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RECONSIDERING PUBLICNESS IN ALLIANCE DEFENCE EXPENDITURES: NATO EXPANSION AND BURDEN SHARING

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Over the past several decades, NATO allies have debated the relative burdens and benefits of NATO membership. Recently, this concern surfaced as members debated the magnitude and distribution of NATO expansion costs. This paper presents an economic model of defence alliances to identify the benefits and burdens of alliance membership. It suggests that defence expenditures provide public benefits if alliance members share common interests and mutual commitment; defence expenditures provide private benefits if countries lack common interests and mutual commitment. The model's results are used to discuss NATO's evolving roles and missions, NATO expansion and burden sharing across NATO members.

Keywords: Burden Sharing; Defense Alliances; NATO; Public Goods

JEL Code: D74, H41, H77

INTRODUCTION

Traditionally, NATO membership burdens have been measured by comparing the costs of defence inputs across alliance members, typically normalizing for ability to pay. The most comprehensive and commonly cited measure is total military expenditures as a percentage of gross domestic product (ME/GDP). Alternative measures focus on subsets of defence inputs, including armoured vehicles, aircraft, ships, military personnel, nuclear missiles, etc. While less comprehensive, these measures focus on quantities of inputs, rather than expenditures, and highlight that the relative emphasis in defence contributions can vary across alliance members (Hartley and Sandler, 1999; Knorr, 1985).[1] However, ME/GDP and the more

[1] Hartley and Sandler observe that ME/GDP is the most comprehensive measure. This measure is cited in the 1981 Defense Authorization Act (Public Law 96–342, Section 1006); US, House (1988); and the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999. Knorr concludes that examining equality in alliance burden sharing is a fruitless concept.

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narrowly focused measures all share a common characteristic: they measure alliance membership burdens using a country's total military expenditures or key military assets, without distinguishing domestic defence burdens from the burdens of alliance membership.

The debate over NATO burdens has received renewed emphasis as NATO redefines its roles and missions and expands its membership (US, General Accounting Office, 1997). This debate continues to discuss the appropriate way to estimate NATO membership costs and benefits. Different estimates lead to different conclusions regarding NATO membership benefits. This paper develops an economic model of defence alliances that identifies the costs and benefits of alliance membership. This model can help provide NATO members with insights regarding the desirability of expanding NATO membership.

DEFENCE ALLIANCE MODELS

Early work on the economics of defense alliances was written during the height of the Cold War period and largely focused on the North Atlantic Treaty Organization (NATO) (Kravis and Davenport, 1963; Olson and Zeckhauser, 1966; van Ypersele de Strihou, 1967). During this period, the NATO allies shared a common objective: containing Warsaw Treaty Organization (WTO) expansion into Western Europe. Olson and Zeckhauser (1966) were among the first to observe that defense benefits are purely public when countries have common security objectives; securing the common objective for one NATO ally benefits all NATO allies sharing the objective (and any other country) at no additional cost, whether or not a particular country helps pay for the effort.

Public, Private and Club Goods

Outputs are classified as purely public if their benefits are both non-rivalrous and non-excludable (Samuelson, 1954). A benefit is non-rivalrous if multiple parties can simultaneously gain from it without affecting the value received by any other party. A good is non-excludable if it is impossible or prohibitively expensive to deny access to any members, irrespective of whether they pay for the good. In contrast, the benefits of private goods are both rivalrous in consumption and excludable. Some outputs may exhibit varying combinations of public and private good attributes. For example, outputs are characterized as club goods if their benefits are non-rivalrous for a limited set of consumers and exclusion is feasible (Buchanan, 1965; Cornes and Sandler, 1986, pp. 159–243). The distinction between public, private, and club goods depends on the attributes associated with the good's benefits, irrespective of the inputs used to produce those benefits.

As is well established, profit-making producers cannot effectively provide pure public goods because consumers 'free ride' on the benefits provided other consumers. The government typically finances public goods through tax revenues. As goods progress along the spectrum from purely public to private, free riding decreases and government provision becomes less important. In contrast, club goods can be provided privately because their benefits are excludable. To exploit their partially non-rivalrous benefits, club goods can be financed cooperatively by groups of consumers (i.e. clubs). With excludability, club admissions fees and dues can finance club goods. Club goods may suffer benefits thinning (e.g. reductions in the quantity or quality of benefits) and congestion across club members as membership increases. This affects optimal club size, admissions fees and dues.[2]

[2] Sandler (1977) introduced alliance defence as a club good and noted benefit thinning in that case.

Publicness in International Defence Alliances

Drawing on the public goods paradigm, Olson and Zeckhauser (1966) concluded that voluntary NATO contributions would under-provide alliance resources and nations that place a higher absolute value on deterring WTO would bear a disproportionate defence burden (i.e. devote larger percentages of national incomes to defence). Using 1964 NATO military expenditure and GDP data, Olson and Zeckhauser examined the effect GDP had on defence expenditures as a percent of GDP, *ceteris paribus*, assuming a Nash equilibrium.[3] Olson and Zeckhauser found a significant positive correlation between GDP and military expenditures as a percentage of GDP, ostensibly confirming that alliances provide public benefits.

