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On Sharing NATO Defence Burdens in the 1990s and Beyond

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Abstract

This article investigates NATO burden sharing in the 1990s in light of strategic, technological, political and membership changes. Both an ability-to-pay and a benefits-received analysis of burden sharing are conducted. During 1990–99, there is no evidence of disproportionate burden sharing, where the large allies shoulder the burdens of the small. Nevertheless, the theoretical model predicts that this disproportionality will plague NATO in the near future. Thus far, there is still a significant concordance between benefits received and defence burdens carried. When alternative expansion scenarios are studied, the extent of disproportionality of burden sharing increases as NATO grows in size. A broader security burden-sharing measure is devised and tested; based on this broader measure, there is still no disproportionality evident in the recent past.

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I. INTRODUCTION

In little more than four months, the Communist regimes in Europe, which had posed the greatest threat to European security for 40 years, unravelled as the Berlin Wall tumbled on 9–10 November 1989, a democratic coalition government formed in Czechoslovakia on 7 December 1989, Ceausecu's regime collapsed on 22 December 1989 and the first free elections in a generation took place in East Germany on 18 March 1990.[1] These events were followed by a unified Germany joining NATO (3 October 1990), the official disbandment of the Warsaw Pact (1 July 1991) and the demise of the Soviet Union (20 December 1991). But these developments, which marked the end to the cold war, were not the only factors behind the momentous change in the nature of European defence. Iraq's invasion of Kuwait on 1 August 1990 underscored that security threats to NATO's resource supplies and interests could come from 'rogue states' that operate outside international conventions and norms.[2] This war also highlighted the recent revolution in military technologies, which would be greatly perfected before their next large-scale deployment against Serbia in 1999. Changes in European defence also derived from NATO's adoption of a new strategic doctrine in 1994 that calls for crisis management and peace enforcement in places even outside of Europe whenever NATO's vital interests are at risk.[3] Still other influential developments included NATO's expansion to encompass some ex-Warsaw-Pact members and the significant downsizing of defence budgets among most NATO allies with the exception of Greece and Turkey.

These changes came so suddenly as to catch NATO policymakers unprepared: almost overnight, threats to NATO security were no longer necessarily from the east, nor were they necessarily even within Europe. As such, allied forces now required the ability to be rapidly projected to theatres outside of Europe. The next generation of weapons had to be more suited to these new concerns and less geared to those of the cold war era of nuclear deterrence. Security challenges also stemmed from transnational terrorism as grievances in other regions of the world (for example, the Middle East) erupted in European terrorist acts designed to capture world attention.[4] The potential collapse of the transition economies and their potential return to Communism presented yet another danger, which can be largely addressed through foreign assistance intended to keep these emerging-market economies buoyant.

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[1]Dates in this paragraph come from NATO Office of Information and Press (1995, pp. 295–351) and Sandler and Hartley (1999, pp. 52–7).

[2]On rogue states and the threats that they pose, see Klare (1995) and Sandler and Hartley (1999, pp. 182–92).

[3]This new doctrine and its genesis were discussed in Gompert and Larrabee (1997), Jordan (1995), Sandler and Hartley (1999) and Thomson (1997).

[4]For a current assessment of the threat of transnational terrorism, consult Enders and Sandler (1999 and 2000) and US Department of State (1999).

Throughout its 50 years, NATO burden sharing has been a divisive issue. All too frequently, the US has alleged that it has carried an 'unfair' and disproportionately large amount of the alliance burden (US Committee on Armed Services, 1988). In recent years, the US Department of Defense (DOD) must annually submit to Congress a report assessing allied contributions to the common defence (see, for example, US DOD (1996 and 1999)). The European allies have countered these charges of undercontributions by pointing out that much of US defence spending is on non-European concerns and by devising alternative burden-sharing measures that put their contributions in a better light. Moreover, some European allies emphasised that they assumed disproportionate burdens for UN peacekeeping and for other activities (for example, NATO infrastructure). Any assessment of burden sharing faces at least two problems: (1) how to measure relative burdens and (2) what activities to include in this burden-sharing accounting.

To analyse the distribution of burdens among NATO allies, researchers have followed the seminal study of Olson and Zeckhauser (1966) and applied the theory of pure public goods.[5] Subsequent studies have hypothesised that defence expenditures yield multiple outputs that vary in their degree of publicness (Sandler, 1977; van Ypersele de Strihou, 1967). By changing the mix of public and private benefits associated with defence activities, recent changes to NATO's strategic doctrine, weapon technologies, perceived threat and membership composition can alter burden-sharing behaviour.

A primary purpose of this article is to investigate burden sharing in NATO in the 1990s in light of recent changes. We apply theoretical insights from a joint product model representation of alliances (Section II) to suggest empirical tests of burden-sharing behaviour so as to assess the impact of recent alterations in NATO's strategic environment on allied support of the alliance (Section III). Empirical tests of burden sharing in the 1990s are based on two alternative public finance principles: an ability-to-pay measure (Section IV) and a benefits-received measure (Section V). Another purpose is to hypothesise how burden sharing will change during the coming decade (Section VI). We are particularly interested in this change under alternative expansion scenarios. A third purpose is to devise a security burden-sharing measure that broadens security-promoting activities to go beyond defence spending (Section VII). Concluding remarks round out the study in Section VIII.

The empirical tests indicate that there is no evidence of disproportionate burden sharing for 1990–99, so that the large allies are not shouldering the defence burdens for the small allies. In the latter 1990s, there is, however, a tiny

[5]This extensive literature has been surveyed recently by Murdoch (1995) and Sandler and Hartley (1999). Key articles include McGuire (1990), Murdoch and Sandler (1982 and 1984), Olson and Zeckhauser (1966), Oneal (1990), Oneal and Elrod (1989), Palmer (1990a, 1990b and 1991), Russett (1970), Sandler (1975, 1987 and 1993), Sandler and Cauley (1975), Smith (1989) and van Ypersele de Strihou (1967).

drift upward in the positive (but insignificant) correlation between defence burdens and the allies' national income, which suggests a gradual return to disproportionate burden sharing, consistent with our theoretical prediction. This return is anticipated to be more pronounced in the years to come as changes in NATO's strategic environment have time to influence actions. When derived benefits are compared with actual defence burdens carried, the match between the two is still significant, indicating that the joint product model with its private inducement to support defence is still relevant. If alliance-wide public benefits increase in the ensuing decade as predicted, then this match may eventually become insignificant. When alternative expansion scenarios are examined, the extent of disproportionality of burden sharing increases if the alliance continues to grow.

II. ALTERNATIVE PUBLIC GOOD MODELS

1. A Pure Public Good Model of Alliances

If defence is purely public for the allies, then the benefits associated with defence must be non-rival and non-excludable. Defence benefits are non-rival among allies when one ally's consumption of the unit of defence does not detract, in the slightest, from the consumption opportunities still available to other allies *from that same unit*. Deterrence, as provided by strategic nuclear weapons (for example, Trident submarines or B-2 stealth bombers), is non-rival among allies because, once deployed, these weapons' ability to deter enemy aggression is independent of the number of allies (or citizens) on whose behalf the retaliatory threat is made, provided that the promised retaliation is automatic and believable. If the allies underwriting deterrence have a 'first-strike' advantage so that they can destroy enough of the enemy's nuclear arsenal in a pre-emptive attack, then any return fire would be minimal and the retaliatory pledge attains greater credibility. When, moreover, the strategic arsenal is sufficiently large to absorb an attack and still possess enough surviving missiles to deliver an unacceptable punishment to a would-be aggressor, the threatened retaliation is credible and can be made on behalf of 15, 18 or more allies.

The benefits of a defence activity are non-excludable if they cannot be withheld at an affordable cost by the provider. For strategic nuclear forces, benefits are non-excludable whenever the defence provider(s) cannot fail to deliver the pledged retaliatory response against an invader of another ally. If an attack on one ally causes unacceptable collateral damage to the allies underwriting the retaliatory response, then the promised retribution is likely to ensue. This automatic response can also be triggered when the deterrence-providing allies have sufficient investment interests, military troops, citizens or other assets in a targeted ally to suffer greatly from any attack. During the cold war, the large numbers of US troops and their dependants stationed in West

Germany, the UK and Italy served as a tripwire to a US response if these host allies were attacked. Thus it is understandable that, at first, the Europeans were opposed to the announced US troop withdrawals from Europe after the cold war, despite their complaints of negative externalities stemming from hosting US troops. Given the proximity of France and the UK to other NATO allies in Europe, these two nuclear allies would have great difficulty in excluding their European allies and neighbours from any promised retaliation owing to collateral damage.

