# Free-Riding in Alliances

## Testing an Old Theory with a New Method

December 03, 2012

Thomas Plümper[a] and Eric Neumayer[b]

[a] Department of Government, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, UK, tpluem@essex.ac.uk

[b] Department of Geography and Environment, London School of Economics and Political Science (LSE), London WC2A 2AE, UK, e.neumayer@lse.ac.uk

**Abstract**

We revisit the old and well-established theory of free-riding in military alliances. Existing empirical evidence infers free-riding from the larger military expenditures per gross domestic product of countries of larger size. Yet, larger countries have broader military and geo-strategic interests that result in larger defense burdens, thus creating an identification problem for existing tests of free-riding behavior. We therefore develop alternative predictions that ignore differences in the level of military spending and instead relate to changes in spending over time. The safety level of smaller members of an alliance is affected, simultaneously, by changes to military spending of the largest alliance member as well as by spending changes of the main enemy. Using the North Atlantic Treaty Organization (NATO) as test case, we estimate country-specific response functions of the smaller alliance members to growth in United States (US) military spending on the one hand and to growth of Soviet spending (if in excess of US growth) on the other hand, covering the period 1956 to 1988. Results from our quasi-spatial approach corroborate one part of the theory in that we find the vast majority of the smaller NATO allies to be free-riders. However, our empirical evidence flatly contradicts the other part of the free-riding theory: the extent of free-riding is not a function of country size. Smaller allies free-ride, but the relatively larger of the smaller allies do not free-ride any less than the relatively even smaller alliance partners.

## 1. Introduction

Smaller members of a military alliance free-ride on the defense burden covered by the largest alliance member (Olson 1965; Olson and Zeckhauser 1966), or don't they? The theory of free-riding in alliances appears to be theoretically plausible, but the empirical evidence that has been brought forward to support the theory suffers from a serious identification problem. In short, the mere facts that larger North Atlantic Treaty Organization (NATO) allies have a larger share of military spending to their gross domestic product (GDP) or gross national product (GNP)[1] than smaller allies, that the correlation between country size and the share of military spending to GDP is positive, or that country size has a positive estimated effect on military spending as share of GDP do not provide convincing evidence for the free-riding in alliance hypothesis because larger countries have broader military and geo-strategic interests than smaller members.

Compare, for example, the United States to Denmark. On the one hand, we have a small European country whose neighbors are NATO members, that had colonies in Faroe Islands and Greenland, and that has no geostrategic interest beyond the Northern Atlantic and North-West Europe. On the other hand, the USA is a superpower with troops stationed in 150 countries of the world, that entertains roughly 80 percent of the global fleet of air craft carriers, and that after the Second World War was involved in militarized conflicts on all continents with the exception of Australia and Antarctica. Political scientists should therefore not be surprised that the USA spends a larger share of her gross domestic income on defense than all other NATO countries.

[1] Some studies look at spending per GDP, others at spending per GNP. As this makes practically no difference, we use the GDP terminology throughout this paper.

Such differences in geo-strategic interests render simple tests of correlation of country size with the size of military burden or the effect of country size on the military burden utterly implausible. Multivariate regression analysis could in principle deal with this problem if one managed to fully control for the influence of such interests. This is unlikely, however. More importantly, there are many other reasons why countries differ in the absolute size of their military spending or their spending relative to GDP, from differences in military recruitment (conscription or professional army) to their geographical position toward the enemy (common border or well distanced) and their historical legacy (e.g., Germany). Unless one can adequately control for these other influences, which is highly implausible, multivariate regression in levels of military spending or spending to GDP will suffer from an identification problem.

This leaves us with a plausible theory – the theory of free-riding in an alliance – but implausible evidence supporting this theory. We therefore suggest alternative predictions from the free-riding theory which lead to different tests that do not focus on the allocation of the total defense burden among NATO allies but on the smaller NATO allies' responsiveness to growth in military spending of the USA and the Soviet Union, respectively. We test these alternative predictions of the "free-riding in alliances" theory by using a quasi-spatial approach. We do not analyze variation in *levels* of military expenditure between the NATO members, but variation in *growth rates* of military spending and we estimate the reaction function to the growth rate in US military spending and the growth rate difference between Soviet Union to US military spending. We argue that free-riding is a function of the responsiveness of NATO allies to both growth in US spending and growth in Soviet spending (if in excess of US spending growth) taken together. We define a country as "free-rider" if

the sum of both response parameters is significantly smaller than 1.0.[2] Based on this definition, we estimate country-specific degrees of free-riding. As we show, there is evidence for free-riding by the vast majority of smaller NATO allies, but the degree of free-riding is not a simple function of country size.

## 2. The Theory of Free-Riding in Alliances: A Brief Review of the Literature

In one of his last speeches as departing US Defense Secretary, Robert M. Gates warned of a growing divide within the NATO "between those willing and able to pay the price and bear the burden of commitments, and those who enjoy the benefits of NATO membership but don't want to share the risks and costs" (International Herald Tribune 2011). Gates predicted that future political leaders of the USA, "those for whom the Cold War was not the formative experience" as it was for him, may be less inclined to accept an unequal burden sharing between the US and her European allies. This American political discussion about burden sharing suggests that the by far largest ally, the US, feels exploited by all other allies ("the Europeans") and in the absence of an obvious distinction, by each of the European allies. In this paper, we will focus on the hypothesis of "the exploitation of the largest ally by all others".

This section reviews the theoretical and empirical literature on free-riding in military alliances. We focus on NATO as the most stable and important military alliance in the world. Specifically, we show that researchers have been aware of the fact that a) geostrategic

[2] We will discuss later that this is not the only possible definition of free-riding, of course. Yet, more demanding definitions that require allies to respond more strongly to Soviet Union military spending growth if they fail to (fully) respond to American spending growth leave our causal inferences intact.

interests of NATO members are only partly aligned, b) that larger countries have broader geostrategic interests and c) that countries also differ in their levels of military spending for other reasons. We also demonstrate that these insights have been mostly ignored by empirical researchers who accept higher military contributions of larger countries as evidence of free-riding and neglected that differences in the *level* of military spending may be caused by differences in geostrategic interests, history, the political system and so on.

### *2.1. The Theory of Free Riding in Alliances*

Countries join military alliances to pool their resources against a common threat. However, complaints about the "free-riding" of European allies at the expense of the USA are (almost) as old as the NATO. To political scientists, there is little new in the suggestion that NATO offers incentives for free-riding behavior by the smaller allies. The theory of free-riding in alliances, as first developed by Olson and Zeckhauser (1966), argues that defense in an alliance is a pure public good: the benefits associated with defence spending are non-excludable and non-rival in consumption among allies (Sandler and Hartley 1999: 29).

But is defense non-excludable among alliance members?[3] The North Atlantic Treaty that established the NATO promises so in article 5: "The Parties agree that an armed attack against one or more of them in Europe or North America shall be considered an attack against them all and consequently they agree that, if such an armed attack occurs, each of them (…) will assist the Party or Parties so attacked (…)." If this rule were obeyed under all circumstance, then military spending would produce a non-excludable good. However, the solemn promise of article 5 has never been tested – the only time Article 5 was invoked was

[3] Non-alliance members can of course always be excluded, making defence in an alliance a club good rather than a pure public good. We nevertheless use the language of public good, keeping in mind that the relevant population are only countries within, not outside an alliance.

after 9/11 when the biggest member of the alliance was under attack, not by a foreign state, however, but by international terrorists. It is therefore unknown whether some governments of NATO countries would decide not to defend a smaller ally in violation of the wording of the treaty.[4] For the smaller allies a particular problem would arise if the US commitment to article 5 were in doubt. However, incentives for smaller allies to free ride continue to exist despite the largest ally's commitment to protect them being uncertain. In fact, the only way the dominant ally or, more generally, larger allies could eliminate free-riding is by credibly committing themselves not to honor their commitment towards smaller alliance members that free-ride. In the presence of at least partly aligned interests, however, such a statement could never become credible. Larger countries could only deter being exploited by their smaller allies via a credible threat of exclusion if the protection of these smaller allies from a potential enemy is not in the interest of larger allies.

