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NATO Security Burden Sharing, 1991–2020

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ABSTRACT

In contrast to much of the extant literature, the paper devises a composite security burden measure for the NATO alliance that accounts for three different contributions by allies to their collective security: namely, military expenditure (ME), foreign assistance, and UN peacekeeping spending. Generally, NATO defense burden sharing and free riding are judged solely based on ME even though foreign assistance and peacekeeping promote world prosperity, stabilize regimes, and quell conflicts that affect NATO's collective security. Our parametric tests for free riding apply a spatial-lag panel model, which addresses the interdependency issues, to a broader security-spending measure that accounts for allies' membership, contiguity, and inverse distance. In all spatial models, we uncover robust evidence of free riding where allies decrease their aggregate security spending in response to increases in the collective security spending of other allies. We apply a panel generalized method of moments (GMM) estimator to adjust for endogeneity concerns.

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Introduction

Formed in 1949, the North Atlantic Treaty Organization (NATO) represents the most successful military alliance in modern history, growing from 12 to 31 allies over the next 74 years, with Sweden currently being considered for admission. The 12 founding members included Belgium, Canada, Denmark, France, Iceland, Italy, Luxembourg, the Netherlands, Norway, Portugal, the United Kingdom, and the United States. Greece and Turkey joined in 1952, followed by West Germany in 1955 (becoming unified Germany in 1990) and Spain in 1982. During 1999–2023, NATO expanded from 16 to 31 allies with the memberships of the Czech Republic, Hungary, and Poland in 1999; Bulgaria, Estonia, Latvia, Lithuania, Romania, Slovakia, and Slovenia in 2004; Albanian and Croatia in 2009; Montenegro in 2017; North Macedonia in 2020; and Finland in 2023. According to Economist (2019, 3), the mean life span of military alliances during the last 500 years has been mere 15 years in marked contrast to NATO impending 75th year anniversary in 2024. NATO's recent growth stems from its Cold War victory in 1990–1991, the Russo-Georgian War in 2008, and Russia's annexation of Crimea in 2014. Russia's invasion of Ukraine on 24 February 2022 motivated Finland and Sweden to apply for NATO membership and encouraged greater cooperation among allies (George and Sandler 2022). To further its relevance, NATO expanded its post-Cold War mission to protect allies' interests in out-of-area places (Article 6 of NATO) with peacekeeping operations in Bosnia, Kosovo, Iraq, Afghanistan, Libya, and elsewhere (North Atlantic Council 2014, 2018; Sandler and Murdoch 2000).

In an interesting and provocative article, Balcaen, Du Bois, and Buts (2023) raised the notion of hybrid threats that require more than traditional military expenditure (ME) to

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address, thus necessitating nondefense actions. Such hybrid contingencies may include cyber security, health exigencies (e.g. confronting pandemics), environmental threats, among others. In light of hybrid threats, Balcaen, Du Bois, and Buts (2023, 5) questioned whether addressing these contingencies is public to the alliance members but private or impurely public among allies. Hence, the mix of security joint products may be skewed to the private and impure public side of the spectrum in contrast to traditional defense threats (on joint product alliance models, see, e.g. Sandler 1977; van Ypersele de Strihou 1967). A larger portion of private and impure public benefits favors reduced free riding. The practical and empirical issues associated with incorporating hybrid threats in burden-sharing studies concern the calculation of allies' spending on cyber security, infrastructure protection, and limiting disinformation. Unfortunately, such expenditures are either buried in the defense budget or specific agencies' spending so that they cannot be included in our security burden measure.

In their overview of the NATO burden-sharing literature, Bogers, Beeres, and Bollen (2022) emphasized that NATO allies' contributions to peacekeeping add a new dimension of alliance burden sharing, not captured by defense-spending burdens. Additionally, Cooper and Stiles (2021) argued that the commitment of NATO allies must be based on more than just defense spending owing to allies' contributions to peacekeeping *and* development assistance, both of which foster allies' security. Because some allies may give disproportionately to these other security activities, a truer measure of security burden sharing among NATO allies must account for more than just ME. Cooper and Stiles (2021) used the number of deployed troops per 100,000 population to out-of-area peacekeeping missions – i.e. the International Security Assistance Force (ISAF) in Afghanistan (2004–2014), the Resolute Support Mission in Afghanistan (2015–2018), the Kosovo Force (2004–2018), the Bosnia Force (1996–2004), and the NATO Training Mission-Iraq (2005–2011) – as their burden-sharing measure. As a consequence, Slovenia, Denmark, the United States, and the United Kingdom were shown to have shouldered the greatest burdens. Although their finding is thought-provoking, the authors ignored the bulk of security spending including foreign assistance and ME.

Our modest, but important, purpose here is to examine the security burden sharing while accounting for NATO allies' ME, foreign assistance payment, and UN peacekeeping spending. Foreign assistance captures not only efforts to address health concerns, but also some actions to support environmental concerns in the developing world. Poverty makes for a good breeding ground for infectious disease among a compromised host population with inadequate nutrition and healthcare infrastructure. Foreign assistance also makes for more viable regimes in developing countries, thereby curbing coups, terrorism, and other destabilizing events that can create negative externalities (e.g. refugee flows, transnational terrorism, and blocked resource supply lines) to NATO members. UN peacekeeping efforts also limit such externalities for NATO allies, thereby bolstering allies' security.