Alliances that rely on deterrence to forestall an attack share a purely public defence good, for which some essential implications follow. First, defence burdens are anticipated to be shared unevenly with the largest allies, which have the most to lose from an attack, assuming a disproportionately large burden in relation to their gross domestic product (GDP).[6] The prediction that the large, wealthy allies will shoulder the defence burdens for smaller, poorer allies is the 'exploitation hypothesis'. If, for example, the large ally spends $250 billion on defence and a small ally desires to spend just $5 billion, then the small ally is likely to spend very little, relying instead on the protection that spills over from its large formidable ally. This conclusion rests on the purely public assumption where the defence efforts of one ally are perfectly substitutable for those of another. If, however, this substitutability is limited, then this disproportionality is curtailed. Second, defence spending will be allocated in a suboptimal fashion, which follows because each ally considers only its own marginal benefits and the associated marginal costs when deciding defence provision. Optimality for a pure public defence good requires that the alliance-wide sum of marginal benefits be equated to marginal costs.[7] Third, the absence of rivalry in consumption implies that all friendly nations can be included in the alliance, in so far as only benefits arise from the expansion of an alliance. Fourth, co-operation needs to be fostered to address suboptimal defence levels and can take the form of 'tight' alliance linkages, whereby allies sacrifice some of their autonomy over their defence decision to the collective or a central authority (Sandler and Forbes, 1980). Fifth, the match between benefits received from defence and the actual defence burden is anticipated for many allies to be weak owing to free riding, which shows up as a negative relationship between an ally's real defence outlays and those of its allies.

2. Joint Product Representation of Alliances

Researchers noticed that after the mid-1960s (see Section IV) many of the implications of the pure public good model of alliances did not hold (for example, Russett (1970)) and, in response, offered a generalisation in the form of

[6]This was first formulated by Olson (1965) and Olson and Zeckhauser (1966).

[7]This was established in Samuelson (1954 and 1955). Sandler and Hartley (1999, Ch. 2) has a much more in-depth analysis of these implications.

a joint product model in which defence yields multiple outputs whose publicness varies. In particular, defence activities can produce deterrence (a pure public benefit), damage limitation or protection for times of conflict (an impure public benefit) and ally-specific outputs (private benefits).[8] Defence outputs are impurely public among allies when the associated benefits are either partially or wholly excludable by the provider, or else partially rival among the allies. Consider conventional forces, deployed along an alliance's perimeter to keep an opposing side from penetrating its front. Because the actual deployment decision can exclude one or more allies, conventional armaments and troops display partially excludable benefits. Such forces are subject to a spatial rivalry in the form of 'force thinning' as a given army is spread over a longer exposed border. Coalescing troops in one place along an alliance's border leads to vulnerabilities elsewhere, and it is these resulting vulnerabilities that imply rivalry in consumption.

Ally-specific benefits occur when a defence activity helps only the providing ally and yields no benefit spillovers to others. In large part, the UK efforts to thwart terrorism in Northern Ireland only benefited the UK. The same can be said of the British forces stationed 12,000 kilometres away in the Falklands, or British efforts to expel Argentine troops from the Falklands between 2 April and 14 June 1982. The recent build-up of Greek and Turkish forces to protect their respective partitions of Cyprus yield largely ally-specific benefits. Unlike public defence outputs, private ally-specific benefits motivate an ally to provide defence, since these benefits cannot be derived from another ally's defence efforts. Similarly, excludable impurely public defence benefits — say, derived from conventional forces assigned to the ally's borders — also provide incentives for an ally to contribute.

Consider the differences in the mix of outputs and the publicness of benefits derived from strategic and conventional weapons. By their nature, strategic weapons do not readily lend themselves to producing ally-specific benefits. Such weapons cannot be used to threaten an insurgency into submission, nor can they be assigned to thwart terrorism or provide disaster relief. If, moreover, these forces have sufficient range, they can be deployed almost anywhere with little or no thinning of strength, so that strategic nuclear forces yield primarily alliance-wide purely public benefits. Some ally-specific benefits follow from the provider's control of the launch button, whose possession can allow it to extract some hegemonic concessions (Morrow, 1991). In contrast, conventional forces possess a large share of ally-specific benefits and impurely public benefits. While it is true that formidable conventional forces deter an enemy, they can also further many ally-specific interests. Their deployment during a conflict is impurely public owing to force thinning. In essence, the extent of publicness is reflected in the ratio of excludable benefits (i.e. ally-specific and damage-

[8]Ally-specific benefits are private among allies but public within an ally.

limiting benefits) to total benefits received from a defence activity's outputs. This ratio depends on the reigning strategic doctrine, weapon technology, perceived threats and alliance composition. For example, curbing the threat posed by the proliferation of nuclear forces, which is part of NATO's new crisis-management doctrine, yields purely public benefits to NATO allies and any nation in harm's way from such weapons.

The implications of the joint product model are at variance with those of the purely public deterrence representation of an alliance. First, a high ratio of excludable benefits implies that an ally must support its own defence, regardless of its economic size, if it is going to be protected. As this ratio increases, the exploitation hypothesis is anticipated to lose its relevancy, so that any disproportionality between an ally's size and its defence burden is predicted to decline. Second, the presence of excludable benefits allows markets and club arrangements to promote preference revelation, thereby achieving a closer equality between marginal benefits and marginal costs. As the ratio of excludable benefits approaches one, this equality of margins becomes closer to being satisfied, thus implying greater optimality. Free riding can be curtailed with a sizeable helping of excludable benefits. Third, alliance size restrictions hinge on the thinning of forces; allies with large exposed borders cause more thinning and must contribute more conventional forces to offset this thinning externality (Sandler, 1977). Because ally-specific benefits are not shared and deterrence can be shared at zero costs, neither of these types of benefits determines membership size. Fourth, alliance links can be kept loose and unintegrated when the ratio of excludable benefits is large, in so far as inefficiencies are small, calling for little co-operative correction. Fifth, the larger is this ratio, the better is the match between benefits received and defence burdens, because a payment must be made to acquire the excludable benefits.

The location and geographical properties of a prospective ally make a difference for both the desirability of including this ally and the extent of its bargaining strength if included. A conventional alliance can save costs owing to the sequestration of interior borders that no longer require protection (Gardner, 1995, pp. 401–6; Sandler, 1999). Consider an alliance of three contiguous square countries of equal sizes lined up in a row.[9] Suppose that each country's sides are of unit length costing 1 to protect. If each country provides its own defence, then each expends 4 in protecting its perimeter from an attack in all directions. If, instead, the countries form an alliance, then only 8 sides need protecting, leading to a cost saving of 4. The middle country possesses a bargaining advantage, because without its participation there would be no cost savings. Countries with long exposed borders are less desirable entrants and, if admitted, are at a bargaining disadvantage when cost savings from sequestered borders are

[9]The formation and expansion of NATO was analysed in Sandler (1999) based on cost savings from interior borders.

distributed. Potential non-contiguous allies, such as the Baltic states (Latvia, Estonia and Lithuania), in which just Lithuania has a common 91-kilometre border with Poland, have little to offer NATO and are unlikely entrants.

III. NATO DOCTRINES AND BURDEN SHARING

1. Mutual Assured Destruction: 1949–66

NATO was initially confronted with a daunting challenge: a Soviet Union bent on a westward expansion as it acquired satellite states. Unlike the NATO allies, which had converted a large share of their defence industries to peacetime uses by 1949, the Soviet Union had continued to run its defence industries at the same wartime pace. As a consequence, the Soviet Union had acquired a conventional weapon advantage, which meant that NATO had to rely on US superiority in strategic nuclear weapons to counter any Soviet aggression. Thus the alliance adopted a strategic doctrine of mutual assured destruction (MAD), whereby any Soviet territorial expansion involving NATO allies would trigger a devastating nuclear attack. Directive MC 48, approved in 1954 by the North Atlantic Council, allowed NATO to use strategic weapons to counter such aggression (Rearden, 1995, p. 73). Any such US retaliatory response had credibility owing to a US first-strike advantage, by which Soviet nuclear assets could be neutralised by a pre-emptive strike. Thus the pledged US response could be exercised with impunity. This reliance on strategic weapons meant that NATO's security rested on purely public deterrence.