In the late 1960s, the relationship between GDP and military expenditures as a percentage of GDP became more ambiguous. While still generally positive, the relationship was rarely statistically significant. To explain this data, some authors incorporated impurely public goods into Olson and Zeckhauser's model by introducing joint products (defence expenditures that simultaneously provide public and private benefits: Sandler and Cauley, 1975; Sandler, 1977, 1988; Sandler and Forbes, 1980). The joint products model argues that strategic weapons (long range missiles and nuclear bombers) are purely public because all allies can simultaneously enjoy a nuclear deterrent umbrella provided by one country, particularly if allies face common adversaries. Conventional and tactical nuclear weapons (small-scale, short-range weapons) are impurely public because these weapons can only protect the area where deployed (rivalrous) and they can be unilaterally withdrawn (excludable).

As NATO switched its emphasis from mutual assured destruction to the flexible response doctrine, it shifted its emphasis from strategic to tactical and conventional weapons. The joint products model maintains that this increased private relative to public defence benefits within NATO and weakened the relationship between GDP and military expenditures as a percentage of GDP (Sandler and Forbes, 1980, pp. 436–438). In this conceptualization, publicness is determined by the characteristics of defence inputs, including weapons technology (strategic versus conventional and tactical nuclear weapons) and defence strategy (mutual assured destruction versus flexible response), not on the characteristics of NATO's output (common interest in containing WTO expansion). This is a subtle but important departure from Olson and Zeckhauser's model, and from the theoretical public goods literature.

Other authors have explained the changing relationship between GDP and military expenditures as a percentage of GDP by questioning other Olson and Zeckhauser assumptions. One explanation involves complementarity across alliance contributions, where an increase in one member's defence expenditures increases the value of defence relative to non-defence expenditures for the other allies (Murdoch and Sandler, 1982, 1984, 1991; Hansen *et al*., 1990). Other authors have suggested that mature alliances, such as NATO after the 1960s, might be more co-operative than implied by a Nash equilibrium (Oppenheimer, 1979; Kuenne, 1988; Oneal and Elrod, 1989; Oneal, 1990a, 1990b; Palmer, 1990).[4] Some authors have introduced increasing marginal costs, comparative advantages in producing defence and private consumption goods, and differing preferences across allies for defence

[3] Under the *ceteris paribus* assumption, alliance members are equal in every respect other than GDP and population (which differ proportionally across allies, leaving GDP/capita the same). In particular, alliance members share the same threat perception and face the same constant marginal costs of providing military contributions. If this *ceteris paribus* assumption does not hold, military expenditures as a percentage of GDP may not increase with GDP.

[4] Sandler and Murdoch (1990) found that empirical evidence supported the Nash equilibrium for a sample of NATO allies between 1956 and 1987.

relative to consumption goods (Loehr, 1973; McGuire, 1990; Weber and Wiesmeth, 1991). Finally, some analysts incorporated adversaries into the alliance model (McGuire and Groth, 1985; Hilton and Vu, 1991).

PUBLIC GOODS, COMMONALITY AND COMMITMENT

An alternative explanation for the empirical data is that defence expenditures do not have inherently public attributes across alliance members; rather, defence inputs are inherently excludable and rivalrous across countries, including strategic nuclear, tactical nuclear and conventional weapons. Military resources are clearly excludable across countries; countries can choose to limit protection to their own national boundaries. Furthermore, it is not costless for countries to pool defence resources when allies have country-specific adversaries. Forming an alliance may reduce the probability of a confrontation with each country's natural adversary, but it can expose countries to new adversaries threatening other alliance members.[5] Finally, with divergent objectives and limited alliance resources, securing country-specific objectives for one ally may detract from benefits available to others (rivalry). As Olson and Zeckhauser initially observed, the exception to this rule occurs when countries share common military objectives. Without common interests, there is no inherent reason for one country to aid another threatened country.

Recognizing this, instances where defence expenditures provide public benefits are special cases. Alliance benefits are only non-excludable and non-rivalrous if all alliance members share a common objective: securing the objective for one alliance member secures it for all, regardless of weapons technology or military strategy. NATO members (and some non-members) shared a common objective during the Cold War era: containing WTO expansion, particularly in Western Europe. This common purpose made defence expenditures at least partially public within the alliance. In fact, the NATO alliance probably reduced the probability of WTO expansion and the expected cost of containment by formally signalling the NATO members' mutual interest.

However, publicness in alliance contributions also depends on the extent to which allied countries are committed to that purpose. There may be limits to a country's commitment to the common objective. When the US maintained a nuclear monopoly, there was no question about the US commitment to NATO (presumably this interest extended to all areas of the globe as evidenced by US involvement in Korea and Vietnam). The US would have undoubtedly aided Germany, Italy, Norway or any other Western European country invaded by WTO, with or without a formal alliance agreement (if necessary, the US may have aided Sweden or other countries with which NATO had no formal alliance agreement).

