RAND

Research Report

KING MALLORY, GENE GERMANOVICH, JONATHAN W. WELBURN, TROY D. SMITH

Burdensharing and Its Discontents

Understanding and Optimizing Allied Contributions to the Collective Defense

For more information on this publication, visit **www.rand.org/t/RR4189z1**.

Published by the RAND Corporation, Santa Monica, Calif.

Library of Congress Cataloging-in-Publication Data is available for this publication.

ISBN: 978-1-9774-1326-0

Cover: Serhii Brovko/istock/Getty Images Plus.

About This Report

The perennial question of whether U.S. allies are contributing enough to the collective defense has once again become a high priority in the U.S. foreign policy agenda. The Office of the Secretary of Defense asked the RAND Corporation to research ways of measuring, understanding, and advancing new theories of burdensharing. RAND was also asked to identify ways in which the U.S. Department of Defense might incentivize U.S. allies and partners to improve their ability to contribute to 2018 U.S. National Defense Strategy objectives, especially strengthening combined deterrence and preparing for potential warfights.

To respond to this request, we reviewed the history of the burdensharing debates in Europe and Asia and the associated theoretical and official literature to identify more than a dozen factors and more than 100 metrics that might be used to measure burdensharing. We then constructed a nested, multi-attribute Burdensharing Index to aid in measurement and analysis. This allowed us to develop a nuanced picture of allied burdensharing that indicates that U.S. allies in Europe and Asia contribute more than half of the total burden of the collective defense required to enforce the post–World War II international security order. They make greater contributions of personnel and ground forces than the United States does, whereas the United States makes greater contributions of air forces, naval forces, and intelligence (command, control, communications, computers, intelligence, surveillance, and reconnaissance). The analysis led us to identify ten potential strategies by which the United States might optimize allied contributions; none is easy to implement, and all require careful analytic consideration and diplomatic follow-through.

This research was conducted between 2016 and 2019 and uses 2017 data, primarily from the 2017 volume of *The Military Balance*, published by the International Institute for Strategic Studies; these were the most current data available at the time that our results were presented to the U.S. Department of Defense. This report is one component of a two-part project that examines burdensharing and takes a deep look at the future military capabilities of two key U.S. allies: France and Japan. Separate reports document the future capabilities of each of these two states.[1] This report is intended for both the expert and the general reader and assumes some prior familiarity with national security topics. The Burdensharing Index described in this report is contained in a spreadsheet that is reproduced in Appendix B. Although we have made every effort to present as complete a version of the index as possible here, more time and resources would allow us to develop more-thorough documentation of the model and make improvements to it of the kind identified in this report.

[1] See Stephanie Pezard, Michael Shurkin, and David Ochmanek, *A Strong Ally Stretched Thin: An Overview of France's Defense Capabilities from a Burdensharing Perspective*, Santa Monica, Calif.: RAND Corporation, RR-A231-1, 2021; and Jeffrey W. Hornung, *Japan's Potential Contributions in an East China Sea Contingency*, Santa Monica, Calif.: RAND Corporation, RR-A314-1, 2020.

The data presented in this report have been double- and, in some cases, triple-checked. Our results are most sensitive to countries' share of total allied net exports lost as a result of United Nations sanctions imposed on Russia and Iran, the discount applied to conscripted active-duty personnel numbers, and aspects of military preparedness. Errors or changes in single data points outside of the first two of these key drivers are unlikely to materially alter the country rankings or overall findings of this report. We present a limited number of counter-intuitive results, and the majority of those results are accounted for by the fact that, when calculating countries' share of the burden of mounting a collective defense, we chose to include the exports that countries lost as a result of sanctions.

The research reported here was completed in January 2021 and underwent security review with the sponsor and the Defense Office of Prepublication and Security Review before public release.

This research was sponsored by the Office of the Secretary of Defense and conducted within the International Security and Defense Policy Program of the RAND National Security Research Division (NSRD), which operates the National Defense Research Institute (NDRI), a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Navy, the Marine Corps, the defense agencies, and the defense intelligence enterprise.

For more information on the RAND International Security and Defense Policy Program, see www.rand.org/nsrd/isdp or contact the director (contact information is provided on the webpage).

Contents

Figures and Tables

Figures

Tables

Summary

Since the end of World War II, the United States and its allies in the North Atlantic Treaty Organization (NATO) and in Asia have mounted a collective defense to enforce the international liberal order established in the late 1940s. With the end of the Cold War, the perennial debate about whether U.S. allies were bearing their fair share of the burden of that defense subsided. In recent years, however, U.S. defense policymakers and analysts have become increasingly alarmed by some adverse geostrategic trends and by the failure of the U.S.-led system of alliances and partnerships to respond and adapt adequately to these emerging challenges.

The general consensus among defense strategists has been that, as the emphasis shifted to fighting terrorism and wars in the Middle East after the September 11, 2001, terrorist attacks in the United States, allies' preparations to defend the international order in Europe and Asia have been chronically underfunded.[1] To explore whether or the extent to which that assessment is true, we developed a new tool—a Burdensharing Index—designed to measure allied contributions to the collective defense. In this report, we document the index's methodology and present some anonymized results. In addition, we outline how U.S. leaders might use the index to help identify countries that may be good candidates to increase investment in specific capabilities needed to meet the future conflicts identified in the 2018 U.S. National Defense Strategy (NDS).[2]

Purpose and Methods

Although the measure of military expenditures as a percentage of gross domestic product (GDP) may be suitable as a rough indicator of the extent of a state's contribution to the collective defense,[3] it provides an incomplete understanding of burdensharing. The measure does not provide DoD with an adequate analytic foundation on which to understand how and under which circumstances policymakers might incentivize additional allied commitments to generating capabilities required for potential future conflicts. The purpose of this research,

[1] Robert M. Gates, "Secretary of Defense Speech: Munich Conference on Security Policy," Washington, D.C.: U.S. Department of Defense, February 11, 2007; Robert M. Gates, "Secretary of Defense Speech: The Security and Defense Agenda (Future of NATO)," Washington, D.C.: U.S. Department of Defense, June 10, 2011; and "Libya War Exposes 'NATO's Chronic Weaknesses,'" *Mail & Guardian*, June 10, 2011.

[2] U.S. Department of Defense (DoD), *Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge*, Washington, D.C., 2018.

[3] In this report, we use defense expenditure numbers compiled by the Stockholm International Peace Research Institute (SIPRI) (see SIPRI, "SIPRI Military Expenditure Database," web tool, undated-a). For an explanation of some of the limitations involved in using these data, see SIPRI, "Sources and Methods," webpage, undated-b.

