third of American military expenditures. The evolution of military expenditure per capita confirms this trend (Figure 2): per capita military spending in the United States stands at just under $2000 in 2018, while Chinese military spending stands at $176.

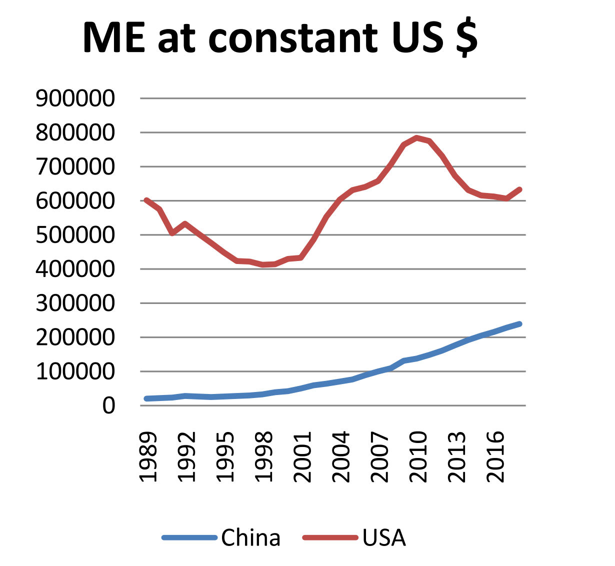


**Figure 1 Military expenditure by country in constant price (2017) US$ (millions), presented according to calendar year, and in current (2018) US$m. for 2018. Source: Sipri 2019. My elaboration.**

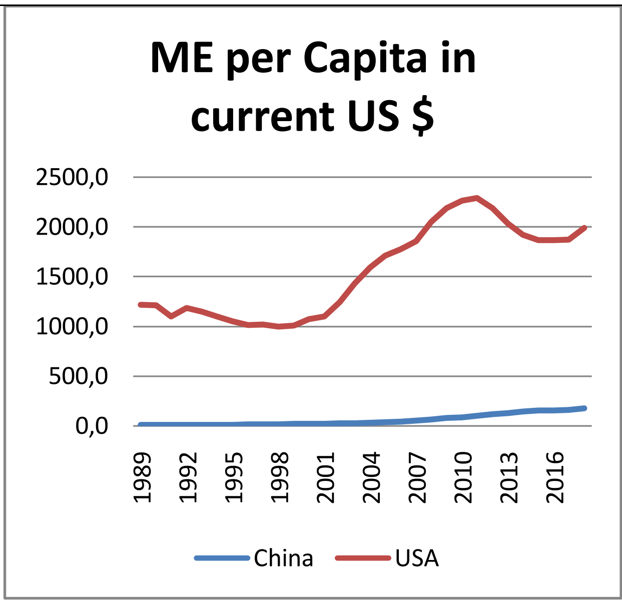


**Figure 2 Military expenditure per capita, in current US$, presented according to calender year. Source: Sipri 2019. My elaboration.**

An analysis of the evolution of military expenditure as a percentage of Gross Domestic Product shows that the share devoted to military expenditure in the USA is significantly higher than in China (Figure 3). In 1989, the share of GDP invested in military expenditure was 5.5% and 2.5% in the USA and China respectively. In 2018 the respective shares of the two countries are 3.2% and 1.9%. In contrast to the share of military expenditures in American GDP, the Chinese share remains rather stable over the time period considered, while the American share seems to vary more. A common tendency to decrease the share of the two countries is to be registered immediately after the end of the Cold War, in the period in which it was theorized and hoped for a disinvestment in military spending, with a view to global pacification, and at the same time a reallocation of these resources to social purposes. This is what the literature defines as "the peace dividend". This trend stopped suddenly in 1999, when military expenditures and the share of GDP dedicated to them began to grow again. However, in China the level of 2% is exceeded (even if only slightly) in very few years, overall it is pointed out that the part of the GDP dedicated to military expenditures in recent years is around 2% without significant variations. In the United States, the part of the GDP dedicated to military spending follows a sort of cyclical trend since 1989 and has almost never fallen below 3%. These data therefore lead us to affirm that the share of military spending on GDP does not demonstrate an evident change toward a more militaristic strategy[3] in China in the allocation of GDP resources to military spending, in fact the share is decreasing from the starting data and rather stable during the time. It should also be noted that the correlation coefficient between the share of military expenditure on GDP in the two

[3] to the extent that an increase in the part of GDP dedicated to military spending means adopting a more militaristic strategy.

countries is positive and equal to 0.6: this element shows that there is a rather important positive correlation in the choices of the two countries, although they are made on a different scale.
The share of military expenditures on government expenditures in the two countries from 2001 to 2018 (Figure 4) shows that China, has constantly decreased the share of government expenditures dedicated to military expenditures, in particular between 2007 and 2008 the share of military expenditures on government expenditures has decreased by 2%, between 2001 and 2018 the share of Chinese military expenditures on total military expenditures has decreased from 11.98% to 5.5% thus reducing by more than half. In the United States, on the other hand, the share of military expenditures in government expenditures is not only much higher than in China, but above all, during the period studied, this ratio grew considerably between 2001 and 2006, and then remained at very high levels (around 12%) until 2011. Since 2012, the share of military spending in government expenditures has started to decrease to 9%, which is only 0.1% lower than the share of military spending in 2001.

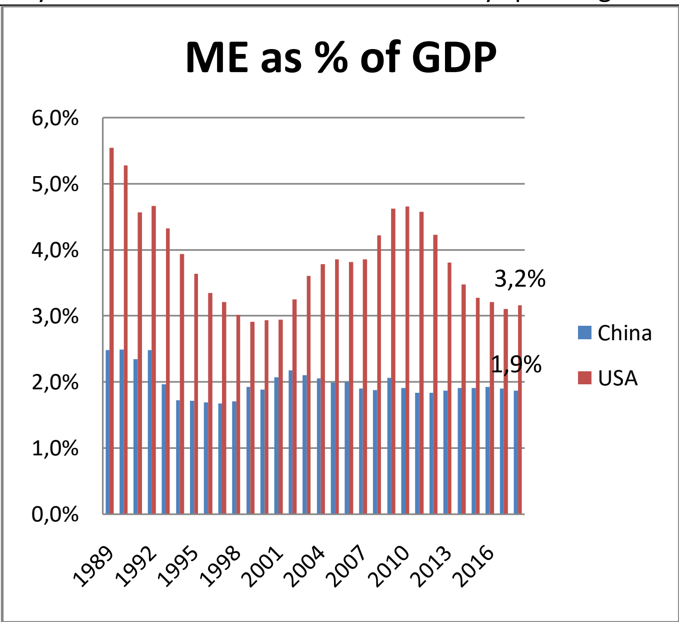


Figure 3 Military expenditure for China and USA as share of gross domestic product, 1989-2018. Source: Sipri 2019. My elaboration

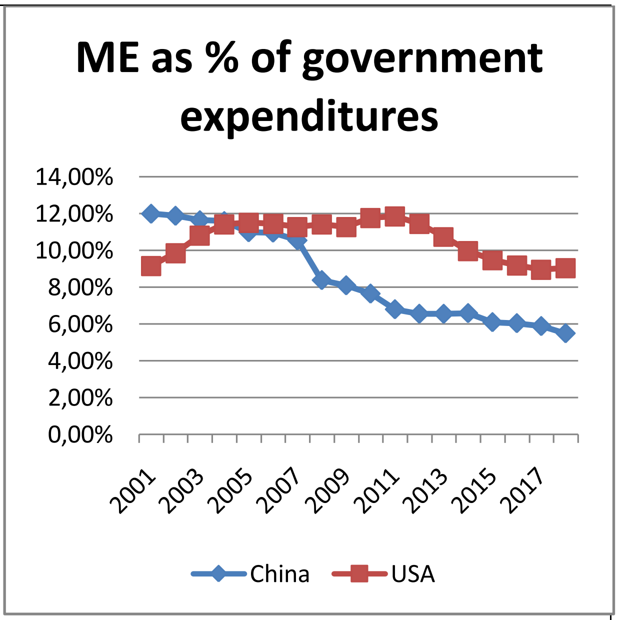


Figure 4 Military expenditures as a percentage of general government expenditures in the period 2001-2018. Source: Sipri 2019. My elaboration.