This leaves us with the question whether defense is rival in consumption. On a trivial level, military goods are rival in consumption. If the US Army fires a bullet on an enemy, another NATO army cannot fire the same bullet on another enemy. Yet, on a non-trivial level the case is less clear. If defense spending aims at deterrence, then deterrence by the US military of its enemies will be non-rival in consumption by other alliance members since it will also deter other NATO members' enemies if these enemies believe the principle laid out in article 5 of the NATO treaty. Especially after NATO abandoned the strategy of mutually assured destruction and implemented the strategy of flexible response in 1967, smaller allies may have wondered, however, whether they are important enough to guarantee a NATO

[4] According to Leeds (2003) alliance commitments are fulfilled about 75 percent of the time. She explains this lack of full commitment by deteriorating support for the alliance over time. As time goes by and interest constellations change, governments become increasingly unwilling to fulfil past commitments.

intervention in case of an open military dispute, which puts doubt on the credibility of deterrence. At the same time, the US begun to develop more "protective" than "deterrent" weaponry (Sandler 1977, Sandler and Forbes 1980).[5] Yet, a move toward "protective" weaponry does not itself weaken the credibility of deterrence. All other things equal, countries that own protective weaponry might even increase their commitment to protect smaller allies as their costs of doing so would decline, given that they are now more protected from the devastating consequences of an attack by the enemy. In other words, the credibility of the American commitment to protect smaller allies partly positively depends on the effectiveness of the US's protective weaponry. Such weaponry thus does not simply produce private rather than public benefits.

In sum, the extent to which defense in an alliance is a public good and therefore invites free-riding by the smaller alliance members is a function of the homogeneity of interests within the alliance (Gates and Terasawa 2003) rather than determined by the existence of an alliance per se or a matter of military technology. In turn, then, unless the interests of alliance members are independent, the existence of NATO affects the perceived military security of member countries and thus potentially their incentives to invest in defense. Much of the debate of free-riding in alliances has focused on small members. They can reduce military spending with no noticeable effect on the alliance's overall ability to defend its borders, while

[5] Sandler and his co-authors augment Olson and Zeckhauser's pure public good theory of military deterrence to account for "changes in NATO's military strategy and the development of new weapon systems" (Sandler and Forbes 1980: 426). To theoretically account for these changes, their 'joint product' model distinguishes between "deterrent", "protective", and "defense" weapons. In their view, only deterrent weapons provide pure public goods, while the other types are excludable. This approach perceives all weapons as being based on a continuum with protective and deterrent weapons marking the two extremes (Sandler and Forbes 1980: 427).

potential cuts in defense spending of large countries would have a noticeable effect on the alliance's military capabilities (Olson 1965; Olson and Zeckhauser 1966; Sandler 1993).[6] To put it more bluntly: Since the defense spending of each single one of the smaller allies is virtually irrelevant for the alliance's joint military strength, the theory predicts that small countries under-contribute to the joint effort or make no own defense spending contribution at all (as Iceland does).

The theory of free-riding in military alliances thus makes two core predictions: First, the largest ally bears a disproportionately large share of the aggregated defense burden of the alliance. And second, the smaller an ally is, the more it free-rides. This does not necessarily mean that middle-sized allies such as the Netherlands, Italy or even Germany do not free-ride. If a single country dominates an alliance as is clearly the case with NATO, even middle-sized countries have an incentive to under-invest in defense. The dominant country in alliances can accept free-riding of smaller alliance members because despite free-riding the alliance reduces the cost of an arms race with other large rival powers and their alliances. In absolute terms, even free-riders contribute to the fight against the enemy and the alliance is more powerful than the sum of its parts including the dominant nation alone.[7] In relative terms, however, they contribute less than the dominant country in the alliance (Diehl 1994).

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[6] If a small NATO member, say Denmark, halved her military expenditures, the total defense spending of NATO would decline by less than 0.5 percentage points. The United States, the NATO's biggest defense spender, could increase her military spending by a little less than 0.5 percent to compensate for Denmark's blatant attempt to free ride.

[7] An alliance may also generate scale economies in government procurement of military products. Alliance members are more likely to agree on joint production of military goods and they may even agree to specialize in their production. Thus, the existence of an alliance is likely to be beneficial for the dominant alliance member even if smaller or all other countries partly free-ride on the military

*2.2. Existing Empirical Evidence for Free-Riding in Alliances*

Theoretically, free-riding in the provision of a public good can be clearly defined as receiving larger benefits from the public good than contributing to the costs of providing the public good. Empirically, in the context of free-riding in military alliances the problem is that the benefits an individual alliance member receives from the public good is very difficult to estimate. Most empirical tests have therefore focused on the contribution to the cost side. Here as well scholars encounter problems, however, since not all military spending contributes to the public good of the alliance, but contributes to the private interests of a country.

Empirically, free-riding is thus a matter of definition. Whether it is detected for an alliance member depends on the definition and on the identification strategy employed. The simplest definition of "free-riding" merely compares the share of military spending to a country's GDP across alliance members, as Olson and Zeckhauser (1966) in their seminal contribution have done. Defined in this way, free-riding becomes immediately obvious. The US's military spending as share of its gross domestic product (GDP) was almost 7.5 percent over the period 1956 to 1988 while all other NATO members on average spent 2.1 percent of their GDP for defense (data from Whitten and Williams 2010).

However, this definition invites an obvious counterargument. It simply assumes that the NATO members have identical geo-strategic interests outside the NATO area. This is implausible. The USA has global military interests that other NATO members either do not have or have to a far lesser extent. One should thus expect that the USA devotes a larger

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expenditures of the dominant ally. Under these circumstances, alliances can be remarkably stable despite free-riding, moderate conflict of interest, and the absence of a plausible military threat.

share of her GDP to military spending. Comparing defense spending to GDP ratios does not make sense if one tries to identify free-riding.

A very similar and thus not any more plausible second test uses correlations: the NATO members' military expenditures as percentage of their GDP is correlated with their total GDP, indicating that larger members contribute a larger share of their total income to defense. Olson and Zeckhauser (1966) also show that the correlation coefficient between a NATO member's defense budget as a percentage of GDP and its GDP is positive.[8] They conclude that "there is a significant positive correlation indicating that the larger nations in NATO bear a disproportionate share of the burden of the common defense" (Olson and Zeckhauser 1966: 275).[9] Again, however: such correlation does not corroborate the free-riding hypothesis as larger allies, and the USA in particular, also have costly military interests beyond the NATO area.

Only the third employed technique, multivariate regression analysis, controls for confounding factors that also influence a country's willingness to invest in defense. Here as well, studies have found a significant effect of country size on the share of military spending to GDP (e.g., Oneal and Diehl 1994). Multivariate regression analysis is more reliable since it can take

[8] They look at defense spending relative to GNP rather than GDP.

