Free Riding Reconsidered: The Influence of Space and Time on NATO Member States' Defence Spending

Ringailė Kuokštytė[1] and Vytautas Kuokštis[2]

[1]General Jonas Žemaitis Military Academy of Lithuania
[2]Institute of IR and Political Science, Vilnius University

August 30, 2023

Abstract

Concerns over free riding are widespread in alliances, in particular NATO. An intuitive approach to analyzing free riding is treating it as spatial interdependence between the allies: How does a country's defence spending react to changes in its allies' military expenditures? Recent work has found a significant negative response for NATO allies and implied that the alliance suffers from substantial free riding. However, this research does not quantify the concerned effect. Furthermore, it does not adequately account for temporal dependence, which risks bias in the parameter of spatial interdependence. Directly accounting for temporal dependence provides a meaningfully different picture of the within-alliance dynamics, revealing that the long-run effect of free riding is indeed more significant than its short-run effect, as suggested by static spatial (autoregressive) models. We discuss the relevant practical and theoretical implications.

Keywords: Free riding, NATO member states, spatial interdependence, long-run spatial effects

1 Introduction

Does belonging to a military alliance induce free riding? More concretely, do NATO members free ride and, if so, to what extent? The relevance of this latter question, in particular, clearly extends beyond academia. Former US President Trump was perhaps the most explicit and vocal in blaming allies for free riding and in calling for substantially ramping up military spending. Yet he was by no means an exception (e.g., Duchin 1992). Notwithstanding the US officials' discourse, there is little consensus on the nature and magnitude of free riding.

This matters not only politically but also militarily and strategically. Crucially, free riding and its extent have implications for the Alliance's deterrence posture in the face of heightened military threats from Russia.

An intuitive strategy to operationalize free riding is treating it as an endogenous spatial lag (George and Sandler 2018; Yesilyurt and Elhorst 2017). That is, it is expected to manifest as a systematic pattern of negative spatial interdependence, whereby an average NATO member decreases its own defence spending in response to other allies' increased military expenditures. The spatial aspect commonly refers to the physical distance between the allies because a closer ally's defence spending is likely to matter more.

The political economy literature on NATO allies' defence spending has made important contributions but still suffers from two important weaknesses. First, it does not require the researcher to systematically account for temporal dynamics, as a consequence of which free riding behavior risks mischaracterization. Omitting autoregressive temporal dependence limits the phenomenon to a short-run perspective alone, although there are good reasons to expect that the full free riding effect manifests gradually over time. Second, the literature does not provide the quantitative magnitude of free riding. Put simply, even if we are convinced by the static estimates of free riding behavior (i.e. that countries freeride), we do not know how much NATO member states free ride. There is therefore a huge missed opportunity in the literature to extract pertinent information from the statistical results (King et al. 2000; Drolc et al. 2019). Ultimately, both of these issues hinder our efforts to fully appreciate the inter-ally dynamics in NATO.

Using the latest methodological insights from the time-series cross-section (TSCS) literature, we show that the short-run effect of free riding in NATO, once we account for temporal dependence, manifests an inflation bias, thus making one reconsider the prior findings. However, in the long run, it turns out to be significantly more substantial. These findings, together with the estimated magnitude of actual free riding in NATO as well as the display of its dynamics over time, offer novel insights with important implications for policy discussions and academic research.

2 Existing Findings

Free riding is related to the concept of public goods. To the extent that security created by alliances is non-excludable and non-rival in consumption, we might expect members to free ride on others' expenditures (Olson and Zeckhauser 1966).

Theoretically, the concept of free riding is quite clear; yet its operationalization is not straightforward.[1] Researchers have mostly analyzed NATO. They have tried to capture free riding by looking at whether smaller members spend less on defence in proportion to GDP (Alley 2021; Kim and Sandler 2020); how countries respond to increasing military expenditure on behalf of the US (e.g., Spangler 2018); or whether and how NATO allies historically reacted to increased threats from potential adversaries, notably the Soviet Union (Plümper and Neumayer 2015).