Important Information About Individual Countries in the Burdensharing Index and Data Limitations

This work is intended to advance theory on burdensharing and provide a starting point for DoD deliberations on this complex topic. To help illustrate how the Burdensharing Index could assist in future policy deliberations but, at the same time, avoid depicting scores and rankings about any single ally, we have anonymized data about individual countries. In their current form, those scores and rankings are not suitable for informing judgments about a given ally. Among the key limitations noted in this report is one of data currency: Because the majority of this project was conducted in 2018, it relies on data primarily from 2017, the most current available at the time. Many nations, including the United States, have since begun to invest in new capabilities while reorienting their forces toward threats from highly capable nation-states.

therefore, was to design an index that more systematically captures the essential contributions of each ally and that would be helpful when analyzing the extent of existing allied contributions to the collective defense, as defined in this report.[4]

We began by reviewing the theoretical literature on burdensharing, which tends to examine state contributions to formal alliance structures (such as NATO), and such contributions are largely driven by regional threat perceptions. In contrast to the traditional literature, we echo the 2018 NDS by considering all U.S. allies that participate in a global, U.S.-led system of collective defenses, and we examine both the allied supply of military goods and services and the demand for them.[5]

Comparing supply (what allies contribute today in military inputs and outputs, as measured by the Burdensharing Index) and demand (what more the United States desires from allies) allows us to both assess allied contributions and, in a second step, identify which allies might be asked to increase investment in specific capabilities needed to meet the future needs identified in the 2018 NDS. The final step in our methodology involves considering which of the potential techniques identified by our review of burdensharing theory might best incentivize individual allies to contribute more.

Our review of the burdensharing literature informed our development of an expansive set of potential metrics for inclusion into a nested, multi-attribute Burdensharing Index.[6] A simplified summary of the resulting index's structure is shown in Figure S.1.

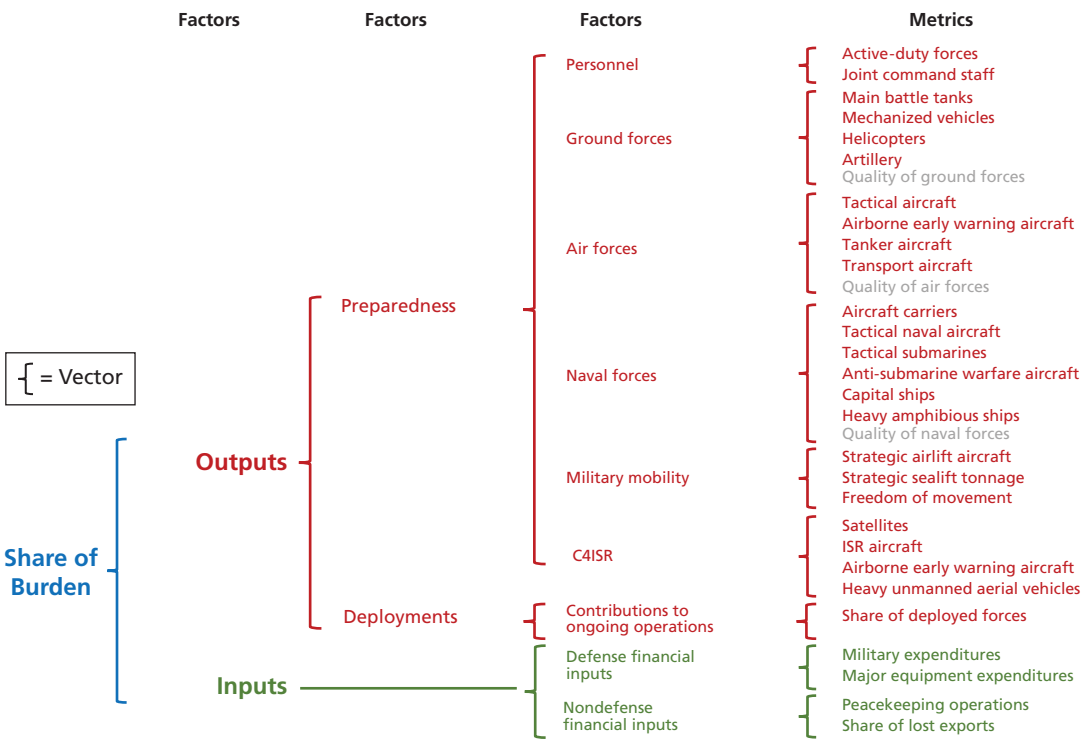
We developed two measures: the burdensharing index score and the burdensharing ratio. The *burdensharing index score* (or *share of burden* in the figure) can serve as a top-level composite measure akin to a stock market index, such as Standard & Poor's 500 Index. The second top-level measure, the *burdensharing ratio*, adjusts the burdensharing index score to account for

[4] An *index* is a mathematical tool that allows us to abstract from reality while still capturing the most-essential elements of that reality. An index can be particularly helpful when measuring a large phenomenon, such as the valuation of the stock market, for which it is unrealistic to expect to be able to measure every single component.

[5] This work focuses primarily on preparedness for warfighting, not the competition under the threshold of armed conflict.

[6] The version of the Burdensharing Index published in this report uses data from 2017. Although we used more than a dozen sources, the primary source was *The Military Balance* (International Institute for Strategic Studies, *The Military Balance*, Vol. 117, No. 1, February 13, 2017). All sources are specified in Appendix B of the main report.

Figure S.1
Simplified Structure of the Burdensharing Index



NOTES: Red items represent outputs; green items represent inputs. Gray items are not yet included in the index. The index's structure has been simplified here for purposes of exposition. C4ISR = command, control, communications, computers, intelligence, surveillance, and reconnaissance; ISR = intelligence, surveillance, and reconnaissance.

each state's level of relative wealth. In a separate step, we used these two measures, along with the underlying aggregated data, to begin analyzing allied contributions to burdensharing with a higher level of granularity.

Despite the Burdensharing Index's shortcomings and limitations (e.g., it does not consider nuclear weapons or distinguish between differing levels of allied combat proficiency), it provides a fair abstraction of a much more complicated reality that can help generate useful analytical results. *Although the index alone cannot be used to reach a firm conclusion about any individual nation's contributions, it is a sound basis for further inquiry and case study analysis.*

Policy Options for Enhancing Burdensharing and Methods to Achieve Those Options

After our analysis and grouping of allies based on their burdensharing index scores and burdensharing ratios, three potential policy options emerge: urgent measures, selective upgrades, and targeted requests.