As our first cut at introducing an operational security-burden measure, we deliberately choose to aggregate three security-promoting activities, which are denominated in expenditure terms. Thus, we use annual UN peacekeeping assessments for each of the NATO allies during 1991–2020 to capture peacekeeping contributions. Currently, data on the troops sent by NATO allies to *non-UN* peacekeeping operations are available but are not in terms of a spending metric.[1] For the three-fold security burden analyzed here, we find that an ally generally free rides on the security spillovers of their allies, so that an ally's security spending declines as its allies' total security spending increases. For 1991–2020, free riding characterizes three alternative spatial-lag models based on NATO membership status, NATO allies contiguity, and inverse distance between allies, respectively, for standard controls (i.e. gross domestic product (GDP) per capita, population, a global non-state conflict indicator, and the number of transnational terrorist attacks). Thus, a broader security or a more-encompassing commitment measure does not eliminate free riding as some presuppose (Balcaen, Du Bois, and Buts 2023; Bogers, Beeres, and Bollen 2022; Cooper and Stiles 2021). Future studies can apply our method to include more security-promoting activities.

To our knowledge, Boyer (1989) was the first to argue that NATO security burden sharing involves more than ME. In particular, he included spending on foreign aid. Unlike our current paper, Boyer (1989) did not sum ME and foreign aid into an aggregate spending measure. Also, he only presented Spearman rank-order correlation tests between ME and ME/GDP, and between foreign aid and foreign aid/GDP, showing that select large allies were exploited by small allies in terms of ME burdens, but that select small allies were exploited by large allies in terms of foreign aid burdens. By not aggregating the two burden measures, Boyer did not provide an overall picture of burden sharing for the two measures. Chalmers (2001) made a similar point to that of Boyer (1989) with respect to NATO burden sharing for ME, foreign aid, and other activities (e.g. EU integration and UN peacekeeping), but he offered no empirical analysis. Sandler and Murdoch (2000) and Sandler and Shimizu (2014) presented Spearman rank-order correlation tests between security burdens (S/GDP) and GDP for various pre-2010 intervals. Like the current paper, their security measure summed allies' spending on ME, foreign aid, and UN peacekeeping. However, unlike the current paper, those earlier articles did not estimate spatial-based panels in a parametric framework for NATO burden sharing. All earlier security burden-sharing studies offered nonparametric analyses or correlations.

The remainder of the paper is organized into five sections. In the next section, a brief literature review is presented with a focus on selected recent articles. The third section develops a security-demand theoretical model that accounts for alternative spatial representations and forms the basis for the subsequent panel empirical estimations. In the fourth section, we indicate our empirical methodology along with the data, followed by the empirical results and robustness runs in the next-to-last section. The final section contains concluding remarks along with directions for future results.

Literature Review

Just under 60 years have passed since Olson and Zeckhauser (1966) presented their seminal article, 'An Economic Theory of Alliances,' which specified a pure public good model of collective defense. Those authors viewed NATO allies as sharing nuclear deterrence of the Warsaw Pact based on the threat of nuclear retaliation with unacceptable destruction. As a pure public good, deterrence benefits are nonexcludable and nonrival. Once the deterrence is provided by the nuclear triad (i.e. intercontinental ballistic missiles, nuclear submarine ballistic missiles, and bombers), NATO allies obtain the embodied deterrent benefits, regardless of their own defense spending, that forestall Warsaw Pact aggression. Benefit nonrivalry means that one ally's consumption of deterrence does not reduce, in the slightest, the deterrent benefits still available for other allies. Even the addition of new allies does not diminish the retaliatory threat embodied in the nuclear arsenal, provided the allies are perceived as unified. Article 5 of the NATO Treaty, where allies view an armed attack on one ally as an attack on all, is intended to promote alliance unification and unity of purpose. The stationing of US troops and bases in Europe bolstered the US commitment to protect NATO interests because US assets would sustain collateral damage from a European invasion. The collateral damage to the United States along with its credible commitment was heightened by US foreign direct investment and residents in Europe.

With pure public defense benefits, Olson and Zeckhauser (1966) predicted that poorer NATO allies would free ride, saddling the richer allies – the United States, the United Kingdom, and France – with a disproportionate share of the defense burden. For their nonparametric empirical test (Spearman rank-order correlation test), Olson and Zeckhauser (1966) found that the rich allies in terms of GDP indeed shouldered the lion's share of defense burdens during the single test year of 1964. Subsequent studies hypothesized that defense spending yields multiple outputs or joint products that vary in their degree of publicness (McGuire 1990; Sandler 1977; Sandler and Hartley 2001; Sandler and Murdoch 1990; van Ypersele de Strihou 1967). According to the joint product alliance model, defense spending can yield ally-specific benefits (e.g. disaster relief or coastal resource protection), impure public benefits (e.g. conventional front protection), and pure public deterrence.

