

# Not Just Guns or Butter, but What Came First—Guns or Butter? Introducing GVAR to International Relations

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## Abstract

Power remains a crucial concept in international relations. In recent decades a prevailing notion became present in the literature explaining that economic power is a prerequisite for all other forms of power (military, political and cultural). Yet, such an assumption has never been properly tested. To test this assumption, the paper introduces a new time-series method to political science—Global Vector Auto-regression (GVAR). While the method is widely used in economics, it has not been employed in political science. The method should be appealing to scholars in political science since it enables big-N and big-T hypotheses tests. We also present Granger-causality tests within the context of GVAR and test if economic power is a prerequisite for military power. Our results suggest that the role of the economy has changed through history. Namely, in 19th century it was the military power that drove (Granger-caused) the economy; yet, since 1955 the roles are reversed.

**Keywords**— time series; IPE; GVAR; IR

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## POWER: ASSUMED BUT UNTESTED

*“Power is the ultimate aphrodisiac”*

Kissinger (1973)

Since the dawn of social and political science, *power* has been a key concept of multiple research projects (Lasswell and Kaplan 1950). In recent decades a prevailing notion became present in international relations, which sometimes takes the shape of a latent assumption (Kennedy 1989; Luttwak 1990; Fukuyama 1992; Nau 1995; Kirshner 1997; Gilpin 2001; Brooks 2005; Ikenberry 2011). The argument is neatly summed by Organski, who claimed that economic power is a prerequisite for all other power capabilities: without a strong economy a dominant state stagnates and declines (Organski 1958, 299-306). However, this claim has never been properly tested. For instance, Mearsheimer (2001, Ch. 3) dedicates a whole chapter to explain how latent power matters to military power,<sup>1</sup>. Yet his explanation remains untested.

We believe that if the literature offers assumptions about the nature of power while proposing causal mechanisms between power factors—military, economic, political and cultural (Mann 1986)—then it should also provide empirical evidence about those. We focus one of these assumptions, particularly, that economic power is a *prerequisite* of all other power factors.

This paper contributes to the literature by introducing Global Vector Autoregression (GVAR) methods to international relations. While panel-data methods handle well numerous panels (countries) within relatively short timespan, and time-series methods do the same but for longer timespan but for small panels (usually just one), GVAR perform statistically well with both big  $N$  and long  $T$ . In particular, we show how Granger-causality tests (C. W. J. Granger 1969) within the framework of GVAR methods should shed some light on the power prerequisite assumption. In this paper we focus solely on the (Granger) causal relation between *economic* and *military* powers. We hypothesize that pre-WWI it was military power that Granger-caused economic power—greater military led to greater economic power. Conversely, we expect that post WWII economic power Granger-caused military power.

The paper proceeds as follows. First, [section I](#) discusses the concept of power by particularly focusing on the relationship between economic and military power. In [section II](#) we present actual time-series data on economic and military power for the maximum possible number of available

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ies. I think  
we should  
change op-  
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do is to ex-  
amine the  
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panels. The section also shows Granger-causality tests within the GVAR framework. We also show some simulations. Finally in section V we propose future research avenues regarding this scientific inquiry.

did we?

did we?

## I. CONCEPTUALIZING POWER

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## II. INTRODUCING THE GVAR METHODOLOGY

GVAR was introduced in M. Pesaran, Schuermann, and S. M. Weiner (2004). It “was developed in the aftermath of the 1997 Asian financial crisis to quantify the effects of macroeconomic developments on the losses of major financial institutions.” The main feature of GVAR is that it “take[s] into account the various interlinkages in the global economy in the context of a truly multicountry setting” (H. Pesaran, Schuermann, and S. Weiner 2004, 139) by incorporating a large number of panels (“big  $N$ ”) for long time-spans (“big  $T$ ”) which are weighted by exogenous factors such as bilateral trade.

While GVAR has been widely used in economics (Favero 2013; Mauro, Filippo, and Pesaran 2013; Chudik and Pesaran 2016; Eickmeier and Ng 2015) its characteristics are also appealing for political science. Therefore, it is ideal for testing relations between economic and military power in a truly global setting. Yet, to our knowledge, the GVAR method has not been used or introduced in political science so far. In the rest of the paper we do so by rephrasing the famous dilemma about whether governments should allocate resources to finance “guns” (military power) or “butter” (economic power or economic development in general).