Our review of the history of the burdensharing debate and of burdensharing theory suggested the following five potential methods that the United States might apply to strengthen and provide greater incentives for allied burdensharing when pursuing the three policy options:

1. Update alliance treaties and associated architecture.
2. Unbundle the collective defense good.
3. Use assurance contracts.
4. Benchmark allied performance.
5. Segment allied defense contractors.

Recommendations

Our primary recommendation in this report is that DoD should systemize the Burdensharing Index methodology presented here to develop an analytically informed, policy-relevant, and enduring approach for incentivizing greater allied contributions. In addition, DoD should populate the index with data biennially to provide an improved basis on which to formulate policies toward key allies.

As noted, the Burdensharing Index presented here is an abstraction from reality and can serve as a point of departure for further analysis. Policymakers should resist the temptation to depict the allied burdensharing index scores and burdensharing ratios that the index generates as definitive stand-alone judgments about the contributions of any single U.S. ally or group of U.S. allies. The index serves as an exploratory tool that can only assist in the judgment and critical thinking required to address such an inherently complex, politically sensitive issue as burdensharing.

Acknowledgments

We would like to thank our RAND colleagues Howard Shatz, Michael Spirtas, JD Williams, Bruce McClintock, Michael Linick, Yvonne Crane, Natasha Lander, Adrienne Propp, Sara Heintz, Melissa Shostak, Chandler Sachs, Christine Wormuth, Michael McNerney, Sonni Efron, Allison Kerns, and Amanda Wilson for their assistance and for the valuable thoughts and insights that they shared with us during the course of this research. We are also particularly grateful for the thoughtful guidance and feedback that we received from our colleagues in the Office of the Deputy Assistant Secretary of Defense for Strategy and Force Development: Kaleb Redden, Paul Avery, Nina Wagner, Michael Donofrio, and Samuel Binkley. Finally, we wish to acknowledge and express our gratitude to our peer reviewers, Julianne Smith and Thomas Szayna, for their constructive criticism and for the improvements that they suggested. Responsibility for any errors that may remain rests with us alone.

Abbreviations

AAM-ER	air-to-air missile – extended range
AARGM-ER	advanced anti-radiation guided missile – extended range
AFRICOM	U.S. Africa Command
ASCM	anti-ship cruise missile
ASM	anti-ship missile
AWACS	Airborne Warning and Control System
BPI	boost-phase intercept
C4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CBF	counter-battery fire
CENTCOM	U.S. Central Command
CIA	Central Intelligence Agency
DoD	U.S. Department of Defense
DPRK	Democratic People's Republic of Korea
EUCOM	U.S. European Command
GDP	gross domestic product
IISS	International Institute for Strategic Studies
ISR	intelligence, surveillance, and reconnaissance
LRASM	long-range anti-ship missile
MBT	main battle tank
MLRS	Multiple-Launch Rocket System
NATO	North Atlantic Treaty Organization
NDS	National Defense Strategy

NORTHCOM	U.S. Northern Command
PACOM	U.S. Indo-Pacific Command
ROK	Republic of Korea
SHORAD	short-range air defenses
SIPRI	Stockholm International Peace Research Institute
SOUTHCOM	U.S. Southern Command
THAAD	Terminal High Altitude Area Defense
UAV	unmanned aerial vehicle
UN	United Nations

CHAPTER ONE

Introduction

The 2018 U.S. National Defense Strategy (NDS) notes the importance of mutually beneficial alliances and partnerships that have characterized the post–World War II international order and emphasizes the need to maintain and expand them. The NDS notes that allies and partners provide the United States with a variety of advantages for managing military competition with China and Russia, mitigating the continued threat from the regimes in Iran and North Korea (officially the Democratic People's Republic of Korea [DPRK]), and combating terrorism.[1] At the same time, the NDS makes explicit the U.S. expectation that allies and partners will do their fair share to underwrite international security:

> We will uphold our commitments and we expect allies and partners to contribute an equitable share to our mutually beneficial collective security, including effective investment in modernizing their defense capabilities. We have shared responsibilities for resisting authoritarian trends, contesting radical ideologies, and serving as bulwarks against instability.[2]

Throughout the Cold War, *burdensharing*—that is, sharing the responsibility of collectively defending the liberal international order—was a consistent feature of alliance politics and a routine issue in U.S. relations with allies and partners, beginning in 1950. The issue became less important in the decades immediately following the end of the Cold War, but it was reemphasized after the terrorist attacks of September 11, 2001, first by the George W. Bush administration and then by the Barack Obama administration. In 2011, then–U.S. Secretary of Defense Robert M. Gates, whose tenure spanned both administrations, reanimated the burdensharing issue further in a speech in Brussels about the future of the North Atlantic Treaty Organization (NATO):

> Looking ahead, to avoid the very real possibility of collective military irrelevance, member nations must examine new approaches to boosting combat capabilities—in procurement, in training, in logistics, in sustainment. While it is clear NATO members should do more to pool military assets, such "Smart Defense" initiatives are not a panacea. In the final analysis, there is no substitute for nations providing the resources necessary to have the military capability the Alliance needs when faced with a security challenge. Ultimately, nations must be responsible for their fair share of the common defense. . . .

[1] U.S. Department of Defense (DoD), *Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge*, Washington, D.C., 2018, p. 8.

[2] DoD, 2018, p. 9.

> With respect to Europe, for the better part of six decades there has been relatively little doubt or debate in the United States about the value and necessity of the transatlantic alliance. . . . Thus, for most of the Cold War U.S. governments could justify defense investments and costly forward bases that made up roughly 50 percent of all NATO military spending. But some two decades after the collapse of the Berlin Wall, the U.S. share of NATO defense spending has now risen to more than 75 percent—at a time when politically painful budget and benefit cuts are being considered at home.
>
> The blunt reality is that there will be dwindling appetite and patience in the U.S. Congress—and in the American body politic writ large—to expend increasingly precious funds on behalf of nations that are apparently unwilling to devote the necessary resources or make the necessary changes to be serious and capable partners in their own defense. Nations apparently willing and eager for American taxpayers to assume the growing security burden left by reductions in European defense budgets.
>
> Indeed, if current trends in the decline of European defense capabilities are not halted and reversed, future U.S. political leaders—those for whom the Cold War was *not* the formative experience that it was for me—may not consider the return on America's investment in NATO worth the cost.[3]

President Obama further elevated this issue in 2016, when he announced bluntly in an interview with *The Atlantic* that "Free riders aggravate me," using in public a term for underperformance that U.S. officials had previously only used in private.[4] In the next administration, President Donald Trump raised the issue of allied investment in defense to the very top of his policy agenda. For example, in remarks in 2017, he said,

> [O]ur allies are not paying their fair share, and I've been talking about this recently a lot. Our allies must contribute toward their financial, political, and human costs, have to do it, of our tremendous security burden. But many of them are simply not doing so.
>
> They look at the United States as weak and forgiving and feel no obligation to honor their agreements with us. In NATO, for instance, only 4 of 28 other member countries besides America, are spending the minimum required 2 percent of [gross domestic product (GDP)] on defense.[5]

Through all administrations, the percentage of GDP committed to defense spending has served as the primary measure of comparison in this diplomatic pursuit.[6] Although military expenditure as a percentage of GDP may be suitable as a high-level indicator to describe, roughly, the extent of a nation's contribution to collective defense, the measure provides an

---

[3] Robert M. Gates, "Secretary of Defense Speech: The Security and Defense Agenda (Future of NATO)," Washington, D.C.: U.S. Department of Defense, June 10, 2011.