The joint product model yields implications at odds with those of the pure public deterrence theory of alliances. First, the higher the ratio of excludable private (country-specific) and impure defense benefits to total defense benefits, the greater the incentive for allies to support their own defense regardless of their economic size. Second, excludable ally-specific defense benefits permit market and club arrangements to foster a closer equality between marginal benefits and marginal costs. As the ratio of excludable to total defense benefits approaches one, the resulting closer equality of margins implies greater allocative efficiency. Third, free riding becomes less of a concern as does disproportionate burden sharing for larger ratios of excludable to total defense benefits (Khanna and Sandler 1996; Sandler and Hartley 1995; Sandler and Murdoch 2000). Over the years, as NATO strategic doctrine (i.e. Mutual Assured Destruction deterrence, Doctrine of Flexible Response, or Out-of-Area Crisis Management), weapons technology, perceived threats, and alliance composition evolved, the ratio of excludable defense benefits altered, thereby affecting the extent of free riding. Fourth, the presence of joint products raises the possibility of allies' ME being complements, especially for country-specific benefits, so that one ally may *increase* its defense spending as its allies collectively raise their defense spending (Murdoch and Sandler 1984). The ability of the joint product model to reflect the changing nature of defense spillovers allows the theory of alliances to remain relevant. In fact, empirical tests indicated that the extent of NATO free riding along with the match between defense benefits and burdens evolved along with strategic doctrine, weapons technology, and alliance composition (Bogers, Beeres, and Bollen 2022; George and Sandler 2022; Kim and Sandler 2020; McGuire 1990; Sandler and Shimizu 2014; Solomon 2004, 2005, and many others).

More recently, there has been a surge in scholarship in the study of alliances and the demand for defense spending. One important avenue of research examined how European Union (EU) members respond to the defense spending of other EU members and the United States (see, e.g. Christie 2019; Douch and Solomon 2014; George and Sandler 2021; Kollias 2008; Kuokštytė, Kuokštis, and Miklaševskaja 2021; Nikolaidou 2008). A recent important EU article showed the EU members' demand for ME, as measured by ME/GDP, is more responsive to fiscal capacity than to projected GDP growth or real GDP (Christie 2019). This follows because some NATO EU allies were constrained by high levels of public debt that stymied their ability to raise ME to respond to the increase in Russian aggression (also see Odehnal and Neubauer 2020). Christie's (2019) emphasis on fiscal capacity underscored that NATO allies, which are also EU members, may respond differently than non-EU NATO allies.[2] Kuokštytė, Kuokštis, and Miklaševskaja (2021) also found that defense-spending behavior, including free riding, differed between NATO and non-NATO EU members. Those and other EU studies made the point that institutional arrangements can profoundly affect the demand for ME.

Recent articles stressed various developments in NATO. For instance, some articles investigated NATO burden sharing in light of the Wales Summit of September 2014 where allies pledged to devote 2% of GDP to defense spending by 2024 (Christie 2019; George and Sandler 2022; Haesebrouck 2022). Moreover, NATO allies further pledged that 20% of their defense spending would finance new equipment acquisition. In an innovative exercise, Becker and Malesky (2017) disaggregated NATO spending among four functional categories: defense equipment, operations & maintenance (O&M), personnel, and infrastructure. Those authors contended that NATO allies following an Atlanticist or US, rather than a Europeanist, strategic culture, were inclined to spend a larger portion of their defense budget on O&M as they emphasized out-of-area missions during 2000–2012. Evidence to support their hypothesis was presented where the allies' strategic cultural orientation was based on the language in important national security documents.

More germane to the current study, researchers stressed the effects of the spatial positions of allies and adversaries on countries' demand for ME (see Flores 2011; George and Sandler 2018, 2021, 2022; Goldsmith 2007; Skogstad 2016; Yesilyurt and Elhorst 2017). In particular, nearer allies can better free ride on one another, thereby favoring contiguous allies. As the *inverse distance* between allies' capitals increases, the countries are closer together and more ideally situated to share or substitute their armed forces, thus promoting free riding. The free-riding advantage is particularly strong for conventional armies (e.g. tanks, artillery, armored transports, and ground forces). If, however, an ally can rapidly project its power through air or sea transport, as in the case of the United States, then propinquity of forces becomes less important for free riding (George and Sandler 2022; Skogstad 2016). In addition to contiguity and inverse distance, a host of spatial-weight metrics have been applied in the spatial-based models of military alliances (Skogstad 2016). By contrast, spatial propinquity enhances the demand for ME among adversarial countries that pose a threat to one another.

Theoretical Model of Security Demand Among Allies

A country's security (S) expenditure includes military or defense expenditure (d), foreign assistance (f), and UN peacekeeping assessed contributions (k), so that

$$S = d + f + k. \tag{1}$$

All three components add to the stability of the security environment that an ally occupies with its allies. The model depicts an N-country alliances, such as NATO, where each ally's executive decision maker maximizes its country's social welfare (U^i) by assigning national income between aggregate security spending, S^i, and real consumption, c^i. The unit price of security is p, while the unit price of non-security consumption is normalized to 1. Thus, each ally's decision maker confronts the income constraint,

$$I^i = c^i + pS^i \tag{2}$$

for which income is represented by gross domestic product (GDP). In a democracy, social welfare corresponds to that of the executive branch (e.g. the prime minister).

