Title

Héctor Bahamonde *[1] and

Name Lastname †[2]

[1]Assistant Professor, O′Higgins University (Chile)

[2]Position, Institution

July 30, 2020

Abstract

This is the abstract.

Keywords— time series, IPE, IR

Work in progress. Please don't cite.

*hector.bahamonde@uoh.cl; `www.HectorBahamonde.com`.

†hector.bahamonde@uoh.cl; `http://www.hectorbahamonde.com`.

We both thank Tsung-wu Ho.

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,

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

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 $\mathbf{W}_{i,t-p}$ (weights which are captured by parameters $\boldsymbol{\Lambda}_i$).

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:

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

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

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 $\mathbf{W}_t$. 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 $\mathbf{W}_t$ matrix. More formally, $\mathbf{W}_t$ contains t sub-matrices with dimensions $i \times i$.

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

Following the literature on Granger-causality, we focus our attention on the joint hypothesis 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	2.834	0.017	8,31	0.273	1
	guns → steel	1.393	0.238	8,31	0.075	
Belgium	steel → guns	4.216	0.001	10,28	0.458	2
	guns → steel	2.759	0.017	10,28	0.316	
France	steel → guns	1.35	0.257	8,31	0.067	1
	guns → steel	1.907	0.095	8,31	0.157	
Germany	steel → guns	3.827	0.003	8,31	0.367	1
	guns → steel	2.694	0.022	8,31	0.258	
Italy	steel → guns	3.61	0.004	10,28	0.407	2
	guns → steel	5.039	0	10,28	0.515	
Russia	steel → guns	10.499	0	16,19	0.813	5
	guns → steel	2.423	0.034	16,19	0.394	
Spain	steel → guns	1.749	0.126	8,31	0.133	1
	guns → steel	1.454	0.214	8,31	0.085	
United Kingdom	steel → guns	2.674	0.023	8,31	0.256	1
	guns → steel	1.29	0.284	8,31	0.056	
United States	steel → guns	2.254	0.044	10,28	0.248	2
	guns → steel	5.528	0	10,28	0.544	