An intuitive strategy to operationalize free riding consists of treating it as an endogenous spatial lag (see Yesilyurt and Elhorst 2017). In the case of free riding, we would expect spatial interdependence in defence spending to be negative, meaning that when other allies increase their military expenditures, a specific country is likely to decrease its own. The fundamentally strategic nature of these dynamics implies the presence of spatial interdependence (Drolc et al. 2019: 5; Cook et al. 2020; Flores 2011).

Research on NATO allies' defence spending has seen important methodological improvements. Recently, there have been a few studies that, using spatial econometric techniques, specifically address spatial interdependence among NATO allies' defence spending (George and Sandler 2018, 2022; Kim and Sandler 2023),[2] rather than worldwide patterns of military expenditures which tend to point to arms race (Yesilyurt and Elhorst 2017; Goldsmith 2007). According to the authors of these recent studies, their research "present[s] the first spatial-based estimates of NATO allies' demand for defense spending" (George and Sandler 2018, 223; emphasis added).

The core takeaway from this research is a negative and statistically significant spatial interdependence among NATO allies' defence expenditures. While the implied substantive interpretation is that free riding is prevalent and substantial, this interpretation suffers from two significant limitations. First, temporal dependence is omitted. Second, a substantively meaningful estimate of the free riding effect is not provided.

3 The Need to Directly Adjust for Spatiotemporal Dependencies

The vast majority of research based on TSCS data considers either the temporal dimension or the spatial one as a source of dependence. As noted by Cook et al. (2022: 1), only a meager percentage of such articles in top political science journals have been concerned with "model[ing] both temporal and spatial dependence directly."

[1] E.g., Lanoszka (2015) offers an enlightening discussion of different ways to understand free riding.

[2] See also their similar analysis on EU military expenditure (George and Sandler 2021).

Fixed effects (FE) have often been used to adjust for the underspecified dimension, that is, to correct for either within-country (across time) or within-period (across units) correlation (see Cook et al. 2022). However, by incorporating FE, one imposes a specific structure of correlation (e.g., time-invariant spatial clustering in the case of unit FE, or homogenous period-based shocks in the case of time FE). Other solutions to deal with spatial correlation (assuming the temporal dimension has been correctly specified), including regional indicators or the method of panel-corrected standard errors (PCSE) (Beck and Katz 1995), do not resolve the distinctive challenges of two-dimensional data analysis either.

Spatial lags capture autoregressive patterns – this implies that units influence other units in a decaying manner and thus allows for this influence to manifest as more diffuse, for instance, without it being constrained to a pre-defined region (Cook et al. 2022: 18). Another aspect of diffusion which characterizes spatial autoregressive processes is its global spillovers, meaning that units affect other units beyond their (direct) neighbors (e.g., Yesilyurt and Elhorst 2017: 788). Furthermore, the very logic of correcting standard errors (the PCSE case) prevents us from any theoretical insight into how space and time interact to define the outcome of interest.

Inadequate attention to modeling the spatial and temporal dimensions jointly leads to biased estimates of the dependence parameters (notably, overestimation of the included parameter if the other is omitted) and also biases the covariates' coefficients, as well as their effects (Cook et al. 2022, 2–4). Lately, therefore, there has been a notable methodological shift aimed at directly modeling space and time (Cook et al. 2022). This shift is no longer solely reliant on an empirical perspective (e.g., Yesilyurt and Elhorst 2017), but is backed by theoretical insights and analytical evidence.

Beyond the relevant methodological concerns, researchers are also interested in providing a substantive interpretation of the phenomenon of interest. Yet the lack of attention to spatiotemporal dependence compromises this endeavor (Cook et al. 2022), as there is a high risk that the researcher has failed to identify an exact mechanism that underlies the spatially- and temporally-correlated data they observe. Even if a researcher is only interested in accurately modeling instantaneous spatial interdependence, neglecting the temporal dimension is likely to result in a biased coefficient of the spatial parameter, as well as inaccurate covariates' estimates, thus impairing the validity of inferences and the theoretical scope of the analysis.