[9] Interestingly, even some critics of the free-riding theory have used bivariate correlation analyses to cast doubt on the hypothesis (e.g., Sandler and Murdoch 2000). Russett (1970) was one of the first to show that the explanatory power of the free-riding hypothesis declines over time. Reinforcing this argument, Sandler and Forbes (1980) demonstrate that the correlation between defense expenditures and GNP began to diminish in the mid-1960s and loses statistical significance after 1967. While Olson and Zeckhauser reported a rank correlation between the military spending to GNP ratio and GNP of .490, Sandler and Forbes show that this correlation is only .319 in 1960 and declines to 0.099 in 1975. Sandler and Forbes attribute the declining correlation to changes in NATO's strategy.

some of the confounding factors into account. Yet, early models were notably parsimonious. Sandler and Murdoch (1990) include income and allied spending as well as Soviet military spending as explanatory variables. Oneal (1990) as well as Oneal and Diehl (1994) include economic size, the fraction of NATO's annual expenditures accounted for by contiguous allies (zero else) – a variable meant to control for the geographical distribution of NATO's capabilities – and the number of militarized disputes the NATO member countries are engaged in over the 5 years prior to the estimation year. Apparently, this latter variable marks a first attempt to account for heterogeneous interests. However, the operationalization of this variable violates the general idea that the vast majority of military expenditures aims at deterrence and not at actually engaging in militarized conflicts. This variable may thus account for the differences between Portugal and, say, Denmark, but not necessarily for the costly military interests the US entertains all around the world in order to deter actual and potential enemies. Oneal and Diehl (1994) also include military expenditures of the Soviet Union and a variable for the tensions between the US and the Soviet Union.[10] They analyze the period from 1950 to 1986 and find a positive coefficient for country size. They also separately analyze the years before 1968 and after 1967 and find that the coefficient of country size becomes significantly smaller and drops from 0.21 to 0.05, but does not lose statistical significance. Finally, they show that NATO countries of smaller economic size respond less to Soviet military spending than larger NATO countries. Yet, unless the broader geo-strategic interests of larger alliance members are adequately accounted for, country size may still simply catch the effect of expensive broader military and geostrategic interests of larger allies like the USA, France, or the UK which have little effect on the safety of, say, Denmark and Finland who do not entertain such interests.

[10] The model does not account for serial correlation of errors and other forms of heterogeneity between NATO members.

*2.3. Discussion*

The existing empirical evidence for the theoretically plausible albeit not uncontested theory of free-riding in alliances rests on weak testing strategies. They all suffer from an important identification problem. Since larger countries typically have broader geostrategic interests, the effect of country size on military spending could be caused by these different interests rather than by free-riding. In other words: Even in the absence of NATO, the US with its global military interests would still devote a larger share of her income to defense than, say, Denmark and Italy. More generally, differences across allies, both observed and unobserved, in the form of their geographical position, history, political system and so on cause differences in levels of military spending that have nothing to do with free-riding. A persuasive test of the free-riding hypothesis therefore calls for a different identification strategy. In the remainder of this article, we develop such an alternative identification strategy.

## 3. Research Design

In our analysis, we employ a quasi-spatial approach to testing augmented predictions of the free-riding in alliances theory. We start by developing these predictions before discussing our empirical research design in more detail. We argue that free-riding is better studied by looking at the responsiveness of smaller NATO members to changes in the military balance between the Soviet Union and the USA.

*3.1. Rethinking the "Free-Riding" Predictions*

We suggest an alternative interpretation of the free-riding hypothesis to the one tested in the existing literature, namely an interpretation that assumes that the incentives to free-ride for smaller NATO members result not simply from the total defense burden that the USA

musters, but from changes in the defense burden of the USA and the Soviet Union over time. Our alternative interpretation is based on the premise that incentives to free-ride are a function of the safety level of NATO members. Changes to this safety level are triggered by growth in US spending on the one hand and growth in Soviet spending if in excess of US spending on the other hand.[11]

All other things equal, an increase in US spending raises the safety level of NATO members as it shifts the security balance between the alliance and its adversaries in the alliance's favor. Free-riding on the USA seemingly occurs if her allies increase their spending in response to higher US spending less than proportionally: they free-ride on the US effort to increase NATO's safety level if they match an increase of US military spending of one percent with an increase in their own military spending by less than one percent.

Yet, all other things are not equal since a stronger increase of Soviet above US spending meanwhile lowers the safety level of NATO members. For a full judgment on free-riding, one must therefore also take into account the responsiveness of the smaller NATO allies to situations of stronger Soviet relative to US spending growth. By increasing in certain years its spending less than the Soviet Union, the USA lets the security balance slip against the alliance. The smaller allies can thus make contributions to the public good of alliance security not merely by matching US military spending growth, but also by matching Soviet spending growth in years in which the Soviet Union increases military spending more than the US does. If, hypothetically, the smaller allies were totally unresponsive to higher US spending as such, but fully matched a stronger increase in Soviet relative to US spending with an equally

[11] We use growth in Soviet Union military spending in our main estimations, but growth in Warsaw Pact military spending in robustness tests.

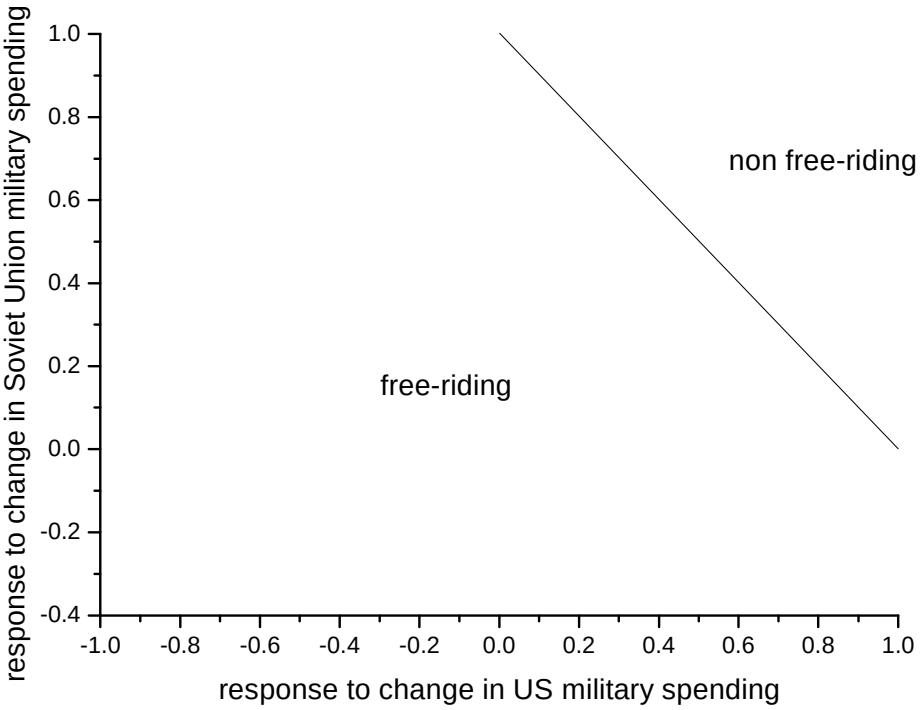
strong increase in their own spending, then in total they have fully contributed toward preventing the security balance from moving in the adversary's favor.

The upshot is that in order to assess free-riding we need to examine a combination of the two types of responsiveness. Allies do not free ride on the US if they either fully match all US spending increases or they match all Soviet spending increases above US spending increases or they combine the two types of responsiveness with each other such that the combined sum fulfils these requirements. This gives us two polar cases, which can then be linearly combined with each other to create a free-riding threshold. To illustrate graphically, the point at the co-ordinates (1.0; 0.0) in figure 1 below is the first point through which all plausible free-riding thresholds should go through. That is, a small NATO ally that fully responds to growth in US military spending with equal growth and simply ignores growth in Soviet Union military spending cannot be called a free-rider since it perfectly matches US spending changes. Second, the co-ordinate point (0.0, 1.0) should also be accepted as second plausible anchor point of the free-riding threshold. In words, a country that fully responds to any deterioration of the security balance in the adversary's favor – a consequence of Soviet spending increase in excess of US spending increase – by fully matching Soviet spending increases cannot be called a free-rider since it fully contributes toward stemming a shift in the security balance against the alliance, even if it simply ignores growth in US military spending in all other years.