[4] Jeffrey Goldberg, "The Obama Doctrine: The U.S. President Talks Through His Hardest Decisions About America's Role in the World," *The Atlantic*, April 2016.

[5] Donald Trump, "Transcript: Donald Trump's Foreign Policy Speech," *New York Times*, April 27, 2016.

[6] See, for example, Robin Emmott, "NATO Edges Toward Trump's Spending Demands, Germany Lags," Reuters, March 14, 2019. Another metric emphasized during the Trump administration, and in earlier periods, is the cost of stationing U.S. troops overseas. See, for example, Nick Wadhams and Jennifer Jacobs, "Trump Seeks Huge Premium from Allies Hosting U.S. Troops," *Bloomberg*, March 8, 2019.

incomplete understanding of burdensharing. It does not provide DoD with an adequate analytic foundation on which to understand how the allies' military spending translates into military capabilities or the varying proficiency with which individual allies are able to employ those capabilities. Both factors are relevant when trying to identify and prioritize targeted requests for allied investments that will make the optimal contribution to anticipated warfights. In addition, military expenditure as a percentage of GDP does not shed light on how U.S. policymakers might incentivize additional allied commitments or the circumstances under which allies might be willing to bolster specific, NDS-relevant capabilities.

Recognizing the need to develop approaches to and measures of burdensharing that can both help assess allied contributions and support implementation of the 2018 NDS, the Office of the Secretary of Defense asked the RAND Corporation to research ways of measuring, understanding, and advancing new theories of burdensharing and to identify ways that DoD might incentivize U.S. allies and partners to improve their ability to contribute to NDS objectives, especially strengthening combined deterrence and preparing for potential warfights.[7] This report documents how we developed a nested, multi-attribute Burdensharing Index that allows DoD to quantify and assess ally and partner contributions and, in a related but separate exercise, use the Burdensharing Index to identify and prioritize targeted requests for additional investments to help achieve NDS objectives.[8] In this report, we first present the index's theoretical and practical underpinnings and then present recommendations on potential pathways by which to incentivize greater allied contributions to defending and enforcing the post–World War II liberal international order in Europe and Asia.[9] Our assumption is that the defense and maintenance of this order in its current or an adapted form constitutes the core goal of the 2018 NDS.

Burdensharing and the Liberal International Order

Although "there is no consistent, widely understood definition of a rules-based liberal order," Michael Mazarr and colleagues have defined the *international order* as "the body of rules, norms, and institutions that govern relations among the key players in the international environment."[10] In particular, the post–World War II order rests on principles and norms shared by the democracies that helped create the order. Among those principles and norms are

- nonaggression, nonproliferation, and territorial integrity
- collective security—that is, the collective responsibility to ensure the security of each state in the international system by means of a collective response to threats to and breaches of peace

[7] This work focuses primarily on preparedness for warfighting, not the competition under the threshold of armed conflict.

[8] From this point forward, unless otherwise stated, we use the term *allies* to indicate *allies and partners* because 34 of the 35 allies and partners examined in this report are formal U.S. allies (only Taiwan is not).

[9] Throughout this report, our use of *Asia* should be understood to include the Australasia region (comprising Australia, New Zealand, the Philippines, and other islands in the region).

[10] Michael J. Mazarr, Miranda Priebe, Andrew Radin, and Astrid Stuth Cevallos, *Understanding the Current International Order*, Santa Monica, Calif.: RAND Corporation, RR-1598-OSD, 2016, pp. x, 7. The authors use the term *international environment* instead of *international system* to avoid a definitional issue. We use *international system*, which Mazarr and colleagues define as "the comprehensive global context in which states operate" (Mazarr, Priebe, et al., 2016, p. 8).

- economic growth and stability, as well as the suppression of mercantilism and beggar-thy-neighbor protectionism[11]
- the prevention of genocide, the defense of human rights, and the promotion of democracy.[12]

Core rules-based institutions, such as the World Trade Organization (and its predecessor, the General Agreement on Tariffs and Trade), the International Monetary Fund, and the World Bank, were established to promote and implement these principles and norms.[13] The concept of collective security thus extends well beyond the military and territorial realm to encompass the more holistic system of security provided by these Bretton Woods institutions and their derivatives, spin-offs, and successors.[14]

To ensure its legitimacy, the United Nations (UN)—the principal post-war collective security institution—has an inclusive architecture that is dictated by its founding goal (implementing collective security); it is open to all states in the international system, affording them equal voting rights in its General Assembly.[15] For much of the post–World War II period, the international system was divided into three opposing Communist, Capitalist, and Nonaligned Blocs.[16] The Communist Bloc repeatedly violated the nonaggression, territorial integrity, genocide, human rights, and democracy principles and norms of the international order that the allied democracies sought to establish. The Communist Bloc used its voting rights on the UN Security Council to thwart enforcement of these principles and norms.[17] After a crisis in Berlin in 1948 and a three-year war in Korea (1950–1953), both the Communist and Capitalist camps came to perceive the UN's collective security system as providing insufficient enforcement of the types of security and economic orders and underlying norms that each

---

[11] Mazarr and colleagues define *beggar-thy-neighbor protectionism* as "when a state enacts economic policies that benefit it but worsen the economic problems of other countries" (Michael J. Mazarr, Astrid Stuth Cevallos, Miranda Priebe, Andrew Radin, Kathleen Reedy, Alexander D. Rothenburg, Julia A. Thompson, and Jordan Wilcox, *Measuring the Health of the Liberal International Order*, Santa Monica, Calif.: RAND Corporation, RR-1994-OSD, 2017, p. xx).