## 3 Litterature review

Since Benoit's seminal work (1973, 1978), finding positive influence between defense expenditures and economic growth, numerous studies on the evaluation of the impact of military spending on the economic system have followed, without, however, reaching a consensus on the results, which instead often appear to be contradictory[4]. The findings of the studies in the literature are inconclusive and vary depending on the countries examined, samples, and econometric methods. So not only there is no consensus regarding the direction of causality but still there is no consensus as to whether military expenditure has a positive, a negative or a neutral effect on economic growth.
"Most of the studies on the defence-growth relationship are based on the Neoclassical or Keynesian theoretical frameworks, which allow the development of consistent formal models. While Neoclassical models concentrate on supply-side (modernisation, positive externalities from infrastructure, technological spin-offs), Keynesian models concentrate on demand-side (crowding-out of investment, exports, education, health)" (Dunne and Nikolaidou, 2001). Neoclassical studies include Biswas and Ram (1986), Alexander (1990), Mintz and Huang (1990), Mintz and Stevenson (1995), Sezgin (1996), Murdoch, Pi and Sandler (1997), Nikolaidou (1998a). Among the Keynesian studies we can find Smith (1980), Lim (1983), Faini, Annez

[4]For a critical in-depth analysis of the economic litterature of military spending see Herrera and Gentilucci (2013).

and Taylor (1984), Chletsos and Kollias (1995). Researchers have adopted different econometric model to study the defence-growth nexus: time series, cross-section or panel studies such as the Feder-Ram model (Feder, 1983; Biswas and Ram, 1986), Deger-type model (Deger and Smith, 1983; Deger, 1986), the endogenous growth model (Barro, 1990), the augmented Solow growth model (Mankiw and al., 1992) and the new macroeconomic model (Romer, 2000; Taylor, 2000).
A large literature has used Granger (1969) causality tests to examine the interaction of military spending with the economy, for instance, Dunne and Smith (1990), Madden and Hasleuhurst (1995), Chang et al. (2001), Smith and Dunne (2002), Tang et al. (2009), Meng et al. (2013), Menyah and Wolde-Rufael (2013). A lot of study deepen on the Granger causality relationship between military expenditures and GDP, for instance, Joerding (1986), Kinsella (1990), Kollias (1997), Gold (1997), Chowdhury (1991), Chen (1993), Kollias and Makrydakis (2000), Abu-Bader and Abu-Qarn (2003), Kollias et al. (2004, 2007), Dunne and Nikolaidou (2001), Dunne, Nikolaidou and Vougas (2001), Al-Yousif (2002), Atesoglu (2002), Morales-Ramos (2002), Kollias, Naxakis and Zarangas (2004), Lai, Huang and Yang (2005), Karagol and Palaz (2004), Narayan and Singh (2007), Pradhan (2010), Zhong et al. (2017), Hatemi et al. (2018). In particular Zhong and al. (2017) performed an analysis to evaluate the causal linkages between military expenditures and economic growth in the BRICS and the US and Chang and al. (2014) performed an Granger causality study for China and G7 countries, pointing out the causal links between military expenditures and economic growth, in particular they causality from real GDP to military expenditures is founded.

However, not many studies have tried to apply the Toda-Yamamoto approach to Granger causality test in the field of military expenditures and economic growth. Among them there is the work of Abu-qarn (2010) which revisits the defence–growth nexus for the rivals of the Israeli–Arab conflict over four decades utilizing the Toda and Yamamoto (1995) causality test and the generalized variance decomposition. Ozun & Erbaykal (2014) examined the causal relationship between defense spending and economic growth in the case of selected NATO countries for the period of 1949-2006. The results show that unidirectional causality exists in seven NATO countries while for five countries no causal relationships were found. On the other hand, Turkey differs from other countries in that the relationship is bilateral. Others studies applying the Toda-Yamamoto procedure to the relationship between military expenditures and economic Growth are the following: Aminu & Abu Bakar (2015),

Wolde-Rufael (2014) applies the Toda-Yamamoto procedure to the analysis of military expenditures and income inequality. Another study by Raza & al. (2016), utilizes the Toda-Yamamoto and variance decomposition approaches in order to analyze relationship between military expenditures and income inequality.

# 4 Methodology

## 4.1 Data Sources

The annual data used in this study covers the period from 1989 to 2018 for both the countries taken into account (China and US). The data on military expenditure for China and United States are carried out from the Sipri 2020 database and World Bank online Database 2020.
The variables used in this study include the military expenditures at current US dollars, the military expenditures at constant US dollars, military expenditures as a percentage of GDP, military expenditures as a percentage of government expenditures, all of which have been taken from the Sipri online database 2020.
The annual rate of growth of GDP measured in constant US dollars has been taken from the World Bank online database 2020.

## 4.2 Econometric analysis

“Using Vector Autoregressive (VAR) models has the advantage that they are dynamic specifications, free of economic assumptions imposed a priori" (Dunne, 2001). In order to perform the econometric analysis and to evaluate the strategic role of military expenditures in the economic system of the two countries, I utilize a time series analysis for the two countries based on the following tools:

- The Toda and Yamamoto (1995) procedure to test for Granger causality in order to examine the economic causal relationship among endogenous variables, in this case between military expenditures and GDP. This procedure is based in the estimation of an augmented VAR that guarantees the asymptotic distribution of the Wald statistic. This procedure does not require pretesting for integration or cointegration, so it avoids the potential biases of pre-testing. In estimating the MWALD test for granger causality, it is prerequisite to determine the maximum possible order of the integration of the basic variables (dmax) using a unit roots test. Therefore, the first step was to run the Augmented Dickey-Fuller (ADF) test in order to determine dmax[5].
  The second step was the determination of the optimal lag length (k). By identifying dmax and k, a level VAR model of order (k + dmax) is estimated and zero restrictions test is conducted on lagged

$$Y_{1t} = \mu_1 + \sum_{k=1}^{p+d_{max}} \beta_{11,k} Y_{1t-k} + \sum_{k=1}^{p+d_{max}} \beta_{12,k} Y_{2t-k} + \varepsilon_{1t}$$

$$Y_{2t} = \mu_2 + \sum_{k=1}^{p+d_{max}} \beta_{21,k} Y_{1t-k} + \sum_{k=1}^{p+d_{max}} \beta_{22,k} Y_{2t-k} + \varepsilon_{1t}$$

  where long-run Granger causality from variable $Y_2$ to variable $Y_1$ is evaluated by testing the null hypothesis that $\beta_{12,1} = \ldots = \beta_{12,p}$ , and causality from variable $Y_1$ to $Y_2$ is examined by testing the null hypothesis that $\beta_{21,1} = \ldots = \beta_{21,p} = 0$ .
- The impulse response function (IRF) using the traditional orthogonalized Cholesky method. This set of statistics often used to evaluate a VAR is to simulate some shocks to the system and trace out the effects of those shocks on endogenous variables. However, it must be kept in mind that the shocks were correlated across equations.
- The forecast-error variance decomposition (Fevds) which measures the extent to which each shock contributes to unexplained movements (forecast errors) in each variable in a VAR system. So the method enables scholars to detect not only the direction, but also the intensity of causal relationship between variables.

# 5 The econometric analysis

The focus of this research is to test the starting hypotheses. evaluating the relationship between the two fundamental variables in the China and in US, namely the gross domestic product and the military expenditure.

First of all, and before deepening in the econometric analysis, it's interesting to evaluate the correlation between military expenditures at constant prices and constant GDP in the two countries.

**Table 1 - Correlation rate between the annual growth rate of military expenditure at constant prices and the annual growth rate of gross domestic product. Data sources: Sipri 2019 e World Bank. My elaboration.**

| | Correlation between the constant Military Expenditures (ME) and the constant GDP (g) |
|---|---|
| **China** | 1,00 |
| **USA** | 0,66 |

[5] The maximum degree of integration of the variables.

In particular, this analysis (Table 1) shows that the Chinese military expenditure at constant prices is perfectly positive correlated with the GDP in the Chinese economy, while for the United States, there is an average correlation between the two variables considered.
This result makes it possible to investigate whether there is causality between the two variables and the possible impact of such causality in the two countries considered. This section proposes to carry out this analysis with the help of econometric techniques. In particular, as mentioned in the methodology section, three main tools will be used: Toda-Yamamoto's approach to Granger's causality, the Impulse Response Function, and the Forecast Error Variance Decomposition.

## 5.1 The Toda-Yamamoto Granger causality test for China

In order to assess whether there is a causality, in the economic sense of the term, between GDP and military expenditure, the objective is to perform an analysis through the Toda-Yamamoto Granger causality test.
First of all, since the values at the level of the two historical series considered and their respective logarithms are not stationary, they must be made stationary.
In order to evaluate the stationarity of the series we refer to the Augmented Dickey-Fuller Unit Root Test.

**Table 2 – Results of the Augmented Dickey-Fuller Unit Root Test for d2lnGDP in China**

| | | | | | | |
|---|---|---|---|---|---|---|
| Augmented Dickey-Fuller test for unit root | | | | Number of obs = | | 2525 |
| | | | Interpolated Dickey-Fuller | | | |
| | Test Statistc | | 1% Critical Value | 5% Critical Value | | 10% Critical Value |
| Z(t) | -4.016 | | -2.660 | - -1.950 | | -1.600 |
| D. d2lnGDP | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. Interval] | |
| L1 | -1.013335 | .2523407 | -4.02 | 0.001 | -1.535342 | -.491329 |
| LD | .1483961 | .1634769 | 0.91 | 0.373 | -.1897816 | .4865739 |

In the case of the Dickey-Fuller test for the variable d2lnGDP, the estimation of the reference model shown above, allows to evaluate the validity of the choice of the lag. In particular, if the highest lag corresponds to a t of Student (non-standard) in absolute value lower than 1.645, the test is performed again, reducing the lag, until the highest lag is significant (|t|> 1.645). In our case we have that 4.02 > 1.645, therefore the choice of lag is valid.
We can then move on to the analysis of the Dickey-Fuller test results. From the comparison in absolute value of the statistic test t, of the ADF test (4.016) with the critical value at 5% (1.950), it emerges that the first is greater than the second in absolute value, so we can reject the null hypothesis and say that the series is stationary.
It proceeds in the same way for the analysis of the military expenses in logarithmic form and from the analysis it emerges that the series is stationary to the first differences I(1) as it is shown in the table of the variable d1lnME.
So I can conclude that the maximum order of integration for the group of time series (dmax) is equal to two.