Global vector auto-regressive models (GVAR) are a special category of vector auto-regressive models (VAR). Following Box-Steffensmeier et al. (2014, 164), define a VAR model as follows,

$$\mathbf{x}_{it} = \boldsymbol{\alpha}_i + \boldsymbol{\Phi}_i \mathbf{x}_{i,t-p} + \mathbf{u}_{it} \quad (1)$$

where  $\mathbf{x}_{it}$  is a  $k_i \times 1$  vector of endogenous variables which are lagged  $p$  times on the right-hand side, and where  $E(\mathbf{u}_{it}) = 0$ . Now, following Mauro and Pesaran (2013, 14), define a GVAR model with  $p$  lags for country  $i$  as follows,

$$\mathbf{x}_{it} = \boldsymbol{\alpha}_i + \boldsymbol{\Phi}_i \mathbf{x}_{i,t-p} + \boldsymbol{\Lambda}_{1i} \mathbf{W}_{x,t} + \boldsymbol{\Lambda}_{2i} \mathbf{W}_{x,t-p} + \mathbf{u}_{it} \quad (2)$$

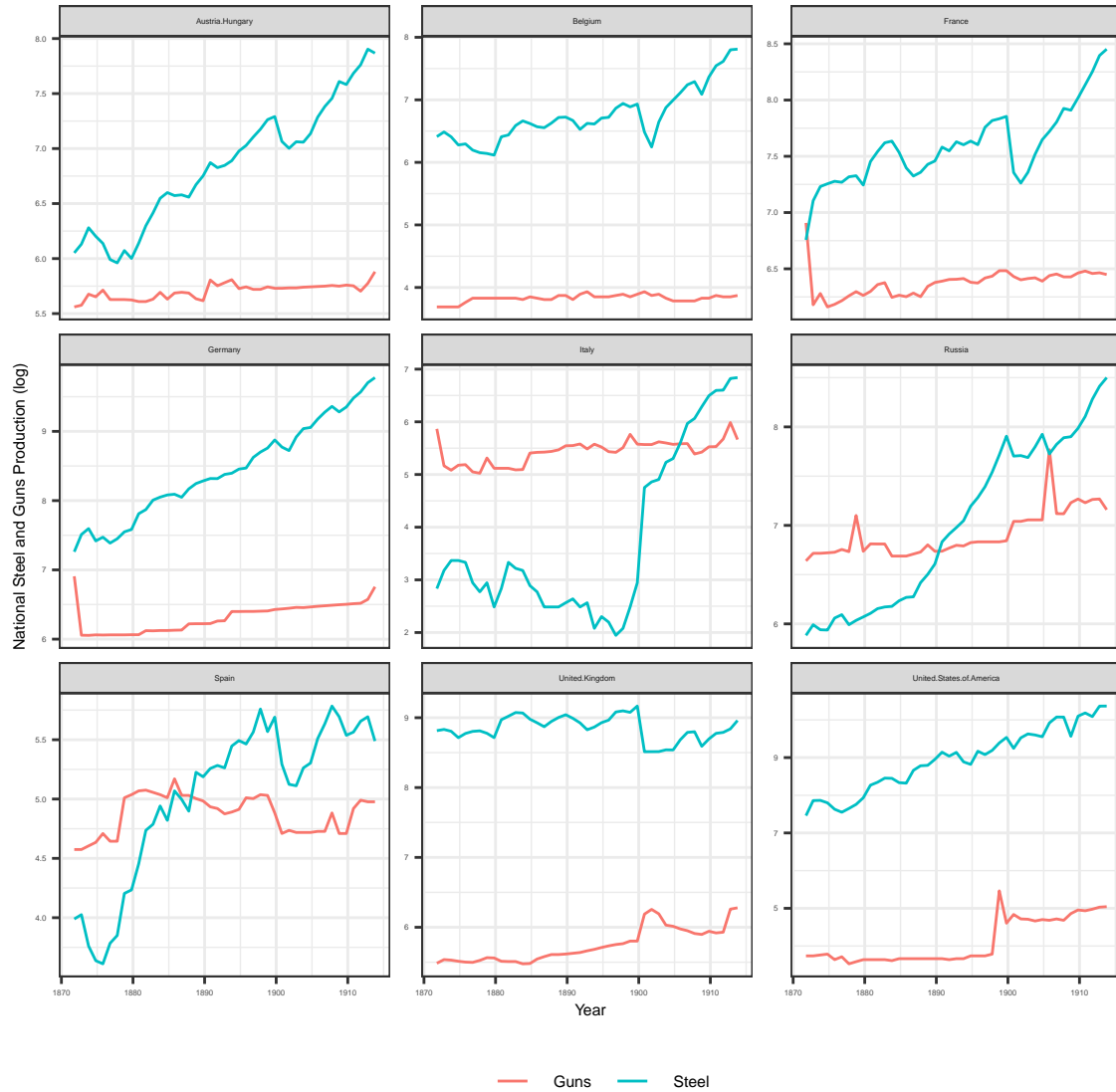
where  $\mathbf{x}_{it}$  is a  $k_i \times 1$  vector of domestic (i.e. endogenous) variables,  $\mathbf{W}_t$  is a  $k_i \times 1$  vector of weakly-exogenous foreign variables, and  $\mathbf{u}_{it}$  is a serially uncorrelated and cross-sectionally weakly dependent process.