There are strong reasons to expect that military spending, like other forms of budgetary expenditure, has considerable persistence over time (see, e.g., Cantekin et al. 2022). While certain authors have effectively incorporated such "habit persistence" in their analysis of worldwide defence expenditures, including within a spatial setup (Yesilyurt and Elhorst 2017; Goldsmith 2007), this consideration has not systematically featured the defence economics literature (e.g., Flores 2011; Skogstad 2016). Importantly, it has been largely overlooked in spatial analysis of free riding in NATO (George and Sandler 2018, 2021; Kim and Sandler 2023). An equally significant area of advancement in defence economics is the estimation of the full free-riding effect, which, to the best of our knowledge, has not been estimated in the literature so far.

4 Empirics

We directly model both the spatial and temporal dimension in our analysis of 27 NATO allies' defence expenditures.[3] Relative to previous work, we update the data on defence spending measured as total spending (in millions, constant 2020 USD) up to 2021 (SIPRI, 2022). We generally follow an empirical strategy motivated by George and Sandler's (2018, 2022) work. Our covariates thus include GDP measured in absolute value (constant 2015 USD; World Bank, 2022) and population (World Bank, 2022). We use the logarithmic transformations of these covariates as well as the dependent variable and adjust our models for country FE. These FE, among other unobserved time-invariant influences, also account for fixed patterns of spatial clustering in the outcome (Cook et al., 2022: 18).

Following, again, George and Sandler (2018), we look at several time periods – from 1975 to 2021, from 1991 to 2021, and from 1999 to 2021 –, in order to test whether there were differences in free riding across these periods. Furthermore, our models introduce the time trend and its polynomials, which capture non-linear patterns of defence spending over time.

Our estimation strategy is based on the spatial autoregressive (SAR) model. We use a weights matrix representing inverse distances (in hundreds of kilometers) between the capital cities. The relevance of this matrix rests on the notion that geographically closer allies may be expected to assist militarily in the case of a conventional conflict (George and Sandler 2018). Furthermore, closer allies are expected to face similar threats and develop similar defence capabilities, thus making a given country benefit more from its ally-neighbors' military spending. In addition, weight matrices derived from physical distances offer a notable advantage in terms of exogeneity.

Table 1 presents the results of our static spatial models, – that is, when the temporal dimension in the form of the lagged dependent variable (LDV) is neglected. In Table 2, the LDV is included. We find that, when the temporal autoregressive dynamics are accounted for (Table 2), our models improve considerably in terms of model fit (e.g., log likelihood improves by a factor of more than 2.5 for the period of 1975–2021). The estimated spatial lag (ρ), similar to

[3]We exclude Iceland, Montenegro, and North Macedonia.

the results obtained from the static spatial models (Table 1), is negative and significant, thus suggesting free riding. Importantly, however, the spatiotemporal models offer a meaningfully distinct understanding, revealing that the impact of other allies' military expenditures on a given member state's defence spending extends beyond a single period (see Cook et al. 2022: 17). Instead, it unfolds over time, ultimately proving to be substantially larger than its short-run effect.

Table 1: Static Spatial Autoregressive (SAR) Models. Defence Spending (Logged) as the Dependent Variable

	(1975-2021)	Spatial effect (short-run)	(1991-2021)	Spatial effect (SR)	(1999-2021)	Spatial effect (SR)
ρ	-0.013^{***}	-0.032	-0.012^{***}	-0.030	-0.028^{***}	-0.065
	(0.004)		(0.004)		(0.005)	
lngdp	1.211^{***}		1.091^{***}		1.126^{***}	
	(0.061)		(0.068)		(0.073)	
lnpop	-0.278^{**}		-0.408^{***}		-0.698^{***}	
	(0.124)		(0.143)		(0.155)	
trend	0.008		0.011		0.070^{***}	
	(0.005)		(0.008)		(0.013)	
trend^2	-0.002^{***}		-0.003^{***}		-0.009^{***}	
	(0.000)		(0.001)		(0.001)	
trend^3	0.000^{***}		0.000^{***}		0.00^{***}	
	(0.000)		(0.000)		(0.000)	
Constant	-17.315^{*}		-11.571^{***}		-7.186^{**}	
	(1.883)		(2.662)		(3.298)	
Observations	897		680		566	
Country FE	Yes		Yes		Yes	
Log Likelihood	368.698		336.358		296.722	
σ^2	0.026		0.022		0.021	
Akaike Inf. Crit.	-669.396		-604.715		-525.445	