[12] Mazarr, Priebe, et al., 2016, pp. xi, 2, 3, 10, 11, 15, 16, 44; Michael J. Mazarr, *Summary of the Building a Sustainable International Order Project*, Santa Monica, Calif.: RAND Corporation, RR-2397-OSD, 2018, pp. 3–5; Mazarr, Cevallos, et al., 2017, p. 9.

[13] Institutions are "a combination of formal organizations and formal or informal rules that govern international behavior" (Mazarr, Cevallos, et al., 2017, p. 10).

[14] The 1944 Bretton Woods Agreement established rules regulating commercial relations among the United States, Canada, Western European countries, Australia, and Japan.

[15] However, the UN is not entirely democratic. In recognition of the role of great-power influence in international affairs, the UN grants veto voting rights to the five permanent members of its Security Council. The permanent members are China, France, Russia, the United Kingdom, and the United States.

[16] The Soviet Union and the People's Republic of China competed for a leading role in the Communist Bloc. The other members included the German Democratic Republic (East Germany), the Polish Republic, the Czechoslovak Socialist Republic, the Hungarian People's Republic, the Socialist Republic of Romania, the People's Republic of Bulgaria, the People's Socialist Republic of Albania, the Mongolian People's Republic, the DPRK, the Socialist Republic of Vietnam, the Lao People's Democratic Republic, the People's Republic of Kampuchea, and the Republic of Cuba.

[17] Examples of the Communist Bloc's violations of the principles and norms include the following: the Soviet Union's 1956 invasion of Hungary, 1968 invasion of Czechoslovakia, and 1979 invasion of Afghanistan; the Chinese Communist Party–led Cultural Revolution (1966–1976) and Great Leap Forward (1958–1962), which accounted for 30 million and 18 million Chinese deaths, respectively; the Cambodian Khmer Rouge's killing of more than 1 million people between 1975 and 1979 for being opponents and class enemies; and the falsified June 1946 referendum and 1947 general election in Poland, as well as the 1948 coup d'état in Czechoslovakia, sponsored by the Soviet Union.

bloc wished to see prevail. Consequently, each bloc formed narrower, limited-membership military alliances: the Warsaw Pact for the Communist Bloc and NATO for the Capitalist Bloc. Under these arrangements, each set of allies agreed to jointly deter and defend any one or more allies against violations of the nonaggression and territorial integrity principles by other parties. These narrower collective defense agreements became key supplemental mechanisms by which to enforce the principles underlying the two blocs' competing visions of the international order.

Ultimately, the Warsaw Pact collapsed and NATO survived. Opposition to two of the more liberal principles and norms envisioned at the inception of the international order (democracy and human rights) receded. And the United States and like-minded democracies started promoting those principles and norms more forcefully, not without success.[18]

This provoked a counter-reaction by illiberal authoritarian states, led by China and Russia. These states began to resist the promotion of democracy and human rights, started to violate the nonaggression and territorial integrity principles once again, and deepened their violation of the anti-mercantilism and human rights principles. They also began to establish competing international institutions, with the goals of undermining the liberal international order, changing the balance of power within it, and accelerating movement toward a more illiberal and multipolar order.[19]

Scholars regard the following two elements of the post-war, liberal international order as key to its success: (1) global economic institutions, because global commerce generates the most-pressing incentive for comprehensive international cooperation, and (2) alliances and collective defense agreements, because they provide a strong mechanism by which to enforce the nonaggression and territorial integrity principles and to deter violations of them.[20]

It was lack of enforcement of the nonaggression, territorial integrity, and anti-mercantilism principles that caused the collapse of the collective security systems at the heart of two previous international orders—the Concert of Europe (1815–1914) and the League of Nations (1918–1939).[21]

We have just outlined a nested series of ordering concepts of diminishing scope: an international system, within which an international order comprising institutions that provide collective security prevails; collective defense arrangements strengthen the enforcement and deterrence mechanisms of that collective security system. The question of how to define allied burdensharing falls at the intersection of collective security and collective defense.

---

[18] Evidence of that success can be seen in the color revolutions in Yugoslavia (2000), Georgia (2003), Ukraine (2004), Lebanon (2005), and Kuwait (2004), as well as the 2010–2011 Arab Spring in Tunisia, Libya, Egypt, Yemen, Syria, and Bahrain.

[19] The Chinese-led Asian Infrastructure Investment Bank is one example of such an institution. See Mazarr, Priebe, et al., 2016, pp. 11, 21; Michael J. Mazarr, Jonathan S. Blake, Abigail Casey, Tim McDonald, Stephanie Pezard, and Michael Spirtas, *Understanding the Emerging Era of International Competition: Theoretical and Historical Perspectives*, Santa Monica, Calif.: RAND Corporation, RR-2726-AF, 2018, p. 1; and Mazarr, 2018, p. 5.

[20] Mazarr, Priebe, et al., 2016, pp. 13, 22, 27, 40, 45.

[21] Mazarr, Blake, et al., 2018, pp. 6–9.

Defining Burdensharing

In the past, analysts and policymakers typically have defined *burdensharing* narrowly, focusing on the military measures needed to provide the collective defense essential to enforcing the international order and deterring violation of its principles. As allies' contributions to collective defense have declined, some have attempted to introduce a broader and looser definition. Those promoting a broader definition argue that the burdensharing concept should include features that go beyond collective defense alone to encompass aspects of collective security, such as

- the stabilizing role of official development assistance
- multilateral diplomatic conflict prevention and conflict management efforts
- economic sanctions imposed with the goal of enforcing the international order.[22]

Recognizing that burdensharing does extend to some nonmilitary aspects of maintaining collective security, we define the term as including economic sanctions but not official development assistance or conflict prevention efforts. Specifically, we define *burdensharing* as follows:

> Burdensharing is the phenomenon of allies' contributing, relative to their national wealth, to maintaining the collective defense alliances that enforce the principles and norms underlying the post–World War II, rules-based, liberal international order and that deter violation of them.

The concepts of enforcement and deterrence are key. Because official development assistance does not play an enforcement or deterrent role but rather is used to implement the economic growth and stability principle, it is not included in our characterization of burdensharing. Because economic sanctions do play an enforcement and deterrent role, they are included. Diplomatic efforts qualify as part of burdensharing under these criteria, but their outcomes are not easy to measure.

Therefore, a country's *share of burden* refers to the individual nation's relative contribution primarily to collective defense but also to limited additional aspects of collective security. This definition of *burdensharing* allows us to consider an extensive range of national contributions to collective defense (i.e., *supply*, as measured by the Burdensharing Index), as well as NDS capability requirements (i.e., *demand*).