2. Flexible Response Eras: 1967–80 and 1981–90

The embarrassment experienced by the Soviet Union when it had to back down during the Cuban missile crisis, owing to the US pre-emptive advantage, set in motion a Soviet build-up of its strategic forces. As the US lost some of its strategic advantage, NATO needed a new defence doctrine that would not result in an immediate nuclear exchange during an exigency. In 1967, NATO adopted directive MC 14/3, which embodied the doctrine of flexible response, whereby NATO would respond in a measured way to Warsaw Pact challenges. The doctrine envisioned a commensurate response to acts of aggression and allowed for an escalation if necessary. As a result of this doctrine, strategic, tactical and conventional forces became complementary as they had to be used together, so that the extent of substitutability between allied forces and the incentives to free ride diminished (Murdoch and Sandler, 1984). NATO allies that failed to maintain their conventional forces became the weak link that might draw an attack.

By relying on all three kinds of weapons, this 1967 doctrine meant that defence activities within NATO yielded joint products with varying degrees of

TABLE 1

NATO Doctrines, Defining Events and Underlying Model

Doctrines and defining events	*Model*	*Implications*
Mutual assured destruction 1949–66 • Reliance on US strategic forces • MC 48: NATO use of nuclear weapons • NATO conventional inferiority • Soviet nuclear force vulnerability	Deterrence as a pure public good	• Disproportionate burdens • Suboptimality and free riding • Inclusive alliance (do not limit size) • Need for co-operation and tight links • Poor match between benefits received and defence burdens
Doctrine of flexible response 1967–80 • Reliance on conventional and strategic forces • Thinning of conventional forces • MC 14/3 in 1967: flexible response doctrine • Complementarity between strategic and conventional forces • US troops and investments in Europe	Joint products	• Reduced disproportionality of burdens • Less suboptimality • Exclusive alliances (limit size) • Looser alliance linkages • Better match between benefits received and defence burdens
Doctrine of flexible response 1981–90 • France and UK strategic build-up • Reagan procurement and strategic build-up • Precision-guided munitions • 'Deep strike' or forward-defence strategy	Joint products with more purely public benefits	• Some increase in disproportionality • More suboptimality • Less exclusive alliance • Need for tighter alliance links • Reduced match between benefits received and defence burdens
Crisis management 1991–2000 • Fall of Berlin Wall (9–10 November 1989) • Dissolution of Warsaw Pact and Soviet Union • Downsizing of defence spending • Desert Shield and Desert Storm • Rome Summit (7–8 November 1991) • Oslo Declaration (June 1992) • Brussels Summit (10–11 January 1994) • Bosnia IFOR and SFOR • NATO expansion (April 1999) • Kosovo and KFOR	Joint products with still more purely public benefits likely in the future	• Some increase in disproportionality • More suboptimality and free riding • Less exclusive alliance • Need for tighter alliance links • Reduced match between benefits received and defence burdens • These predictions will take some time to show up as downsizing initially placed more burdens on the small allies

publicness. In Table 1, we list the defining events and doctrines for MAD and three subsequent strategic eras. On the right-hand side of the table, the implications of the appropriate underlying model are tabulated. By 1981, a host of events, as given on the left-hand side of Table 1, increased the share of non-excludable, purely public benefits and, in so doing, are predicted to have the influences indicated on the right. For example, the nuclear allies' build-up and modernisation of their strategic arsenals increased the share of jointly produced non-excludable public outputs. The deterrence derived from French and British enhanced strategic forces provided non-excludable and non-rival benefits to the other European allies.

When NATO adopted the forward-defence strategy or 'deep strike' in 1984, this flexible-response upgrade shifted the focus away from NATO's eastern perimeter by relying on precision-guided munitions to target and destroy the Warsaw Pact's rear-echelon forces. The new strategy reduced thinning and the impurity of conventional forces, since their deployment along the front loses some of its importance; nevertheless, this upgraded doctrine's reliance on conventional forces still meant that excludable joint products are important. In Table 1, we hypothesise that the net influence of these strategic, procurement and technological events was to augment the share of non-excludable benefits derived from defence. In other words, these events increased the publicness of the defence activity and enhanced the concerns over disproportionate burdens and suboptimality, which the first era of flexible response greatly corrected.

3. Crisis-Management Doctrine: 1991–2000

With the fall of the Berlin Wall in November 1989 and the subsequent dissolution of the Warsaw Pact, the flexible-response strategy to an eastern attack lost much of its relevancy. The immediate impact was defence downsizing to take advantage of a peace dividend. As the large allies downsized to a greater extent relative to the smaller allies, defence burdens should at first shift to the latter — a tendency enhanced by Greek and Turkish military build-ups. The Gulf War of 1991 underscored that threats to NATO's interests can come from so-called rogue nations. As Communist regimes in Europe collapsed, ethnic conflicts, once held in check by powerful governments, erupted and threatened stability in Europe.

These developments and the need to reshape NATO to the post-cold-war era resulted in a new strategic doctrine (see Table 1), which first emerged at a Rome summit on 7–8 November 1991 when the Ministers acknowledged that NATO must assume responsibility for ensuring Europe's security from challenges both within and beyond NATO's boundaries (Asmus, 1997, p. 37). During an Oslo summit in 1992, NATO included peacekeeping as part of its new strategic crisis-management doctrine, which required the development of multilateral rapid-deployment forces with air, land and maritime components, known as Combined

Joint Task Forces (CJTFs). At the Brussels Summit on 10–11 January 1994, NATO allies agreed officially to develop these CJTFs and to broaden the strategic doctrine to include policing the non-proliferation of nuclear and other weapons of mass destruction. NATO peacekeeping troops were deployed in Bosnia in December 1995 as an Implementation Force (IFOR) for the Dayton peace agreement. A year later, this force became the Stabilisation Force (SFOR), which is still in Bosnia in 2000. In June 1999, another contingent of NATO peacekeeping troops were dispatched as part of the Kosovo Peacekeeping Force (KFOR), following the NATO springtime bombing campaign against Serbia.

There are a number of factors that promote a hypothesised increase in publicness. First, peacekeeping and crisis-management activities, if successful, provide an increased measure of world stability and security that benefits all nations — contributors and non-contributors – so that benefits are non-excludable and non-rival.[10] Second, allies that acquire sufficient capacity to project forces to trouble spots are likely to provide a free ride in times of crises for allies that have not invested in this capability. During the Gulf War, the US transported much of the coalition's equipment from Europe (Klare, 1995). Only the four largest allies — the US, the UK, France and Germany — are currently making sizeable investments in their power-projecting capacity (Sandler and Hartley, 1999). Third, R&D breakthroughs associated with the revolution in military technologies can yield non-rival, though excludable, benefits. The US, the UK and France spend the most on weapon R&D (Hartley, 1997, p. 31). The experience in Kosovo is instructive: most of the bombing missions were flown by the US military because of the sophisticated ordnance involved and the adverse weather conditions. As the technology gap in weapons expands between the large and small allies, this disproportionality of burdens should increase. This follows because only the few largest NATO allies can afford the huge fixed costs associated with the new generations of weapons. In fact, only the US has the means to make the necessary investments, so that the technology gap, so prevalent during Kosovo, is apt to open wider.

This increased share of purely public joint products will eventually increase free riding and thus place a greater burden on the richest allies once the effects of downsizing are finished. In addition, there is eventually expected to be a reduced match between defence benefits received and burdens carried, so that greater co-operation will someday be needed if allied efforts are to be efficiently allocated. The search for these relationships in Sections IV and V requires some caveats. The crisis-management shares of the allies' defence budget are still small for 1990–99, so that this movement to increased publicness may not yet be

[10]On the publicness of peacekeeping, see Khanna, Sandler and Shimizu (1998 and 1999).

evident. Similarly, the build-up of rich allies' transport capacity is occurring in 1998–2005 and, except for 1998–99, will not be reflected in the data.[11]

IV. ABILITY TO PAY AND BURDEN SHARING

The standard burden-sharing measure for defence, used to reflect the ability to pay, is the share of GDP devoted to military expenditures (i.e. ME/GDP). Division by GDP normalises the burden based on the allies' capacity to pay. Other burden-sharing measures (for example, military expenditures per capita and military manpower per capita) have been applied, but are less useful because they either include only a portion of the military activity or else do not really account for an ally's true ability to underwrite its defence spending.[12] Since the Olson and Zeckhauser (1966) study, disproportionality of defence burdens is typically tested non-parametrically by checking the correlation between the allies' defence burdens ranks and their GDP ranks. If a significant positive correlation exists, then this indicates that the rich allies carried a disproportionately large burden of defence spending. The standard test statistics are the Spearman rank correlation coefficient (ρ) and the Kendall rank correlation coefficient or the Kendall tau (τ).