**Table 3 – Results of the Augmented Dickey-Fuller Unit Root Test for d1lnME in China**

| | | | | | | |
|---|---|---|---|---|---|---|
| Augmented Dickey-Fuller test for unit root | | | | Number of obs = | | 2526 |
| | | | Z(t) has t-distribution | | | |
| | Test Statistc | | 1% Critical Value | 5% Critical Value | | 10% Critical Value |

| Z(t) | -2.724 | | -2.500 | - -1.914 | | -1.319 |
|---|---|---|---|---|---|---|
| D. d1lnME | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. Interval] | |
| L1 | -.6934861 | .25455686 | -2.72 | 0.012 | -1.220101 | -.1668709 |
| LD | -.1445744 | .1942308 | -0.74 | 0.464 | -.5463714 | .2572226 |
| cons | .0563123 | .0258057 | 2.18 | 0.040 | .0029291 | .1096955 |

Secondly, we set up a VAR model in level and determine the appropriate maximum lag length (p) for the variables in the VAR (p) using the usual information criteria. In order to perform the causality analysis, the number of lags needed for the VAR model to be estimated is established.

**Table 4 - Optimal number of lag for the VAR model in China**

Selection-order criteria

Sample: 1994-2018 Number of obs = 25

| lag | LL | LR | df | p | FPE | AIC | HQIC | SBIC |
|---|---|---|---|---|---|---|---|---|
| 0 | 7.6977 | | | | .002173 | -.455816 | -.428771 | -.358306 |
| 1 | 116.992 | 218.59 | 4 | 0.000 | 4.8e-07 | -8.87936 | -8.79823 | -8.5868. |
| 2 | 130.312 | 26.64 | 4 | 0.000 | 2.3e-07 | -9.62497 | -9.48974 | -9.13742* |
| 3 | 134.183 | 7.7409 | 4 | 0.102 | 2.4e-07 | -9.61461 | -9.42529 | -8.93204 |
| 4 | 143.017 | 17.669* | 4 | 0.001 | 1.7e-07* | -10.0014* | -9.75796* | -9.12378 |

Endogenous: lnME lnGDP
Exogenous: cons

The lag lenght is selected based on the Akaike information criterion (AIC). The optimal number of lags is therefore 4 based on the AIC criterion and most criteria. This show that the la length prior to the augmentation is determinate as 4 where used the appropriate lag of the model in six due to the condition of VAR (p+dmax)

To test the VAR model for the serial correlation in residuals

**Table 5 - Lagrange-multiplier test for VAR in China**

| Lagrange multiplier test | | | |
|---|---|---|---|
| lag | ch i2 | df | Prob > ch i2 |
| 1 | 7.1157 | 4 | 0.12990 |
| 2 | 2.3252 | 4 | 0.67619 |
| $H_0$: no autocorrelation at lag order | | | |

The results show that there is no serial correlation in residuals for our VAR model at 1%, 5% and 10% significance level.

Now, after we know that the value of *p*+*d*=6 for the VAR (unrestricted) and *p*=4 for the VAR (restricted), we will perform the Granger causality test as follows:

. quiet var lnME lnGDP, lags (1/6)

**Table 6 - Toda-Yamamoto Granger causality test from lnME to lnGDP for China**

| . testTest [lnGDP] L1.lnME [lnGDP] L2.lnME [lnGDP] L3.lnME | |
|---|---|
| (1) | [lnGDP]L.lnME = 0 |
| (2) | [lnGDP]L2.lnME = 0 |
| (3) | [lnGDP]L3.lnME = 0 |
| (4) | [lnGDP]L4.lnME = 0 |
| chi2( 4) = 6.47 | |
| Prob > chi2 = 0.1669 | |

The previous Toda-Yamamoto Granger causality test tests for Granger's causality from military spending to GDP.

Table 7 - Toda-Yamamoto Granger causality test from lnGDP to lnME for China

| . test [lnME] L1.lnGDP [lnME] L2.lnGDP [lnME] L3.lnGDP | |
|---|---|
| (1) | [lnME]L.lnGDP = 0 |
| (2) | [lnME]L2.lnGDP = 0 |
| (3) | [lnME]L3.lnGDP = 0 |
| (4) | [lnME]L4.lnGDP = 0 |
| chi2( 4) = 33.00 | |
| Prob > chi2 = 0.0000 | |

The previous Toda-Yamamoto Granger causality test tests Granger's causality from GDP to military spending. From the analysis of Toda-Yamamoto causality, it emerges that, for China, there is a causality from GDP to military expenditure, but not from military expenditure to GDP. This result confirms our starting hypothesis that the increase in Chinese military expenditures follows the exploit in GDP growth that characterizes this country. So I can argue that over time military expenditure has been only a response to economic growth, a sort of economic dependence.

## 5.2 Impulse response function (IRF) for China

Considering that the results of the T-Y Granger causality test show a causality from GDP to military expenditure, but not vice versa, I calculated the IRF, ordering the variables in this sense, i.e. first the GDP then the ME. However, in order to assess the reliability of the results the IRF was tested giving the reverse order to the variables. The results obtained are highlighted at the end of the paragraph.

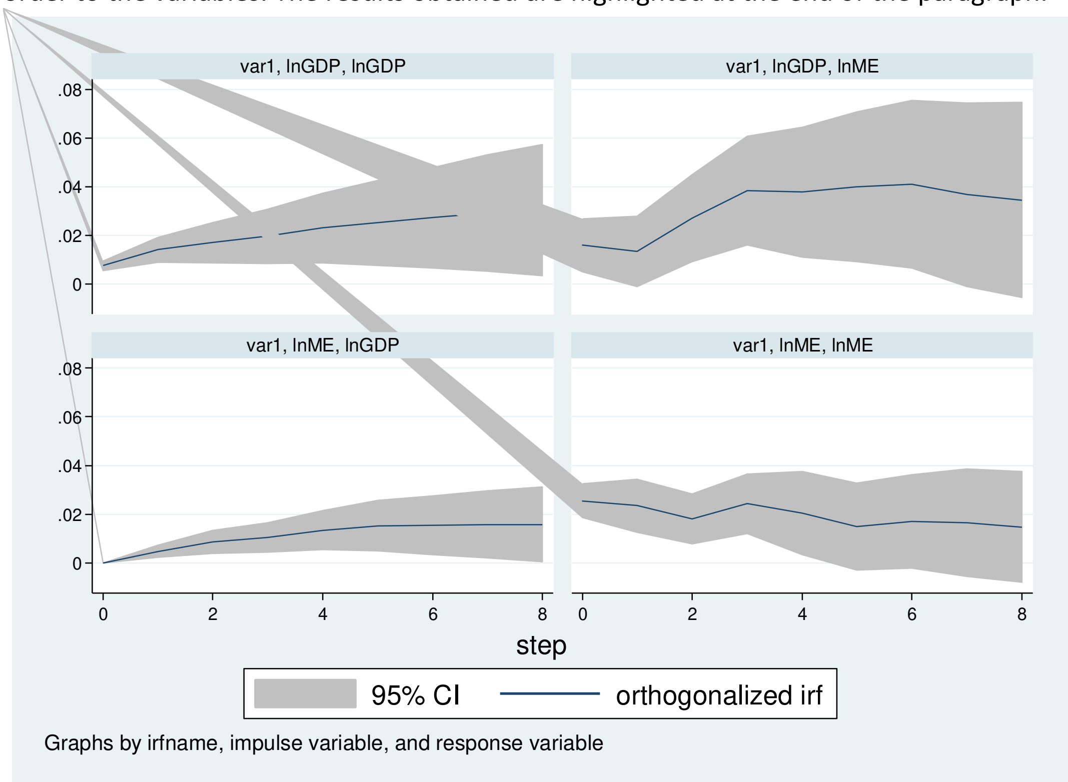


Figure 5 Impulse response function for China

The horizontal axis for each graph is in the units of time that your VAR is estimated in, in this case years; hence, the impulse–response graph shows the effect of a shock over a 8-years period. The vertical axis is in units of the variables in the VAR; in this case, everything is measured in percentage points, so the vertical units in all panels are percentage point changes.

