THE RELATIONSHIP BETWEEN NUCLEAR POWER AND MILITARY EXPENDITURES: A PANEL DATA ANALYSIS

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Overview

This paper seeks to explain the dynamics of nuclear power since the early 1990s following the collapse of the Soviet Union. Since its early days, in the 1950s, nuclear power has been a controversial issue: Nuclear power emerged as the "child of science and warfare" (Lévêque, 2015), in the victory countries of the war, i.e. the USA, the USSR, the UK and France, later on also in China; since then, nucler power has been developed at the intersection of military use and electricity generation. With the failure of nuclear power as a competitive means of electricity generation, pressure on the sector to generate scope economies (i.e. military and "civil" purposes) has increased. Today, most of the countries maintaining nuclear power for electricity generation also have a large, and sometimes growing, military sector and military expenditures at the same time reached 1739 billion in 2017; the highest level since the end of the cold war (SIPRI, 2018). Nine out of the ten countries with the highest military expenditures are using nuclear power for civilian purposes and Saudi Arabia is excepted to use nuclear power by 2040. Six out of those ten are nuclear-weapon states and most of them weapons had nuclear weapons well before they had civilian nuclear power indicating that nuclear power is developed for both military and civilian purposes. Moreover, Fuhrmann and Tkach (2015) showed that 60% of enrichment and reprocessing facilities have been built exclusively for military purposes and only 40% served civilian purposes. Against this background, this paper analyzes the relationship between military expenditures of a country and its civilian use of nuclear power. Our hypothesis, is that military expenditures and nuclear energy generation sources are jointly determined.

Data and Methodology

This paper empirically analysis the relationship between between military expenditures and the deployment of electricity produced by nuclear energy using data from the World Bank. In total, 27 countries are included in the analysis which produce electricity by nuclear sources in every year over the period 1993 to 2014. The selection of variables however determines country and time dimension. The panel is strongly balanced which is a necessary condition for the application of the econometric methods. We use the following linear regression models:

Model 1: $\ln(N_t)=\alpha_i+\beta 1_{it}\ln(M)+\beta 2_{it}\ln(C)+\beta 3_{it}\ln(E)+e_{it}$

Model 2: $\ln(N_t)=\alpha_i+\beta 1_{it}\ln(M)+\beta 2_{it}\ln(C)+\beta 3_{it}\ln(E)+\beta 4_{it}\ln(Y)+e_{it}$

Model 3: $\ln(N_t)=\alpha_i+\beta 1_{it}\ln(M)+\beta 2_{it}\ln(C)+\beta 3_{it}\ln(E)+\beta 4_{it}\ln(T)+e_{it}$

Our dependent variable (**N**) is electricity production from nuclear sources measured as the share in total electricity production. We use the following explanatory variables: our main variable of interest, military expenditures (**M**), is measured in percentage of GDP. As nuclear power plants are acknowledged to be capital intensive, we control for gross fixed capital formation (**C**) measured in constant 2010 USD. Moreover, we control for electric power consumption (**E**) measured in kWh per capita, GDP per capita (**Y**), and trade-openness (**T**) which is defined as the sum of exports and imports of goods and services measured as a share of gross domestic product. All variables are in logarithm to reduce heteroscedasticity. This paper uses a panel autoregressive distributed lag (ARDL) model developed by Pesaran et al. (1999) to obtain the coefficients. Moreover, we apply the Dumitrescu and Hurlin (2012) panel causality tests to further identify the causal relationship between military expenditures and electricity production from nuclear sources. As this methodology requires stationarity of all the variables involved, we apply the test on the variables in first differences. Thus, we determine the direction (unidirectional or bidirectional) of short-run causality between the variables.

Preliminary results

The table below reports the results of the pooled mean group (PMG) estimation and the Dumitrescu and Hurlin (2012) panel causality test:

		All-income			*High-income*			*Non high-income*		
		Model 1	***Model 2***	***Model 3***	***Model 1***	***Model 2***	***Model 3***	***Model 1***	***Model 2***	***Model 3***
Long-run	***M***	0.128***	0.074***	0.237***	0.135***	-0.395***	-0.754***	0.538***	2.049***	0.578***
	C	-0.164**	0.142**	-0.128**	-0.305***	-0.462**	-0.134	-0.095**	0.068	-0.105**
	E	0.342***	0.953***	0.308***	0.574***	0.614***	2.115***	0.279***	3.375***	0.255***
	Y	-	-0.756***	-	-	-1.740***	-	-	-3.398***	-
	T	-	-	0.123**	-	-	-1.992***	-	-	0.124
Short-run	***ECM***	-0.303***	-0.287***	-0.304***	-0.256***	-0.238***	-0.126**	-0.420***	-0.158	-0.416***
	ΔM	0.320	0.592	0.735	0.775	1.22	1.322	-0.618	-0.601	-0.373
	ΔC	-0.417	-0.691	-0.489	0.017	-0.048	-0.083	-1.220	-1.716	-1.129
	ΔE	0.397	-0.130	0.494	0.156	0.099	-0.032	0.729	-0.225	0.834
	ΔY	-	1.116	-	-	0.924*	-	-	1.761	-
	ΔT	-	-	-0.068	-	-	0.185	-		-0.344
	Const.	0.040	0.388*	-0.077	-0.229**	4.224***	-0.910**	-0.123	0.359**	-0.250
Dumitrescu and Hurlin (2012) panel causality test										
H0: N does not homogeneously cause M		1.23*			0.62			1.31**		
H0: M does not homogeneously cause N		1.14*			1.84***			2.46**		

Notes: *,**, and *** indicate significance at the 10%, 5%, and 1% levels respectively. I use the PMG estimation technique in any model. The decision which estimator to chose is based on the results of Hausman (1987) specification tests. For the Dumitrescu and Hurlin (2012) panel causality test, the Z-bar value is displayed.

The estimated coefficients on military expenditures (**M**) are positive and statistically significant at the 1% level in any specification except for both model 2 and model 3 for the high-income panel, where the signs of the coefficients for military expenditures are negative. Dependeing on the specification and panel, a 1% increase in military expenditures is associated with a 0.07% to 2.05% increase in electricity production from nuclear sources. The Dumitrescu and Hurlin (2012) panel causality tests resulst indicate that bidirectional causality between military expenditures and electricity production from nuclear sources exist except for the high-income panel: We are able to reject both of the homogeneous non-causality (absence of causality) null hypothesis indicating that in the short-run, military expenditures and electricity production from nuclear sources are jointly determined.

Preliminary conclusions

The preliminary empirical results indicate that linkages between the civilian use of nuclear power and inceasing miliatarization impede a nuclear phase out. The race of militarization increases energy consumption (Bildirici, 2017) and similarly, a strong domestic civil nuclear sector is necessary for the military sector to provide experts and expertise, nuclear Navy requirements, and to develop small reactors which potentially can power domestic bases and operational units abroad. Our empirical results tends to be driven by by the non high-income panel consisting of Bulgaria, Brazil, China, India, Mexico, Pakistan, Russia, South Africa, and Ukraine.

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