As it becomes apparent, the inclusion of foreign variables  $\mathbf{W}_t$  in Equation 2 is one of the main characteristics of the GVAR approach, and the main difference with the VAR equation described in Equation 1. As explained by others “[t]hrough the use of foreign variables, the GVAR is able to account for bilateral inter-relationships amongst countries, and therefore control for spillovers on the basis of cross-country exposure.”<sup>2</sup> We detail in section III that to construct  $\mathbf{W}_t$  we employ bilateral trade—but the particular choice of exogenous variable depends on the application. In simple, the Global vector autoregressive GVAR model in Equation 2 explains  $\mathbf{x}_{i,t}$  as a function of past values  $\mathbf{x}_{i,t-p}$  lagged  $p$  times, at the same time that it weights these dynamics by weakly-exogenous foreign variables  $\mathbf{W}_{t-p}$  (weights which are captured by parameters  $\mathbf{\Lambda}_{ni}$ ). Note that the exogeneity of  $x$  is obtained by multiplying this term by the weights matrix  $\mathbf{W}_t$ , both with its current values and  $p$  lagged values.

**Granger-causality tests** Since we are substantively interested in whether “guns” (Granger) *cause* “butter” or the other way around, in this paper we estimate country-specific bivariate Granger-causality tests within the GVAR framework.<sup>3</sup> The Granger-causality method was introduced by C. Granger (1969) and seeks to investigate if some variable  $X$  (Granger) “causes” another variable  $Y$ , or the other way around. A variable  $X$  is said to “Granger-cause”  $Y$  if predictions of  $Y$  based on lagged values of  $Y$  and lagged values of  $X$  perform better than explaining  $Y$  just with its own past values.

Since Granger-causality tests are usually estimated via VAR equations (Equation 1) we now derive the Granger-causality test within the GVAR framework. The substantive advantage of GVAR Granger-causality tests over regular Granger-causality tests is that estimates are weighted by the global economy ( $\mathbf{W}_t$  in Equation 2), situating the domestic dynamics within the global context. More formally, we estimate a GVAR Granger-causality system for every country  $i$  with  $p$  lags as shown in Equation 3. Likewise, note that the exogeneity of  $x$  and  $y$  are obtained by multiplying each by the weights matrix  $\mathbf{W}_t$ , both with its current values and  $p$  lags.

More formally, we estimate the following GVAR Granger-causality tests:



**Figure 1: National Steel and Guns Production (log), 1871-1913.**

**Note:** Variables are “*milper*” and “*irst*.” Both were obtained from Singer, Bremer, and Stuckey (1972).

$$\begin{aligned}
\mathbf{x}_{it} &= \alpha_i + \Phi_{1i}\mathbf{y}_{i,t-p} + \Phi_{2i}\mathbf{x}_{i,t-p} + \Lambda_{1i}\mathbf{W}_{x,t} + \Lambda_{2i}\mathbf{W}_{x,t-p} + \Lambda_{3i}\mathbf{W}_{y,t} + \Lambda_{4i}\mathbf{W}_{y,t-p} + \mathbf{u}_{it} \\
\mathbf{y}_{it} &= \alpha_i + \Phi_{1i}\mathbf{x}_{i,t-p} + \Phi_{2i}\mathbf{y}_{i,t-p} + \Lambda_{1i}\mathbf{W}_{y,t} + \Lambda_{2i}\mathbf{W}_{y,t-p} + \Lambda_{3i}\mathbf{W}_{x,t} + \Lambda_{4i}\mathbf{W}_{x,t-p} + \mathbf{u}_{it}
\end{aligned} \tag{3}$$

where the only added complexity is the introduction of a second variable ( $y$ ), but the lag and weight structure remains the same as in Equation 2.