Our method differs from most of the traditional literature on burdensharing, which has parochial tendencies of examining state contributions to formal regional alliance structures, such as NATO. In contrast, we echo the NDS in considering all U.S. allies that participate in a global, U.S.-led international order. In this approach and the index methodology, we consider the entire U.S.-led international system of alliances and measure national contributions in this wider context.

We assume that the primary objective of the 2018 NDS is to strengthen both enforcement of the international order and deterrence of the violation of its underlying principles in the face of increasing challenges by revisionist, illiberal, authoritarian regimes. We further

[22] In March 2017, German Foreign Minister Sigmar Gabriel argued in a speech that German official development assistance should be considered part of the country's defense spending in support of NATO. NATO Secretary-General Jens Stoltenberg rejected this suggestion shortly thereafter (Robert-Jan Bartunek, "Development Aid Cannot Be Part of Defense Spending: NATO's Stoltenberg," Reuters, March 31, 2017).

assume that this objective is broadly shared by U.S. allies, notwithstanding the fact that those allies have differing views on adapting the international order to modernity and on the amount of influence the United States should continue to exert within the order.

We acknowledge that differing geography and differing perceptions of the threats posed to the international order mean that U.S. and allied objectives will never be completely aligned. Nonetheless, we operate on the additional assumption that the area of overlap in U.S. and allied objectives is broad enough that allies will remain receptive to the idea of supporting U.S. objectives.

Research Questions and Methodology

The primary research questions addressed in this analysis are as follows:

- How can we better measure allied burdensharing, as defined in this report?
- How can these measurements be used to help U.S. policymakers incentivize greater allied contributions to NDS objectives?

Answering these questions required us to explore four subordinate questions:

- What does the theoretical literature and practical evidence on burdensharing reveal about what motivates allies to make contributions to joint defense objectives?
- Which metrics should be examined, and included in an index, to measure and enhance understanding of allied contributions to the collective defense?
- How can policymakers identify and request prospective NDS-relevant capability contributions from specific allies?
- What strategies are most promising for encouraging allies to make new investments?

To answer these questions, we began by reviewing the theoretical literature on burdensharing, as well as DoD's own documentation on how the United States has historically approached this issue and set standards for allied contributions to the common defense. Economic and defense-specific publications, including the literature on alliance dynamics, reveal a variety of theories about why nations contribute at varying levels and what explains free-riding behavior.[23] Additionally, this literature informed our development of an expansive set of potential measures for inclusion in a Burdensharing Index. We reviewed candidate measures related to financial inputs to national defense, financial contributions to other aspects of national security, nonfinancial submissions, capability outputs relevant to preparedness for potential conflicts, and contributions to ongoing operations.

Next, we developed criteria to inform the selection of *metrics* for inclusion in the index, clustered the metrics into categories that we termed *factors*,[24] and developed an initial baseline weighting scheme for each factor and its constituent metrics. Although allied contributions of

[23] We use the term *free-riding* instead of the more accurate but less commonplace *cheap-riding*. With the possible exception of small island nations that have no military, all allied or partner nations contribute to the collective defense (and thus their benefits are not free).

[24] The *factors* into which individual burdensharing *metrics* are grouped should not be confused with statistical factor analysis.

troops to ongoing military operations designed to enforce the international order are important and deserve recognition, the primary purpose of the Burdensharing Index is to measure allied preparedness for a major international conflict of the kind envisioned by the 2018 NDS. For this reason, we treated allied deployments of active-duty combat troops as a stand-alone factor and grouped the six factors that we considered essential to providing preparedness under a single preparedness factor.

Constructed with metrics that are grouped into factors, a Burdensharing Index can provide relatively uncontroversial insights into the capabilities that each ally brings to the table and into the efficiency with which allies convert defense inputs into defense outputs. However, such an index says nothing about the differing levels of proficiency with which allies might be expected to employ those capabilities in combat. When U.S. leaders attempt to identify and prioritize what investments they need to ask allies to make in order to best satisfy the future warfighting requirements noted in the 2018 NDS, the differing military capabilities and combat proficiencies among allies affect those decisions.

Because previous methods of analyzing allied burdensharing have failed to distinguish military capability from military combat proficiency, we developed a qualitative survey instrument that DoD could use to elicit and quantify expert perspectives on the expected combat proficiency of allied forces (see Appendix C). However, we did not administer this survey, so no results from it are included in the version of the Burdensharing Index provided in this report. The political ramifications of conducting the survey would likely prove controversial, particularly among allies that are seen to be underperforming. DoD might therefore wish to administer the survey separately, on a confidential basis, and integrate the results in an updated, restricted-circulation version of the Burdensharing Index. An index that has been updated in this manner might allow DoD to obtain a more complete and holistic view of allied burdensharing and compile a more tightly focused set of targeted investment requests.

The index's mathematical structure and logic result in a singular *burdensharing index score* that reflects each ally's share of the total burden of providing collective defense in Europe and Asia, based on the combination of weighted factors and metrics. We also calculated a *burdensharing ratio*, which is the burdensharing index score adjusted to account for a nation's ability to pay. (See Chapter Four for detailed explanations of these measures.) These two scores, along with constituent data about an ally's contribution to each factor and the metrics that constitute it, represent the supply side of the alliance system's collective defenses.

NDS-derived requirements for allied capabilities form the demand side of our methodology. We used existing assessments of major defense planning scenarios and operational challenges identified in the NDS to inform the selection of capabilities that are highly relevant to potential warfights and that allies could invest in and field over the next ten years.[25] As depicted in Figure 1.1, comparing supply (what allies contribute today in military inputs and outputs, as measured by the Burdensharing Index) and demand (what more the United States desires from its allies) allows us to determine which allies might be asked to invest in which specific capabilities in order to best meet the future needs identified in the NDS. The final step in our methodology involves considering which of the potential techniques identified by our review of burdensharing theory might work best to incentivize allies to contribute more.

[25] Prior RAND research assessed NDS requirements and shortfalls. See David Ochmanek, Peter A. Wilson, Brenna Allen, John Speed Meyers, and Carter C. Price, *U.S. Military Capabilities and Forces for a Dangerous World: Rethinking the U.S. Approach to Force Planning*, Santa Monica, Calif.: RAND Corporation, RR-1782-1-RC, 2017.

Figure 1.1
Study Methodology

Limitations and Caveats

Producing defense capabilities is an extraordinarily complex endeavor that involves threat assessment, scenario planning, budgeting, and political processes. Implementing collective defense arrangements is even more complex. Identifying what and how much contribution to common defense constitutes fairness among a disparate group of allies requires normative judgments informed by a deep understanding of each nation's history, political constraints, and geopolitical and economic conditions—issues that we do not explore in this report. With this overarching consideration in mind, we note five limitations and caveats to our research approach.