Over time, the commitment within NATO became more dubious as NATO military superiority diminished. Closer military parity and WTO's perceived willingness to retaliate decisively against military action raised questions about NATO's willingness to use all military means, including strategic nuclear weapons, to contain WTO expansion. For example, there might have been little question about US commitment to countering a major WTO offensive against Germany, but this commitment might have been questionable for more modest skirmishes involving smaller NATO allies. If fear of retaliation or escalation limits the US commitment in at least some cases, US military expenditures do not provide pure public goods. Without unconditional commitment, defence contributions are not perfect substitutes across allies, and defence expenditure data will not correspond to Olson and

[5] The Triple Entente and the Triple Alliance addressed the introduction of new threats by tying mutual defence support to common enemies (Conybeare and Sandler, 1990).

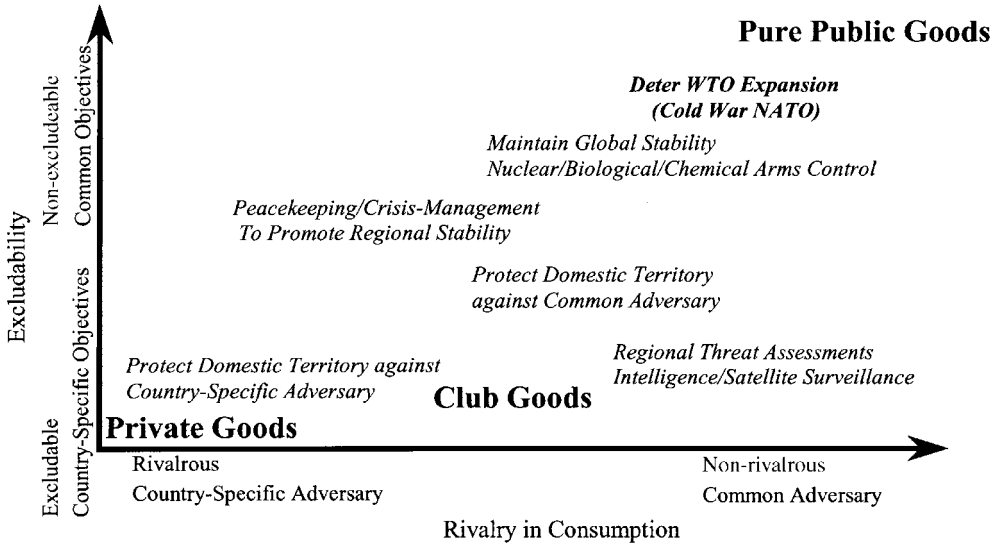

FIGURE 1 NATO mission attributes and classifications

Zeckhauser's pure public goods alliance model. Adding commitment to commonality of interest introduces impurely public military expenditures but retains commonality of purpose as the basic motivation for forming an alliance.[6]

Commonality of Interest in Post-Cold War NATO

NATO's roles and responsibilities have evolved since the WTO threat disintegrated (NATO; Bailes, 1996; Yost, 1998; Sandler and Hartley, 1999). At least four major policy decisions reflect NATO's shifting emphasis:

- NATO assumed responsibility for protecting Europe from threats both within and beyond NATO's boundaries (Rome Summit, November 1991);
- NATO added peacekeeping as an official NATO mission (Oslo Summit, June 1992);
- NATO membership expanded to Hungary, the Czech Republic and Poland (Madrid Summit, July 1997);
- NATO policy expanded to ensuring a stable Euro-Atlantic security environment by standing ready to engage in crisis management and crisis response operations (Washington Summit, April 1999).

These policy decisions all expand NATO's responsibilities to a broader set of concerns than traditional Article 5 self-protection focused on the common WTO threat. Current concerns extend beyond NATO's boundaries and new NATO missions include: crisis management involving 'rogue nations'; peacekeeping missions to maintain regional or global stability;

[6] When alliance members have divergent interests, alliance agreements can transform fundamentally private defence expenditures into public goods. Commitment signals, such as foreign-based troops, use the 'slippery slope' concept to enhance credibility (once engagement begins, allies are unavoidably drawn in). To be perceived as public goods by both allies and adversaries, commitment signals become increasingly important as allies' interests diverge.

military missions to protect alliance members against either country-specific or common adversaries; nuclear, biological or chemical arms control; and local or regional threat assessments or intelligence gathering operations. Some NATO members may perceive little or no benefit from a proposed NATO operation.

As indicated in Figure 1, the benefits of future NATO missions have mixed attributes compared with the relatively public attributes of WTO containment during the Cold War. Missions focused on country-specific objectives generally provide benefits that are excludable and rivalrous (private goods); missions focused on common objectives provide benefits that are non-excludable and non-rilvalrous (public goods); finally, some missions provide benefits that are non-rivalrous but excludable (club goods). For private and club goods, credible mutual aid agreements between alliance members are intended to make alliance benefits effectively non-excludable (with credible commitments). Considering the pivotal role common interests and commitment play in determining the publicness of allied defence expenditures, alliance models should explicitly incorporate these attributes.