Note: *p<0.1; **p<0.05; ***p<0.01

Estimated spatial parameters are hardly directly interpretable, despite being able to offer much information (LeSage and Pace 2009; Whitten et al. 2019). Interpreting free riding makes sense if we try to answer the following question: What is the expected effect of 1 per cent positive shock in all allies' military expenditures, except for a given country, on that country's defence spending for one period and all the periods? Alternatively, what is the average effect of a shock in an ally's military spending on another ally's defence expenditures, again, for one and all the periods? These counterfactuals appeal to the core idea of outcome interdependence, whereby a relationship is posited between a country's expected outcome and those of its neighbors (Ward and Gleditsch 2019: 61).

To provide quantitative estimates, two derivation methods are applied. When the LDV is not included, we derive the average effect of free riding with respect to all other allies from the off-diagonal elements of the spatial multiplier with N by N dimensions (see Franzese and Hays 2006). That is, we are interested in what is known as indirect spatial effects. In case the LDV is present, the average

Table 2: Dynamic Spatial Autoregressive (SAR) Models. Defence Spending (Logged) as the Dependent Variable

	1975-2021	Spatial effect (SR & long-run)	1991-2021	Spatial effect (SR & LR)	1999-2021	Spatial effect (SR & LR)
ρ	-0.006^{***}	-0.015 (SR)	-0.007^{***}	-0.016 (SR)	-0.011^{***}	-0.026 (SR)
	(0.002)	-0.324 (LR)	(0.002)	-0.244 (LR)	(0.003)	-0.323 (LR)
lnmilsp_lag	0.829^{***}		0.788^{***}		0.756^{***}	
	(0.016)		(0.020)		(0.024)	
lngdp	0.311^{***}		0.337^{***}		0.396^{***}	
	(0.036)		(0.043)		(0.050)	
lnpop	-0.274^{***}		-0.305^{***}		-0.341^{***}	
	(0.062)		(0.080)		(0.095)	
trend	-0.000		0.011^{**}		0.007	
	(0.003)		(0.004)		(0.008)	
trend^2	-0.000^{***}		-0.001^{***}		-0.001^{**}	
	(0.000)		(0.000)		(0.001)	
trend^3	0.000^{***}		0.000^{***}		0.00^{***}	
	(0.000)		(0.000)		(0.000)	
Constant	-1.644^{*}		-1.433		-2.031^{*}	
	(0.999)		(1.512)		(2.015)	
Observations	897		680		566	
Country FE	Yes		Yes		Yes	
Log Likelihood	981.491		730.684		577.722	
σ^2	0.007		0.007		0.008	
Akaike Inf. Crit.	$-1{,}892.981$		$-1{,}391.367$		$-1{,}085.445$	

Note: *p<0.1; **p<0.05; ***p<0.01

long-run effect is derived from the spatiotemporal multiplier, the dimensions of which are those of our respective unbalanced panels. The long-run effect of free riding with respect to other allies' defence spending is therefore the average of the sums, for each country, of the indirect effects across all the periods. For a single country's effect, one has to first calculate the average effect (either short-run or long-run) of free riding emanating from a single ally.

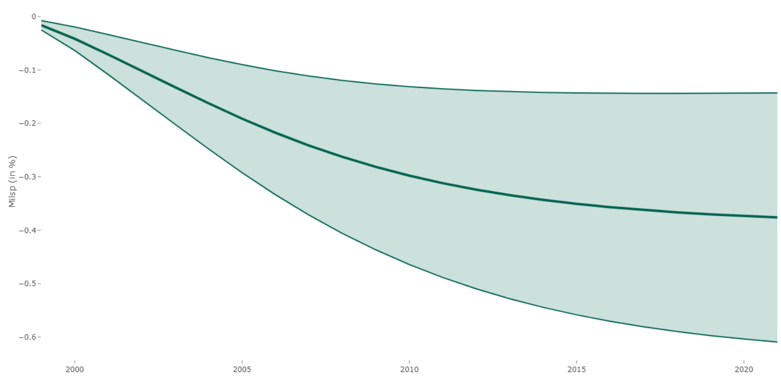
When considering an increase in defense spending of all allies, except for a specific country, the non-dynamic models (Table 1) indicate an immediate spatial free riding effect on that country, which is much greater than the short-run effect derived from the spatiotemporal models (Table 2). For example, it is greater by a factor of around 2.5 for the period of 1999–2021 (–0.065 per cent vs. –0.026 per cent), and greater by around a factor of 2 for the remaining periods (e.g., –0.032 per cent vs. –0.015 per cent for 1975–2021). The expected effect of an increase in a single ally's military expenditures is similarly inflated in the static models (e.g., –0.002 per cent vs. –0.001 per cent for 1999–2021[4]).We also observe that other covariates' coefficient-estimates turn out to be substantially smaller when we account for temporal dependence.