The first row shows the effect of a one-standard-deviation impulse to the GDP equation. A standard deviation shock to GDP determines a decrease of military expenses in the first year, after the first year and until the sixth year military expenses begin to grow, then from the sixth year military expenses decrease

slowly, although remaining in the positive region. The graphs is inside the 95% percent interval of confidence. Overall a shock to GDP will have positive impact on military expenditures both in the short run and in the long run because the graph is in the positive region.
The second row shows the effect of a one-standard-deviation impulse to the ME equation. The first thing to notice is that the effect is zero in the current period (at zero lag). This is a direct result of our identification assumption: we imposed the condition that military expenditures has no immediate effect on GDP in order to identify the shocks. A standard deviation shock to ME results in a slight increase in GDP until the fifth year, which then stabilizes. Overall a shock to military expenditures will have a positive impact on GDP both in the short and long run because the graph is above the zero.
In conclusion these results are consistent with the a priory expectations because military expenditures grows following GDP shock, as hypothesized in our model and as inferred from the conclusions of T-Y Granger causality test.
IRFs can be sensitive to the identification assumptions we make. I computed IRFs for alternative orderings and I find that the results are similar, then I gain confidence that my conclusions are not sensitive to the assumptions I make about contemporaneous causality.

## 5.3 Forecast-error variance decomposition (FEVDs) in China

Another tool that is available for analysis of identified VARs is the forecast-error variance decomposition, which measures the extent to which each shock contributes to unexplained movements (forecast errors) in each variable. Variance decomposition of the forecast error gives the percentage of unexpected variation in each variable that is produced by shocks from other variables. It indicates the relative impact that a variable has on another. The variance decomposition enables assessment of economic significance of this impact as a percentage of the forecast error for a variable sum to one. The orthogonalisation procedure of the VAR system decomposes the forecast error variance. The component measures the fraction in a variable explained by innovations/shocks in other variables.
All variance decompositions start at zero because there is no forecast error at a zero lag.

**Table 8 – Results of the variance decomposition analysis for China**

| | (1) | (1) | (1) | (2) | (2) | (2) | (3) | (3) | (3) |
|---|---|---|---|---|---|---|---|---|---|
| step | fevd | Lower | Upper | fevd | Lower | Upper | fevd | Lower | Upper |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | .2803 | -.018425 | .579024 | 0 | 0 | 0 |
| 2 | .920046 | .83105 | 100.904 | .265078 | -.057737 | .587893 | .079954 | -.009042 | .16895 |
| 3 | .850494 | .690937 | 101.005 | .432551 | .080857 | .784244 | .149506 | -.01005 | .309063 |
| 4 | .819075 | .628843 | 100.931 | .55357 | .235503 | .871636 | .180925 | -.009308 | .371157 |
| 5 | .790876 | .577192 | 100.456 | .614978 | .306644 | .923313 | .209124 | -.00456 | .422808 |
| 6 | .771355 | .537158 | 100.555 | .671277 | .379282 | .963272 | .228645 | -.005552 | .462842 |
| 7 | .766905 | .524469 | 100.934 | .705557 | .431549 | .979566 | .233095 | -.009341 | .475531 |
| 8 | .768459 | .525226 | 101.169 | .72276 | .45471 | .99081 | .231541 | -.011691 | .474774 |

| | (4) | (4) | (4) |
|---|---|---|---|
| step | fevd | Lower | Upper |
| 0 | 0 | 0 | 0 |

| | | | |
|---|---|---|---|
| 1 | .7197 | .420976 | 101.843 |
| 2 | .734922 | .412107 | 105.774 |
| 3 | .567449 | .215756 | .919143 |
| 4 | .44643 | .128364 | .764497 |
| 5 | .385022 | .076687 | .693356 |
| 6 | .328723 | .036728 | .620718 |
| 7 | .294443 | .020434 | .568451 |
| 8 | .27724 | .00919 | .54529 |

95% lower and upper bounds reported

(1) Irf name=var 1, impulse=lnGDP, and response=lnGDP

(2) Irf name=var1, impulse=lnGDP, and response=lnME

(3) Irf name=var1, impulse=lnME, and response=lnGDP

(4) Irf name=var1, impulse=lnME, and response=lnME

The analysis of the results shows that in (1) and (3), (with the preferred identification assumption) the GDP shock contributes 100% of the variance in the one-period-ahead forecast error for GDP, with the ME shock not contributing at all. As the forecast horizon moves further into the future, the effect of the GDP shock on ME increases and the shares converge to about 76,9% of variation in GDP being due to GDP shock and 23.1% due to the ME shock in the period 8. Table (2)and (4) indicate that the GDP shock contributes 28% of the variance one-period-ahead forecast error for ME, with military expenditures contributing to the other 78%. As our forecast horizon moves further into the future, the effect of the GDP shock on ME increases and the shares converge to about 72% of variation in ME being due to GDP shock and to about 28% due ME shock in the period 8. So the percentage of an unexpected variation in ME produced by a shock from GDP is very high in China in the long run.

Below is the graphical representation of variance decomposition in China (FEVDs) :

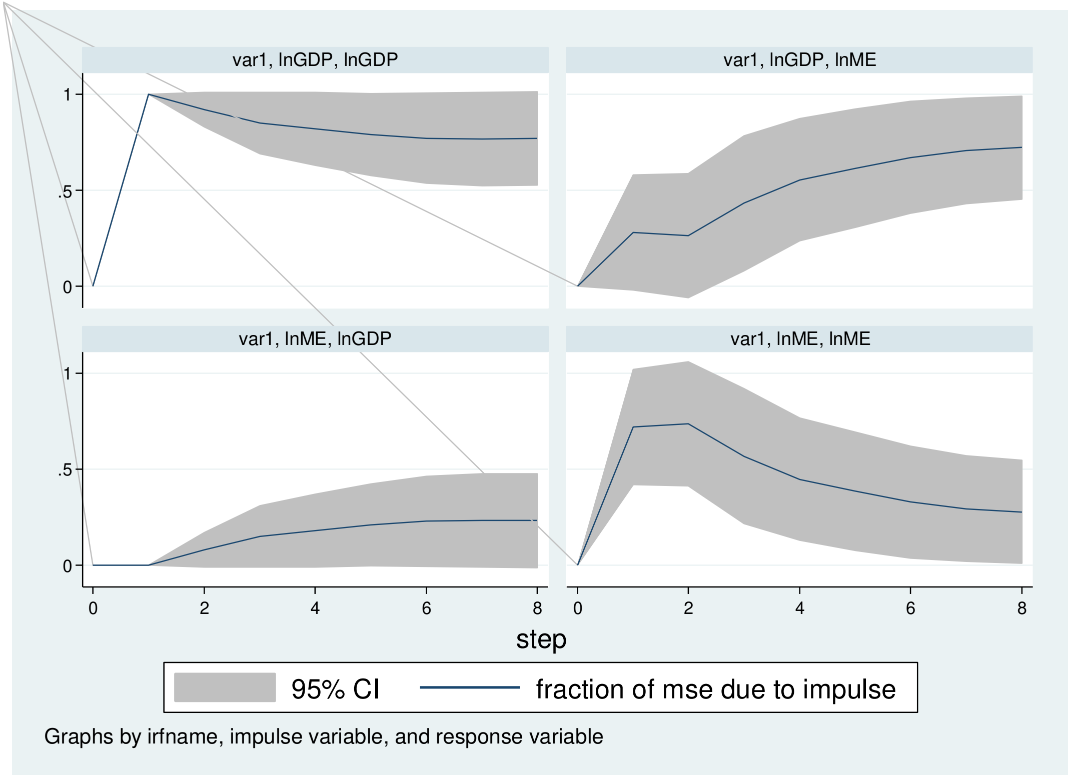


Figura 6 Graphical representation of variance decomposition analysis for China

FEVDs like IRF, can be sensitive to the identification assumptions we make. I computed FEVDs for alternative orderings and I find that the results are similar, then I gain confidence that my conclusions are not sensitive to the  assumptions I make about contemporaneous causality.

## 5.4 The Toda-Yamamoto Granger causality test for United States

**Table 9 - Results of the Augmented Dickey-Fuller Unit Root Test for d2lnME in USA**

| Augmented Dickey-Fuller test for unit root | | | Number of obs = | | 2525 |
|---|---|---|---|---|---|
| | | | Interpolated Dickey-Fuller | | |
| | Test Statistc | | 1% Critical Value | 5% Critical Value | 10% Critical Value |
| Z(t) | -3.398 | | -2.660 | - -1.950 | -1.600 |
| D. d2lnME | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. Interval] | |
| L1 | -.9032472 | .2658443 | -3.40 | 0.002 | -1.453188 | -.3533063 |
| LD | .0176421 | .1442412 | 0.12 | 0.904 | -.2807436 | .3160278 |

In the case of the Dickey-Fuller test for the variable d2lnME, the estimation of the reference model shown above, allows to evaluate the validity of the choice of the lag. In particular, if the highest lag corresponds to a t of Student (non-standard) in absolute value lower than 1.645, the test is performed again, reducing the lag, until the highest lag is significant (|t|> 1.645). In our case we have that 3,40 > 1,645, therefore the choice of lag equal to 1 is valid.
We can then move on to the analysis of the Dickey-Fuller test results. From the comparison in absolute value of the statistic test t, of the ADF test (3,398) with the critical value at 5% (1.950), it emerges that the first is greater than the second in absolute value, so we can reject the null hypothesis and say that the series is stationary.  So the series is stationary to the second differences I(2).
We proceed in the same way for the analysis of the GDP in logarithmic form and the analysis shows that the series is stationary at level I(0) as shown in the table of the variable lnGDP.
So I can conclude that the maximum order of integration for the group of time-series (dmax) is equal to two.