The alternative (H_a) and null (H_0) hypotheses for a rank correlation test are

H_a: Within NATO, there is a positive association between the allies' GDP and their share of GDP devoted to military expenditure.
H_0: There is no association between these variables.

Table 2 indicates the past findings of these tests for various periods from 1950 to 1992. Previous studies have *all* found a significant positive rank correlation for 1950–66, thus rejecting the null hypothesis in favour of the alternative hypothesis. These results are consistent with the pure public deterrence model's prediction that the rich allies carried the defence burden of the small allies during the MAD era. At the start of flexible response, the positive correlations were insignificant except for 1973 during the Vietnam War. This finding suggests that considerations other than size directed burden sharing during the beginning of flexible response when ally-specific and excludable joint products provided allies with greater interests to contribute to defence. Thus this empirical result is consistent with the joint product model's prediction that economic size becomes less of a determinant of defence burden sharing. During the second half of flexible response in the early 1980s, there was some increase in this correlation, which remained insignificant.

[11]For example, the US plans to spend over $20 billion on strategic mobility over the next five years (US Congressional Budget Office, 1997, Table 3).
[12]Hartley and Sandler (1999) provide a discussion of alternative burden-sharing measures and why ME/GDP is the most appropriate ability-to-pay measure.

TABLE 2

Past Studies of Defence Burdens and Ability to Pay

Study	*Test*	*Year(s)*	*Conclusion*
Olson and Zeckhauser, 1966	Spearman rank correlation	1964	Significant positive rank correlation between ME/GNP and GNP.
van Ypersele de Strihou, 1968	Regression	1955, 1963	Significant coefficient on GNP when ME/GNP is regressed against the log of GNP.
Russett, 1970	Kendall τ	1950–67	Significant rank correlation between ME/GNP and GNP for all sample years, with a marked decline in correlation starting in 1961.
Sandler and Forbes, 1980	Kendall τ	1960–75	Significant rank correlation between ME/GDP and GDP for 1960–66. Thereafter, the relationship is insignificant except for 1973.
Oneal and Elrod, 1989	Percentage of variance explained	1953–84[a]	Significant percentage of variance of ME/GDP is explained by GDP during 1953–68. After 1968, only an insignificant percentage of this variance is explained.
Khanna and Sandler, 1996	Kendall τ	1960–92	Many significant rank correlations between ME/GDP and GDP during 1960–66. No significant rank correlations are found after 1966. During the late 1970s and early 1980s, these correlations are elevated but not significant.

[a]For selected years.

We now update these earlier burden-sharing studies using data from 1988–99. The null hypothesis is tested with the non-parametric Spearman rank correlation coefficient (Mendenhall and Beaver, 1991). Spearman's ρ statistic is calculated in the same fashion as the familiar Pearson correlation coefficient except that the *ranks* of the data replace the actual measurements, making the statistic robust to outliers and minor measurement errors that do not alter the rankings. Moreover, this statistic makes no parametric demands on the distributions of the GDP and defence burden data. This is ideal for our situation in so far as some relatively large allies (for example, the US) are grouped with some small ones (for example, Luxemburg), making it unlikely that the GDP observations are

generated from the same distribution. The tests of the relationship between defence burden and GDP are apt to suffer from confounding influences. For instance, a longer exposed border generally necessitates greater defensive expenditures. To the extent that larger nations tend to have greater GDP, the strength of the defence burden and GDP relationship appears greater owing to this confounding variable. To assess the role of potential confounding influences, we also test the hypotheses using Spearman's partial correlation coefficients. Intuitively, a partial coefficient measures the correlation of the residuals of two regressions: the first set comes from a regression of defence burden ranks on (say) exposed borders, while the second comes from a regression on GDP and exposed borders. With the partial correlation coefficient, we thus remove any explanatory power of the confounding variable before computing the statistic.[13]

The dataset for the updated burden-sharing tests in Sections IV and V includes observations on military expenditures, GDP, exchange rates, population (POP), imports (IMP), exports (EXP) and exposed borders. For the 15 NATO allies (minus Iceland), we have data for 1988–99. The data on ME for 1988–98 were obtained from Stockholm International Peace Research Institute (1999), while ME estimates for 1999 of the NATO allies were taken from NATO (1999). In the case of exposed borders (length in kilometres of borders with non-NATO nations plus coastlines), data were obtained from the US Central Intelligence Agency (1999). With some minor exceptions, data on the remaining variables were taken from International Monetary Fund (1999a and 1999b).[14] Each ally's openness measure equals its sum of exports and imports as a share of the country's GDP. Currency-based data for ME, GDP, IMP and EXP were expressed in nominal US dollars using the current average exchange rate for each year of data with the exception of the EU countries in 1999. For these observations, data were expressed in US dollars using the 1 January 1999 exchange rates adjusted by the value of the Euro on 1 July 1999.

In Table 3, the Spearman rank correlations between defence burdens and GDP are given annually for the 1988–99 period. Numbers in parentheses beneath the various Spearman ρ coefficients indicate the prob-values or the probability of

[13]While several non-parametric statistics are available to test for association, two in particular — Kendall's τ and Spearman's ρ — readily extend to partial measures. We employed the Spearman ρ because the sampling distribution for Kendall's partial τ is unknown. To obtain prob-values for this τ, we would have to resort to some sort of simulation (for example, Hoflund (1963)). Although not presented here, we also estimated the alternative Kendall's τs and found that the patterns of the correlations are essentially identical to those reported with Spearman's ρ below.

[14]The exceptions are as follows. The GDPs for Portugal in 1997, 1998 and 1999 were inferred from the ratio of ME to GDP as reported in US Department of Defense (1999). For countries with incomplete series on imports and exports, our measure of openness in Section V was estimated as the previous year's value. In cases where population is missing, we used the previous year's value to complete the series.

TABLE 3

Spearman Rank Correlations between Defence Burdens (ME/GDP) and GDP

	ρ_{12}[a]	$\rho_{12,3}$[b]	$\rho_{12,34}$[c]
1988	0.31	0.35	0.32
	(0.27)	(0.22)	(0.29)
1989	0.27	0.33	0.33
	(0.33)	(0.24)	(0.27)
1990	0.31	0.35	0.31
	(0.27)	(0.22)	(0.30)
1991	0.18	0.22	0.22
	(0.53)	(0.44)	(0.58)
1992	0.21	0.25	0.20
	(0.44)	(0.39)	(0.52)
1993	0.20	0.23	0.17
	(0.48)	(0.43)	(0.59)
1994	0.11	0.16	0.07
	(0.68)	(0.59)	(0.83)
1995	0.06	0.12	0.04
	(0.82)	(0.69)	(0.89)
1996	0.05	0.09	0.03
	(0.87)	(0.75)	(0.92)
1997	0.09	0.12	0.05
	(0.75)	(0.69)	(0.87)
1998	0.08	0.11	0.04
	(0.79)	(0.71)	(0.89)
1999[d]	0.12	0.23	0.07
	(0.64)	(0.37)	(0.79)

Note: Numbers in parentheses are prob-values, indicating the probability of a type I error when testing the null hypothesis of no association between ME/GDP and GDP versus the alternative hypothesis of a positive association.
Variables: 1 = ME/GDP; 2 = GDP; 3 = GDP/POP; 4 = exposed borders.
[a]Simple rank correlation coefficient.
[b]Partial rank correlation coefficient with GDP/POP held constant.
[c]Partial rank correlation coefficient with GDP/POP and exposed borders held constant.
[d]The number of allies is 18 for 1999, since Iceland is excluded.

a type I error when testing for no association. Prob-values of 0.05 or less would reflect statistically significant coefficients. In the second column, the simple rank correlation coefficients, ρ_{12}, are displayed, all of which are insignificant. The positive and insignificant rank correlations for 1988–96 decline in value during the post-cold-war period, indicating less correlation between economic size and defence burdens. This finding is consistent with the smaller allies cutting back on defence spending during this period by less than the large allies. Additionally, the absence of correlation between economic size and defence burdens suggests

the continued applicability of the joint product model during the post-cold-war era. In 1997–99, there is a small increase in this rank correlation, which might forebode that the crisis-management doctrine and other developments are beginning to have their anticipated impact on burden sharing. It is, however, apt to take more years of crisis-management activities and the build-up of mobile forces before the predicted disproportionality shows up. The last two columns of Table 3 contain partial rank correlation coefficients with GDP per capita held constant and with GDP per capita and exposed borders held constant, respectively. Both partial rank correlation coefficients show an identical pattern to that of the simple rank correlation. When GDP per capita is held constant, the positive correlations are slightly elevated from the simple rank correlations. A similar result applies for 1988–91 but not for 1992–99 when both GDP per capita and exposed borders are held constant. After 1992, this partial rank correlation displays the same trend as the simple rank correlation but is smaller.[15] *These findings imply no exploitation of the large by the small during the post-cold-war period*.