A key aspect of the social welfare function is the security spillovers stemming from the three-component security spending of the other $N - 1$ NATO allies. As such, security spillovers, S_{-1}, to ally i equal

$$S_{-i} = \sum_{\substack{k \neq i \\ k=1}}^{N} \gamma^k S^k \tag{3}$$

for $i = 1, \ldots, N$ where spatial weights, γ^k, of the other allies are included. If $\gamma^k = 1$, for member allies and 0 otherwise, then the standard alliance theory model applies (Murdoch 1995; Olson and Zeckhauser 1966; Sandler and Hartley 2001). When the precise distance between allies' capital apply, γ^kequals the *inverse* distance between country i's and country k's capitals for which a larger inter-capital distance results in a smaller weight, consistent with reduced substitutability between these two allies' forces. Finally, the spatial weight can refer to allies k and i contiguity status in which γ^k equals 1 for contiguous allies, and 0 otherwise. Supposedly, contiguous allies allow for greater security expenditure substitution possibility owing to extreme propinquity (Flores 2011; George and Sandler 2018, 2021; Skogstad 2016).

To derive an ally's security expenditure demand, we cast each ally's decision maker as choosing its security spending, S^i, to

$$\max_{S^i} U^i\left(I^i - pS^i, S^i + S_{-i}, \mathbf{X}^i\right), i = 1, \ldots, N \tag{4}$$

where the budget constraint is used to replace private consumption. In (4), ally i's choice of security spending is dependent on to its own security expenditure and that of its allies, where social welfare is increasing in terms of its own consumption and alliance-wide security spending but at a diminishing rate of increase. Additionally, the marginal utility of consumption increases with greater total security spending, $Q^i = S^i + S_{-i}$, so that $U_{cQ} = U_{Qc} > 0$, consistent with Edgeworth-Pareto complements. In the above maximization problem, vector $\mathbf{X}^i$ includes ally-specific determinants of security spending such as its population, exposed borders, the number of global non-state conflicts, ally i's transnational terrorist attacks, and Russian defense spending or some other measure of Russian threat (nearness to Moscow or contiguity with Russia).

By maximizing (4) while taking spillover security spending as given (at its maximizing level), each ally's Nash-equilibrium security spending satisfies:

$$S^i = S^i\left(I^i, p, \sum_{k \neq i}^{N} \gamma^k S^k, \mathbf{X}^i\right), i = 1, \ldots, N \tag{5}$$

via the application of the implicit function rule applied to the first-order conditions of (4). Simultaneous satisfaction of those N demand equations results in the Nash-equilibrium set of demand equations for the alliance. Additionally, comparative statics with respect to changes in each of the exogeneous factors (e.g. income, allies' defense spillovers, or the number of global non-state conflicts) yield testable hypotheses (George and Sandler 2022).

For NATO allies, increased security spillovers, when $\gamma^k = 1$ for all allies, are expected to result in decreases in allies' security expenditure as they exercise their ability to free ride on substitutable security outlays of other allies, particularly when the ratio of excludable security benefits is small. Greater defense spending, foreign assistance, and UN peacekeeping contributions by other allies bolster security and reduce the amount that an ally must spend on the three components promoting peace and tranquility. Standard comparative statics can establish this hypothesis as has been shown for defense spending spillovers in earlier studies (e.g. George and Sandler 2018, 2021, 2022; Murdoch and Sandler 1984; Sandler and Murdoch 1990). Moreover, a similar negative security response is anticipated when the spatial-weight measures are the inverse-distance or contiguity representations. As nearness increases owing to a greater inverse distance (i.e. smaller distance) between allies' capitals, allies' enhanced security spending alleviates somewhat the need for an ally's own security outlays. Similarly, contiguous allies are well positioned to free ride on their neighboring allies' security spending, thus resulting in an ally's negative response to its contiguous allies' increased security spending (Flores 2011; Goldsmith 2007; Yesilyurt and Elhorst 2017).

An important control variable in an ally's security demand function is its income or wealth measure, which we proxy by GDP per capita. When security is an income-normal good, comparative statics show that each ally's security spending responds positively to greater GDP per capita (Dudley and Montmarquette 1981; George and Sandler 2018; Hilton and Vu 1991; Sandler and Hartley 1999, 2001; Smith 1980, 1990). If an ally places importance on protecting people, then an increase in population is anticipated to increase security spending. If, instead, larger populations raise the need for more social spending that drains the public budget, then security demand will respond negatively to population increases (Dunne and Perlo-Freeman 2003; Hilton and Vu 1991). Hence, the net influence of population on security spending is an empirical question. As the number of global non-state conflicts, including civil wars and internal wars, increase in numbers, allies' security spending is hypothesized to rise because this expenditure includes UN peacekeeping and foreign assistance, the latter of which involves some military assistance to the aid-recipient. We use global non-state conflicts to get the broadest possible measure of global security instabilities that can affect allies' security externalities (e.g. refugee flows and supply lines) and, hence, allies' security spending. In an ally's demand function, other threat measures – the number of transnational terrorist attacks, an ally's exposed borders, and Russia's military expenditure (ME) – are predicted to increase an ally's security spending. We single out transnational terrorist attacks, rather than domestic attacks since the latter is often addressed by the police and not the military. Foreign aid, part of security spending, can stabilize foreign regimes and result in fewer transnational terrorist attacks being exported abroad from a host country. As an ally's exposed borders increase, a thinning of forces occur, which, in turn, requires more defense spending, an important component of security spending (Sandler 1977 on force thinning). Finally, if allies view Russia as a sovereignty threat, then increases in Russian ME should have a positive influence on security spending. If, however, allies do not view Russia as a threat, then their security spending will respond negatively or not significantly to increases in Russia's ME. Since proximity to Russia may heighten the perceived threat, we include a couple proximity measures (i.e. contiguity with Russia and the distance between allies' capital from Moscow) in robustness runs.