**Table 10 - Results of the Augmented Dickey-Fuller Unit Root Test for lnGDP in USA**

| Augmented Dickey-Fuller test for unit root | | | Number of obs = | | 2527 |
|---|---|---|---|---|---|
| | | | Interpolated Dickey-Fuller | | |
| | Test Statistc | | 1% Critical Value | 5% Critical Value | 10% Critical Value |
| Z(t) | -3.096 | | -2.657 | - -1.950 | -1.601 |
| lnGDP | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. Interval] | |
| L1 | .0005079 | -.0001641 | 3.10 | 0.005 | .0001701 | .0008458 |
| LD | .4123876 | .1715112 | 2.40 | 0.024 | -.0591537 | .7656215 |

Secondly, we set up a VAR model in level and determine the appropriate maximum lag length (p) for the variables in the VAR (p) using the usual information criteria. In order to proceed to the causality analysis, the number of lags needed for the VAR model to be estimated is determined.

**Table 11 - Optimal number of lag for the VAR model in USA**

Selection-order criteria

Sample: 1993-2018 Number of obs = 26

| lag | LL | LR | df | p | FPE | AIC | HQIC | SBIC |
|---|---|---|---|---|---|---|---|---|
| 0 | 22.1793 | | | | .000726 | -1.55225 | -1.52438 | -1.45547 |
| 1 | 118.882 | 193.4 | 4 | 0.000 | 5.8e-07 | -8.68321 | -8.59961 | -8.39288 |
| 2 | 137.145 | 36.526 | 4 | 0.000 | 2.0e-07 | -9.78036 | -9.64102 | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 9.29648* |
| 3 | 142.323 | 10.356* | 4 | 0.035 | 1.8e-07* | -9.87097* | -9.67589* | -9.19353 |

Endogenous: lnME lnGDP
Exogenous: _cons

The lag length is selected based on the Akaike information criterion (AIC). The optimal number of lags is therefore 3 based on the AIC criterion and on most of the reported criteria. This show that the la length prior to the augmentation is determinate as 3 where used the appropriate lag of the model in five due to the condition of VAR (p+dmax).
To test the VAR model for the serial correlation in residuals
. quiet var lnGDP lnME, lags(1/5)

. varlmar

**Table 12 - Lagrange-multiplier test for VAR in USA**

Lagrange-multiplier test

| lag | Chi2 | df | Prob > chi2 |
|---|---|---|---|
| 1 | 4.1853 | 4 | 0.38150 |
| 2 | 8.2383 | 4 | 0.08323 |

$H_0$ : No autocorrelation at lag order
The results show that there is no serial correlation in residuals for our VAR model at 5% significance level.
Now, after we know that the value of *p+d*=5 for the VAR (unrestricted) and *p*=3 for the VAR (restricted), we will perform the Toda-Yamamoto Granger causality test as follows:

**Table 13- Toda-Yamamoto Granger causality test from lnME to lnGDP for USA**

| . test [lnGDP] L1.lnME [lnGDP] L2.lnME [lnGDP] L3.lnME | |
|---|---|
| (1) | [lnGDP]L.lnME = 0 |
| (2) | [lnGDP]L2.lnME = 0 |
| (3) | [lnGDP]L3.lnME = 0 |
| chi2( 3) = 8.28 | |
| Prob > chi2 = 0.0406 | |

The previous Toda-Yamamoto Granger causality test tests for Granger's causality from military spending to GDP.

**Tabella 14 - Toda-Yamamoto Granger causality test from lnGDP to lnME for USA**

| . test [lnME] L1.lnGDP [lnME] L2.lnGDP [lnME] L3.lnGDP | |
|---|---|
| (1) | [lnME]L.lnGDP = 0 |
| (2) | [lnME]L2.lnGDP = 0 |
| (3) | [lnME]L3.lnGDP = 0 |
| chi2( 3) = 12.87 | |
| Prob > chi2 = 0.0049 | |

The previous Toda-Yamamoto Granger causality test tests for Granger's causality from GDP to military spending.
From the analysis of Toda-Yamamoto Granger causality, it emerges that for the United States there is a causality from GDP to military expenditure and vice versa. From the results it would also seem that the Toda-Yamamoto causality of military expenditures is better explained by the GDP than the latter is explained by military expenditures. The causality of military expenditures towards the GDP is valid at the confidence level of 5%, but it is not valid at the confidence level of 1%, while the T-Y Granger causality from GDP to military expenditures for the United States is valid at the confidence levels of 5% and 1%. So I can

argue that over time there has been a mutually reinforcing relationship between economic growth and military expenditures.

## 5.5 Impulse response function (IRF) for United States

Considering that the results of the T-Y Granger causality test show a causality at confidence level of 5% and 1% from GDP to military expenditure, I decided to calculate the IRF, ordering the variables in this sense, i.e. first the GDP then the ME. However, in order to assess the reliability of the results the IRF was tested giving the reverse order to the variables. The results obtained are highlighted at the end of the paragraph.

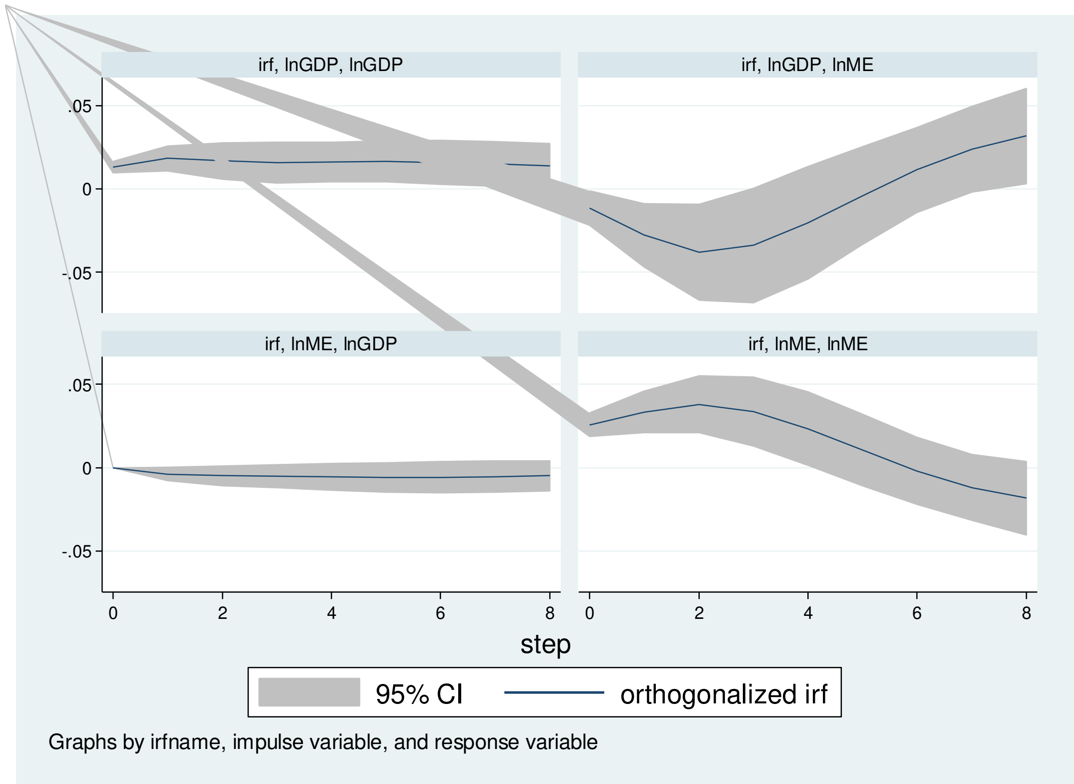


**Figura 7 Impulse response function for USA**

The horizontal axis for each graph is in the units of time that your VAR is estimated in, in this case years; hence, the impulse–response graph shows the effect of a shock over a 8-years period. The vertical axis is in units of the variables in the VAR; in this case, everything is measured in percentage points, so the vertical units in all panels are percentage point changes.

The first row shows the effect of a one-standard-deviation impulse to the GDP equation. A standard deviation shock to GDP leads to a decrease in military spending in the first year and up to the second, from the third year military spending starts to grow. The graphs is inside the 95% percent interval of confidence. Overall a shock to GDP will have negative impact on military expenditures in the short run and medium run (until the sixth year the graph is in the negative region), in the long run a shock to GDP will have a positive impact because the graph is in the positive region only after six years.

