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Abstract

This is the abstract.

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I. Modelling "Steel and Guns" in a Global Setting: Presenting the GVAR Methodology

I. GVAR: Country-specific Equations and Granger-causality Tests

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,

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

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,

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

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. 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 $\boldsymbol{\Lambda}_{ni}$).

Since we are substantively interested in weather "guns" *cause* "steel" or the other way around, in this paper we estimate country-specific bivariate Granger-causality tests within the GVAR framework.[1] The Granger-causality method was introduced in Granger (1969) and it 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 by fitting 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, situating the domestic dynamics within the global context. More formally, we estimate the following GVAR Granger-causality system for every country i with p lags as follows:

$$\mathbf{x}_{it} = \boldsymbol{\alpha}_i + \boldsymbol{\Phi}_{1i}\mathbf{y}_{i,t-p} + \boldsymbol{\Phi}_{2i}\mathbf{x}_{i,t-p} + \boldsymbol{\Lambda}_{1i}\mathbf{W}_t + \boldsymbol{\Lambda}_{2i}\mathbf{W}_{t-p} + \boldsymbol{\Lambda}_{3i}\mathbf{W}_t + \boldsymbol{\Lambda}_{4i}\mathbf{W}_{t-p} + \mathbf{u}_{it} \tag{3}$$

$$\mathbf{y}_{it} = \boldsymbol{\alpha}_i + \boldsymbol{\Phi}_{1i}\mathbf{x}_{i,t-p} + \boldsymbol{\Phi}_{2i}\mathbf{y}_{i,t-p} + \boldsymbol{\Lambda}_{1i}\mathbf{W}_t + \boldsymbol{\Lambda}_{2i}\mathbf{W}_{t-p} + \boldsymbol{\Lambda}_{3i}\mathbf{W}_t + \boldsymbol{\Lambda}_{4i}\mathbf{W}_{t-p} + \mathbf{u}_{it} \tag{4}$$

In our case, the vector $\mathbf{x}_{it}$ contains country-year levels of "military personnel," while vector $\mathbf{y}_{it}$ contains country-year levels of "iron and steel production." Both variables were systematized by the Correlates of War Project, particularly, the National Material Capabilities dataset (Singer, Bremer, and Stuckey 1972).[2] The dataset covers all countries in the world between 1816-2012.

Also, the vector of foreign variables is the single variable "dyadic trade" which measures bilateral trade flows between two countries. This variable was constructed by the same project but in the Trade dataset (Barbieri, Keshk, and Pollins 2009; Barbieri and Keshk 2016)[3] and was used to construct the weight matrix $\mathbf{W}$. The matrix is a square matrix which has all countries in both its columns and rows with zeros as diagonal elements. The matrix represents bilateral trade among two countries. Every country is weighted by the other remaining countries. As Equation 3 shows, the GVAR methodology also considers p lags for the $\mathbf{W}$ matrix. More formally, $\mathbf{W}$ contains t sub-matrices (one matrix per year) with dimensions $k \times k$ for a total of $\mathbf{K}$ countries such that,

$$\mathbf{W}_t = \begin{array}{cc} & \begin{array}{ccccc} \mathbf{i}_1 & \mathbf{i}_2 & \mathbf{i}_3 & \dots & \mathbf{i}_K \end{array} \\ \begin{array}{c} \mathbf{i}_1 \\ \mathbf{i}_2 \\ \mathbf{i}_3 \\ \vdots \\ \mathbf{i}_K \end{array} & \begin{bmatrix} 0 & |i_1 - i_2| & |i_1 - i_3| & \dots & i_{1K} \\ |i_2 - i_1| & 0 & |i_2 - i_3| & \dots & i_{2K} \\ |i_3 - i_1| & |i_3 - i_2| & 0 & \dots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \vdots & \vdots & \vdots & \dots & i_{KK} \end{bmatrix} \end{array}$$

This means that the dynamics of every i country-specific systems of equations are weighted t times. Also note that bilateral trade is the geometric distance (i.e. the absolute value) between countries i for all K countries. Following the literature on Granger-causality, we focus our attention on the joint hypothesis

inflows out-flows?

f tests

add Deterministic variables to table (trend, constant)

II. Results

Table 1: *Bivariate Gobal Granger Causality Tests of the World Political Economy, 1871-1913*

	Granger Relationship	F-Test	P-Value	DF	Adjusted R-sq	Lags
Austria-Hungary	steel → guns	2.441	0.017	8,31	0.228	1
	guns → steel	1.394	0.238	8,31	0.075	
Belgium	steel → guns	4.636	0.001	10,28	0.489	2
	guns → steel	3.114	0.017	10,28	0.357	
France	steel → guns	1.438	0.257	8,31	0.082	1
	guns → steel	2.112	0.095	8,31	0.186	
Germany	steel → guns	4.468	0.003	8,31	0.416	1
	guns → steel	8.412	0.022	8,31	0.603	
Italy	steel → guns	4.485	0.004	10,28	0.478	2
	guns → steel	5.048	0	10,28	0.516	
Russia	steel → guns	11.067	0	16,19	0.821	5
	guns → steel	2.436	0.034	16,19	0.396	
Spain	steel → guns	1.036	0.126	8,31	0.007	1
	guns → steel	0.493	0.214	8,31	-0.116	
United Kingdom	steel → guns	3.621	0.023	16,19	0.545	5
	guns → steel	1.334	0.284	16,19	0.132	
United States	steel → guns	3.197	0.044	8,31	0.311	1
	guns → steel	5.405	0	8,31	0.475	