### III. DATA

We operationalize military and economic power using variables from the Correlates of War Project, particularly, the National Material Capabilities dataset (Singer, Bremer, and Stuckey 1972).<sup>4</sup> To proxy for military power we use the “military personnel” variable and to proxy for economic power we use the “iron and steel production” variable. Figure 1 portrays the values of the two variables used in our model by country between 1871 and 1913. Let military power be  $\mathbf{x}_{it}$  and economic power be  $\mathbf{y}_{it}$  in Equation 3. To construct the weight matrix  $\mathbf{W}$  we use the *Bilateral Trade Data* from the same database that is used when operationalizing the domestic variables (Barbieri and O. M. Keshk 2016). This dataset covers all countries in the world between 1816-2012. Since we are interested in analyzing the longest ( $T$ ) and the widest ( $N$ ) dataset possible, using the COW dataset seemed the most obvious choice.

Relatedly, in order to maximize the extension of the dataset, it was necessary to split it in two. Since wars typically not only redraw country borders but also end, merge or split countries, the most efficient way of having the least missing data possible was partitioning the dataset in two. We believe that while GVAR methods offer interesting properties for scholars in international relations in general, there is the inevitable issue of missingness: not all countries remain observed, especially, during long periods of times. The biggest concern is that the ones that do remain observed are systematically different from the ones that do not. For instance, it is reasonable to expect that countries that cease to exist were weaker economically, politically and militarily. Missing data is not a new problem and there are several ways to cope with this issue, for instance, multiple imputation. However we leave possible solutions for this problem for future research.

cite something

While the need for splitting the dataset in two was empirical, the cut points were decided based

on theory and history. The hope is to take theoretical advantage of an empirical problem. In fact, both timespans conform our two working hypotheses. The first period is between 1871 and 1913. The time spread is rather obvious—unification of Germany and the beginning of World War I. The second period of our analysis takes place between 1955 and 2012. As it is evident, there is a considerable gap between 1913 and 1955. At the risk of sounding repetitive, a country needs to remain available for the whole time. Even if just one year is missing then that particular country cannot be considered. To be sure, balanced panels are not a GVAR requirement but rather a general statistical need in most TS-PD models.

briefly justify second period in one sentence

With these two timespan, we hypothesize the following:

**Hypothesis 1.** *Between 1871 and 1913 military power Granger causes economic power.*

and

**Hypothesis 2.** *Between 1955 and 2012 economic power Granger causes military power.*

Nevertheless, we suspect that the nature of relations between economic and military power would be reversed in this period. This is not due to the technological advancement of the military, but rather due to the changed nature of the economy. The latter became finance driven, which is detached from the real economy. Namely, exponential growth of trade, Foreign Direct Investments, and monetary transactions altogether all attribute to the growth of monetary velocity (Cagan and Schwartz 1987), the creation of international banking consortia—by 1971 90% of 50 world’s biggest banks had become a part of broader and larger conglomerates (Ganoe 1972), and “by the end of 1970s financial flow size dwarfed trade flows by 25:1 and they were much more volatile” (Gilpin 2011) therefore, today 99% of all financial transactions are short term-speculative transactions. All this contributes to the fact that the economy is not only adjacent to the strategic interactions of states, but in fact has become its own domain of power relations among states.<sup>5</sup> Subsequently, we hypothesize:

Figure 2 displays the values of the two variables used in our model by country from 1955 and 2012.

When it comes to the foreign or global variable that determines the structure of international relations in our model, we have opted for dyadic trade data, which is available also for the period in 19th century. This variable was constructed by the same project but in the Trade dataset (Barbieri, Keshk, and Pollins 2009; Barbieri and O. Keshk 2016)<sup>6</sup> and was used to construct the weight matrix