The second row shows the effect of a one-standard-deviation impulse to the ME equation. The first thing to notice is that the effect is zero in the current period (at zero lag). This is a direct result of our identification assumption: we imposed the condition that military expenditures has no immediate effect on GDP in order to identify the shocks. A standard deviation shock to ME however, does not seem to determine any significant change in GDP, which remains virtually stable throughout the period under consideration. Overall a shock to military expenditures will have a small but negative impact on GDP both in the short and long run because the graph is below but very near to the zero.

In conclusion, facing a GDP shock, American military expenditures have a negative impact on the short run and a positive impact in the long run, unlike the Chinese case, where a GDP shock will have always a

positive impact on ME. On the other side, a shock on military expenditures will have a small, but negative impact on the GDP on the short and long run in the US.
IRFs can be sensitive to the identification assumptions I make. I computed IRFs for alternative orderings and I find that the results are similar, then I gain confidence that my conclusions are not sensitive to the assumptions I make about contemporaneous causality.

## 5.6 Forecast-error variance decomposition (FEVDs) for the USA

**Table 15 - Results of the variance decomposition analysis for USA**

| | (1) | (1) | (1) | (2) | (2) | (2) | (3) | (3) | (3) |
|---|---|---|---|---|---|---|---|---|---|
| step | fevd | Lower | Upper | fevd | Lower | Upper | fevd | Lower | Upper |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | .171975 | -.092003 | .435952 | 0 | 0 | 0 |
| 2 | .971082 | .911445 | 1.03072 | .339208 | -.003784 | .674631 | .028918 | -.030719 | .088555 |
| 3 | .953239 | .848885 | 1.05759 | .424357 | .043614 | .8051 | .046761 | -.057594 | .151115 |
| 4 | .940635 | .8049 | 1.07637 | .447421 | .235508 | .871335 | .059365 | -.076369 | .1951 |
| 5 | .931025 | .77271 | 1.08934 | .44591 | -.00785 | .89967 | .068975 | -.08934 | .22729 |
| 6 | .92326 | .746723 | 1.0998 | .441468 | -.018679 | .901615 | .07674 | -.099797 | .253277 |
| 7 | .917482 | .72669 | 1.10827 | .449235 | .001953 | .896516 | .082518 | -.108275 | .27331 |
| 8 | .913756 | .525226 | 1.11424 | .474481 | .043793 | .90517 | .086244 | -.114244 | .286732 |

| | (4) | (4) | (4) |
|---|---|---|---|
| step | fevd | Lower | Upper |
| 0 | 0 | 0 | 0 |
| 1 | .828025 | .564048 | 1.092 |
| 2 | .660792 | .325369 | .996216 |
| 3 | .575643 | .1949 | .956386 |
| 4 | .552579 | .128665 | .976492 |
| 5 | .55409 | .10033 | 1.00785 |
| 6 | .558532 | .098385 | 1.01868 |
| 7 | .550765 | .103484 | .998047 |
| 8 | .525519 | .09483 | .956207 |

95% lower and upper bounds reported
(1) Irf name-irf, impulse-lnGDP, and response-lnGDP
(2) Irf name-irf, impulse-lnGDP, and response-lnME
(3) Irf name-irf, impulse-lnME, and response-lnGDP
(4) Irf name-irf, impulse-lnME, and response-lnME

The left-column panels(tables 1 and 3) show that (with the preferred identification assumption) the GDP shock contributes about 100% of the variance in the one-period-ahead forecast error for GDP, with the ME shock not contributing at all. As our forecast horizon moves further into the future, the effect of the ME shock on GDP increases just a little and the shares converge to more than 91% of variation in GDP being due to the GDP shock and less than 9% due to the ME shock. The right-column panels (tables 2 and 4) indicate that the GDP shock contributes about 17,2% of the variance in the one-period-ahead forecast error for ME , with the ME contributing to the other 82,8%. As our forecast horizon moves further into the future, the effect of the GDP shock on military expenditures increases and the shares converge to more than 47,4% of variation in ME being due to GDP shock and less than 52,6% due to ME shock. In any case it can be concluded that in the United States, military expenditures have zero impact in predicting GDP in the short term, and also in the long term the impact of military expenditures in predicting GDP is very low. Regarding the GDP's ability to predict military expenditure, it can be seen from the analysis that in the short run it is rather weak, not exceeding 20%, while in the long term (8) it reaches about 47%. So the percentage of an unexpected variation in ME produced by a shock from GDP in USA is not as high as it is in China where it reached about 72% in the long run. The results lead to assumptions about the possible existence of factors different from GDP, that could explain military spending in the United States, as supposed in the starting hypothesis.

Below is the graphical representation of the variance decomposition (FEVDs):

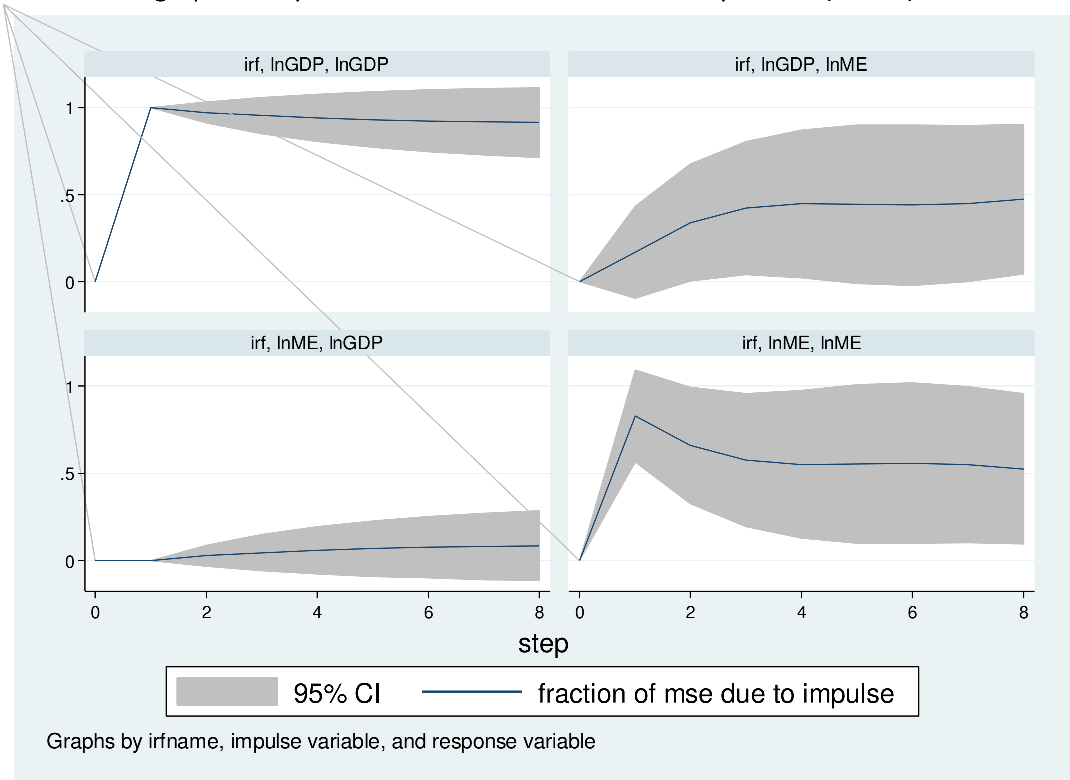


**Figure 8 Graphical representation of variance decomposition analysis for USA**

FEVDs like IRF, can be sensitive to the identification assumptions we make. I computed FEVDs for alternative orderings and I find that the results are similar, then I gain confidence that my conclusions are not sensitive to the assumptions I make about contemporaneous causality.