[4]Effect estimates for the remaining time periods are not reported. In Tables 1 and 2, spatial effects refer to the percentage increase in military spending of an average country if all the reamining allies increase their military expenditure by 1 per cent.

In the spatiotemporal scenario, however, the effect of a shock in allies' defence spending reverberates not only across space but also time. The estimated long-run free riding effects, over time, end up larger than suggested by the static models. The results are generally similar across different time periods. An increase of 1 per cent in defence spending of a country's allies may be expected to lead, depending on the time period considered, to a decrease of 0.24–0.32 per cent in its own military expenditures in the long run.[5]

Figure 1 depicts the expected average long-run effect for a NATO member state, considering a 1 per cent increase in defence spending of all its allies. Figure 2 shows the expected average long-run effect, assuming an increase in defence spending in a single ally.

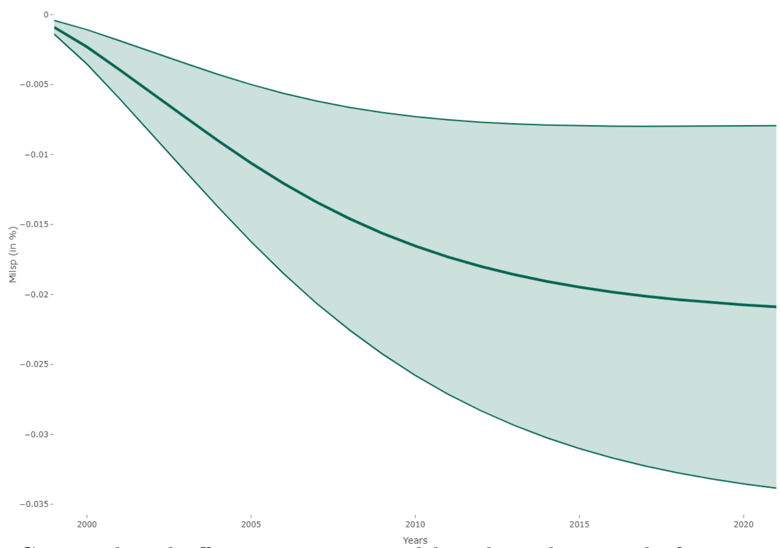
Figure 1: Average Long-run Effect of an Increase in Defence Spending of a Member State's Allies (1999-2021)



Notes: Country-based effects were estimated based on the period of 1999–2021 and for those allies that were members of NATO in 1999. Confidence intervals of 95% were obtained after running 1000 simulations.

[5]Similar results (not reported) are also obtained with the spatial autocorrelation (SAC) model.

Figure 2: Average Long-run Effect of an Increase in Defence Spending of a Single Ally (1999-2021)



Notes: Country-based effects were estimated based on the period of 1999–2021 and for those allies that were members of NATO in 1999. Confidence intervals of 95% were obtained after running 1000 simulations.

5 Conclusion

In this research note we suggest two principal contributions. First, we quantify the estimated effect of free riding within NATO. Second, we present the first study on free riding in NATO that models directly both temporal and spatial dependence. Based on the state-of-the-art methodological knowledge in TSCS analysis, we argue that accurate derivation of spatial interdependence, which is used in the literature as a measure for free riding, cannot be modeled appropriately if temporal dependence is present but unaccounted for.