A COMMITMENT-BASED ALLIANCE MODEL

Consider a multi-country model, where each country (i) produces a private non-defence good (X_i) and a defence good (Y_i) (Gates and Terasawa, 1992). In addition, countries benefit from their allies' defence expenditures. In particular, Z_i represents country i's total consumption of the defence good, where:

$$Z_i = Y_i + \sum_{j \neq i} E_{ij} Y_j \tag{1}$$

In this relationship, country j produces Y_j of the defence good, but country i perceives that only E_{ij} of Y_j is credibly committed (or relevant) to country i's defence. In general, E_{ij} is expected to take on values between zero and one. If $E_{ij} = 1$, country j's defence expenditures are purely public. This corresponds to Olson and Zeckhauser's alliance model. Conversely, defence expenditures are purely private if $E_{ij} = 0$: country i perceives no commitment to its defence from j.[7] As E_{ij} varies between one and zero, private benefits become relatively more important. This case reflects countries, such as the US, where defence expenditures are only partially committed to the alliance.

Countries are modelled as utility maximizers; utility is given by: $U_i = U(X_i, Z_i)$, where X_i is country i's non-defence goods consumption. Each country faces a resource constraint: $G_i = P_i X_i + Y_i$, where G_i denotes i's income (GDP) and P_i is the price of the private good relative to the defence good. For expositional purposes, the remainder of this paper is based on a Stone–Geary utility function.[8] In particular, country i's utility is given by:

$$U_i = (X_i - S_i)^{\alpha_i} (Z_i - T_i)^{\beta_i} \tag{2}$$

[7] This specification is similar to McGuire (1990). McGuire suggests $E_{ij} < 1$, reflecting that alliance members do not consider their allies' defence resources as equal, one-for-one substitutes for domestic contributions.

[8] These results extrapolate to a more general 'Gorman form' utility function, which includes Stone–Geary. The Gorman form is a general indirect utility function including homothetic and quasilinear functions (Gorman, 1953; Varian, 1992). McGuire (1990), Sandler and Hartley (1995, p. 25) and Hilton and Vu (1991) suggest the Stone–Geary utility function.

where S_i measures country i's minimum (subsistence) non-defence good requirement, T_i measures country i's minimum total defence requirement (threat), and α_i and β_i represent i's utility elasticity of non-defence and defence goods, respectively ($\alpha_i, \beta_i > 0$).[9]

Given this utility function and GDP constraint, country i's isolation defence expenditures ($E_{ij} = 0$) are:

$$Y_i^I = \frac{\beta_i (G_i - S_i P_i) + \alpha_i T_i^I}{\alpha_i + \beta_i} \tag{3}$$

where T_i^{I} is country i's perceived threat in the isolation case.

If country i joins an alliance, (Nash) equilibrium defence expenditures are given by:

$$Y_i^N = \frac{\beta_i (G_i - S_i P_i) + \alpha_i (T_i^N - Z_{-i})}{\alpha_i + \beta_i} \tag{4}$$

where T_i^{N} is country i's threat perception in the (Nash) alliance case, and Z_{-i} is the sum of committed allied defence expenditures, excluding the home country (i.e.

$$Z_{-i} = \sum_{j \neq i} E_{ij} Y_j).$$

The (Nash) equilibrium defence expenditure simplifies to:

$$Y_i^N = Y_i^I + \gamma_i (\Delta T_i - Z_{-i}) \tag{5}$$

where

$$\gamma_i = \left(\frac{\alpha_i}{\alpha_i + \beta_i} \right) < 1,$$

and ΔT_i is the change in threat perception from the isolation to the alliance case ($T_i^{\mathrm{N}} - T_i^{\mathrm{I}}$).

Equation (5) indicates that the net difference between isolation and alliance defence expenditures depends on the relative changes in defence spill-ins (Z_{-i}) and threat perceptions (ΔT_i), scaled by the utility elasticities of the non-defence and defence goods (γ_i). Momentarily ignoring threat perception changes, alliance defence expenditures decrease relative to the isolation case as defence spill-ins (defence expenditures committed to the alliance) increase from other alliance members (Z_{-i}); country i's perceived value of defence spill-ins depends on both the allies' defence expenditures and their commitment to the alliance, as perceived by country i. In response to these spill-ins, country i reduces defence expenditures by less than one dollar for each dollar increase in perceived allied contributions. As a result, country i's domestic defence expenditures (Y_i) decrease, country i's non-defence expenditures increase, and country i's total effective defence consumption (Z_i) increases. This increases country i's utility.[10]

[9] Threat perception is captured in the values of T_i and β_i. For example, T_i could reflect adversaries' defence expenditures and β_i could reflect the relative value of meeting that threat.

[10] Note that commitment differs from cooperation. Commitment implies countries are inextricably tied to mutual defense, at least against particular adversaries; cooperation implies that countries coordinate defence efforts. Mutual commitment generally reduces defence expenditures; cooperation could increase defence expenditures.