By necessity, we must drop the relative price of security expenditure since there are no data on this variable.

Methodology and Data

As previously discussed, alliance theory includes spillover effects, which posit that ally *i*'s security spending demand (dependent variable) is contingent upon the security spending of other NATO allies (main independent variable) at each point in time. NATO members not only consider their own security spendings but also the aggregate security spending of fellow allies, the latter of which may result in a free-riding problem. Additionally, NATO allies make their security spending decision subject to other controls, such as the log of GDP per capita, the log of population, transnational terrorist attacks, and the log of the global number of non-state conflicts. Other controls – log of exposed borders and log of Russia ME – characterize the robustness models. The resulting interdependency between an ally's security spending and security spillovers (variously defined below) presents an endogeneity concern that must be addressed in order to accurately identify the determinants of NATO security burden sharing. To mitigate this spending interdependency among NATO allies, the spatial autoregressive (SAR) or spatial-lag model is employed (Elhorst 2003; Franzese and Hays 2007). The SAR model is defined as

$$\ln(S_{it}) = \rho \sum_{k \neq i} w_{ikt} \ln(S_{kt}) + \mathbf{x}'_{it}\boldsymbol{\beta} + \mu_i + \varepsilon_{it} \qquad (6)$$

where S_{it} denotes ally *i*'s security spending at time *t*, and $\sum_{k \neq i} w_{ikt} \ln(S_{kt})$ is the spatially lagged security expenditure with w_{ikt} representing the connectivity between NATO members *i* and *k* ($i \neq k$) at time *t*. As defined below, security spending is measured in constant 2010 US dollars. In (6), ρ measures the effect of security spillovers on security spendings. $\mathbf{x}$ and $\boldsymbol{\beta}$ are vectors of control variables and corresponding coefficients, respectively. Lastly, μ_i is the country fixed effects and ε_{it} is the idiosyncratic error term.

The spatial-weighted matrix, w_{ikt}, is a symmetric matrix that measures the geographical connectivity between a pair of NATO allies at time *t* based on their membership, inverse distance, or contiguity. The three different connectivity matrices have the following elements: i) $w_{ikt} = 1$ if country *i* and county *k* are NATO allies at time *t*, and 0 otherwise, ii) $w_{ikt} = 1/distance_{ik}$ between the capital cities of countries *i* and *k*, and iii) $w_{ikt} = 1$ when two allies share land or water borders, and 0 otherwise.

In applied spatial econometric models, the spatial matrix is typically row-standardized, which involves dividing each row element by the sum of the spatial weights in the row for a given year, so that the sum of all elements in the row equals 1. However following Böhmelt, Bove, and Nussio (2020) and George and Sandler (2018, 2022), we do not row-standardize our spatial weight matrix because the changing size of NATO membership over time affects the *influence of large allies' spending*, namely reducing their spending influence with each alliance expansion. That reduction is particularly worrisome because of the large expansion of allies after 1999, after which large allies such as the United States, the United Kingdom, and France still account of much of the security spending spillovers. Moreover, the practice of row-standardization causes the aggregate exposure to spatial stimulus to remain unchanged regardless of the addition of new allies because the sum of spatial weights must remain at one. Finally, the explicit theoretical model obviates the need for such row-standardization.

Table 1. Summary statistics.

	Count	Mean	SD	Min	Max
Ln (*Security burden*)	664	22.610	1.934	18	27
Ln (*GDP per capita*)	664	10.083	0.751	8	12
Ln (*Population*)	664	16.468	1.512	13	20
Ln (*Global non-state conflicts*)	664	6.532	0.950	5	8
Ln (*Exposed border*)	664	7.734	2.446	0	12
Number of trans terror attacks	664	1.917	8.800	0	181
Ln (*Russia ME*)	634	24.357	0.653	23	25

Finally, we employ the two-step GMM estimator, which allows for a more accurate estimation of the determinants of NATO allies' security burden sharing and helps to control for potential biases arising from endogeneity issues. One advantage of the GMM estimator in SAR is that it uses the spatial lags of the independent variables as instrumental variables (Kelejian and Prucha 1998). In our analysis, we construct instrumental variables using GDP per capita and population variables.

Data

To estimate the demand for NATO security burden sharing during 1991–2020, we focus on 28 NATO members, excluding Iceland, which has virtually no defense burdens, and North Macedonia, which only joined in 2020. Each NATO ally's annual observations are only included for the year of membership on. The dependent variable, security burden, aggregates members' ME, their official development assistance (ODA), their UN PKOs contributions. Given our panel estimates, the unit of analysis is country-year observations. Budget variables are converted into 2010 US dollars using the Consumer Price Index (World Bank 2023) with allies' annual ME drawn from the SIPRI (2023). UN PKO's annual financial budgets from 1991 to 2010 are taken from United Nations (UN) (1991–2011); however, after 2011, UN PKO's annual budgets are drawn from United Nations (2011, 2012b, 2012c, 2014, 2015b, 2015c, 2017a, 2017b, 2019a, 2019b, 2020). Based on each NATO allies' assessment percentage (United Nations 2009, 2012a, 2015a, 2018, we calculate the ally's annual assessment for each year. ODA figures are drawn from the OECD (2023).