1. *The Burdensharing Index is a mathematical tool that simplifies a more complex reality.* Policymakers should resist the temptation to interpret a nation's burdensharing index score as a singular determinant of whether an ally contributes enough. The score, while analytically rigorous, needs to be presented in the context of each ally's unique situation and with due consideration of the state of bilateral relations with the United States and the broader foreign and security policy context.
2. *In its current form, the Burdensharing Index accounts for how much a nation spends, the number of personnel it contributes, and how much military capability it produces but not how well it can use its military assets.* For this study, we developed a combat proficiency survey instrument and identified potential respondents, but we did not administer the survey or include the results in the Burdensharing Index.
3. *We assess allied military contributions to collective defense through the lens of U.S. strategic policy guidance.* In doing so, we assume that the primary, if not sole, goal of the United States and its allies in any future major contingencies is to enforce and continue the post–World War II international order. We further assume that alliances and collective defense agreements will be primary instruments by which the United States intervenes and that a plurality of the U.S. allies will agree to such a means of intervention, despite differing levels of threat perception. It is, by no means, a given that future events will unfold in this fashion.

4. *We assume that U.S. priorities articulated in the NDS will remain stable*. Major changes to U.S. defense objectives or fundamental shifts in relations with allies would require reexamining the basic structure and purpose of the index.
5. *We acknowledge that U.S. officials have struggled with the burdensharing issue for decades, with mixed results.* Our insights are offered with due respect for the difficulties that policymakers will inevitably face in turning recommendations into reality.

The methodologies for the Burdensharing Index and targeted requests for investment presented in this report offer a snapshot of allied contributions and a data- and theory-informed construct for prioritizing requests for allied investments in future capabilities. Our ultimate aim in this study is to provide a methodology that can inform U.S. defense practitioners ahead of the difficult tasks of measuring allied contributions, making targeted requests of allies, and providing the allies with incentives to contribute more to the collective defense that enforces the post-war liberal order in Europe and Asia.

Report Organization

Chapter Two provides a historical overview and summarizes the theoretical literature on burdensharing, the phenomenon of free-riding, and the more limited body of work on motivating greater allied contributions. Chapter Three outlines the Burdensharing Index's design concept and the factors and metrics selected for inclusion. Chapter Four demonstrates how the index might be used to identify desired investments and to develop strategies for approaching allies with targeted investment and cooperation requests. Chapter Five offers conclusions, including on how DoD can systemize the Burdensharing Index methodology to develop an analytically informed, policy-relevant, and enduring approach for incentivizing greater allied contributions. The appendixes include a mathematical definition of the index, details of the spreadsheet in which the index resides, and the proposed combat proficiency survey instruments (one each for air, naval, and ground forces).

CHAPTER TWO

Burdensharing: History, Theory, and Private-Sector Insights

In this chapter, we provide a brief historical overview of the burdensharing debates between the United States and its allies in Europe and Asia. We highlight common assumptions and issues bedeviling the burdensharing debate. We provide theoretical explanations about why public goods, such as collective defense, are afflicted by the free-rider problem and describe the principal differing academic schools of thought about burdensharing. We then tie economic theory and the burdensharing schools of thought together by suggesting that the collective defense good might be unbundled into its constituent parts. We suggest that, where at least one of the two key enablers of free-riding behavior is absent in constituent parts of the collective defense good, this fact might be exploited to boost allied contributions. We propose assurance contracts as potential vehicles by which to create more collective defense goods in this connection. Finally, we suggest that significant efficiency and cost savings might be achieved if two private-sector management practices, benchmarking and market segmentation, were applied to the U.S. international network of alliances and collective defense agreements.

Why the Burdensharing Debate Was Renewed

During the Cold War, the United States repeatedly attempted to pressure its European and Asian allies into making greater contributions to collective defense. These efforts met with mixed success. Over the past decade, a series of developments has reignited the perennial debate about allied burdensharing that had subsided after the end of the Cold War.

Most U.S. attempts to pressure European allies originated in the U.S. Congress, starting in 1950 with a requirement that the Joint Chiefs of Staff certify that the allies were making a realistic effort.[1] Setting goals for allies' spending or force and major equipment totals was another favored tactic, starting with the Lisbon goals of 1952 and continuing in 1985 with goals to grow defense budgets by 3 percent annually.[2] The U.S. Congress repeatedly threatened to cut U.S. force levels in Europe unilaterally, to little effect.[3] It also proposed to defund U.S.

[1] The requirement was qualified in the Connally-Russell resolution. For all details in this paragraph, see Simon Duke, *The Burdensharing Debate: A Reassessment*, New York: St. Martin's Press, 1993.

[2] The 1985 Nunn-Roth amendment tied the avoidance of annual U.S. troop reductions of 30,000 to a 3-percent increase in NATO members' defense budgets or a comparable rise in ammunition stocks.

[3] The Radford plan, 1956; the Mansfield resolution I, 1966; and the Cranston amendment, 1974.

troops,[4] and it later threatened to impose a ceiling on such troops.[5] With the end of the Cold War, the burdensharing debate in Europe subsided.[6]

In the Pacific, efforts to induce greater allied contributions met with the most success when there had been stark changes in fundamental underlying regional threat levels. U.S. arm-twisting was only partially successful; it also caused undesirable consequences, particularly relating to Country A, as described later. And the burdensharing debate in the Pacific after the fall of the Soviet Union involved miscalculations about the peace dividend to be had. As we will explain, potential future opponents profited from those mistakes.

The 1951 Australia, New Zealand, United States Security Treaty is one example of such miscalculations, and the ill-defined geographic area of applicability in the treaty has led to some attempts at burdenshifting.[7] For example, senior Country B officials have made statements that the treaty commitments do not apply to Taiwan and the East China Sea, and Country B has attempted to interpret the treaty as applying to Country B's Indian Ocean approaches.[8]

But Country B is not alone. U.S. President Richard Nixon's July 26, 1969, announcement of the Guam Doctrine (in which he asserted that U.S. allies in Asia would have to do more to help themselves) is but one example of U.S. burdenshifting.[9] And Country C has engaged in burdenshifting as well (to Taiwan).[10] After 35 years of free-riding,[11] Country C began to

---

4 Senator Stuart Symington's proposal, 1968; the Mansfield resolution II, 1971.

5 The Cohen amendment, 1984; the Nunn-Roth amendment, 1985.

6 Duke, 1993, pp. 33, 43, 54, 56, 57, 64, 78, 79.

7 For the purposes of this report, *burdenshifting* involves an attempt by one ally to have another ally assume greater or primary responsibility for collective defense tasks that might be considered to be the first ally's responsibility alone or the responsibility of all parties.