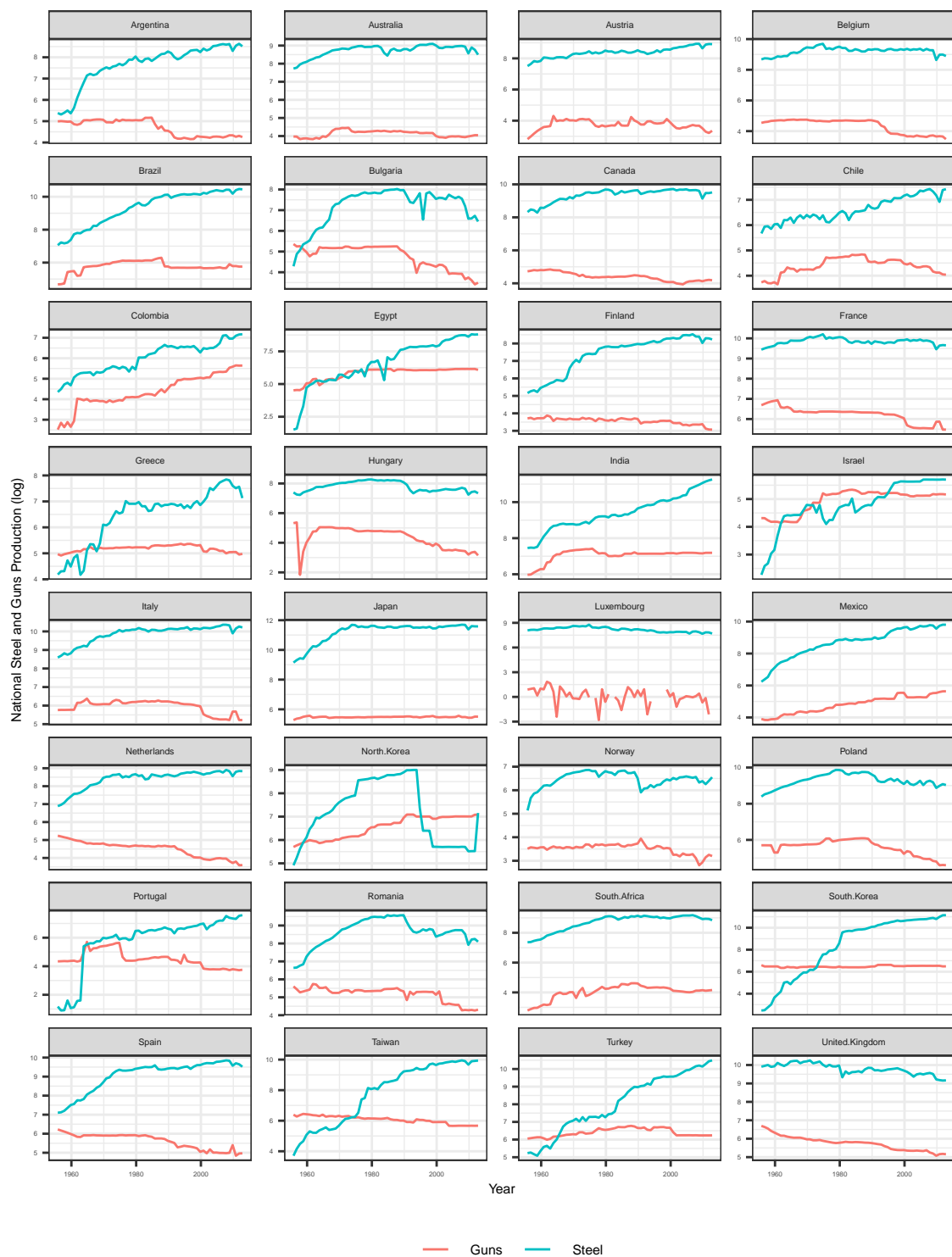


Figure 2: National Steel and Guns Production<sup>7</sup>, 1955-2012.

Note: Variables are "milper" and "irst." Both were obtained from Singer, Bremer, and Stuckey (1972).



$\mathbf{W}$ . The matrix is a square matrix which has all  $K$  countries in both its columns and rows with zeros as diagonal elements. The matrix represents bilateral trade among two countries measured by the *flow1* and the *flow2* variables. The former measures imports from a country (*importer1*) to another country (*importer2*), and the latter measures the reverse dyad, i.e. imports from *importer2* to *importer1*. More formally,  $\mathbf{W}$  contains  $t$  sub-matrices (one sub-matrix per year) with dimensions  $k \times k$  for a total of  $\mathbf{K}$  countries such that,

$$\mathbf{W}_t = \begin{bmatrix} & \mathbf{i}_1 & \mathbf{i}_2 & \mathbf{i}_3 & \dots & \mathbf{i}_K \\ \mathbf{i}_1 & 0 & f_{21} & f_{31} & \dots & i_{K1} \\ \mathbf{i}_2 & f_{12} & 0 & f_{32} & \dots & i_{K2} \\ \mathbf{i}_3 & f_{13} & f_{23} & 0 & \dots & i_{K3} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \mathbf{i}_K & f_{1K} & f_{2K} & f_{3K} & \dots & i_{KK} \end{bmatrix}$$