Population and GDP per capita (in 2010 US dollars) are from World Bank (2023). The number of global non-state conflict is drawn from the Uppsala Conflict Data Program (UCDP) Georeferenced Event Dataset (GED) version 21.1 (Sundberg and Melander 2013). According to the UCDP, non-state conflicts are defined as 'the use of armed force between two organized armed groups, neither of which is the government of a state, which results in at least 25 battle-related deaths in a year' (Högbladh 2021, 29). We transform two economic variables – population and GDP per capita – and non-state conflict into natural logs. Similar to countries' ME, Russian ME is drawn from SIPRI (2023) and converted into billions of 2010 US dollars. Transnational terrorist incidents occurring in NATO allies are taken from *International Terrorism: Attributes of Terrorist Events* (ITERATE) dataset (Mickolus et al. 2022) and are measured as annual counts. The distances in kilometers (kms) between two allies' capitals are taken from Gleditsch and Ward (2001). Finally, allies' exposed borders include their coastlines and their land borders with non-NATO countries (US Central Intelligence Agency 2022).

Table 1 presents the summary statistics of the variables. Specifically, the logged security burden had an average value of 22.610. In 2010, the United States incurred the maximum (max) security expenditure of approximately 770 billion dollars (= exp(27.37)). On average worldwide, 1,076 [= exp (6.5)] non-state conflicts occurred annually, with a max value of 3,191 such conflicts in 2020. For each NATO ally, the average annual number of transnational terrorist attacks is 1.9. From 1991 to 2020, the maximum number of transnational terrorist attacks occurred in Germany in 1993, with a total of 181 attacks. On average, NATO allies shared around 15,088 kms of borders with other countries, and the longest border line is 202,080 kms for Canada.

Table 2. NATO security expenditure in 1991–2020.

	Model 1	Model 2	Model 3
SL (*NATO membership*)	−0.001***		
	(0.000)		
SL (*Contiguity*)		−0.003***	
		(0.001)	
SL (*Inverse distance*)			−0.600***
			(0.073)
Ln (*GDP per capita*)	0.951***	0.890***	0.968***
	(0.034)	(0.033)	(0.033)
Ln (*Population*)	0.687***	0.231	0.412***
	(0.154)	(0.158)	(0.147)
Ln (*Global non-state conflicts*)	0.023***	0.010	0.027***
	(0.008)	(0.008)	(0.008)
Country FE	Yes	Yes	Yes
F statistics	291.044	272.192	307.784
N	664	664	664

* indicates $p < 0.1$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$. Cluster-robust standard errors based on countries are in the parentheses.

Empirical Results

In Table 2, the NATO panel estimates for 1991–2020 are displayed, where the sample size is 664 observations, which accounts for the 30 years and the relevant number of NATO members in each sample year. Recall that NATO membership (excluding Iceland) is 15 during 1991–1998 and expands from 1999 on as allies join as indicated at the outset of the paper. The *F*-statistics support the empirical representation of the three models, where cluster-robust standard errors, based on countries, are in parentheses beneath the coefficients.

The baseline panel runs for NATO security spending are contained in Table 2 where the three spatial-lag (SL) coefficients capture free riding from different vantages. For the standard alliance representation, each ally is assigned a spatial weight of 1 during their membership years. The estimated SL coefficient of membership is negative and significant at the 0.01 level. As such, there is clear evidence of free riding because a NATO ally reduces its security spending in response to increases in the collective security spending of its allies. When the spatial lag is, instead, based on allies' contiguity, there is again evidence of NATO free riding, given the negative and significant SL contiguity coefficient. For a spatial weight based on inverse distance, there is yet again evidence of security free riding among nearer NATO allies. Compared to the coefficients for membership and contiguity SL, the spillover coefficient for the inverse-distance spatial weight is noticeably larger in absolute value at .600. This is because, in the absence of row-standardization, inverse-distance weights scale down the spatial lag variable in comparison to the binary weights used for alliance membership and contiguity, thereby resulting in a larger spillover response in absolute value (George and Sandler 2018, 2022). Our security measure does not eliminate the relevance of free riding within NATO during the sample period. Free riding holds up even though allies carry different burdens of the three measures of security. Those free-riding results hold for country-fixed effects.

Next, we turn to the controls in the three displayed models. The double log representations, where the dependent and control variables are log transformed, meaning that each estimated control coefficient denotes an elasticity. For all three models, security spending increases by 0.951, 0.890, and 0.968%, respectively, for a one percent increase in GDP per capita, thus indicating that security spending is an income-normal good but inelastic. In Models 1 and 3, population is tied to a positive but inelastic response in security spending ranging from 0.687 to 0.412% for a one percent increase in population. The demand for security spending increases with larger population level for two security spillovers measures. Finally, an increase in global non-state conflicts raises security spending for Models 1 and 3 where security spillovers relate to total NATO allies' security spending and inverse-distance weighted security spending, respectively. The anticipated effect of the number of global non-state conflicts is through the UN peacekeeping spending component of security spending. In Model 1, a one percent increase in the number of such conflicts raises security spending by only 0.023%, while in Model 3, a one percent increase in the number of such conflicts raises security spending by only 0.027%, which is in keeping with comparatively small spending on UN peacekeeping for NATO allies. We, however, note that global non-state conflict is not a significant determinant of security spending for Model 2 for contiguous allies.