Conversely, alliance defence expenditures increase relative to the isolation case if there is any added risk of international conflict (i.e. increases in the perceived threat, ΔT_i). The sign of ΔT_i depends on the relative values of T_i^{N} and T_i^{I}. At least two factors determine these relative values: commonality of adversaries across alliance members and the adversaries' perception of the alliance's intentions (defencive or offensive). If alliance members face country-specific adversaries, joining an alliance requires they face their natural adversaries and the natural adversaries of the other alliance members. Similarly, if adversaries perceive that alliance formation signals offensive inclinations, they may feel threatened and increase their defence expenditures.

DEFENCE ALLIANCE COSTS AND BENEFITS VERSUS DEFENCE BURDENS

This characterization highlights the actual costs and benefits of alliance membership: the benefit is reduced domestic defence burdens as members substitute allied for domestic defence expenditures (free-ride); the cost is the increased perceived threat, if any, when a country joins an alliance. The net balance between the costs and benefits is reflected by changes in the country's utility (U_i). Country i would voluntarily join an alliance if $(\Delta T_i - Z_{-i}) < 0$. Ignoring the more subtle interactions, net alliance benefits and alliance feasibility generally increase as commitment increases from isolationist to full commitment, the commonality of interests increases from country-specific to common, and the alliance's perceived intent moderates from offensive to defensive. This highlights two points: first, the relative balance between alliance costs and benefits depends on the commitment between alliance members, commonality of interests and the alliance's perceived orientation (defensive or offensive); second, alliances are more (less) likely to form when benefits are high (low) and costs are low (high).

This characterization of alliance membership costs and benefits contrasts dramatically with the traditional measures used to assess burden sharing across alliance members, including military expenditures as a percentage of GDP and other measures of aggregate defence expenditures or military assets. A country's actual defence expenditures or military assets after joining a defense alliance (*ex post*), which are measured by these traditional indices, are unrelated to either the burdens or benefits of alliance membership. Instead, the traditional measures indicate the *ex post* burden defence spending imposes on a particular country. The domestic defence burden a country is willing to bear depends on the country's ability to pay or bear the burden (e.g. GDP, population, etc.) and their perceived need (threat). Ability to pay and perceived threat vary significantly across NATO allies, so they will likely accept different *ex post* relative domestic defence burdens, just as they would be expected to bear different relative domestic defence burdens if they were not members of NATO.

The commitment-based alliance model can be used with the Stone–Geary utility function to explore publicness in defence alliances and contrast alliance membership costs and benefits against domestic defence burdens. There are four possible cases, spanning common and country-specific adversaries in both defensive and offensive alliances. With defensive alliances, adversaries do not feel more threatened facing the alliance than facing the allied countries individually. With an offensive alliance, adversaries feel more threatened confronting the alliance than they would facing the allied countries individually.[11] This

[11] If Russia considered NATO a defensive alliance, as defined here, Russia would not feel more threatened by NATO expansion; if Russia considered NATO an offensive alliance, NATO expansion would make Russia feel more threatened by NATO in general, and Poland, Hungary and the Czech Republic in particular.

TABLE I Perceived Threats and Defence Spill-in

	Common Adversary		
	Isolation Case	*Alliance Case*	
	Perceived Threat	*Perceived Threat*	*Defence Spill-In*
Country1	$T_1^I = E_{1A}{}^I Y_A{}^I$	$T_1^N = E_{1A}{}^N Y_A{}^N$	$Z_{-1}{}^N = E_{12}{}^N Y_2{}^N$
Country 2	$T_2^I = E_{2A}{}^I Y_A{}^I$	$T_2^N = E_{2A}{}^N Y_A{}^N$	$Z_{-2}{}^N = E_{21}{}^N Y_1{}^N$
Country A	$T_A^I = E_{A1}{}^I Y_1^I + E_{A2}{}^I Y_2^I$	$T_A{}^N = E_{A1}{}^N Y_1{}^N + E_{A2}{}^N Y_2{}^N$	$Z_{-A}{}^N = 0$

analysis will provide numerical examples for a defensive alliance facing a common adversary, the case most conducive to forming and maintaining a defense alliance. This example illustrates the interactions between alliance commonality, commitment and intent, and the potential inconsistencies between domestic defense burdens and alliance membership's net benefits.

Common Adversaries and a Defensive Military Alliance

This analysis examines two countries (1, 2), facing a common adversary (A). The perceived threat between rivals depends on the defence spending each rival is perceived as devoting to the relevant confrontation. In particular, suppose the perceived threats and defence spill-ins from equation (5) are as given in Table 1, where: Y_A is country A's defence expenditures; E_{iA} represents the portion of country A's defence expenditures directed against country i, as perceived by country i; E_{Ai} represents the portion of country i's defence expenditures directed against country A, as perceived by country A; the superscript I indicates the isolation case; and the superscript N indicates the (Nash) alliance case. Country A prepares for simultaneous confrontations with countries 1 and 2.