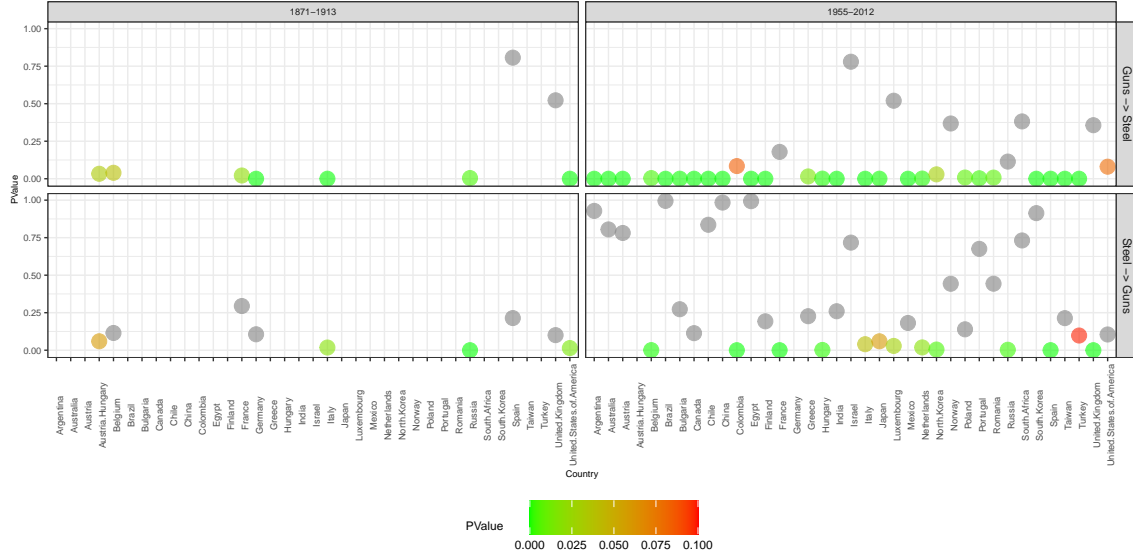
Every  $W_t$  matrix weights all  $K$  country-specific Granger regressions described in Equation 3. Every  $K$  system is weighted by the other  $K - 1$  countries. And as Equation 3 shows, the GVAR methodology also considers  $p$  lags of the  $\mathbf{W}$  matrix. Following the literature on Granger-causality tests we focus our attention model-specific f-tests (one per country) which tests if all variables in the model are jointly significant. Then null is that there is no Granger causality.

#### IV. RESULTS

Figure 3 shows country-specific p-values of the Granger-causality f-tests obtained when fitting Equation 3 (detailed results shown in the Appendix section, particularly Table A1, Table A2 and Table A3).

The plot shows that during the 1871 – 1913 period, in 44% of the countries economic power Granger-caused military power. Yet, interestingly, this percentage drops to 38% and 33% for the great power during the 1955 – 2012 period. On the other hand, in the same second period in 46% of the countries military power Granger-caused economic power.

Hence, we have failed to reject 1, which was expected. However, our results have rejected 2, which was not. Therefore, the results speak in favor of persistent dominance of the military power among the power factors.



**Figure 3: P-Values of the Country-specific Granger-causality F-Tests, 1871-2012.**

**Note:** Plot shows country-specific p-values of the Granger-causality f-tests obtained when fitting Equation 3 (detailed results shown in Table A1, Table A2 and Table A3). The plot shows that during the 1871-1913 period, in 44% of the countries, steel Granger-caused guns. This percentage changes to 38% and to 33% for the hegemonic countries during the 1955-2012 period.

As such, military power has passed the most likely and the most difficult case test. Namely, the first period presents itself as the most likely case for the military power be the prerequisite for the economic power. Furthermore, the second period can be labeled as the most difficult case for the military power. And conversely for the economic power. Its dominance was rejected by both the least likely and the most likely case. Where the second period presents the most likely case and the first one the most difficult case.<sup>7</sup>

## V. DISCUSSION

The present research project makes two contributions to the broader International Relations literature. First, we test the general assumption that the economic power is the prerequisite for all other power factors. Second, we introduce to Political Science a new time series method—GVAR.

Our preliminary results indicate that the assumption of economic power dominance, which is so often and with ease made by scholars, is at least dubious, and flawed at best. In fact, the military power Granger-causes economic power in both periods—19th and 20th century.