# 6 Summary and conclusions

The analysis carried out allows you to outline the following stylized facts:

a.

a) The Chinese military expenditure at constant prices is perfectly positive correlated with the GDP in the Chinese economy, while for the United States, there is an average correlation between the two variables considered. This result makes it possible to investigate whether there is causality between the two variables and the possible impact of such causality in the two countries considered. This aspect has been developped in the section dedicated to econometric analysis using three main tools: Toda-Yamamoto's approach to Granger's causality, the Impulse Response Function, and the Forecast Error Variance Decomposition.

b) A T-Y Granger causality test for China show that there is a causality from GDP to military expenditure, but not from military expenditure to GDP. This result confirms our starting hypothesis that the increase in Chinese military expenditures follows the exploit in GDP growth that characterizes this country. From the analysis of T-Y Granger causality test for USA, it emerges that there is a causality from GDP to military expenditure and vice versa. From the results it would also seem that the Toda-Yamamoto Granger causality of military expenditures is better explained by the GDP than the latter is explained by military expenditures. The causality of military expenditures towards the GDP is valid at the confidence level of 5%, but it is not valid at the confidence level of 1%, while the T-Y Granger causality from GDP to military expenditures for the United States is valid at the confidence levels of 5% and 1%. So from a political economy point of view I can argue that over time there has been a mutually reinforcing relationship between economic growth and military expenditures in the US.

c) The Chinese IRFs shows that overall a shock to GDP will have positive impact on military expenditures both in the short and in the long run because the graph is in the positive region and a shock to military expenditures will have a positive impact on GDP both in the short and long run because the graph is above the zero. In conclusion these results about the IRFs, are consistent with the a priory expectations because military expenditures grow following GDP shock, as hypothesized in our model and as inferred from the conclusions of T-Y Granger causality test. The USA IRFs shows that overall a shock to GDP will have negative impact on military expenditures in the short and medium run (until the sixth year the graph is in the negative region), in the long run a shock to GDP will have a positive impact because the graph is in the positive region only after six years. At the same time, a shock to military expenditures will have a negative impact on GDP both in the short and long run because the graph is below but near the zero.

d) From the FEVDs analysis for China the analysis shows that the percentage of an unexpected variation in ME produced by a shock from GDP is very high in the long run (72%). But the percentage of an unexpected variation in ME produced by a shock from GDP in USA is not as high as it is in China and it reached about 47% in the long run. So from the variance decomposition analysis I can conclude that the starting hypothesis is validated, in fact, in China, unlike the United States, the increase in military spending is essentially due to the increase in resources made available by China's economic boom. On the other hand, in the United States, the high military expenditure is explained only partly and to a limited extent by the variation in GDP, suggesting that there are other factors that can explain this variation. So I can conclude that the level of military expenditures in the United States is determined also by a strategic decision and not only by GDP trends, as I argued in my previous works (Gentilucci, 2019, 2013). This result could be the outcome of power interpenetrations, spanning from military spending to economic growth (or GDP) and from economic growth (or GDP) to military spending.

From the results of econometric analysis, it is possible to conclude that the increase in Chinese military expenditure, unlike American military expenditure, is strongly determined by the increase in GDP. For this reason, unlike what happens for American military expenditures, it could be argued that, the increase in Chinese military expenditures are the result of the country's economic growth and that this increase is, however, much lower than the increase in GDP. About the American military expenditures we can conclude that there are other factors than GDP, explaining American military expenditures. This achievement suggest that strategic dynamics in military expenditures are driven from GDP in China, but not in US. These results validate my staring hypothesis and enable a further and in-depth analysis of the causes and factors that determine the variation in US military spending. It seems, therefore, that in line with the arguments of Gentilucci (2019), military spending in the US follows a much more autonomous dynamic and at least partially independent from GDP trends.

At the same time, as pointed out above, these results are limited by the scope of the factors considered to explain the strategic dimension of military spending. Certainly, in order to fully understand the role of the military as a strategic factor in the two countries, it is necessary to evaluate many political, geographical and economic factors, which involve the analysis, among other things, of access to natural and strategic resources for the two countries. And this would be the subject of further research work.

# 7 Bibliography


Abu-Bader, S., & Abu-Qarn, A.S. (2003). Government Expenditures, Military Spending and Economic Growth: Causality Evidence from Egypt, Israel and Syria. *Journal of Policy Modeling*, 25(6-7), 567-583, https://doi.org/10.1016/S0161-8938(03)00057-7

Abu-Qarn, A.S. (2010). The defence–growth nexus revisited: evidence from the Israeli–Arab conflict, Defence and Peace Economics, 21(4), 291-300, https://doi.org/10.1080/10242694.2010.491699

Alexander, R. (1990). The Impact of Defence Spending on Economic Growth. A Multi-Sectoral Approach to Defence Spending and Economic Growth with Evidence from Developed Economies. *Defence Economics*, 2(1), 39-55, https://doi.org/10.1080/10430719008404677

Al-Yousif, Y.K. (2002). Defense spending and economic growth: Some empirical evidence from the Arab Gulf region. *Defence and Peace Economics*, 13(3), 187–197, https://doi.org/10.1080/10242690210977

Aminu, M.U., & Abu Bakar, A.S. (2015). Defence Expenditure and Economic Growth in Malaysia: An application of Toda Yamamoto Dynamic Granger Causality Test 1980-2014. *The Journal of Amity Business School*, 16(2), 24-31

Arvanitidis, P., & Kollias, C. (2016). Zipf's Law and World Military Expenditures. *Peace Economics, Peace Science and Public Policy,* 22(1), pages 41-71, https://doi.org/10.1515/peps-2015-0016

Atesoglu, H.S. (2002). Defense spending promotes aggregate output in the United States – Evidence from cointegration analysis. *Defence and Peace Economics*, 13(1), 55–60, https://doi.org/10.1080/10242690210963

Barro, R.J. (1990). Government spending in a simple model of endogenous growth. *Journal of Political Economy*, 98 (S5), 103-S126, https://doi.org/10.1086/26172

Beckley, M. (2012). China's century? Why America's edge will endure. *International Security*, 36(3), 41–78. https://doi.org/10.1162/ISEC_a_00066

Benoit, E. (1973). *Defense and economic growth in developing countries Boston*. Lexington Books.

Benoit, E. (1978). Growth and Defence in Developing Countries. *Economic Development and Cultural Change*, 26(2), 271-80, https://doi.org/10.1086/451015

Biswas, B., & Ram, R. (1986). ME and Economic Growth in LDCs: an augmented model and further evidence. *Economic Development and Cultural Change*, 34 (2), 361-372, https://doi.org/10.1086/451533

Chang, T., Fang, W., Wen, L.-F. & Liu, C., (2001). Defence spending, economic growth and temporal causality: evidence from Taiwan and mainland China, 1952-1995. *Applied Economics*, 33(10), pp. 1289-1299, DOI: 10.1080/00036840122529

Chang, T., Lee, C-C., Hung, K. & Lee, K-H. (2014). Does Military Spending Really Matter for Economic Growth in China and G7 Countries: The Roles of Dependency and Heterogeneity. *Defence and Peace Economics*, 25(2), 177-191, https://doi.org/10.1080/10242694.2013.763460

Chen, S., & Feffer, J. (2009). China's military spending: soft rise or hard threat?. *Asian Perspective, 33*(4), 47-67, https://doi.org/10.1353/apr.2009.0002

Chletsos, M., & Kollias, C. (1995). Defence Spending and Growth in Greece 1974-90: Some Preliminary Econometric Results. *Applied Economics*, 27(9), 883-890, https://doi.org/10.1080/00036849500000042

Coulomb, F., Hartley, K., & Intriligator, M. (2008). Pacifism in Economic Analysis: A Historical Perspective. *Defence and Peace Economics*, 19(5), 373-386, https://doi.org/10.1080/10242690802354378.

Cox, R.W. (2014). The Military-Industrial Complex and US Military Spending After 9/11. *Class, Race and Corporate Power*, 2(2), https://doi.org/10.25148/CRCP.2.2.6092117

Deger, S., & Smith, R. (1983). Military Expenditure and Growth in Less Developed Countries. *The Journal of Conflict Resolution, 27*(2), 335-353, https://doi.org/10.1177/0022002783027002006

Deger, S. (1986). Economic development and defense expenditure. *Economic Development and Cultural Change*, 35(1), pp. 179-196, https://doi.org/10.1086/451577

Dimitraki, O. and Menla Ali, F. (2013). The long-run causal relationship between military spending and economic growth in China: revisited, Defence and Peace Economics, 26(3), pp. 311-326, http://dx.doi.org/10.1080/10242694.2013

*Dunne, J., & Nikolaidou, E. (2005). Military Spending and Economic Growth in Greece, Portugal and Spain.* https://www.researchgate.net/publication/228553733_Military_Spending_and_Economic_Growth_in_the_Peripheral_Economies_of_Europe_A_Causal_Analysis_for_Greece_Spain_and_Portugal

Dunne, P., Nikolaidou, E., & Vougas, D. (2001). Defence Spending and Economic Growth: A Causal Analysis for Greece and Turkey. *Defence and Peace Economics*, 12(1), pp. 5-26, https://doi.org/10.1080/10430710108404974.

Dunne, J.P., & Smith, R.P. (1990). Military Expenditure and Unemployment in the OECD. *Defence Economics*, 1(1), 57-73, https://doi.org/10.1080/10430719008404650

Faini, R., Annez, P. & Taylor, L. (1984). Defence Spending, Economic Structure and Growth: Evidence among Countries and over Time. *Economic Development and Cultural Change*, 32(3), 487-498, https://doi.org/10.1086/451402

Feder, G. (1983). On Exports and Economic Growth. *Journal of Development Economics*, 12(1,2), 59-73, https://doi.org/10.1016/0304-3878(83)90031-7

Gentilucci, E. (2013). Dépenses militaires et dynamiques de restructuration du secteur de la défense. *Innovations*, 3(42), 109-125, http://doi.org/10.3917/inno.042.0109.