The free-riding threshold is then simply the linear combination of the two co-ordinate points in figure 1: Free-riding occurs for points to the interior of the threshold line in the sense of lying between the co-ordinate axes and the threshold line, whilst absence of free-riding is represented by points that lie to the exterior of the threshold line. Expressed numerically, we therefore define free-riding as follows: If, over our estimation period 1956 to 1988, the estimated responsiveness of a NATO ally to US spending growth *plus* the responsiveness to

growth in Soviet spending (if in excess of US spending) is smaller than 1.0, then an ally can be called a free-rider and the smaller this sum of the two estimated degrees of responsiveness the larger the extent of free-riding. Conversely, a sum of estimated degrees of responsiveness equal to or above one signals the absence of free-riding.

Figure 1: The Free-Riding Threshold




We do not claim that our definition is 'correct'. Definitions are not correct, they serve a purpose, they make a distinction, and they ought to be plausible. We have argued above that the two anchor points (1.0; 0.0) and (0.0, 1.0) are plausible. Let us further illustrate our definition. For years in which the US and the Soviet Union both increased their defense spending at the same rate of, say, 3 percent, a NATO member free rides if the growth rate of its defense spending is, on average in those years, less than 3 percent and it free rides the more the further below 3 percent its own growth rate is – controlling for relevant covariates. For years in which the US growth rate of military spending exceeds the Soviet Union's

growth rate, our definition would similarly identify a smaller NATO ally as free-riding if its growth rate is, on average in those years, below that of the US. In years in which the Soviet Union increased its military spending by more than the USA does, a smaller NATO ally would be free-riding if, on average in those years, it increased its own military spending by less than the Soviet Union does.

At first sight, this last example appears to be very exacting of the smaller NATO allies, seemingly demanding them to grow their military spending by more than the USA does in response to Soviet spending if the latter's growth is in excess of US spending growth. This would appear placing higher demand on the smaller allies than on the USA. This is not the case, however. Keep in mind that our definition does not demand that smaller NATO allies grow their military spending both proportionally to US spending increases and proportionally to Soviet spending increases (if in excess of US spending increases) at the same time. Instead, all our definition requires is that the sum of responsiveness to the two growth rates is 1.0 or above. This would allow NATO members to have a growth rate of military spending that falls behind the US growth rate in years the USA grows its military spending faster than the Soviet Union as long as the smaller ally makes this up by larger than US spending increases in years in which the Soviet Union grows its military spending by more than the USA does. In other words, being a little responsive to US spending growth can be compensated by being strongly responsive to Soviet spending growth when Soviet spending growth exceeds that of the US, and vice versa.

We understand that by focusing on growth in military spending we change the perspective on free-riding. We do so because our alternative strategy reduces the identification problem that we have discussed in section 2. Our modeling strategy is not without drawbacks either, however. Perhaps most importantly, our approach would not identify "free-riding" if the initial distribution of defense spending is very unequal with the smaller clearly exploiting the

largest alliance member, but – starting from there – the smaller members of an alliance implementing similar growth rates over time as the largest ally. This is very unlikely to occur though because governments in smaller countries are unlikely to keep the level of free-riding stable over time. Instead, they have an incentive to exploit the changing free-riding opportunities over time as the military spending by the largest ally and by the enemy changes.

### *3.2. Response Functions: A Quasi-Spatial Approach to Testing the Augmented Free-Riding Hypotheses*

We test the augmented predictions derived from the theory of free-riding in alliances in a quasi-spatial model. Accordingly, we regress the growth rate in military spending of NATO members other than the USA on the US growth rate in military spending and the Soviet Union growth rate in military spending if in excess of US spending increases (this variable is therefore set to zero in years in which US spending increases exceed Soviet spending increases). We call these estimation models quasi-spatial because growth in military spending by the smaller NATO allies is modeled as a function of growth in military spending by other countries (here: the USA and the Soviet Union). Different from spatial models, we assume no feedback from growth in spending by the smaller NATO allies on either US or Soviet spending, assuming the latter in effect to be exogenous. We have argued above that, as a first approximation, the spending of each single one of the smaller allies is irrelevant to the US and, by implication, to the Soviet Union, which justifies the assumption of treating US and Soviet spending decisions as exogenous.

Recall that the theory predicts that smaller countries free-ride more strongly than others. The standard approach toward testing this hypothesis would be to interact the US and Soviet growth rate variables with a variable measuring the country size of the smaller NATO allies. This would clearly test the hypothesis that free-riding is a function of country size. However,

it would impose the assumption of a fixed and linear influence of country size on the degree of free-riding. If our argument is correct that countries are very heterogeneous in their geo-strategic interests, geographical location, historical legacy and so on, then this means that their responses to US and Soviet spending growth and, by implication, their free-riding behavior will also be heterogeneous and not simply a function of country size. We therefore opt for a superior alternative and let the data tell us the degree to which each of the NATO allies free ride, if at all. We do so by estimating separate response functions for each of the countries in our sample. Doing so still allows us to investigate whether the country-specific degrees of free-riding are correlated with country size.

*3.3. Model Specification*

Our dependent variable is the growth rate in absolute military spending in real US$ rather than growth in military spending per GDP. Firstly, governments directly control military spending, not spending per GDP and, secondly, security is determined by military spending, not by the ratio of spending to GDP.[12] By analyzing growth in military spending we take out all level effects among NATO allies, which is warranted given that both unobserved and observed heterogeneity among allies will create large differences in their levels of military spending. Country-specific response functions to the US growth rate in military spending and the Soviet growth rate (if in excess of the US growth rate) are our central explanatory variables. Military expenditure estimates for Warsaw Pact countries are notoriously uncertain and we use only Soviet spending in our main estimations, but our results are robust to using spending by all Warsaw Pact nations instead, as our robustness section shows.

[12] For example, if the Soviet economy shrank during the 1980s, as it probably did, this would increase its "defense burden", but would not increase the military threat if absolute expenditures did not increase.

A number of control variables account for other factors determining growth in military expenditures. The growth rate of real GDP accounts for the fact that economic growth tends to lead to higher tax revenues which makes it easier to increase military budgets. We also include a measure of the intensity of armed conflicts in which a NATO country was involved in during a year, the lagged dependent variable to account for temporal dynamics and a linear year variable to account for any potential residual global trend. Lastly, we include the growth rate of military spending by all other smaller NATO allies taken together, i.e. by all allies other than the country under observation and other than the USA, as control variable. This variable controls for the ups and downs in military spending by the *group of smaller allies taken together* over time. All data are taken from Whitten and Williams (2010), complemented with data from the Correlates of War project (http://www.correlatesofwar.org/) and from Gleditsch et al. (2002). Table 1 provides summary descriptive statistics. We cluster standard errors on countries.

Table 1. Summary descriptive statistics.

| | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Military spending growth rate | 0.032 | 0.129 | -0.454 | 0.519 |
| US military spending growth rate | 0.017 | 0.062 | -0.097 | 0.237 |
| Soviet Union spending growth rate (if > US rate) | 0.032 | 0.045 | -0.015 | 0.155 |
| GDP growth | 0.032 | 0.088 | -0.211 | 0.247 |
| Intensity of armed conflict involvement | 0.243 | 0.787 | 0 | 6 |
| Growth in military spending by all other small allies | 0.031 | 0.031 | -0.083 | 0.177 |

Iceland, Luxembourg and Spain are the only three NATO members not in the sample. Iceland has no independent army, we have no data for Luxembourg and Spain joined NATO only in 1982, becoming progressively integrated over time, which is too short given we restrict the analyses to the period 1956 to 1988. The years prior to 1956 were heavily affected by the Korean war and its aftermath, while the fall of the Berlin wall and the end of communism in

Eastern Europe fundamentally changed the East-West antagonism for which NATO was originally created.