Table 1 highlights that alliance benefits include the defence spill-ins that countries 1 and 2 receive from one another ($E_{ij}{}^N Y_i^N$); the alliance burden (added benefit) with a common adversary is the potential increase (decrease) in the perceived threat from country A ($T_i^N - T_i^I$) through an increase (decrease) in either E_{iA} or Y_A. The alliance's impact on country A depends entirely on A's threat perception term (no spill-ins). With a defensive alliance, Country A does not feel more threatened than it would facing the allied countries individually (i.e. $E_{Ai}{}^I = E_{Ai}{}^N$). If the alliance allows countries 1 and 2 to reduce their total defence expenditures, country A benefits ($T_A{}^N < T_A{}^I$).

To complete this illustration, the base case parameter values for countries 1, 2 and A are listed in Table 2. For simplicity, this analysis assumes that all countries are identical in all dimensions except GDP; GDP in country 1 exceeds GDP in the other countries (subsistence non-defence consumption, S_i, is 25% of GDP for all countries). The base case $E_{ij}{}^S$ for the isolation and defensive alliance cases are given in Table 3. With a defensive alliance and a common adversary, E_{12} and E_{21} are the only parameters that change from the isolation to the alliance case. In the alliance case, the commitment between countries 1 and 2 is assumed symmetrical, $E_{12} = E_{21}$; alliance results are calculated as the commitment between allies increases from purely private (isolationist: $E_{12} = E_{21} = 0$) to purely public (full commitment: $E_{12} = E_{21} = 1$). With a common adversary and a defensive alliance, the perceived threat between alliance members and the adversary (E_{1A}, E_{2A}, E_{A1} and E_{A2}) are not affected when countries 1 and 2 ally.

TABLE II Base Case Stone–Geary Utility Assumptions

	α_i	β_i	G_i	S_i	P_i
Country 1	0.9	0.1	600	150	2
Country 2	0.9	0.1	400	100	2
Country A	0.9	0.1	400	100	2

TABLE III Commitment and Perceived Threat Scenarios (E_{ij})

		Common Adversary					
		Isolation Case			*Defensive Alliance*		
		Country j			*Country j*		
		1	*2*	*A*	*1*	*2*	*A*
Country *i*	1	–	0	0.25	–	0→1	0.25
	2	0	–	0.25	0→1	–	0.25
	A	0.25	0.25	–	0.25	0.25	–

Figure 2 shows the relationship between changes in alliance commitment (E_{ij}) and the percentage change in defence expenditures relative to the isolation case, assuming $E_{12} = E_{21}$. With common adversaries and a defensive alliance, all three countries are better off after forming an alliance than in isolation; the relative gains across countries depend on the commitment between alliance members. As alliance commitment increases from zero (isolation), both countries 1 and 2 believe they can count on one another for military support. Thus, both countries reduce their defence expenditures relative to the isolation case. Country A observes the decreases in Y_1 and Y_2, but E_{Ai} remains unchanged. Thus, country A perceives a lower effective threat from countries 1 and 2 and also reduces its defence expenditures relative to the isolation case. Correspondingly, defence expenditures decrease and utility increases in all three countries relative to the isolation case. The alliance benefits all three countries.

As the commitment between allies (E_{12} and E_{21}) continues to increase, country 2, the smaller ally, begins feeling increasingly comfortable with country 1's defence expenditures; Y_2 decreases as commitment increases. When Y_2 becomes sufficiently small, Y_1 begins to rise (U_1 falls). Eventually, Y_2 decreases to zero. Country 1 bears the entire alliance defence burden. However, country 1 continues to benefit from the alliance relative to the isolation case because Y_A decreases with Y_2. If commitment between alliance members were endogenous, country 1 would prefer to maintain approximately a 50% commitment between allies (i.e. $E_{12} = E_{21} \sim 0.5$); countries 2 and A would prefer at least 80% commitment (i.e. $E_{12} = E_{21} > 0.8$).[12]

[12] With these parameter values, country 1 would not voluntarily commit over 50% of its defence resources to country 2 unless country 2 offers compensation (e.g. trade concessions, political good will). However, allies sharing common interests have limited influence over commitment. Country 1's preferred commitment is similar to a Stackelberg (leader–follower) equilibrium, except $E_{12} = E_{21}$ here. A Stacklberg equilibrium would relax this assumption and allow country 1 to set its commitment considering country 2's optimal response.