Gentilucci, E. (2019). US Military Spending: A Perspective on the Restructuring Dynamics of the Defense Sector. *Review of Radical Political Economics*, *51*(4), 606–628. https://doi.org/10.1177/0486613419844641

Gold, D. (1997). Evaluating the trade-off between military spending and investment in the United States. *Defence and Peace Economics*, 8(3), 251-266, https://doi.org/10.1080/10430719708404880

Granger, C.W.J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica. The Econometric Society*, 37 (3), 424-438, https://doi.org/10.2307/1912791

Hatemi-J, A., Chang, T., Chen, W., Lin, F-L. & Gupta, R. (2018). Asymmetric causality between military expenditures and economic growth in top six defense spenders. *Qual Quant,* 52, 1193–1207. https://doi.org/10.1007/s11135-017-0512-9

Herrera, R. & Gentilucci, E. (2013). Military Spending, Technical Progress, And Economic Growth. A Critical Overview On Mainstream Defense Economics. *Journal of Innovation Economics and Management*, 2(12), 37-57, https://doi.org/10.3917/jie.012.0013

Joerding, W. (1986). Economic Growth and Defence spending: Granger causality. *Journal of Development Economics*, 21(1), 35-40, https://doi.org/10.1016/0304-3878(86)90037-4

Karagol, E. & Palaz, S. (2004). Does defence expenditure deter economic growth in Turkey? A cointegration analysis. *Defence and Peace Economics*, 15(3), 289–298, https://doi.org/10.1080/10242690320001608908

Kinsella, D. (1990). Defence Spending and Economic Performance in the United States: A Causal Analysis. *Defence and Peace Economics*, 1(4), 295-309, https://doi.org/10.1080/10430719008404669

Kollias, C. (1997). Defence spending and growth in Turkey 1954–1993: A causal analysis. *Defence and Peace Economics*, 8(2), 189–204, https://doi.org/10.1080/10430719708404875

Kolias C., Manolas, G. & Paleologou, S-M. (2004). Defence expenditure and economic growth in the European Union: a causality analysis. *Journal of Policy* Modelling, 26(5), 553-569, https://EconPapers.repec.org/RePEc:eee:jpolmo:v:26:y:2004:i:5:p:553-569

Kollias, C. & Makrydakis, S. (2000). Tax and Spend or Spend and Tax? Empirical Evidence from Greece, Spain, Portugal and Ireland. *Applied Economics*, 32(5), 533-46, https://doi.org/10.1080/000368400322444

Kollias, C., Naxakis, C. and Zarangas, L. (2004a). Defence spending and growth in Cyprus: a causal analysis. *Defence and Peace Economics*, 15(3), 299-307, https://doi.org/10.1080/1024269032000166864

Lai, C.N., Huang, B.N. & Yang, C.W. (2005). Defense spending and economic growth across the Taiwan Straits: A threshold regression model. *Defence and Peace Economics*, 16(1), 45–57, https://doi.org/10.1080/1024269052000323542

Lee, W., Shot, L. & Hit, S. (2008). China as a Military Power and Its Implications for the USA and Taiwan. *Journal of Asian and African Studies*, 43(5), 523-542, https://doi.org/10.1177/0021909608094598

Lim, D. (1983). Another look at Growth and Defence in Developed Countries. *Economic Development and Cultural Change*, 31(2), 377-384, retrieved from http://repository.vtc.edu.hk/thei-adm-others-sp/8

Manchester, C. (2017). The Relationship Between Defense Expenditures and Economic Growth: A Granger Causality Approach. *Business/Business Administration*, 37, https://scholarsarchive.library.albany.edu/honorscollege_business/37

Mankiw, N.G., Romer, D. & Weil, D.N. (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics*, 107(2), 407-437, https://doi.org/10.2307/2118477

Meng, B., Lucyshyn, W. & Li, X. (2013). Defense expenditure and income inequality: evidence on co-integration and causality for China. *Defence and Peace Economics*, 26(3), 327-339, doi:10.1080/10242694.2013.810026.

F. Menla Ali & O. Dimitraki (2014) Military spending and economic growth in China: a regime-switching analysis. *Applied Economics*, 46(28), pp. 3408-3420, DOI:10.1080/00036846.2014.929626

Menyah, K., & Wolde-Rufael, Y. (2013). Government expenditure and economic growth: the ethiopian experience, 1950-2007. *The Journal of Developing Areas, 47*(1), 263-280, https://doi.org/10.1353/jda.2013.0015

Mintz, A. & Huang, C. (1990). Defence Expenditures, Economic Growth and the Peace Dividend. *American Political Science Review*, 84(4), 1283-1293, http://www.jstor.org/stable/1963264

Mintz, A. & Stevenson, R. (1995). Defence Expenditures, Economic Growth, and the "Peace Dividend". A Longitudinal Analysis of 103 Countries. *Journal of Conflict Resolution*, 39 (2), 283-305, https://doi.org/10.1177/0022002795039002004

Morales-Ramos, E. (2002). Defence R&D expenditure : The crowding-out hypothesis, *Defence and Peace Economics*, 13(5), 365-383, https://doi.org/10.1080/10242690213507

Murdoch, J., Pi, C-R., Sandler, T. (1997). The Impact of Defence and Non-Defence Public Spending on Growth in Asia and Latin America. *Defence and Peace Economics*, 8(2), 205-224, https://doi.org/10.1080/10430719708404876

Narayan, P.K. & Singh, B. (2007). Modelling the relationship between defense spending and economic growth for the Fiji Islands. *Defence and Peace Economics*, 18(4), 391-401, https://doi.org/10.1080/10242690600807924

Nikolaidou, E. (1998a, March 13-14). *Military Spending and Economic Growth in Greece: A Neoclassical Model, 1950-1996* [Paper presentation]. International Conference on "The Economics of Military Expenditure in Developing and Emerging Economies", *Middlesex University Business School*, London, United Kingdom

Ozun, A., & Erbaykal, E. (2014). Further Evidence On Defence Spending and Economic Growth in NATO Countries. *Economic Computation & Economic Cybernetics Studies & Research*, 48(2), 1-12.

Pradhan, R. P. (2010). Defence spending and economic growth in China, India, Nepal and Pakistan: evidence from cointegrated panel analysis. *International Journal of Economics and Finance*, 12, 65–74.

Raza, S.A., Shahbaz, M. & Paramati, S.R. (2017). Dynamics of Military Expenditure and Income Inequality in Pakistan. *Soc Indic Res*, 131, 1035–1055 https://doi.org/10.1007/s11205-016-1284-7

Romer, P.M. (2000). Keynesian macroeconomics without the LM Curve, *Journal of Economic Perspectives*, 14(2), 149-170.

Schwartz, H.M. (2019). American hegemony: intellectual property rights, dollar centrality, and infrastructural power. *Review of International Political Economy*, 26(3), 490-519, https://doi.org/10.1080/09692290.2019.1597754

Sezgin, S. (1996). Country Survey X: Defence Spending in Turkey. *Defence and Peace Economics*, 8, 381-409, https://doi.org/10.1080/10430719708404887

Smith, R. (1980). ME and Investment in OECD Countries, 1954-1973. *Journal of Comparative Economics*, 4, 19-32, https://EconPapers.repec.org/RePEc:eee:jcecon:v:4:y:1980:i:1:p:19-32

Smith, R. and Dunne, J.P. (2002). Military Expenditure Growth and Investment. Birkbeck College: Mimeo.

SIPRI (Stockholm International Peace Research Institute). (2020). *Yearbooks World Armament and Disarmament*. Oxford University Press.

Tang, J.H., Lai C-C. & Lin, E.S. (2009). Military Expenditure and Unemployment Rates: Granger Causality Tests using Global Panel Data. *Defence and Peace Economics*, 20(4), 253-268, https://doi.org/10.1080/10242690903105257

Taylor, J.B. (2000). Teaching modern macroeconomics at the principles level. *American Economic Review*, 90(2), 90-94. https://doi.org/*10.1257/aer.90.2.90*

Toda, H. & Yamamoto, T. (1995). Statistical Inference in Vector Autoregressions with Possibly Integrated Processes. *Journal of Econometrics*, 66(1-2), 225-250, https://doi.org/10.1016/0304-4076(94)01616-8

Madden, G.G. & Haslehurst, P.I. (1995), Causal analysis of Australian economic growth and military expenditures: A note. *Defence and Peace Economics*, 6(2), 115-121, https://doi.org 10.1080/10430719508404818

Ming, Z., Chang, T., Goswami. S., Gupta, R. & Lou, T-W. (2017). The nexus between military expenditures and economic growth in the BRICS and the US: an empirical note. *Defence and Peace Economics*, 28(5), 609-620, https://doi.org/10.1080/10242694.2016.1144897

Wolde-Rufael, M. (2014). Defence spending and income inequality in Taiwan. *Defence and Peace Economics*, 27(6), 871-884, https://doi.org/10.1080/10242694.2014.886436.

World Bank. (2020). *World Bank online Database 2020*. www.data.worldbank.org