## 4. Results

Our empirical specification allows for country-specific responses to the US growth rate and Soviet growth rate (if in excess of the US growth rate) in military spending, for which table 2 reports results. Before we turn to discussing the country-specific response functions, let us briefly report results for the control variables. The lagged growth rate has a positive coefficient that is far from being statistically significant, however. This suggests that there is no temporal persistence in military spending growth rates controlling for the other explanatory variables in the model. We find the expected positive effect for the GDP growth rate on military budgets. As countries grow faster, they also increase their military budgets more than if they grow more slowly.[13] That the estimated effect of economic growth on military spending growth is marginally statistically insignificant is entirely due to the presence of the growth in military spending by other smaller allies in the estimation model. If this variable were dropped from the model then the coefficient of the economic growth rate becomes slightly larger and statistically significant at the 0.05 level. A one percentage point

[13] This could dampen any degree of free-riding: If the resources not contributed to defence in period 1 were spent in a way that fosters economic growth, then in period 2 military spending increases because of a higher economic growth rate. However, the effect is too small to be relevant. Assume that all resources not spent on defence are used for investment. The coefficient with which investment translates into economic growth usually varies between 0.3 and 0.4. Thus, if one percent of GDP not spent on defence were invested, it would increase GDP growth by 0.4 percent, which according to our estimates would translate into an increase of merely slightly less than 0.3 percent in the defence budget in period 2. If we relax the unrealistic assumption that all non-military spending is invested and assume that only half of it is invested the effect would also halve.

increase in the military spending by the other small allies is associated, on average, by an 0.68 percentage point increase by a NATO member. We find no significant effect of conflict involvement on the growth rate of military budgets. This does not come as a surprise. Defense budgets are so large even in peace years that fighting a limited armed conflict does not put much extra stress on countries' military expenditures. The smaller NATO allies did not fight any major prolonged wars during our period of study and entertained militaries large enough to fight limited wars such as the one in the Falklands without a noticeable increase in military expenditures during the conflict period.

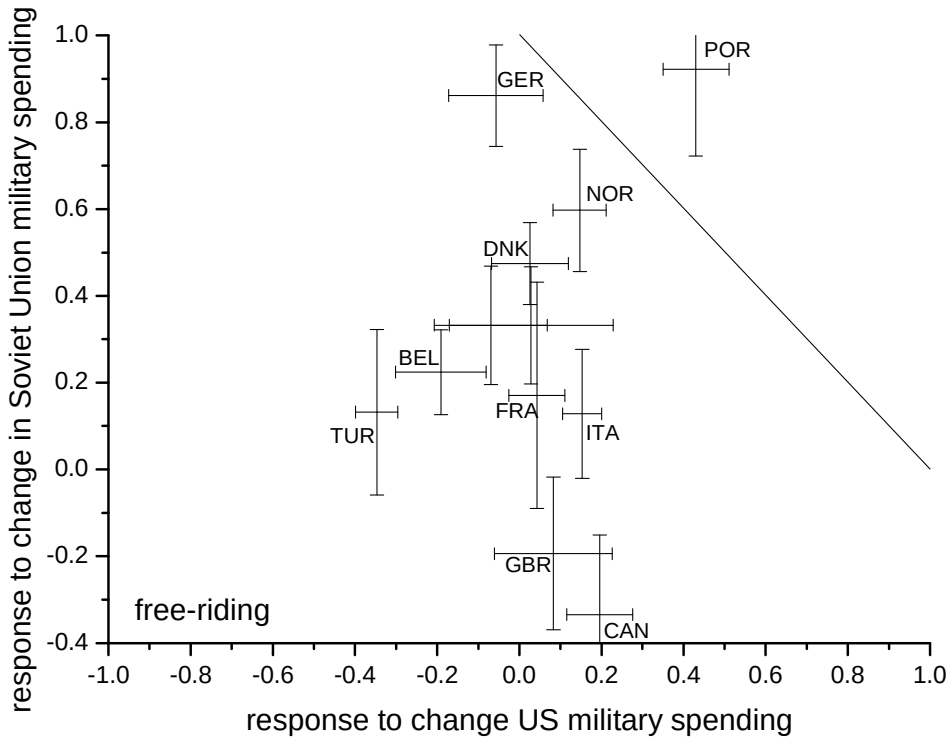
Table 2. Estimation results for entire period 1956 to 1988.

| Country-specific response of: | to US growth | to Soviet growth (if in excess of US growth) |
|---|---|---|
| Canada | 0.196** | -0.334** |
| | (0.0411) | (0.0937) |
| Great Britain | 0.0828 | -0.194* |
| | (0.0731) | (0.0897) |
| Netherlands | -0.0696 | 0.332** |
| | (0.0703) | (0.0695) |
| Belgium | -0.191** | 0.224** |
| | (0.0562) | (0.0497) |
| France | 0.0429 | 0.171 |
| | (0.0346) | (0.133) |
| Portugal | 0.430** | 0.922** |
| | (0.0408) | (0.102) |
| West Germany | -0.0567 | 0.861** |
| | (0.0584) | (0.0595) |
| Italy | 0.153** | 0.128 |
| | (0.0240) | (0.0758) |
| Greece | 0.0289 | 0.332** |
| | (0.102) | (0.0687) |
| Norway | 0.147** | 0.597** |
| | (0.0329) | (0.0718) |
| Denmark | 0.0257 | 0.474** |
| | (0.0477) | (0.0481) |
| Turkey | -0.347** | 0.132 |
| | (0.0262) | (0.0974) |
| Lagged dependent variable | | 0.0496 |
| | | (0.0603) |
| GDP growth | | 0.619 |
| | | (0.383) |
| Intensity of armed conflict involvement | | -0.00407 |
| | | (0.00747) |
| Growth in military spending by all other small allies | | 0.685** |
| | | (0.135) |
| Linear year trend | | 0.000884* |
| | | (0.000296) |
| Constant | | -1.763* |
| | | (0.584) |
| Observations | | 383 |
| R-squared | | 0.306 |

Note: Dependent variable is growth in military expenditures. Standard errors clustered on countries in parentheses. * statistically significant at 0.05, or ** 0.01 level.

Turning to the ally-specific response functions, recall that we have argued that the response to the US growth rate plus the response to the Soviet growth rate in case the latter exceeds the US growth rate indicates the degree of free-riding, if any – a sum of coefficients of 1.0 or above suggests no free-riding. This information is best represented graphically. Figure 2 plots the responsiveness to the Soviet growth rate (if in excess of the US growth rate) on the y-axis against the responsiveness to the US growth rate on the x-axis for each of the NATO countries in the sample, together with their respective 95 percent confidence intervals. It also displays the threshold for our definition of free-riding.

Figure 2: Response Functions for 12 NATO Members with 95 Percent Confidence Intervals.




The distance to this threshold marks the degree to which countries free ride. According to our definition, our results reject the free-riding hypotheses for only one country clearly, namely Portugal, which is well above the free-riding threshold. For West Germany and Norway, the sum of coefficients are below the free-riding threshold, but the confidence intervals almost

reach the threshold, indicating we can reject the hypothesis that West Germany and Norway were no free-rider at the 95 percent confidence level, but we cannot be entirely sure they were not free-riders after all. Figure 2 does not support the hypothesis that the degree of free-riding is correlated with country size: larger countries do not appear to be systematically closer to the free-riding threshold than smaller countries. This is confirmed by bivariate correlation analysis between the estimated degrees of free-riding and the average size of GDP of the NATO allies over the estimation period, which suggests that the degree of free-riding is not correlated with country size ($r = 0.04$, p-value 0.227).