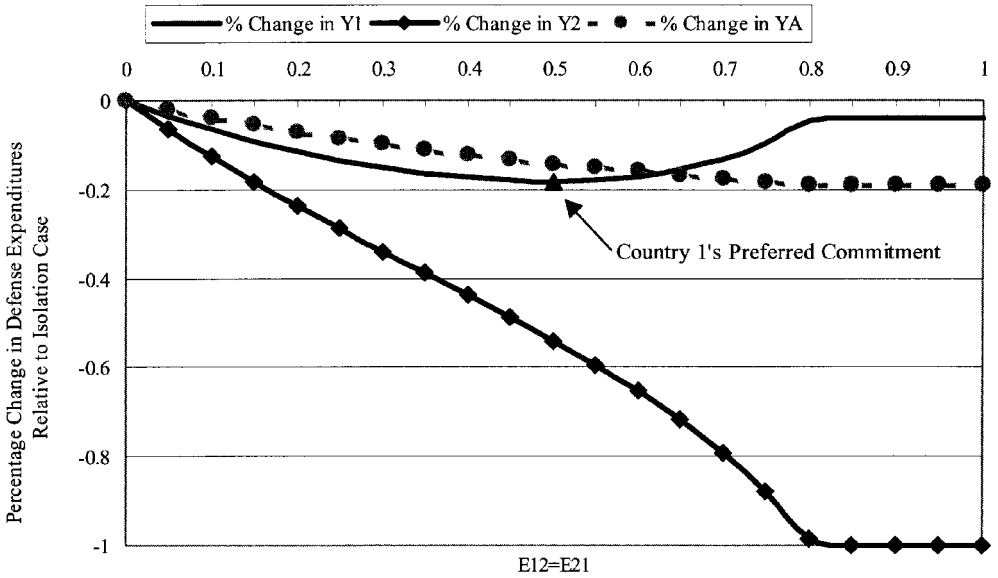

FIGURE 2 Percentage change in defense expenditures relative to isolation case – common adversary/defensive alliance

This general pattern holds for changes in other parameter values; the main differences involve the magnitude of the changes in defence expenditures relative to the isolation case and the point at which country 1's defence expenditures begin increasing relative to their minimum value (i.e. the commitment level that minimizes Y_1). For example, as the perceived threat between adversaries and allies increases, defence expenditures for all three countries increase in the isolation case. Thus, the alliance provides greater potential gains. Correspondingly, defence expenditures relative to the isolation case decrease more rapidly as commitment to the alliance increases. Country 2 also continues to contribute to the alliance at higher commitment levels with a more menacing adversary.

Alliance Membership Burdens and Benefits versus Domestic Defence Burdens

Recall that equation (5), $Y_i^{\mathrm{N}} = Y_i^{\mathrm{I}} + \gamma_{\mathrm{i}} (\Delta T_i - Z_{-i})$, indicates that the benefits of alliance membership include allied defence spill-ins (Z_{-i}) and the country's corresponding higher effective national security (Z_i). The burden of alliance membership includes any added risks of international conflict (ΔT_i). The net balance between these costs and benefits is reflected by the change in either the country's domestic defence expenditures (Y_i) or utility (U_i), which typically follow a similar but opposite pattern (i.e. U_i increases as Y_i decreases). This discussion will focus on percentage change in domestic defence expenditures to measure the net benefit of alliance membership; the relative domestic defence burden will be measured by defence expenditures as a percentage of GDP.

Using the 'Base Case' parameter values in Tables 2 and 3, Figure 3 shows the relative net alliance benefits for countries 1 and 2, as indicated by the percentage change in their domestic defence expenditures from the isolation case (solid lines measured by percentage change in Y_i on the left-hand vertical axis), and their domestic defence burden as indicated by ME/GDP (dashed lines measured by Y_i/G_i on the right-hand vertical axis), as alliance commitment varies from zero (isolation) to one (complete commitment). While domestic defence burdens and alliance membership burdens and benefits involve distinctly different

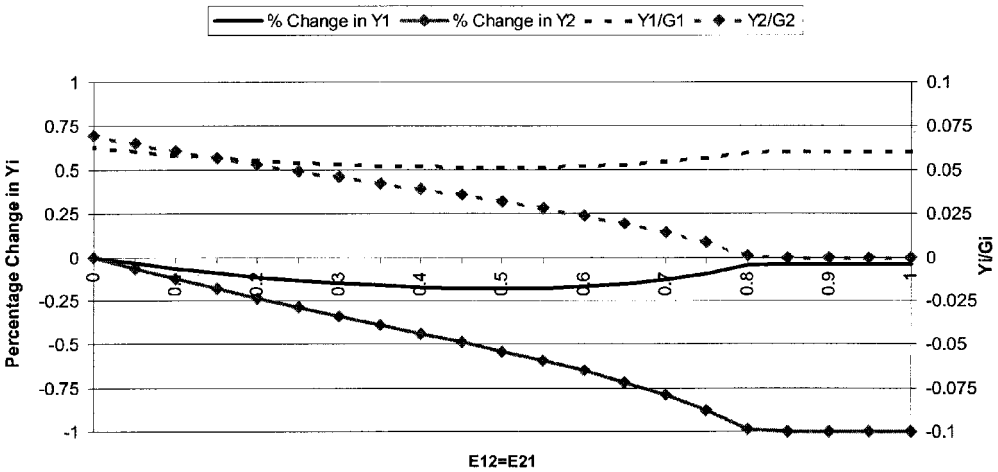

FIGURE 3 Alliance net benefit and defense burdens – base casE

measurements, Figure 3 highlights that there is close agreement between the two measures in this case. With the exception of very low levels of alliance commitment, country 2 spends a lower percentage of its GDP on defence (has a lower defense burden), and decreases its defense expenditures by a larger percentage relative to the isolation case (has a higher net alliance benefit). Unfortunately, this correspondence is not always the case.