The robustness runs in Table 3 add two additional threat variables – the number of transnational terrorist attacks in an ally and the exposed borders of allies, where the natural log is just applied to exposed borders. Once again, country-cluster robust standard errors are reported in parentheses below the estimated coefficients. There are again 664 panel observations for the 1991–2020 sample period. Evidence of security free riding is uncovered for NATO for all three representations of spatial spillovers of security spending. The extent of free riding is similar to that reported in Models 1 and 3 in the baseline runs.

The three previous controls display estimated coefficients quite similar to the corresponding coefficients in the baseline models of Table 2 so that GDP per capita is income-normal but inelastic, population exerts a positive but inelastic influence on security in just Models 1 and 3, and the number of global non-state conflicts has a positive impact, as before, in Models 1 and 3. The number of transnational terrorist attacks displays a small positive, but only marginally significant, influence in Models 1 and 2,[3] where a one incident increase in such attacks raises security spending by 0.1% and 0.2%, respectively. This finding for transnational terrorist attacks is in keeping with earlier NATO studies (George and Sandler 2018, 2022). For all three models, a one percent increase in exposed borders augments security spending significantly by 0.184, 0.173, and 0.139%, respectively, in Models 1–3. Exposed borders increase as the NATO alliance expanded in size from 1999 onward, thereby raising ME, a component of security spending, to protect longer land and sea borders.

As another robustness test, we rerun the three models with the natural log of Russian ME added as another control to those listed in Table 3. Those runs are reported in Tables A1 in the Appendix, where the only significant spatial-lag spillover term is that of inverse distance, which indicates NATO security free riding for this distance-weighted metric. Generally, other controls perform as before with GDP per capita and population exerting a positive influence on security spending. Also, the estimated coefficient of global non-state conflicts is positive and significant in Models 1–3 at the 0.05 and 0.01 levels, respectively, while exposed borders are positive and significant in all three models at

Table 3. Robustness check with additional variables in 1991–2020.

	Model 1	Model 2	Model 3
SL (*NATO membership*)	−0.0005***		
	(0.0001)		
SL (*Contiguity*)		−0.001*	
		(0.001)	
SL (*Inverse distance*)			−0.440***
			(0.079)
Ln (*GDP per capita*)	0.953***	0.886***	0.956***
	(0.034)	(0.033)	(0.032)
Ln (*Population*)	0.575***	0.248	0.341**
	(0.159)	(0.163)	(0.150)
Ln (*Global non-state conflicts*)	0.026***	0.012	0.026***
	(0.008)	(0.008)	(0.008)
Number of trans terror attacks	0.001*	0.002*	0.001
	(0.001)	(0.001)	(0.001)
Ln (*Exposed border*)	0.184***	0.173***	0.139***
	(0.035)	(0.040)	(0.037)
Country FE	Yes	Yes	Yes
F statistics	201.246	198.008	213.096
N	664	664	664

* indicates $p < 0.1$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$. Cluster-robust standard errors based on countries are in the parentheses.

the 0.01 level. Transnational terrorist incidents do not display a significant influence on security spending, consistent with the recent literature (George and Sandler 2022). Russian ME affects security spending negatively and significant in all three models, which agrees with recent articles for a similar time frame (George and Sandler 2018, 2022) where NATO defense spending is the dependent variable, consistent with NATO allies not taking or responding to the Russian threat seriously before 2020.

Motivated by the study by Christie (2019), we include two additional proxies for measuring the Russian threat in Tables A2– A3; namely, the inverse distance between each ally's capital from Moscow and contiguity to Russia (only Poland, Estonia, Lithuania, and Latvia are contiguous to Russia) in Tables A2 and A3, respectively. These variables are considered to be time-invariant, which introduces the potential issue of multi-collinearity when running the regressions with country-fixed effects. To address this concern, we estimate the regressions without country-fixed effects. In Table A2, all three spatial-lag spillover terms are negative and significant indicating free riding when the inverse distance to Russia is the threat variable. Notably, GDP per capita, population, and exposed border are significant and positive as in Table 3. The new Russian threat variable is not significant. For contiguity with Russia, the runs in Table A3 tell a similar story in terms of the spatial-lag spillover terms and key controls as Table 3. Once again, the Russian threat variable is insignificant.

Concluding Remarks

This paper shows that a broader definition of security spending or commitment, which includes ME, foreign assistance, and UN peacekeeping contributions, remains consistent with marked evidence of NATO free riding during 1991–2020. Our results imply that small allies that disproportionately support foreign assistance or UN peacekeeping *do not overturn* the prediction of NATO free riding even when different spatial-based weighting schemes are applied to the definition of security spillovers. This is an important finding that is missing in the extant literature.

Future efforts to include contributions to non-UN PKOs are unlikely to change our finding because rich allies such as the United States, the United Kingdom, and France are primary contributors to such PKOs. If security spending is expanded further to include contributions to the World Health Organization (WHO), our results are anticipated to hold since rich nations contribute disproportionately to WHO. Moreover, WHO health spending is very small compared to defense spending, a primary component of security spending, so that any disproportionate health spending by some poor countries cannot compensate rich countries' ME burdens. Thus, far, our security spending measure does not explicitly identify what is spent on cyber security; however, rich countries' MEs include military spending on cyber security, which is essential to the operation of modern-day military forces. The amount spent by private firms on cyber security is impossible to ascertain but would be a useful addition to the security burden measure here. We see further effort at devising a broader measure of security spending as a worthwhile task; however, we do not anticipate that broader security indices will find the absence of NATO free riding.