**5. Robustness**

Table 3 reports results from testing the robustness of our inferences to plausible changes in model specification. To facilitate interpretation of the results from the robustness tests, figure 3 displays the responsiveness parameters and their 95-percent confidence intervals for each of the small NATO member included in our analysis for the five robustness test models.

Not all military spending growth by the US and the Soviet Union is relevant to the safety of the smaller NATO allies. Both superpowers have fought major wars outside the North Atlantic area which affected their military spending growth. The most important of these are the Vietnam war and the invasion of Afghanistan by the Soviet Union, respectively. Model 2 reports the country-specific response rates for the period outside the main Vietnam war activity (1965-73), while model 3 does the same for the period outside the period of Soviet occupation of Afghanistan (1980-88).

In model 4, we take into account that the smaller NATO allies may also respond heterogeneously to changes in the sum of military spending by all other smaller NATO allies. To do so we allow country-specific response functions to this variable. This specification resembles models suggested by Murdoch and Sandler (Murdoch and Sandler 1984; Sandler

and Murdoch 1990). The specification introduces some endogeneity, but since the degree of spatial dependence is small (each small NATO ally only has a small effect on each other small NATO ally's spending), we stick to ordinary least squares (OLS), following Franzese and Hays' (2007) finding that spatial-OLS does not lead to much bias when the degree of endogeneity due to spatial dependence is small.

In model 5 we replace military spending growth rates of the Soviet Union by military spending growth rates of the Warsaw Pact nations. Lastly, in model 6 we include further control variables from Whitten and Williams (2011), namely various measures of government composition such as the number of government parties, whether the government is a minority government as well as the left-right position of the government and the presence of an election in any one year. For this model, we had to drop Portugal and Greece from the sample as they do not have available data for these political variables until late into the period of our estimations.

The Vietnam war period captured by model 2 allows us to explore the influence of abnormal growth rates of military expenditure on our inferences.[14] One might expect that abnormal growth rates of military spending by the USA during the Vietnam war era push the response functions of NATO members somewhat down. This would then spuriously lend additional support for the free-riding hypothesis even though the NATO members merely do not respond to higher military spending for wars they do not fight – which seems a quite reasonable strategy and does not amount to free-riding. We find that for the UK and West Germany the estimated degrees of free-riding are slightly smaller and for Belgium and Denmark they are slightly larger outside the Vietnam war period than in the main estimations, but – more importantly – on the whole there is little effect on the response

[14] The Afghanistan war does not lead to abnormal growth rates in military spending in the Soviet Union.

functions of NATO allies of removing the Vietnam war years from the estimations. There are two stark exceptions, however, namely Greece and Turkey who are estimated to be quite drastically *less* of a free-rider in the main estimations than in the period outside the Vietnam war era. What explains this counter-intuitive result is the correlation of abnormal US growth rates of military spending with abnormal growth rates in military spending in these two NATO countries. By coincidence, the Vietnam intermezzo takes place right at the same time as the Cyprus conflict between Turkey and Greece escalades. In contrast, the abnormal US spending growth rates during the Vietnam era are not correlated with abnormal spending growth rates in any of the other allies. Thus, we see a relatively large effect (a left shift) of removing the Vietnam years from the estimates on the response functions of Turkey and Greece and virtually no effect of removing the Vietnam years on other countries. This exercise in turn demonstrates that our inferences of free-riding are not invalidated by years of abnormal growth rates of military spending in the USA.

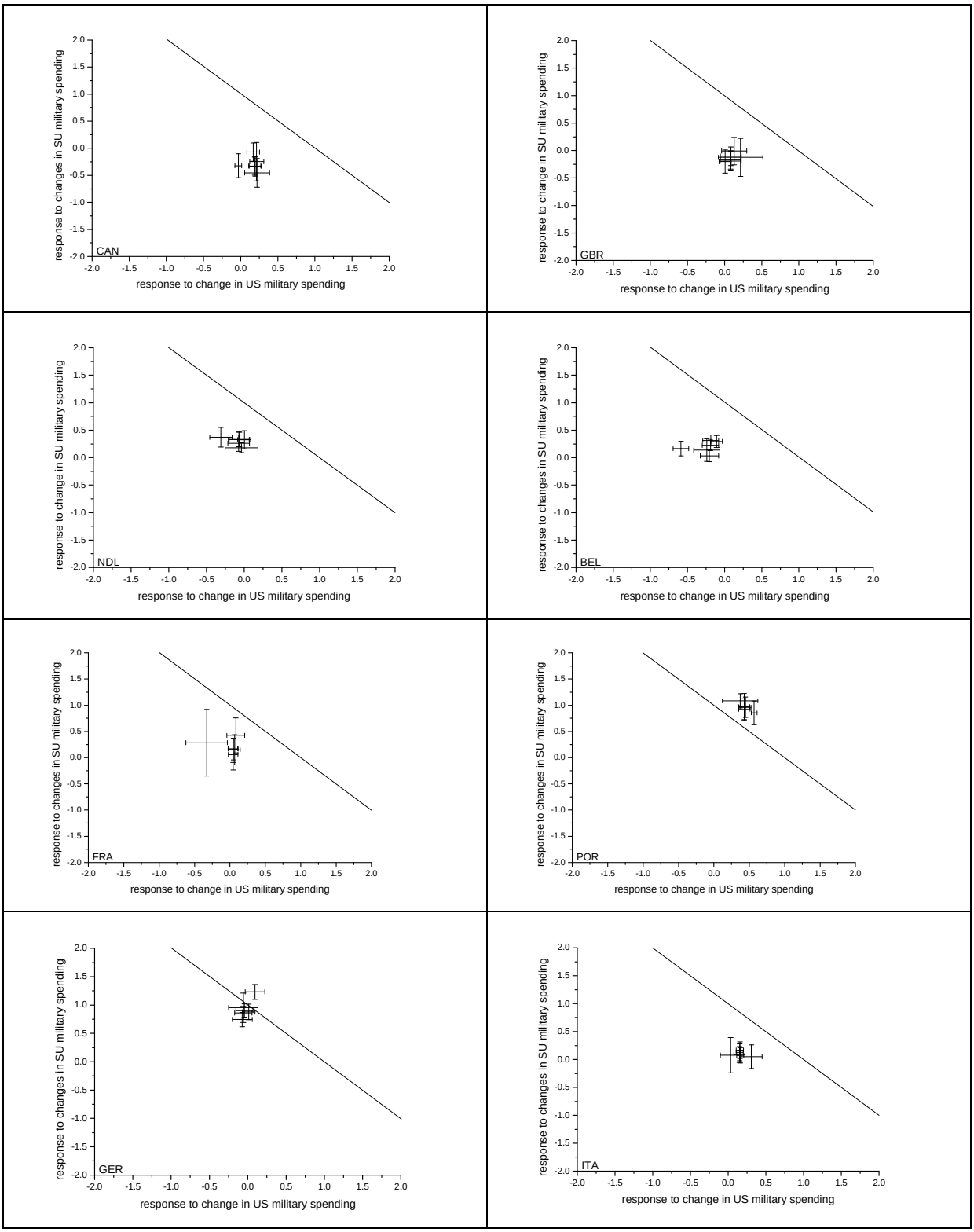
Table 3. Robustness tests.