We empirically show that the inclusion of the LDV substantially reduces – although does not render insignificant – the spatial interdependence parameter. We therefore corroborate the earlier research's findings that free riding, defined as negative spatial spillovers in allies' military expenditures, exists within NATO during the periods analyzed. Yet, at the same time, we show that the short-run effect is markedly lower than the one that can be derived from one-dimensional spatial models. More importantly still, in the long run, the spatial effect is substantially more profound. As already noted, these are meaningfully different versions of the phenomenon in terms of dynamics and inference.

These findings have a few important implications. On the policy (or practical) level, they suggest that some of the concerns over free riding may have been justified, as the phenomenon appears to manifest itself in a more significant manner than previously thought (with the caveat that spatial interdependence is only one, albeit important, way to capture free riding). Our evidence suggests that additional efforts are necessary to mitigate free riding in NATO, especially given the prospect of new members joining the alliance, as well as the actual need to increase NATO defence spending in the context of support for Ukraine and Russia's aggression more generally. Our analysis also points to the complexity of free riding, which is not limited to short-run annual dynamics but unfolds over a longer time period. This underscores the need for allies' strategic commitment.

One implication for researchers is that scholarship investigating free riding in NATO and other alliances or, more generally, modeling interdependence in military expenditures needs to also directly model the temporal dependence, at least as a sensitivity check. In fact, this implication has a broader bearing – while the use of TSCS analysis has grown very substantially in social science, only a minority of studies addresses both time and spatial dependence directly (Cook et al. 2022).

Finally, the bias stemming from the neglect of temporal dependence is not limited to the overestimation of spatial parameters. Covariates' coefficient-estimates will also suffer from bias, while the effects of interest will be estimated inaccurately, including by omitting their meaningfully diverse dynamics. All this speaks directly to the researcher's efforts of uncovering the true DGP of any given phenomenon and therefore provides an indispensable basis for future research motivated by TSCS data.

Acknowledgments

Part of this research was carried out during R. Kuokštytė's 2022 Fulbright Visiting Scholarship at The Department of Political Science at the Bush School of Government and Public Service, Texas A&M University. This co-author remains much indebted to Professors Scott J. Cook and Guy D. Whitten. The authors would also like to express their gratitude to the participants of the 2023 PEIO conference, especially Harry Oppenheimer and Martin Gassebner, for their valuable feedback, as well as to the participants of the 2023 International Security Seminar hosted by West Point.

6 References

[1] Alley, Joshua. 2021. "Reassessing the Public Goods Theory of Alliances." *Research & Politics* 85(1):10.1177/20531680211005225.

[2] Beck, Nathaniel, and Jonathan N. Katz. 1995. "What to Do (and Not

to Do) with Time-series Cross-section Data." *American Political Science Review* 89(3): 634–47.

[3] Cantenkin, Keren, Ceyhun Elgin, and Adem Yavuz Elveren. 2022. "Persistency of Military Spending and Fiscal Policy Responses to Covid-19." *Critical Military Studies*, 1-14.

[4] Cook, Scott J., Jude C. Hays, and Robert Franzese. 2020. "Model Specification and Spatial Interdependence." In Luigi Curini and Robert Franzese (eds.), *The SAGE Handbook of Research Methods in Political Science and International Relations*, SAGE Publications Ltd, pp. 730–47.

[5] Cook, Scott J., Jude C. Hays, and Robert Franzese. 2022. "STADL Up! The Spatiotemporal Autoregressive Distributed Lag Model for TSCS Data Analysis." *American Political Science Review*, 1–21.

[6] Drolc, Cody A., Christopher Gandrud, and Larron K. Williams. 2019. "Taking Time (and Space) Seriously: How Scholars Falsely Infer Policy Diffusion from Model Misspecification." *Policy Studies Journal* 49(2): 484–515.

[7] Duchin, Brian R. 1992. "The Agonizing Reappraisal: Eisenhower Dulles, and the European Defense Community." *Diplomatic History* 16(2): 201–22.

[8] Elhorst, J. Paul. 2001. "Dynamic Models in Space and Time." *Geographical Analysis* 33(2): 119–40.

[9] Flores, Alejandro Q. 2011. "Alliances as Contiguity in Spatial Models of Military Expenditures." *Conflict Management and Peace Science* 28(4): 402–418.

[10] Franzese, Robert J., and Jude C. Hays. 2006. "Strategic Interaction among EU Governments in Active Labor Market Policy-making." *European Union Politics* 7(2): 167–89.