V. BENEFIT MEASURES AND BURDEN SHARING

Benefits from defence spending arise from what is protected by both conventional and strategic arsenals: the ally's industrial base, its population and its exposed borders. To calculate an overall measure for these defence benefits, we followed the methodology of Sandler and Forbes (1980) and computed each ally's share of NATO's GDP (i.e. ally's GDP/NATO GDP), its share of NATO's population and its share of NATO's exposed borders. Myriad weighting schemes can be devised to aggregate these three benefit measures to derive some aggregate benefit share for each ally. In essence, the appropriate weights depend on an ally's preferences, which are not known nor easily observed. As a reasonable proxy in light of our ignorance, we weighted these shares equally by adding them up and dividing by three for an 'average benefit share'.

If the average benefit share is a good predictor of an ally's actual defence burden share within NATO (ME/NATO ME), then the distributions of the two measures should be similar, i.e. there should be no systematic difference between them. This new burden-sharing measure represents *between-ally* sharing in contrast to the earlier ME/GDP measure which denotes *within-ally* sharing based on country-specific variables. To determine the correspondence between defence burdens and its benefits, we used a Wilcoxon signed-rank test which is a non-

[15]Other partial rank correlations, not displayed, (for example, holding exposed borders constant) indicate the same results: all coefficients are insignificant and the coefficient pattern over time is the same as those in Table 3.

parametric alternative to the familiar paired difference test (Mendenhall and Beaver, 1991).[16] The alternative hypothesis (H_{2a}) and null hypothesis (H_{20}) are

H_{2a}: The distributions of defence burdens and average benefit shares for the NATO allies are different.
H_{20}: The distributions of defence burdens and average benefit shares for the NATO allies are the same.

In our case of $N = 15$ for 1990–98, the critical value for the Wilcoxon R statistic is 25 at the 5 per cent level of significance for a two-tailed test. The null hypothesis is rejected when R is less than or equal to 25. For 1999, $N = 18$ and the critical Wilcoxon R statistic is then 40.

Before presenting the results for the 1990s, we review three studies that compared defence burdens and average benefit shares for earlier periods. Sandler and Forbes (1980) uncovered a much closer match between defence burdens and their benefit proxies in 1975 than in 1960 during MAD, where the underlying distributions were different. Khanna and Sandler (1996 and 1997) were unable to reject the null hypothesis H_{20} at intervals for 1965, 1970, 1975, 1980 and 1990, thus leading to the conclusion that during much of the flexible-response era there was a statistically significant match between defence burdens and their benefits. This finding supports the joint product model over the purely public deterrent model as the underlying paradigm. For 1985, however, at the height of the Reagan defence build-up, the null hypothesis is rejected in favour of the alternative hypothesis. Thus the Reagan administration's concentration on procurement and the build-up of strategic, tactical and other armaments appeared to increase the extent of publicness in the defence activity and, in so doing, induced more free riding, thus breaking the match between defence burdens and defence benefits.

Our update for the 1990s is indicated in Tables 4 and 5, where defence burdens and average benefit shares are displayed annually for 1990–94 and 1995–99, respectively. Data sources were the same as those described in Section IV for the Spearman test. As in this previous test, current-year nominal data were converted to nominal US dollars using that year's exchange rates. For each country, its share of NATO's GDP, population and exposed borders were computed and then averaged. In each table, the left column beneath each year is the actual defence burden, while the right column is the average benefit share. For example, in 1990, France assumed 8.45 per cent of NATO total defence spending, while it received a benefit share of 6.39 per cent, thus implying an

[16]The Wilcoxon test involves (i) assigning ranks based on the absolute value of the differences between the two measures and (ii) computing the sum of the ranks with positive differences and the sum with negative differences. The smaller of these two rank sums is the R statistic of interest, and its critical values are available in most introductory statistics books.

TABLE 4

Defence Burdens and Average Benefit Shares in NATO using Population, GDP and Exposed Borders as Proxies for Benefits: 1990–94

	1990		1991		1992		1993		1994	
	Defence burden	*Average benefit share*	*Defence burden*	*Average benefit share*	*Defence burden*	*Average benefit share*	*Defence burden*	*Average benefit share*	*Defence burden*	*Average benefit share*
Belgium	0.92	1.03	0.96	1.00	0.81	1.02	0.78	1.01	0.84	1.01
Denmark	0.52	1.30	0.56	1.28	0.56	1.28	0.56	1.27	0.58	1.28
France	8.45	6.39	8.90	6.20	8.86	6.27	8.86	6.16	9.45	6.19
Germany	8.39	7.58	8.23	8.67	8.25	8.97	7.74	8.92	7.73	8.99
Greece	0.77	2.11	0.79	2.10	0.86	2.11	0.85	2.10	0.92	2.10
Italy	4.64	5.93	5.07	5.81	4.91	5.76	4.28	5.24	4.34	5.19
Luxemburg	0.02	0.04	0.02	0.05	0.02	0.05	0.02	0.05	0.03	0.05
Netherlands	1.47	1.54	1.51	1.51	1.55	1.53	1.47	1.53	1.52	1.54
Norway	0.67	2.81	0.69	2.80	0.75	2.80	0.66	2.78	0.72	2.78
Portugal	0.37	0.98	0.44	0.98	0.50	1.00	0.46	0.98	0.46	0.97
Spain	1.80	3.73	1.90	3.71	1.78	3.72	1.72	3.50	1.58	3.44
Turkey	1.05	4.12	1.18	4.08	1.21	4.11	1.47	4.21	1.13	4.10
UK	7.89	6.69	8.99	6.59	7.92	6.50	7.09	6.27	7.33	6.33
Canada	2.29	25.82	2.33	25.77	2.13	25.63	2.14	25.62	2.03	25.55
US	60.74	29.93	58.42	29.45	59.90	29.24	61.91	30.35	61.33	30.47
NATO-Europe	36.97	44.26	39.25	44.78	37.97	45.13	35.95	44.03	36.64	43.98
NATO-North-America	63.03	55.74	60.75	55.22	62.03	54.87	64.05	55.97	63.36	56.02

Notes: Figures represent percentage shares of NATO's total for each variable. For example, defence burden indicates the ally's defence spending divided by total NATO defence spending. Average benefit share denotes the sum of each ally's shares of NATO's population, NATO's GDP and NATO's exposed borders, divided by three. The totals for NATO-Europe and NATO-North-America may not add up due to rounding.

TABLE 5

Defence Burdens and Average Benefit Shares in NATO using Population, GDP and Exposed Borders as Proxies for Benefits: 1995–99

	1995		1996		1997		1998		1999	
	Defence burden	*Average benefit share*	*Defence burden*	*Average benefit share*	*Defence burden*	*Average benefit share*	*Defence burden*	*Average benefit share*	*Defence burden*	*Average benefit share*
Belgium	0.94	1.06	0.91	1.02	0.83	0.97	0.82	0.96	0.75	0.90
Czech Republic									0.25	0.59
Denmark	0.66	1.31	0.66	1.31	0.62	1.28	0.63	1.27	0.59	1.21
France	10.12	6.34	9.95	6.23	9.17	5.93	9.01	5.90	8.28	5.53
Germany	8.72	9.34	8.36	9.03	7.38	8.51	7.33	8.77	6.80	7.69
Greece	1.07	2.12	1.20	2.12	1.22	2.11	1.29	2.10	1.27	2.02
Hungary									0.16	0.70
Italy	4.10	5.12	5.03	5.28	4.82	5.13	5.12	5.06	4.82	5.43
Luxemburg	0.03	0.06	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.05
Netherlands	1.70	1.60	1.68	1.56	1.52	1.50	1.50	1.50	1.38	1.41
Norway	0.72	2.81	0.79	2.82	0.74	2.81	0.71	2.78	0.68	2.69
Poland									0.70	2.14
Portugal	0.57	0.99	0.56	0.98	0.56	0.97	0.53	0.95	0.50	0.91
Spain	1.83	3.50	1.85	3.49	1.66	3.38	1.65	3.36	1.59	3.18
Turkey	1.40	4.18	1.61	4.20	1.60	4.26	1.84	4.22	2.20	3.94
UK	7.17	6.29	7.40	6.30	7.89	6.52	8.17	6.56	7.54	6.25
Canada	1.92	25.50	1.81	25.52	1.71	25.57	1.50	25.47	1.60	24.67
US	59.06	29.80	58.18	30.07	60.25	31.01	59.85	31.06	60.87	30.66
NATO-Europe	39.02	44.69	40.01	44.41	38.04	43.43	38.65	43.47	37.54	44.66
NATO-North-America	60.98	55.31	59.99	55.59	61.96	56.57	61.35	56.53	62.46	55.34

Notes: See Table 4.