However, future iterations of this project are necessary to be fully confident in such a result and conclusion. First, we need to enhance our model to also include military expenditures and energy consumption. Second, robustness checks using different time frames and imputation needs to be performed as well. Third, a comparison of results using GVAR with PVAR method would be beneficial. Namely, the amount of countries whose data is available for 19th century would still be classified as a small N. Thus, PVAR would also be appropriate method to be used for this period with small N. Consequently, we would expect that for 19th century conclusions from PVAR and GVAR would be the same, whereas for 20th century the conclusions would differ due to the big N in that period.

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## VI. APPENDIX

### I. Appendix

**Table A1:** *Bivariate Goba Granger Causality Tests of the World Political Economy, 1871-1913*

	Granger Relationship	F-Test	P-Value	DF	Adjusted R-sq	Lags
Austria-Hungary	butter $\rightarrow$ guns	2.16	0.06	8,31	0.192	1
	guns $\rightarrow$ butter	2.48	0.03	8,31	0.233	
Belgium	butter $\rightarrow$ guns	1.781	0.11	16,19	0.263	5
	guns $\rightarrow$ butter	2.339	0.04	16,19	0.38	
France	butter $\rightarrow$ guns	1.27	0.29	8,31	0.052	1
	guns $\rightarrow$ butter	2.72	0.02	8,31	0.261	
Germany	butter $\rightarrow$ guns	1.844	0.11	8,31	0.148	1
	guns $\rightarrow$ butter	7.891	0	8,31	0.586	
Italy	butter $\rightarrow$ guns	2.777	0.02	16,19	0.448	5
	guns $\rightarrow$ butter	6.801	0	16,19	0.726	
Russia	butter $\rightarrow$ guns	8.725	0	16,19	0.779	5
	guns $\rightarrow$ butter	3.595	0	16,19	0.543	
Spain	butter $\rightarrow$ guns	1.454	0.21	8,31	0.085	1
	guns $\rightarrow$ butter	0.554	0.81	8,31	-0.101	
United Kingdom	butter $\rightarrow$ guns	1.85	0.1	16,19	0.28	5
	guns $\rightarrow$ butter	0.966	0.52	16,19	-0.016	
United States	butter $\rightarrow$ guns	2.942	0.01	8,31	0.285	1
	guns $\rightarrow$ butter	8.608	0	8,31	0.609	

Table shows country-specific Granger-causality F-tests. Last column shows number of domestic lags used per every country-specific Granger model. Number of lags for endogenous variables = 2. Number of lags for foreign variables = 2. Max number of lags for estimating the country-specific VAR model = 5. Information criteria for optimal lag length = AIC. Deterministic variables: Trend and constant.