[11] George, Justin, and Todd Sandler. 2018. "Demand for Military Spending in NATO 1968–2015: A Spatial Panel Approach." *European Journal of Political Economy* 53: 222–36.

[12] George, Justin, and Todd Sandler. 2021. "EU Demand for Defense, 1990–2019: A Strategic Spatial Approach." *Games* 12(1):10.3390/g12010013.

[13] George, Justin, and Todd Sandler. 2022. "NATO Defense Demand, Free Riding, and the Russo-Ukrainian War in 2022." *Journal of Industrial and Business Economics* 49: 783–806.

[14] Goldsmith, Benjamin E. 2007. "Arms Racing in 'Space': Spatial Modelling of Military Spending Around the World." *Australian Journal of Political Science* 42(3): 419–440.

[15] Keele, Luke, and Nathan J. Kelly. 2006. "Dynamic Models for Dynamic Theories: The Ins and Outs of Lagged Dependent Variables." *Political Analysis* 14(2): 186–205.

[16] Kim, Wukki, and Todd Sandler. 2020. "NATO at 70: Pledges, Free Riding, and Benefit-burden Concordance." *Defence and Peace Economics* 31(4): 400–13.

[17] Kim, Wukki, and Tod Sandler. 2023. "NATO Security Burden Sharing, 1991–2020." *Defence and Peace Economics*, 1–16.

[18] King, Gary, Michael Tomz, and Jason Wittenberg. 2000. "Making the Most of Statistical Analyses: Improving Interpretation and Presentation." *American Journal of Political Science* 44(2): 347–61.

[19] Lanoszka, Alexander. 2015. "Do Allies Really Free Ride?" *Survival* 57(3): 133–52.

[20] LeSage, James, and R. Kelley Pace. 2009. *Introduction to Spatial Econometrics*. Chapman and Hall/CRC.

[21] Murdoch, James C., and Todd Sandler. 1984. "Complementarity, Free Riding, and the Military Expenditures of NATO Allies." *Journal of Public Economics* 25(1-2): 83–101.

[22] Olson, Mancur, and Richard Zeckhauser. 1966. "An Economic Theory of Alliances." *The Review of Economics and Statistics* 48(3): 266–79.

[23] Plümper, Thomas, and Eric Neumayer. 2015. "Free-riding in Alliances: Testing an Old Theory with a New Method." *Conflict Management and Peace Science* 32(3): 247–68.

[24] SIPRI. 2022. *SIPRI Military Expenditure Database*. `https://milex.sipri.org/sipri` (accessed October 24, 2022).

[25] Skogstad, Karl. 2016. "Defence Budgets in the Post-Cold War Era: A Spatial Econometrics Approach." *Defence and Peace Economics* 27(3): 323–352.

[26] Spangler, Ethan. 2018. "Allies with Benefits: US Effect on European Demand for Military Expenditures." *Defence and Peace Economics* 29(7): 731–47.

[27] Yesilyurt, M. E., & Elhorst, J. P. 2017. "Impacts of neighboring Countries on Military Expenditures: A Dynamic Spatial Panel Approach." *Journal of Peace Research* 54(6): 777–90.

[28] Ward, Michael D., and Kristian Skrede Gleditsch. 2019. *Spatial Regression Models* (Second ed.). SAGE Publications Inc. `https://methods.sagepub.com/book/spatial-regression-models-2e` (accessed September 14, 2022).

[29] Whitten, Guy D., Larron K. Williams, and Cameron Wimpy. 2019. "Interpretation: The Final Spatial Frontier." *Political Science Research and Methods* 9(1): 140–56.

[30] Williams, Larrron K., and Guy D. Whitten. 2012. "But Wait There's More! Maximizing Substantive Inferences from TSCS Models." *The Journal of Politics* 74(3): 685–93.

[31] World Bank. 2022. GDP (constant 2015 US$). `https://data.worldbank.org/indicator/NY.GDP.MKTP.KD` (accessed October 24, 2022).

[32] World Bank. 2022. Population, total. `https://data.worldbank.org/indicator/SP.POP.TOTL` (accessed October 24, 2022).