Table 2: *Bivariate Gobal Granger Causality Tests of the World Political Economy, 1955-2014 (A)*

	Granger Relationship	F-Test	P-Value	DF	Adjusted R-sq	Lags
Argentina	steel → guns	0.83	0.568	7,48	-0.022	1
	guns → steel	5.463	0	7,48	0.362	
Australia	steel → guns	0.764	0.649	9,45	-0.041	2
	guns → steel	6.141	0	9,45	0.461	
Austria	steel → guns	0.633	0.726	7,48	-0.049	1
	guns → steel	2.587	0.024	7,48	0.168	
Belgium	steel → guns	3.557	0.002	9,45	0.299	2
	guns → steel	3.159	0.005	9,45	0.265	
Brazil	steel → guns	0.472	0.91	11,42	-0.123	3
	guns → steel	7.741	0	11,42	0.583	
Bulgaria	steel → guns	0.844	0.58	9,45	-0.027	2
	guns → steel	6.111	0	9,45	0.46	
Canada	steel → guns	1.418	0.22	7,48	0.05	1
	guns → steel	2.71	0.019	7,48	0.179	
Chile	steel → guns	0.251	0.969	7,48	-0.105	1
	guns → steel	6.929	0	7,48	0.43	
Colombia	steel → guns	3.581	0.001	15,36	0.432	5
	guns → steel	2.904	0.004	15,36	0.359	
Egypt	steel → guns	0.29	0.955	7,48	-0.099	1
	guns → steel	2.89	0.013	7,48	0.194	
Finland	steel → guns	1.808	0.093	9,45	0.119	2
	guns → steel	7.975	0	9,45	0.538	
France	steel → guns	1.16	0.343	13,39	0.039	4
	guns → steel	1.639	0.116	13,39	0.138	
Greece	steel → guns	2.344	0.023	11,42	0.218	3
	guns → steel	2.894	0.006	11,42	0.282	
Hungary	steel → guns	2.798	0.011	9,45	0.231	2
	guns → steel	3.664	0.002	9,45	0.308	
India	steel → guns	0.476	0.847	7,48	-0.072	1
	guns → steel	10.531	0	7,48	0.548	
Israel	steel → guns	0.761	0.622	7,48	-0.031	1
	guns → steel	0.804	0.588	7,48	-0.026	
Italy	steel → guns	1.48	0.169	13,39	0.107	4
	guns → steel	3.83	0.001	13,39	0.414	
Japan	steel → guns	2.542	0.015	11,42	0.242	3
	guns → steel	4.007	0.001	11,42	0.384	
Luxembourg	steel → guns	3.596	0.003	7,48	0.248	1
	guns → steel	0.865	0.541	7,48	-0.018	
Mexico	steel → guns	1.286	0.262	13,39	0.067	4
	guns → steel	7.102	0	13,39	0.604	
Netherlands	steel → guns	3.758	0.001	9,45	0.315	2
	guns → steel	3.73	0.001	9,45	0.313	
North Korea	steel → guns	2.828	0.006	13,39	0.314	4
	guns → steel	2.508	0.013	13,39	0.274	
Norway	steel → guns	1.497	0.178	9,45	0.076	2
	guns → steel	0.701	0.704	9,45	-0.052	
Poland	steel → guns	0.623	0.734	7,48	-0.05	1
	guns → steel	3.36	0.005	7,48	0.231	
Portugal	steel → guns	1.059	0.404	7,48	0.007	1
	guns → steel	3.492	0.004	7,48	0.241	
Romania	steel → guns	0.969	0.464	7,48	-0.004	1
	guns → steel	4.438	0.001	7,48	0.304	
South Africa	steel → guns	0.375	0.912	7,48	-0.086	1
	guns → steel	0.857	0.547	7,48	-0.019	
South Korea	steel → guns	0.355	0.924	7,48	-0.089	1
	guns → steel	7.729	0	7,48	0.461	
Spain	steel → guns	4.538	0.001	7,48	0.31	1
	guns → steel	3.829	0.002	7,48	0.265	
Taiwan	steel → guns	1.882	0.064	13,39	0.181	4
	guns → steel	5.251	0	13,39	0.515	
Turkey	steel → guns	1.56	0.157	9,45	0.085	2
	guns → steel	19.467	0	9,45	0.755	
United Kingdom	steel → guns	18.12	0	7,48	0.685	1
	guns → steel	1.06	0.404	7,48	0.008	

Table 3: *Bivariate Gobal Granger Causality Tests of the World Political Economy, 1955-2014 (B)*

	Granger Relationship	F-Test	P-Value	DF	Adjusted R-sq	Lags
China	steel → guns	0.238	0.996	13,39	-0.235	4
	guns → steel	64.667	0	13,39	0.941	
Russia	steel → guns	3.59	0.003	7,48	0.248	1
	guns → steel	2.453	0.031	7,48	0.156	
United States	steel → guns	1.845	0.1	7,48	0.097	1
	guns → steel	2.085	0.063	7,48	0.121	

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II. Appendix

I. Info that goes into the Appendix