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

	Granger Relationship	F-Test	P-Value	DF	Adjusted R-sq	Lags
Argentina	steel → guns	1.072	0.402	9,45	0.012	1
	guns → steel	6.222	0	9,45	0.465	
Australia	steel → guns	0.996	0.466	11,42	-0.001	2
	guns → steel	3.564	0.001	11,42	0.347	
Austria	steel → guns	0.694	0.736	11,42	-0.068	2
	guns → steel	2.526	0.015	11,42	0.24	
Belgium	steel → guns	4.525	0	13,39	0.468	3
	guns → steel	1.012	0.459	13,39	0.003	
Brazil	steel → guns	0.19	0.997	11,42	-0.202	2
	guns → steel	5.779	0	11,42	0.498	
Bulgaria	steel → guns	0.606	0.813	11,42	-0.089	2
	guns → steel	3.202	0.003	11,42	0.314	
Canada	steel → guns	1.531	0.157	11,42	0.099	2
	guns → steel	3.517	0.002	11,42	0.343	
Chile	steel → guns	0.294	0.973	9,45	-0.133	1
	guns → steel	5.678	0	9,45	0.438	
China	steel → guns	0.13	0.999	9,45	-0.17	1
	guns → steel	25.707	0	9,45	0.805	
Colombia	steel → guns	3.422	0.001	17,33	0.452	5
	guns → steel	1.719	0.089	17,33	0.196	
Egypt	steel → guns	0.19	0.994	9,45	-0.156	1
	guns → steel	2.639	0.015	9,45	0.215	
Finland	steel → guns	1.504	0.154	17,33	0.146	5
	guns → steel	2.994	0.003	17,33	0.404	
France	steel → guns	1.456	0.194	9,45	0.071	1
	guns → steel	2.438	0.024	9,45	0.193	
Greece	steel → guns	1.35	0.232	11,42	0.068	2
	guns → steel	1.917	0.064	11,42	0.16	
Hungary	steel → guns	3.568	0.001	11,42	0.348	2
	guns → steel	4.868	0	11,42	0.445	
India	steel → guns	0.45	0.9	9,45	-0.101	1
	guns → steel	7.349	0	9,45	0.514	
Israel	steel → guns	1.405	0.201	13,39	0.092	3
	guns → steel	1.291	0.259	13,39	0.068	
Italy	steel → guns	0.386	0.936	9,45	-0.114	1
	guns → steel	1.142	0.355	9,45	0.023	
Japan	steel → guns	2.783	0.006	17,33	0.377	5
	guns → steel	2.074	0.036	17,33	0.267	
Luxembourg	steel → guns	5.861	0	17,33	0.623	5
	guns → steel	1.483	0.162	17,33	0.141	
Mexico	steel → guns	2.421	0.014	17,33	0.326	5
	guns → steel	4.269	0	17,33	0.526	
Netherlands	steel → guns	4.03	0	13,39	0.431	3
	guns → steel	1.771	0.084	13,39	0.162	
North Korea	steel → guns	3.9	0.001	11,42	0.376	2
	guns → steel	5.135	0	11,42	0.462	
Norway	steel → guns	0.786	0.684	15,36	-0.067	4
	guns → steel	1.26	0.276	15,36	0.071	
Poland	steel → guns	0.597	0.792	9,45	-0.072	1
	guns → steel	1.487	0.182	9,45	0.075	
Portugal	steel → guns	0.678	0.724	9,45	-0.057	1
	guns → steel	1.59	0.147	9,45	0.089	
Romania	steel → guns	0.753	0.659	9,45	-0.043	1
	guns → steel	2.089	0.051	9,45	0.154	
Russia	steel → guns	2.955	0.008	9,45	0.246	1
	guns → steel	1.032	0.43	9,45	0.005	
South.Africa	steel → guns	0.323	0.963	9,45	-0.127	1
	guns → steel	1.282	0.273	9,45	0.045	
South Korea	steel → guns	0.306	0.969	9,45	-0.131	1
	guns → steel	7.079	0	9,45	0.503	
Spain	steel → guns	3.799	0.001	13,39	0.412	3
	guns → steel	1.347	0.229	13,39	0.08	
Taiwan	steel → guns	2.099	0.05	9,45	0.155	1
	guns → steel	2.644	0.015	9,45	0.215	
Turkey	steel → guns	1.617	0.139	9,45	0.093	1
	guns → steel	10.103	0	9,45	0.603	
United Kingdom	steel → guns	10.371	0	9,45	0.61	1
	guns → steel	0.994	0.459	9,45	-0.001	
United States	steel → guns	1.527	0.168	9,45	0.081	1
	guns → steel	2.986	0.007	9,45	0.249	

References

Barbieri, Katherine, and Omar Keshk. 2016. "Correlates of War Project Trade Data Set Codebook, Version 4.0." http://correlatesofwar.org.

Barbieri, Katherine, Omar Keshk, and Brian Pollins. 2009. "TRADING DATA: Evaluating our Assumptions and Coding Rules." *Conflict Management and Peace Science* 26 (5): 471–491.

Box-Steffensmeier, Janet, John Freeman, Matthew Hitt, and Jon Pevehouse. 2014. *Time Series Analysis for the Social Sciences.* Cambridge University Press.

Granger, Clive. 1969. "Investigating Causal Relations by Econometric Models and Cross-spectral Methods." *Econometrica* 37 (3): 424.

Mauro, Filippo di, and Hashem Pesaran. 2013. *The GVAR Handbook: Structure and Applications of a Macro Model of the Global Economy for Policy Analysis.* 1st, edited by Filippo di Mauro and Hashem Pesaran. Oxford University Press.

Singer, David, Stuart Bremer, and John Stuckey. 1972. *Capability Distribution, Uncertainty, and Major Power War, 1820-1965,* edited by Bruce Russett, 19–48. Sage.

Word count: 641

II. Appendix

I. Info that goes into the Appendix