Figure 4 shows the same data for countries 1 and 2 after changing the threat perception between countries 2 and A. In particular, $E_{2A} = E_{A2}$ increases from 0.25 in the base case to 0.4 in the 'Country 2 Threat Case'; the perceived threat between countries 1 and A is unchanged from the Base Case ($E_{1A} = E_{A1} = 0.25$). When the smaller country perceives a greater threat, it will spend more of its GDP on defence than the larger country for low levels of commitment. Thus, for $E_{12} = E_{21}$ between 0 and 0.5, country 2 spends a higher percentage of GDP on ME than country 1 (dashed lines measured by Y_i/G_i on the right-hand vertical axis), but also reduces ME by a greater percentage relative to the isolation case (solid lines measured by percentage change in Y_i on the left-hand vertical axis). Over this range, country

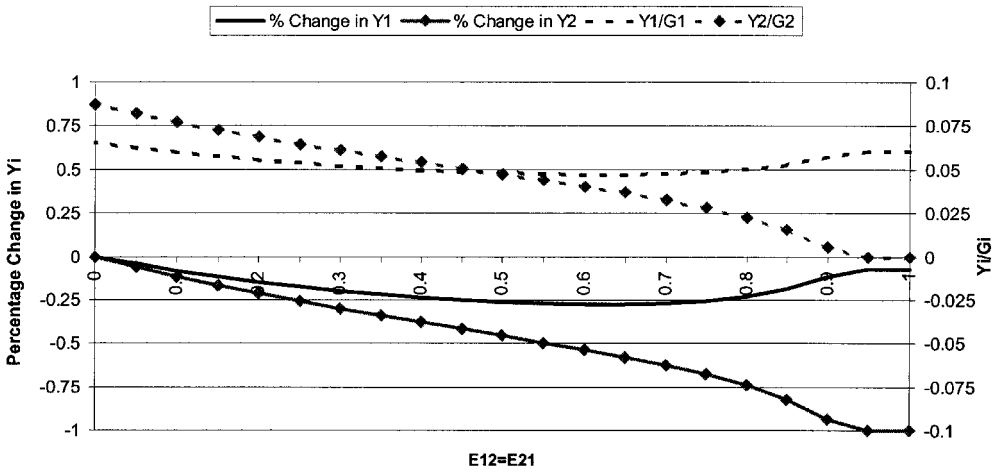

FIGURE 4 Alliance net benefit and defense burdens – country 2 threat case

2 has a higher domestic defence burden and a higher net benefit of alliance membership; these two measures contradict one another. The range over which these measures conflict varies significantly with the perceived threat between countries 2 and A. This highlights the fact that domestic defence burdens and alliance net benefits involve different factors. There is no reason to expect domestic defence burdens to be an accurate proxy for alliance net benefits, except under the strictest *ceteris paribus* conditions, such as those assumed by Olson and Zeckhauser.

SUMMARY AND CONCLUSIONS

To date, the economics of alliance literature has focused primarily on the NATO alliance during the Cold War, when NATO members shared strong common interests. When the US maintained a nuclear monopoly, there was little reason to question the US commitment to NATO. Thus, early Cold War NATO represents a case where defence expenditures had inherent public attributes. As the US nuclear monopoly eroded and NATO lost its clear military superiority, commitment across NATO members likely became more ambiguous; publicness correspondingly decreased, particularly for strategic nuclear weapons. This is consistent with the observed data trends discussed earlier in the literature review.

Analysing historical alliance data inappropriately promotes the misconception that defence expenditures provide at least some inherently public benefits across alliance members. Voluntary alliance membership is more likely in situations where members share a common purpose. Without strong common interests, national self-interest likely precludes voluntary defence alliances. Incorrectly presuming that alliance defence expenditures have inherent public attributes may not distort analyses of past alliance data. However, it may misdirect analyses examining potential future alliance agreements, alliance expansion or changes in alliance roles and missions.

The model developed in this paper provides the framework for analysing the implications of defense alliances under a broad set of circumstances. It treats alliance defence expenditures as inherently private goods; publicness is introduced through commonality of interest and commitment across allies. In this model, the net benefits of alliance membership depend critically on the commonality of interest across alliance members (shared threat perceptions), their commitment to one another (spillover benefits) and the adversaries' perceptions of the threat posed by the alliance (a defensive versus offensive alliance).

This analysis suggests at least two primary conclusions.

- Traditional macro-level burden sharing measures do not reflect the relative burdens and benefits of NATO membership.
- Membership in post-Cold War NATO provides public benefits if NATO members truly share common interests in NATO's redefined roles and responsibilities; NATO's benefits are more private if members do not share these interests.

This model highlights the difference between a country's internal defence burden and alliance membership burdens. Military spending as a percentage of GDP measures internal defence burdens; alliance burdens involve any adverse changes in the perceived threat due to alliance membership, while alliance benefits are the reductions in the defence burden as defence spill-ins accrue from the other alliance members. As NATO shifts its roles and missions, it is natural to ask if this evolution will make alliance defence expenditures more or less public. To answer this question, empirical tests need to be developed that reflect the true costs and benefits of alliance membership.

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