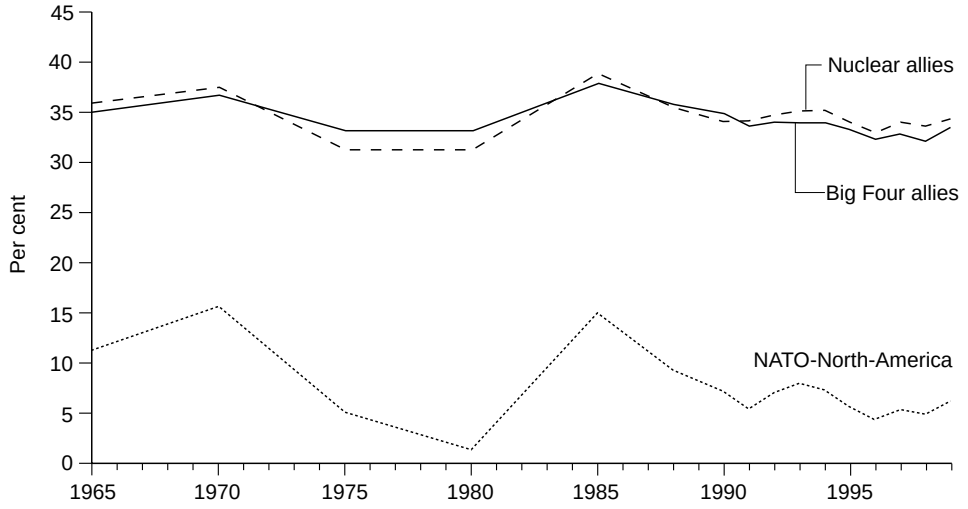
overpayment. In that same year, the Netherlands covered 1.47 per cent of NATO's aggregate defence spending, which is almost a perfect match for its average benefit share of 1.54 per cent. Other figures are interpreted similarly.

The Wilcoxon R statistics for these years are: 39 in 1990; 39 in 1991; 37 in 1992; 33 in 1993; 35 in 1994; 37 in 1995; 40 in 1996; 38 in 1997; 41 in 1998; and 45 in 1999. Because none of the R statistics is less than 25 (or 40 for 1999), we cannot reject the null hypothesis; hence there is evidence of a match between defence burdens and our proxy measure of defence benefits for each year of the 1990s.[17] Based on this comparison, the joint product model still describes behaviour in the post-cold-war years, but the match is less significant for 1999, consistent with the increasing share of public benefits. As long as the associated distributions for defence burdens and benefits are the same, there is support for NATO's current loosely integrated alliance, because suboptimality is limited by this concordance.

Figure 1 splices together a key finding of the Khanna and Sandler (1996) study with that of this study. The three time series displayed show the difference between actual defence burdens and those predicted by the average benefit share for the two North American allies, the three nuclear allies and the four largest allies (i.e. the three nuclear allies plus Germany). In so far as each time series

FIGURE 1

Difference between Actual and Predicted Defence Burdens: NATO-North-America, Big Four and Nuclear Allies



[17]We also computed the defence burdens and benefits for 1988 and 1989, and found R statistics of 35 and 29, respectively. In neither case did we reject the null hypothesis at the 5 per cent level for a two-tailed test.

TABLE 6

Defence Burdens and Average Benefit Shares in NATO using Openness, Population, GDP and Exposed Borders as Proxies for Benefits: Selected Years

	1991		1993		1995		1997		1998	
	Defence burden	*Average benefit share*	*Defence burden*	*Average benefit share*	*Defence burden*	*Average benefit share*	*Defence burden*	*Average benefit share*	*Defence burden*	*Average benefit share*
Belgium	0.96	4.07	0.78	3.93	0.94	3.97	0.83	4.05	0.82	4.04
Denmark	0.56	2.70	0.56	2.63	0.66	2.61	0.62	2.59	0.63	2.59
France	8.90	5.79	8.86	5.72	10.12	5.84	9.17	5.63	9.01	5.60
Germany	8.23	7.80	7.74	7.85	8.72	8.10	7.38	7.57	7.33	7.76
Greece	0.79	2.67	0.85	2.67	1.07	2.56	1.22	2.50	1.29	2.49
Italy	5.07	5.25	4.28	4.96	4.10	4.99	4.82	4.95	5.12	4.89
Luxemburg	0.02	4.77	0.02	4.57	0.03	4.25	0.03	4.10	0.03	4.10
Netherlands	1.51	3.75	1.47	3.67	1.70	3.64	1.52	3.60	1.50	3.60
Norway	0.69	3.94	0.66	3.94	0.72	3.82	0.74	3.90	0.71	3.88
Portugal	0.44	2.34	0.46	2.21	0.57	2.28	0.56	2.24	0.53	2.23
Spain	1.90	3.73	1.72	3.67	1.83	3.79	1.66	3.84	1.65	3.83
Turkey	1.18	3.83	1.47	4.00	1.40	4.19	1.60	3.88	1.84	3.84
UK	8.99	6.16	7.09	6.08	7.17	6.12	7.89	6.25	8.17	6.29
Canada	2.33	20.59	2.14	20.78	1.92	20.90	1.71	21.05	1.50	20.97
US	58.42	22.61	61.91	23.32	59.06	22.93	60.25	23.85	59.85	23.89
NATO-Europe	39.25	56.80	35.95	55.90	39.02	56.17	38.04	55.10	38.65	55.14
NATO-North-America	60.75	43.20	64.05	44.10	60.98	43.83	61.96	44.90	61.35	44.86

Notes: Figures represent percentage shares of NATO's total for each variable. For example, defence burden indicates the ally's defence spending divided by total NATO defence spending. Average benefit share denotes the sum of each ally's shares of NATO's population, NATO's GDP, NATO's exposed borders and NATO's openness, divided by four. The totals for NATO-Europe and NATO-North-America may not add up due to rounding.

shows the same pattern, we focus on the time series for North America, where this difference declined between 1970 and 1980 as flexible response shifted more defence burdens to Europe. The Reagan build-up reversed this shift. Since 1985, the overall trend for this difference is downward, except for 1999 where a small rise is noted. The pattern for exploitation, reflected by these time series for various aggregates of the large allies, is closely in keeping with our theoretical predictions.

Next, we broadened the proxy for average benefit shares to include a fourth benefit measure of openness. In a secure environment, an ally also gains from international trade. To devise a measure for the relative benefit that an ally derives from its openness ({exports + imports}/GDP), we calculated an ally's share of NATO's aggregate openness, which equals an ally's openness divided by the sum of these openness measures for the alliance. Average benefit shares were then computed by summing each ally's four benefit shares and dividing by four. In Table 6, we depict defence burdens and the new average benefit shares for five selected years in the 1990s. Other years display very similar values. The Wilcoxon signed-rank test statistic equals: 37 in 1991; 29 in 1992; 28 in 1993; 30 in 1994; 32 in 1995; 32 in 1996; 31 in 1997; and 33 in 1998.[18] For these new R statistics, we cannot reject the null hypothesis at the 5 per cent level of significance. Thus we again conclude that there is evidence of a match between defence burdens paid and defence benefits received. This inclusion of another benefit measure indicates that the results are not so sensitive to the benefit proxies chosen.

VI. ALTERNATIVE NATO EXPANSION SCENARIOS

With the inclusion of the Czech Republic, Hungary and Poland in NATO in March 1999, NATO confronts new concerns about burden sharing. As the alliance expands, a greater heterogeneity of tastes is introduced at a time when the theory of alliances predicts more disproportionate burden sharing in the future with large allies assuming increased burdens in terms of the proportion of GDP devoted to defence. The Partnership for Peace (PFP) programme, started in 1994, is geared to preparing other nations for NATO membership and fostering co-operation between NATO and the countries of eastern and central Europe (Gompert and Larrabee, 1997; Sandler and Hartley, 1999, p. 19).