In final summation, we note two potential shortcomings of our study. First, an important component of our security measure is ME, which is an imperfect measure of defense burden (Balcaen, Du Bois, and Buts 2023) because some defense efforts show up in agencies that are not part of the defense department. Second, our new security burden-sharing measure relies on assessed UN peacekeeping spending and foreign assistance spending, both of which are small compared to ME. This concern can be addressed in future studies by aggregating over more security spending categories such as non-UN peacekeeping, intelligence gathering, cyber security, and homeland security once spending data on these activities become available. For example, except for the United States, NATO allies do not currently publish their homeland security budgets. Also, NATO allies do not publish their intelligence-gathering budgets. Extension of our measure to be more broad-based is the most important direction for future research.

Notes

1. To include non-UN troop contributions as a fourth security activity, a researcher must devise a means for converting each ally's contributed non-UN troops into an expenditure measure accounting for the value of deployed troops, which differs among allies greatly according to training and human capital investments (see Gaibulloev, Sandler, and Shimizu 2009). Given that the United States and the United Kingdom contribute the most non-UN troops, the inclusion of this fourth measure in future research will not overturn qualitatively the free-riding results found later in the paper.
2. At a later point, we choose not to use a fiscal-constraint control (e.g. debt share of GDP) other than GDP per capita since debt constraints are not germane to the United States, the United Kingdom, Canada, or other non-EU members of NATO. Also, such a fiscal constraint is generally correlated with GDP controls, which is often ignored in the literature.
3. The transnational terrorism coefficient does not appear in Table 3 for Model 1 to be significant at the 0.10 level because of rounding. The actual coefficient is 0.00139 with a standard error of 0.00083 so that the *p*-value is 0.095 and marginally significant.

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Appendix

Table A1. Robustness check with Russia military expenditure in 1991–2020.

	Model 1	Model 2	Model 3
SL (*NATO membership*)	0.0001		
	(0.0001)		
SL (*Contiguity*)		−0.0001	
		(0.001)	
SL (*Inverse distance*)			−0.197**
			(0.097)
Ln (*GDP per capita*)	1.015***	0.993***	1.031***
	(0.040)	(0.042)	(0.040)
Ln (*Population*)	0.518***	0.613***	0.562***
	(0.165)	(0.166)	(0.157)
Ln (*Global non-state conflicts*)	0.027***	0.021**	0.029***
	(0.009)	(0.009)	(0.009)
Number of trans terror attacks	0.001	0.001	0.000
	(0.000)	(0.000)	(0.000)
Ln (*Exposed border*)	0.176***	0.175***	0.155***
	(0.034)	(0.038)	(0.036)
Ln (*Russia ME*)	−0.094***	−0.078***	−0.068***
	(0.020)	(0.017)	(0.019)
Country FE	Yes	Yes	Yes
F statistics	173.218	168.727	184.357
N	634	634	634

* indicates $p < 0.1$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$. Cluster-robust standard errors based on countries are in the parentheses.

Table A2. Robustness check with the inverse distance to Russia in 1991–2020.

	Model 1	Model 2	Model 3
SL (*NATO membership*)	−0.001***		
	(0.000)		
SL (*Contiguity*)		−0.003***	
		(0.000)	
SL (*Inverse distance*)			−0.407***
			(0.065)
Ln (*GDP per capita*)	1.047***	1.075***	1.065***
	(0.015)	(0.015)	(0.014)
Ln (*Population*)	1.056***	1.103***	1.063***
	(0.010)	(0.012)	(0.010)
Ln (*Global non-state conflicts*)	0.023	−0.042***	−0.013
	(0.014)	(0.011)	(0.012)
Number of trans terror attacks	0.002	0.004	0.005
	(0.002)	(0.003)	(0.003)
Ln (*Exposed border*)	0.053***	0.019**	0.029***
	(0.006)	(0.008)	(0.007)
Inverse distance to Russia	−52.538	−9.451	−18.020
	(59.843)	(61.185)	(62.870)
Country FE	No	No	No
F statistics	4558.175	6443.167	5901.869
N	664	664	664

* indicates $p < 0.1$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$. Cluster-robust standard errors based on countries are in the parentheses.

Table A3. Robustness check with the contiguity to Russia in 1991–2020.

	Model 1	Model 2	Model 3
SL (*NATO membership*)	−0.001***		
	(0.000)		
SL (*Contiguity*)		−0.003***	
		(0.000)	
SL (*Inverse distance*)			−0.420***
			(0.064)
Ln (*GDP per capita*)	1.049***	1.070***	1.067***
	(0.015)	(0.015)	(0.014)
Ln (*Population*)	1.058***	1.103***	1.058***
	(0.009)	(0.010)	(0.009)
Ln (*Global non-state conflicts*)	0.023*	−0.041***	−0.010
	(0.014)	(0.011)	(0.012)
Number of trans terror attacks	0.002	0.004	0.005*
	(0.002)	(0.003)	(0.003)
Ln (*Exposed border*)	0.053***	0.018**	0.032***
	(0.006)	(0.007)	(0.006)
Contiguity to Russia	−0.036	−0.020	−0.070**
	(0.034)	(0.037)	(0.036)
Country FE	No	No	No
F statistics	4085.811	5314.876	5556.880
N	664	664	664

* indicates $p < 0.1$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$. Cluster-robust standard errors based on countries are in the parentheses.