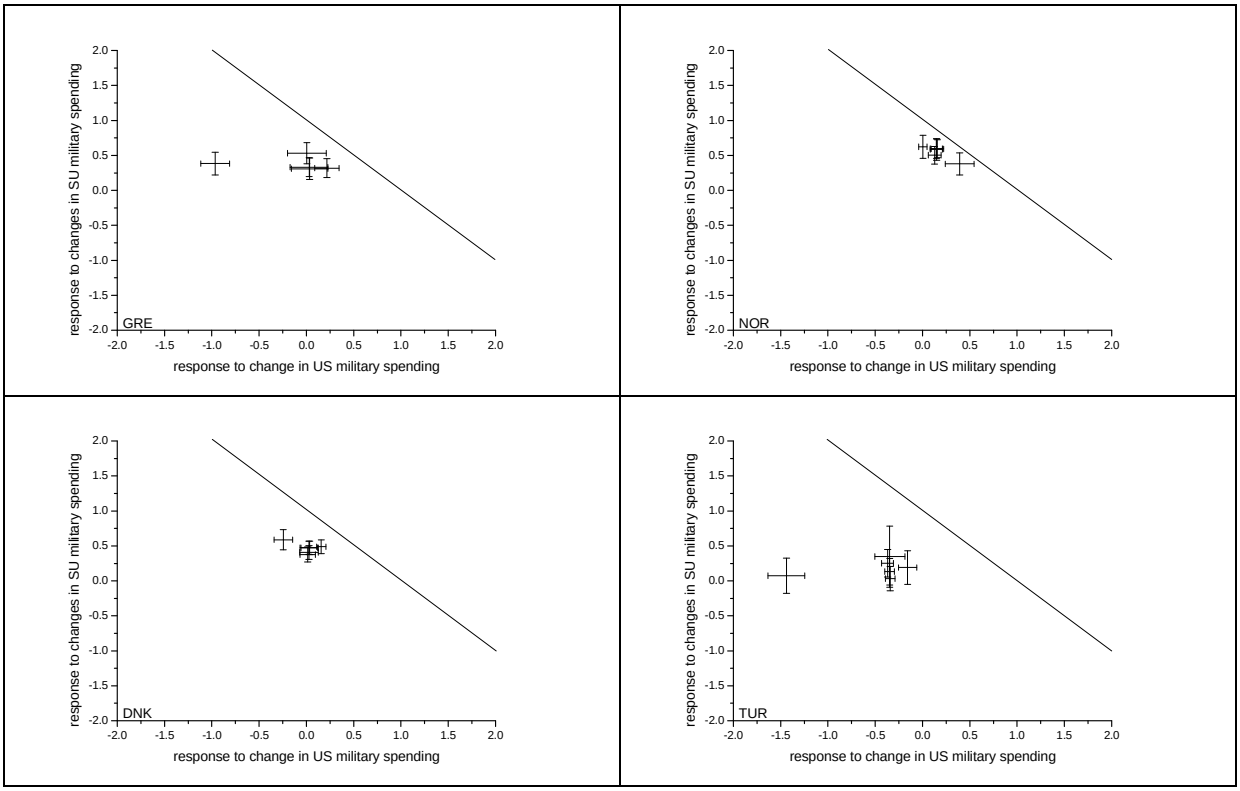
| Robustness test: | Model 2 Outside Vietnam war period (1965-73) | | Model 3 Outside invasion of Afghanistan period (1980-88) | | Model 4 Controlling for spatial dependence among small allies | | Model 5 Replacing Soviet with Warsaw Pact spending growth | | Model 6 Further political control variables | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country-specific response of: | to US growth | to SU-US growth diff | to US growth | to SU-US growth diff | to US growth | to SU-US growth diff | to US growth | to SU-US growth diff | to US growth | to SU-US growth diff |
| Canada | 0.222 | -0.455* | -0.0310 | -0.324* | 0.170* | -0.0718 | 0.190*** | -0.329*** | 0.215*** | -0.248 |
| | (0.143) | (0.135) | (0.0227) | (0.113) | (0.0428) | (0.0859) | (0.0414) | (0.0850) | (0.0482) | (0.181) |
| Great Britain | 0.129 | -0.00894 | 0.00775 | -0.201* | 0.0842 | -0.104 | 0.0807 | -0.171* | 0.215 | -0.126 |
| | (0.186) | (0.127) | (0.0414) | (0.108) | (0.0714) | (0.0864) | (0.0722) | (0.0859) | (0.153) | (0.177) |
| Netherlands | -0.308 | 0.371* | 0.00271 | 0.325* | -0.0741 | 0.262** | -0.0638 | 0.330** | -0.0355 | 0.179** |
| | (0.177) | (0.0914) | (0.0451) | (0.0836) | (0.0730) | (0.0757) | (0.0696) | (0.0661) | (0.111) | (0.0452) |
| Belgium | -0.588* | 0.164* | -0.107* | 0.293* | -0.205* | 0.0326 | -0.188** | 0.314** | -0.239** | 0.138 |
| | (0.147) | (0.0674) | (0.0396) | (0.0563) | (0.0638) | (0.0538) | (0.0542) | (0.0503) | (0.0895) | (0.106) |
| France | -0.328* | 0.285 | 0.0654 | 0.148 | 0.0467 | 0.0608 | 0.0489 | 0.165 | 0.0835 | 0.426** |
| | (0.0902) | (0.325) | (0.0409) | (0.146) | (0.0345) | (0.150) | (0.0341) | (0.105) | (0.0637) | (0.170) |
| Portugal | 0.372* | 1.084* | 0.569* | 0.854* | 0.429* | 0.971** | 0.447** | 0.962** | | |
| | (0.0924) | (0.0694) | (0.0214) | (0.115) | (0.0395) | (0.128) | (0.0401) | (0.0986) | | |
| West Germany | 0.0957 | 1.233* | 0.0137 | 0.878* | -0.0705 | 0.743** | -0.0419 | 0.903** | -0.0570 | 0.954** |
| | (0.146) | (0.0664) | (0.0418) | (0.0700) | (0.0659) | (0.0646) | (0.0567) | (0.0595) | (0.0980) | (0.132) |
| Italy | 0.309* | 0.0500 | 0.151* | 0.0874 | 0.161* | 0.0748 | 0.156** | 0.168** | 0.0345 | 0.0775 |
| | (0.108) | (0.109) | (0.0374) | (0.0723) | (0.0234) | (0.0715) | (0.0251) | (0.0751) | (0.0707) | (0.161) |
| Greece | -0.964* | 0.382* | 0.217* | 0.317* | 0.00522 | 0.530** | 0.0342 | 0.307** | | |
| | (0.254) | (0.0824) | (0.0658) | (0.0680) | (0.104) | (0.0773) | (0.0987) | (0.0777) | | |
| Norway | 0.393* | 0.379* | 0.00484 | 0.622* | 0.149* | 0.584** | 0.158** | 0.595** | 0.129** | 0.502** |
| | (0.0938) | (0.0805) | (0.0227) | (0.0837) | (0.0333) | (0.0775) | (0.0336) | (0.0665) | (0.0344) | (0.0652) |
| Denmark | -0.244 | 0.588* | 0.157* | 0.488* | 0.0280 | 0.406** | 0.0344 | 0.472** | 0.0140 | 0.376** |
| | (0.149) | (0.0740) | (0.0254) | (0.0497) | (0.0499) | (0.0500) | (0.0468) | (0.0497) | (0.0404) | (0.0550) |
| Turkey | -1.439* | 0.0738 | -0.158* | 0.192 | -0.370* | 0.251** | -0.342** | 0.0327 | -0.346** | 0.347 |
| | (0.111) | (0.128) | (0.0495) | (0.123) | (0.0314) | (0.0992) | (0.0258) | (0.0889) | (0.0811) | (0.223) |

Note: Control variables included, but not reported. Standard errors clustered on countries in parentheses. * statistically significant at 0.05, or ** 0.01 level.