To investigate what might be the impact of alternative expansion scenarios, we conducted a thought experiment which allows for nine possible alliance-composition scenarios:

[18]Because openness data were not available for 1999, this year was not examined with the four-proxy benefit measure.

- Scenario 1 is NATO 15 (excluding Iceland and the three entrants);
- Scenario 2 is NATO 18 (excluding Iceland);
- Scenario 3 is NATO 18, Slovenia and Slovakia;
- Scenario 4 is NATO 18, Slovenia, Slovakia and Romania;
- Scenario 5 is NATO 18, Slovenia, Slovakia, Romania and the three Baltic states (Estonia, Latvia and Lithuania);
- Scenario 6 consists of Scenario 2 allies plus the neutrals (Austria, Finland, Ireland, Sweden and Switzerland);
- Scenario 7 consists of Scenario 3 allies plus the neutrals;
- Scenario 8 consists of Scenario 4 allies plus the neutrals; and
- Scenario 9 consists of Scenario 5 allies plus the neutrals.

Scenario 1 is, of course, NATO prior to March 1999, while Scenario 2 is NATO today. The remaining scenarios are numbered from 3 to 5 or from 6 to 9, according to their likelihood of being realised, where smaller numbers are associated with more likely cases. These scenarios and their likelihood are based on locational and spatial considerations (i.e. exposed borders and geographical position) as well as political considerations as analysed in Sandler (1999). For example, Slovenia and Slovakia are the most likely entrants, because each has relatively little exposed border so that their admittance saves on cost by sequestering interior borders of existing allies. Moreover, these two countries do not face insurgencies or border disputes. In contrast, the inclusion of the Baltic states does little, except for a small contiguous border with Poland, to sequester borders. Moreover, their inclusion is rigorously opposed by Russia, thus implying political costs.

Our thought experiment first consisted of computing the Spearman rank correlations between defence burdens and GDP for various scenarios in 1998 to ascertain how burdens would be shared. This experiment implies that new allies do not alter their share of GDP for defence, which, if the behaviour of the three recent entrants is any indication, is a reasonable assumption. As in the case of the NATO 15, the data for these three NATO entrants, the other prospective entrants and the neutral nations are obtained as follows: ME from Stockholm International Peace Research Institute (1999); exposed borders from US Central Intelligence Agency (1999); and POP from International Monetary Fund (1999a and 1999b).

In Table 7, we display various Spearman rank correlation coefficients and their prob-values. The scenarios are indicated in the first column, while the number of observations is given in the second column. In the third column, the simple rank correlations increase in value as the number of allies increases for the five scenarios without the neutrals. This result suggests that, as the alliance expands, the extent of disproportionate burden sharing increases. This outcome is in complete agreement with the general principles of collective action where

TABLE 7

Spearman Rank Correlations between ME/GDP and GDP for Various Membership Scenarios: 1998

Scenario[a]	*No. of observations*	ρ_{12}[b]	$\rho_{12,3}$[c]	$\rho_{12,4}$[d]	$\rho_{12,34}$[e]
1	15	0.08	0.11	0.01	0.04
		(0.79)	(0.71)	(0.98)	(0.89)
2	18	0.10	0.19	–0.05	0.04
		(0.68)	(0.47)	(0.86)	(0.88)
3	20	0.14	0.25	–0.07	0.04
		(0.55)	(0.30)	(0.76)	(0.87)
4	21	0.16	0.27	–0.07	0.06
		(0.49)	(0.25)	(0.78)	(0.82)
5	24	0.37	0.40	0.24	0.29
		(0.07)	(0.06)	(0.28)	(0.19)
6	23	0.15	0.25	–0.01	0.09
		(0.49)	(0.25)	(0.96)	(0.69)
7	25	0.14	0.28	–0.04	0.11
		(0.50)	(0.19)	(0.87)	(0.61)
8	26	0.14	0.29	–0.04	0.12
		(0.50)	(0.16)	(0.85)	(0.57)
9	29	0.30	0.40	0.20	0.30
		(0.11)	(0.04)	(0.30)	(0.13)

Note: Numbers in parentheses are prob-values, indicating the probability of a type I error when testing the null hypothesis of no association between ME/GDP and GDP versus the alternative hypothesis of a positive association.
Variables: 1 = ME/GDP; 2 = GDP; 3 = GDP/POP; 4 = exposed borders.
[a]Scenario 1 is NATO 15 excluding Iceland.
Scenario 2 is NATO 15 plus three new entrants (Czech Republic, Hungary and Poland).
Scenario 3 is NATO 18, Slovenia and Slovakia.
Scenario 4 is NATO 18, Slovenia, Slovakia and Romania.
Scenario 5 consists of Scenario 4 plus three Baltic countries (Estonia, Latvia and Lithuania).
Scenario 6 is NATO 18 plus five neutrals (Austria, Finland, Ireland, Sweden and Switzerland).
Scenario 7 is NATO 18, five neutrals, Slovenia and Slovakia.
Scenario 8 consists of Scenario 7 plus Romania.
Scenario 9 consists of Scenario 8 plus three Baltic countries.
[b]Simple rank correlation coefficient.
[c]Partial rank correlation coefficient with GDP/POP held constant.
[d]Partial rank correlation coefficient with exposed borders held constant.
[e]Partial rank correlation coefficient with GDP/POP and exposed borders held constant.

free riding increases with group size (Olson, 1965; Sandler, 1992). For the scenarios involving the neutrals, this increasing disproportionality only arises with the addition of the Baltic states. Interestingly, the neutrals share burdens today not too dissimilarly from other small allies in regards to the proportion of

TABLE 8

Defence Burdens and Average Benefit Shares for Various Enlargement Scenarios using Population, GDP and Exposed Borders as Proxies for Benefits: 1998

	Scenario 2 ($N = 18$)		Scenario 4 ($N = 21$)		Scenario 5 ($N = 24$)		Scenario 6 ($N = 23$)		Scenario 9 ($N = 29$)	
	DB	*ABS*	*DB*	*ABS*	*DB*	*ABS*	*DB*	*ABS*	*DB*	*ABS*
Austria	NA	NA	NA	NA	NA	NA	0.38	.075	0.38	0.70
Belgium	0.81	0.92	0.81	0.90	0.81	0.89	0.79	0.88	0.79	0.85
Czech Republic	0.25	0.60	0.25	0.56	0.25	0.56	0.24	0.54	0.24	0.50
Denmark	0.63	1.24	0.62	1.22	0.62	1.21	0.61	1.21	0.61	1.19
Estonia	NA	NA	NA	NA	0.01	0.44	NA	NA	0.01	0.44
Finland	NA	NA	NA	NA	NA	NA	0.40	0.67	0.40	0.65
France	8.91	5.65	8.88	5.54	8.88	5.51	8.67	5.35	8.64	5.22
Germany	7.25	8.31	7.23	8.15	7.22	8.11	7.06	7.84	7.03	7.67
Greece	1.28	2.04	1.28	2.02	1.28	2.00	1.25	2.01	1.24	1.97
Hungary	0.13	0.69	0.13	0.57	0.12	0.57	0.12	0.63	0.12	0.52
Ireland	NA	NA	NA	NA	NA	NA	0.15	0.40	0.15	0.39
Italy	5.07	4.82	5.05	4.70	5.05	4.67	4.93	4.50	4.91	4.36
Latvia	NA	NA	NA	NA	0.01	0.19	NA	NA	0.01	0.19
Lithuania	NA	NA	NA	NA	0.03	0.25	NA	NA	0.03	0.24
Luxemburg	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.05
Netherlands	1.49	1.43	1.48	1.40	1.48	1.39	1.45	1.37	1.44	1.34
Norway	0.70	2.74	0.70	2.72	0.70	2.68	0.68	2.49	0.68	2.45
Poland	0.73	2.17	0.73	2.07	0.73	2.04	0.71	2.10	0.71	1.96
Portugal	0.52	0.91	0.52	0.89	0.52	0.88	0.51	0.88	0.51	0.86
Romania	NA	NA	0.16	1.21	0.16	1.20	NA	NA	0.15	1.16
Slovakia	NA	NA	0.09	0.28	0.09	0.28	NA	NA	0.09	0.26
Slovenia	NA	NA	0.07	0.22	0.07	0.21	NA	NA	0.07	0.18
Spain	1.63	3.20	1.62	3.14	1.62	3.11	1.58	3.08	1.58	2.99
Sweden	NA	NA	NA	NA	NA	NA	1.04	1.07	1.03	1.05
Switzerland	NA	NA	NA	NA	NA	NA	0.68	0.77	0.68	0.75
Turkey	1.82	3.98	1.82	3.87	1.82	3.83	1.77	3.85	1.77	3.71
UK	8.08	6.31	8.06	6.20	8.05	6.15	7.87	6.04	7.84	5.90
Canada	1.49	25.11	1.48	24.95	1.48	24.59	1.45	24.93	1.44	24.47
US	59.19	29.85	59.00	29.34	58.97	29.18	57.62	28.60	57.41	27.98
Wilcoxon R[a]	53 (40)		65 (59)		78 (81)		77 (73)		103 (127)	

Abbreviations and notes: See overleaf.