**Table A2: Bivariate Goba Granger Causality Tests of the World Political Economy, 1955-2012 (A)**

	Granger Relationship	F-Test	P-Value	DF	Adjusted R-sq	Lags
Argentina	butter → guns	0.422	0.93	10,44	-0.12	1
	guns → butter	7.765	0	10,44	0.556	
Australia	butter → guns	0.629	0.8	12,41	-0.092	2
	guns → butter	5.618	0	12,41	0.511	
Austria	butter → guns	0.656	0.78	12,41	-0.084	2
	guns → butter	7.305	0	12,41	0.588	
Belgium	butter → guns	3.842	0	12,41	0.392	2
	guns → butter	3.001	0	12,41	0.312	
Brazil	butter → guns	0.237	0.99	12,41	-0.209	2
	guns → butter	9.498	0	12,41	0.658	
Bulgaria	butter → guns	1.269	0.27	12,41	0.057	2
	guns → butter	4.286	0	12,41	0.427	
Canada	butter → guns	1.69	0.11	10,44	0.113	1
	guns → butter	5.055	0	10,44	0.429	
Chile	butter → guns	0.561	0.84	10,44	-0.088	1
	guns → butter	7.313	0	10,44	0.539	
Colombia	butter → guns	4.855	0	18,32	0.581	5
	guns → butter	1.737	0.08	18,32	0.21	
Egypt	butter → guns	0.219	0.99	10,44	-0.169	1
	guns → butter	5.471	0	10,44	0.453	
Finland	butter → guns	1.428	0.19	12,41	0.088	2
	guns → butter	5.041	0	12,41	0.478	
France	butter → guns	8.235	0	16,35	0.694	4
	guns → butter	1.442	0.18	16,35	0.122	
Greece	butter → guns	1.344	0.23	18,32	0.11	5
	guns → butter	2.39	0.02	18,32	0.334	
Hungary	butter → guns	3.363	0	12,41	0.349	2
	guns → butter	3.711	0	12,41	0.38	
India	butter → guns	1.287	0.26	14,38	0.072	3
	guns → butter	6.048	0	14,38	0.576	
Israel	butter → guns	0.702	0.72	10,44	-0.058	1
	guns → butter	0.63	0.78	10,44	-0.073	
Italy	butter → guns	2.151	0.04	10,44	0.176	1
	guns → butter	11.365	0	10,44	0.657	
Japan	butter → guns	1.876	0.06	16,35	0.216	4
	guns → butter	4.079	0	16,35	0.491	
Luxembourg	butter → guns	2.296	0.03	10,44	0.194	1
	guns → butter	0.925	0.52	10,44	-0.014	
Mexico	butter → guns	1.436	0.18	16,35	0.12	4
	guns → butter	8.525	0	16,35	0.702	
Netherlands	butter → guns	2.483	0.02	10,44	0.216	1
	guns → butter	3.73	0	10,44	0.336	
North Korea	butter → guns	2.875	0	18,32	0.403	5
	guns → butter	2.143	0.03	18,32	0.292	
Norway	butter → guns	1.02	0.44	10,44	0.004	1
	guns → butter	1.122	0.37	10,44	0.022	
Poland	butter → guns	1.57	0.14	12,41	0.114	2
	guns → butter	2.745	0.01	12,41	0.283	
Portugal	butter → guns	0.749	0.68	10,44	-0.049	1
	guns → butter	3.265	0	10,44	0.296	
Romania	butter → guns	1.019	0.44	10,44	0.004	1
	guns → butter	2.878	0.01	10,44	0.258	
South Africa	butter → guns	0.686	0.73	10,44	-0.062	1
	guns → butter	1.102	0.38	10,44	0.019	
South Korea	butter → guns	0.448	0.91	10,44	-0.114	1
	guns → butter	9.019	0	10,44	0.598	
Spain	butter → guns	4.66	0	10,44	0.404	1
	guns → butter	4.92	0	10,44	0.421	
Taiwan	butter → guns	1.382	0.21	12,41	0.08	2
	guns → butter	5.667	0	12,41	0.514	
Turkey	butter → guns	1.696	0.1	14,38	0.158	3
	guns → butter	25.426	0	14,38	0.868	
United Kingdom	butter → guns	9.085	0	10,44	0.6	1
	guns → butter	1.139	0.36	10,44	0.025	

Table shows country-specific Granger-causality F-tests. Last column shows number of domestic lags used per every country-specific Granger model. Number of lags for endogenous variables = 3. Number of lags for foreign variables = 3. Max number of lags for estimating the country-specific VAR model = 5. Information criteria for optimal lag length = AIC. Deterministic variables: Trend.

**Table A3:** *Bivariate GobaI Granger Causality Tests of the World Political Economy, 1955-2012 (B)*

	<b>Granger Relationship</b>	<b>F-Test</b>	<b>P-Value</b>	<b>DF</b>	<b>Adjusted R-sq</b>	<b>Lags</b>
China	butter → guns	0.252	0.98	9,45	-0.142	2
	guns → butter	83.191	0	9,45	0.932	
Russia	butter → guns	3.663	0	7,48	0.253	1
	guns → butter	1.775	0.11	7,48	0.09	
United States	butter → guns	1.821	0.1	7,48	0.095	1
	guns → butter	1.961	0.08	7,48	0.109	

Table shows country-specific Granger-causality F-tests. Last column shows number of domestic lags used per every country-specific Granger model. Number of lags for endogenous variables = 2. Number of lags for foreign variables = 2. Max number of lags for estimating the country-specific VAR model = 5. Information criteria for optimal lag length = AIC. Deterministic variables: NA.

## NOTES

1. They described it as perhaps the most fundamental power, whereas Elster (1976, 245-70, 249) is even more assertive arguing that power is the most important single idea in political theory.
2. International Monetary Fund (2016, 17).
3. We acknowledge that without proper experimentation and randomization there cannot be proper causation. Consequently, and following the Granger methodology, we employ a rather loose definition of “causation” and explore if lagged values of a variable *forecast* another variable.
4. Version 5.0.
5. On the issue, see Luttwak (1990), Csurgai (2009), and Blackwill and Harris (2016).
6. Version 4.0.
7. On most and least likely case research design see Levy (2008).