Figure 3 shows the estimated responsiveness parameters with their associated 95 percent confidence intervals for the main estimations and all robustness test models. For many of the countries, the estimated coefficients are not robust – if we define robustness as the absence of a significant difference in point estimates across all tests. This follows from the confidence intervals of some of the estimated responsiveness parameters not overlapping with the remaining ones. Thus defined, we would have to conclude that the influence of growth in military spending by the USA and the Soviet Union on growth of military spending of the other NATO members is not robust. However, that is not the question we are interested in. Instead, we want to know whether smaller countries free-ride and this is the causal inference subjected to the robustness tests. Our baseline model provided evidence that all NATO members free-ride bar Portugal. A robustness test should therefore investigate whether this inference is robust. And indeed, the robustness tests affect our inference on the free-riding behavior of NATO members only in one case: Given our definition of free-riding, we cannot be certain whether West Germany free-rides: one of her estimated responsiveness parameter are fully in the non free-riding space and two further parameters cross the free-riding threshold with their 95 percent confidence intervals. The inference for all other countries, however, remains robust to changes in the model specification that we conducted in the robustness tests: all of their estimated responsiveness parameters together with their 95 percent confidence intervals lie to the interior of the free-riding threshold.

Figure 3. Response Functions with 95 Percent Confidence Intervals (robustness test models).






## 6. Conclusion

In this article, we have used a new method to test the old theory of free-riding in military alliances. The shift in methods is justified by the argument that differences in levels of military spending, even when expressed relative to GDP, cannot be used to infer free-riding unless one could appropriately control for the difference between the global aspirations of a superpower like the USA and the more spatially limited military objectives of the smaller allies. Clearly, the relatively higher military spending in the USA mirrors her broader interests – and these broader interests make it impossible to attribute relatively lower military spending in Canada and European countries to free-riding.

By contrast, we have developed a quasi-spatial method, which infers free-riding from the responsiveness of the smaller NATO members' growth in military expenditures to growth in US spending on the one hand and growth in Soviet spending when above US spending growth on the other hand. If, in summing up both responsiveness parameters, the smaller

allies respond such that their total responsiveness is smaller than one, then they are detected as free-riding on the efforts to maintain the security balance between the alliance and its arch enemy.

Does our analysis support the theory of free-riding? Our results are mixed but still suggest free-riding by the vast majority of smaller allies – a result that is robust to a range of plausible changes to model specification. For only one county (West Germany) our results are inconclusive. Only for Portugal can we clearly reject the hypothesis of free-riding.[15] Yet, our analysis does not support the hypothesis that the degree of free-riding is a function of country size. Smaller and larger NATO members do not significantly differ in their degree of free-riding. Instead, we find that West Germany and Norway, which are directly at the frontline of the most likely location of a military confrontation between the two enemy alliances, free-ride less than countries at the NATO periphery.

Our results thus reject the second part of the free-riding in alliances theory that claims that the extent of free-riding is a function of country size, but lend support to the first and main part of the theory: the smaller allies free-ride on the superpower. However, we wish to stress that there is one condition under which this result and interpretation would be spurious, namely if for both the Soviet Union and the USA the military expenditures related to their global interests grew faster over time than the military expenditures related to the geographically

[15] Did Portugal free ride? Our results suggest the country did not, but Portugal is an outlier in many respects: Most importantly, for most of our estimation period, Portugal was governed by a right-wing dictatorship first under Salazar and then Caetano. If we only estimate the response functions during Portugal's democratic period, then this country would also be detected as a free-rider. Does this contradict those who have argued that democracies are more reliable allies than autocracies (Leeds 2003)? We think not. Turkey, a clear free-rider, was not fully democratic in the 1950s and was subject to military dictatorship twice, once in the early 1970s and once in the early 1980s.

more restricted NATO-Warsaw Pact constellation. This seems possible, but unlikely during our period of study and the best test for this possibility is to exclude the Vietnam and Afghanistan periods from the estimates – and our results are robust to these tests. Hence, whilst we are confident that our results correctly identify free-riding by the smaller NATO allies, we see a promising way forward in combining the traditional 'in levels' interpretation of free-riding with our dynamic perspective, namely in research that attempts to identify the dynamically changing share of US military expenditure devoted to the European and North-Atlantic area, and in case study research that seeks to identify the response of NATO members to 'shocks' in the security perception of a limited number of NATO members.

**References**


Diehl, P. F. 1994. "Substitutes or Complements – The Effects of Alliances on Military Spending in Major Power Rivalries." *International Interactions* 19(3): 159-176.

Franzese, Robert and Judith Hays. 2007. "Spatial-econometric models of cross-sectional interdependence in political-science panel and time-series-cross-section data." *Political Analysis* 15(2): 140–164.

Gates, William R. and Katsuaki L. Terasawa. 2003. "Reconsidering Publicness in Alliance Defence Expenditures: NATO Expansion and Burden Sharing." *Defence and Peace Economics* 14 (5): 369-383.

Gleditsch, Nils Petter; Peter Wallensteen, Mikael Eriksson, Margareta Sollenberg & Håvard Strand. 2002. "Armed Conflict 1946–2001: A new dataset." *Journal of Peace Research* 39 (5): 615–37.

International Herald Tribune. 2011. Gates Assails NATO over Willingness to Share Costs. 11-12 June 2011, p. 1.

Leeds, B.A., 2003, "Alliance Reliability in Times of War: Explaining State Decisions to Violate Treaties." *International Organization* 57: 801–27.

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.

Olson, Mancur and Richard Zeckhauser. 1966. "An Economic Theory of Alliances." *Review of Economic Statistics* 48:3: 266–79.

Olson, Mancur. 1965. The Logic of Collective Action. Cambridge, MA: Harvard U. Press.

Oneal, John R. and Paul F. Diehl. 1994. "The Theory of Collective Action and NATO Defense Burdens: New Empirical Tests." *Political Research Quarterly* 47 (2): 373-396.

Oneal, John R. 1990. "Testing the Theory of Collective Action: NATO Defense Burdens, 1950–1984." *Journal of Conflict Resolution* 34:3: 426–48.

Russett, Bruce M. 1970. *What Price Vigilance?* New Haven: Yale U. Press.

Sandler, Todd. 1977. “Impurity of Defense: An Application to the Economics of Alliances.” *Kyklos* 30 (3): 443-460.

Sandler, Todd. 1993. "The Economic Theory of Alliances – A Survey." *Journal of Conflict Resolution* 37(3): 446-483.

Sandler, Todd and James C. Murdoch. 1990. “Nash-Cournot or Lindahl Behavior?: An Empirical Test for the NATO Allies.” *Quarterly Journal of Economics* 105:4: 875–94.

Sandler, Todd and James C. Murdoch. 2000. “On Sharing NATO Defense Burdens in the 1990s and Beyond.” *Fiscal Studies* 21:3: 297–327.

Sandler, Todd and John F. Forbes. 1980. “Burden Sharing, Strategy, and the Design of NATO.” *Economic Inquiry* 18:3: 425–44.

Sandler, Todd and Keith Hartley. 1999. *The Political Economy of NATO: Past, Present, and into the 21st Century*. Cambridge: Cambridge U. Press.

Sandler, Todd. 1977. “Impurity of Defense: An Application to the Economics of Alliances.” *Kyklos* 30:3: 443–60.

Whitten, Guy D. and Laron K. Williams. 2010. “Buttery Guns and Welfare Hawks: The Politics of Defense Spending in Advanced Industrial Democracies.” *American Journal of Political Science* 55 (1): 117-134.