Abbreviations and notes for Table 8
NA = not applicable.
DB = defence burden.
ABS = average benefit share.
Notes: Figures represent percentage shares of NATO's total for each variable. For example, DB indicates the ally's defence spending divided by total NATO defence spending. ABS denotes the sum of each ally's shares of NATO's population, NATO's GDP and NATO's exposed borders, divided by three.
[a]Values in parentheses indicate the critical value below which the null hypothesis is rejected at the 5 per cent level.

GDP devoted to defence. When Scenarios 2 and 6 are compared for the simple rank correlation, there is increased disproportionality, but it is rather limited for the addition of so many nations. Scenarios 5 and 9 suggest that the inclusion of the Baltic states is apt to have an important negative impact on burden sharing. Nearly identical patterns arise for the partial Spearman rank correlations in the fourth and sixth columns. When, however, the partial rank correlation holds only exposed borders constant, no clear pattern emerges in the fifth column except that the addition of the Baltic states leads to an augmented disproportionality in burden sharing.

As a second thought experiment, we computed the average benefit shares and defence burdens for Scenarios 2–9, where the former were based on each ally's shares of POP, GDP and exposed borders. In Table 8, we display these defence burdens and benefit shares for only five of eight scenarios to conserve space.[19] The Wilcoxon R statistic, along with the critical values below which the null hypothesis is rejected at the 5 per cent level, is displayed in the last row. The null hypothesis is rejected in favour of the alternative hypothesis of different underlying distributions for Scenarios 5 and 9, but not for Scenarios 2, 4 and 6. For the scenarios not depicted in Table 8, the Wilcoxon R and its critical value (in parentheses) are: 61 (52) for Scenario 3; 87 (90) for Scenario 7; and 91 (98) for Scenario 8. Thus defence burdens and defence benefits do not match for the inclusion of the Baltic states and three of the four scenarios involving the neutral countries. These findings suggest that expanding the NATO alliance much beyond the inclusion of Slovenia, Slovakia and Romania will create greater inefficiency in resource allocation as benefits and burdens of defence are poorly matched.

VII. SECURITY BURDEN SHARING

Until now, there has been no convincing or successful effort in the literature to define a broader security burden-sharing measure that includes allies' defence efforts, peacekeeping support and foreign-aid activities. Surely peacekeeping bolsters overall security, while foreign assistance does the same by creating more robust and stable economies in developing countries. It is instructive to see how

[19]The values for the other scenarios are available from the authors upon request.

the US DOD addresses this security burden-sharing issue in its annual *Report on Allied Contributions to Common Defense* to the US Congress (see, for example, US DOD (1996 and 1999)). In essence, this report merely presents a rank for each security-enhancing activity and allows readers to draw their own conclusions. Suppose that Norway is highly ranked in peacekeeping and foreign assistance but is lowly ranked in its defence burden as a share of GDP. Are we then to conclude that Norway assumes a respectable burden? This is a hasty conclusion because the expenditure levels on peacekeeping and foreign aid are typically dwarfed by that on defence, so that doing more than one's share on the first two does not necessarily offset a small defence burden. Taking an average of these ranks, as done by Hartley and Sandler (1999), is also ill advised because this procedure implicitly assumes that the amounts spent are of similar magnitudes.

The security burden index proposed here adjusts for differential spending on alternative security-promoting activities. If security derives from defence, peacekeeping and foreign aid, then the proposed measure sums the expenditures on each and then divides this sum by GDP. Ranks are assigned for these security burdens and then compared with each ally's GDP ranks. We performed these computations for 1994–97 in the base case of 15 NATO allies, using data on defence spending, peacekeeping expenditure and foreign aid from US DOD (1999). Because this report presents the data in real 1998 US dollars, current-year nominal values for other variables (for example, GDP) had to be converted into real 1998 US dollars. These real figures were obtained by first 'deflating' the own-country values to 1998 with their respective GDP price deflator before converting to dollars with the 1998 average exchange rate. Deflation of the own-country values is accomplished by multiplying by the ratio of the 1998 price deflator to the annual price deflator. The price deflators are from International Monetary Fund (1999a and 1999b).[20]

In Table 9, we present the various Spearman rank correlation coefficients between our security burden measure and GDP. The most interesting finding is that the results in Table 9 are closely related to those in Table 3, where only defence burdens are correlated with GDP for comparable years. In fact, the broader measure shows a slightly elevated, but highly insignificant, positive correlation. The elevated values suggest not only that the defence burdens overwhelm the peacekeeping and foreign assistance burdens for these years, but also that the smaller countries are not, on average, carrying more of the latter two combined burdens. If peacekeeping continues to grow in importance and if, moreover, these burdens are shouldered by the large allies, as projected here,

[20]For countries with incomplete GDP price deflator series, we applied the rate of change in the consumer price index (also available from International Monetary Fund (1999a)) to the available GDP price deflators to complete the series.

TABLE 9

Spearman Rank Correlations between Security Burdens and GDP (N = 15)

	ρ_{12}[a]	$\rho_{12,3}$[b]	$\rho_{12,34}$[c]
1994	0.19	0.21	0.13
	(0.49)	(0.46)	(0.68)
1995	0.14	0.16	0.07
	(0.61)	(0.58)	(0.82)
1996	0.11	0.13	0.04
	(0.69)	(0.66)	(0.89)
1997	0.11	0.13	0.04
	(0.69)	(0.66)	(0.89)

Note: Numbers in parentheses are prob-values, indicating the probability of a type I error when testing the null hypothesis of no association between the security burden and GDP versus the alternative hypothesis of a positive association.
Variables: 1 = ME/GDP; 2 = GDP; 3 = GDP/POP; 4 = exposed borders.
[a]Simple rank correlation coefficient.
[b]Partial rank correlation coefficient with GDP/POP held constant.
[c]Partial rank correlation coefficient with GDP/POP and exposed borders held constant.

then the rank correlation between the security burdens and GDP will increase and may culminate in disproportionate burden sharing as in the MAD era. Clearly, the argument that a broader security measure would reverse findings based solely on defence burdens is not supported here. The technique put forward for computing a security burden can be extended to include additional security-promoting activities.

VIII. CONCLUDING REMARKS

Although the threat of nuclear Armageddon has subsided greatly since the conclusion of the cold war, Europe and its North American allies still confront myriad common security challenges from crisis management, ethnic unrests, weapons of mass destruction proliferation, rogue nations, transnational terrorism and a Russia at war with some of its ex-republics. As the nature of the threats changes, NATO must respond with new weapons, technology, logistical doctrines and strategies. By changing the publicness character of the shared defence activities, these developments can have profound influences on resource allocation within NATO. The NATO alliance provides a means for collective security at a bargain price, but poses collective action problems from free riding, inefficient resource allocations and disproportionate burden sharing.

This paper has applied the theoretical and empirical tools from the economic study of alliances to take stock of free riding, burden sharing and related issues in the past. More important, we have provided an up-to-date analysis of these resource-allocation concerns for NATO in the 1990s. In the process, we have

shown that the joint product model still applies during the current crisis-management era. There continues to be a concordance between benefits received and defence burdens borne by the allies. Moreover, there is no evidence yet of disproportionate burdens being shouldered by the large allies. At this point in time, NATO's loosely integrated institutional structure therefore remains appropriate. Nevertheless, theoretical arguments are put forward that hypothesise that defence burden sharing will become more disproportionately carried by the large allies in the future as spending on crisis management, force mobility, weapons non-proliferation and high-technology weapons increases as a proportion of the defence budget. If this prediction is realised, then NATO's institutional structure may need to be tightened and, in so doing, allies' discretion will be reduced.

We have also presented alternative NATO expansion scenarios that may result in an increased exploitation of the large by the small if the alliance continues to expand. It would be useful to re-examine NATO's burdens in another five years to evaluate if the predicted trend to disproportionate burden sharing and a greater share of purely public output is realised.

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