8 Coral Bell, *Dependent Ally: A Study of Australia's Relations with the United States and the United Kingdom Since the Fall of Singapore*, Canberra: Department of International Relations, Australian National University, 1984, p. 200; and Alan Renouf, *The Frightened Country*, Melbourne, Australia: Macmillan, 1979, pp. 320, 323. Country B has sought to soften the blow of its cheap-riding by means of intelligence-sharing agreements and by embedding significant numbers of its officers in U.S. joint command staffs. See, for example, Desmond Ball, *A Suitable Piece of Real Estate: American Installations in Australia*, Sydney: Hale & Iremonger, 1980; Peter J. Dean, Stephan Frühling, and Brendan Taylor, eds., *Australia's American Alliance: Towards a New Era?* Melbourne, Australia: Melbourne University Press, 2016; Malcolm Fraser and Cain Roberts, *Dangerous Allies*, Melbourne, Australia: Melbourne University Press, 2014; and Hugh White, "Strategic Interests in Australian Defence Policy: Some Historical and Methodological Reflections," *Security Challenges*, Vol. 4, No. 2, Winter 2008.

9 Previous examples involved the United States attempting to shift the security threat–related burden in the cases of Taiwan, Malaya, West Papua New Guinea, and Borneo. The United States engaged in shifting the burden to Country B again during the 1975, 1999, and 2006 East Timor crises (Bell, 1984, pp. 57, 89, 168, 169; Emma Chanlett-Avery, Mark E. Manyin, Ian E. Rinehart, Rebecca M. Nelson, and Brock R. Williams, *Japan-U.S. Relations: Issues for Congress*, Washington D.C.: Congressional Research Service, RL33436, April 2015, p. 9; Renouf, 1979, pp. 118, 173, 174, 284, 403, 407, 409, 410, 414, 429, 431, 439, 440, 441, 446; and Richard J. Samuels, *Securing Japan: Tokyo's Grand Strategy and the Future of East Asia*, Ithaca, N.Y.: Cornell University Press, 2008).

10 Emma Chanlett-Avery and Ian E. Rinehart, *The U.S.-Japan Alliance*, Washington D.C.: Congressional Research Service, RL33740, July 2016, p. 13; Kenneth B. Pyle, *Japan Rising: The Resurgence of Japanese Power and Purpose*, 1st ed., New York: Public Affairs, 2007, pp. 233, 334; and Renouf, 1979, p. 284.

11 Chanlett-Avery and Rinehart, 2016, p. 28; Pyle, 2007, pp. 250, 252, 254, 287; Samuels, 2008.

reverse course in the early 1980s via an extensive series of measures.[12] The following developments accelerated Country D rearmament and steps by Country D to boost coordination and interoperability with the United States and its Pacific Basin allies:

- heavy criticism of Country E for failing to contribute to the 1991 war to liberate Kuwait
- Country E's inability to assist the United States during the first 1987–1994 nuclear crisis with the DPRK
- the August 1998 DPRK test-firing of a *Taepodong* missile over Country E
- a series of six DPRK nuclear weapon tests between 2006 and 2017
- Chinese revisionist territorial claims in the South and East China Seas.[13]

In Country F, the burdensharing debate involved a series of threatened and actual unilateral U.S. troop withdrawals.[14] Those moves may have helped coerce greater Country F contributions to the collective defense, but they also caused fears of abandonment in Country F. Those fears, in turn, led to five Country F initiatives to start or consider starting an indigenous nuclear weapon program in order to guarantee regime survival and to coerce greater U.S. commitment to Country F.[15] In the post–Cold War period, the burdensharing debate in Country F has continued to revolve around eliciting greater Country F contributions to the cost of basing U.S. forces there,[16] but it has also involved the consolidation and relocation of

[12] Chanlett-Avery and Rinehart, 2016, p. 1; Pyle, 2007, pp. 11, 233, 269, 293, 294, 318, 322, 350; James J. Przystup, *The U.S.-Japan Alliance: Review of the Guidelines for Defense Cooperation*, Washington, D.C.: National Defense University, Strategic Perspectives No. 18, March 2015, p. 10; and Samuels, 2008. Country E's interoperability with the United States was improved by a series of more than 50 measures. See Chanlett-Avery et al., 2015, p. 20; Chanlett-Avery and Rinehart, 2016, pp. 1, 4, 6, 12–14, 17, 21, 26, 27, 29; Yoichi Funabashi, *The Peninsula Question: A Chronicle of the Second Korean Nuclear Crisis*, Washington, D.C.: Brookings Institution Press, 2007, p. 136; Charles L. Pritchard, *Failed Diplomacy: The Tragic Story of How North Korea Got the Bomb*, Washington, D.C.: Brookings Institution Press, 2007, pp. 44, 170; Przystup, 2015, pp. 10–11, 13; Pyle, 2007, pp. 292, 371, 372; Samuels, 2008; Joel S. Wit, Daniel B. Poneman, and Robert L. Gallucci, *Going Critical: The First North Korean Nuclear Crisis*, Washington, D.C.: Brookings Institution Press, 2004, p. 196.

[13] Country G's contribution of more than $13 billion toward U.S. 1991 Gulf War military costs and humanitarian assistance was dismissed as "checkbook diplomacy" (Chanlett-Avery and Rinehart, 2016, p. 29; Pyle, 2007, p. 7). On the DPRK missile and nuclear tests, see Funabashi, 2007, p. 295; Michael J. Mazarr, *North Korea and the Bomb: A Case Study in Nonproliferation*, New York: St. Martin's Press, 1997, pp. 40, 90, 94; Pritchard, 2007, pp. 148, 149; and Pyle, 2007, p. 294. On Country E's improved interoperability with U.S. regional allies, see Chanlett-Avery and Rinehart, 2016, pp. 11, 12; Thomas Lum and Ben Dolven, "In Focus: The Philippines," Washington, D.C.: Congressional Research Service, IF10250, 2018; and Samuels, 2008.

[14] These threats and withdrawals occurred in 1973, 1991, 2003, and 2018. See Peter Baker, "Trump Abandons Trans-Pacific Partnership, Obama's Signature Trade Deal," *New York Times*, January 23, 2017; Funabashi, 2007, p. 244; Mazarr, 1997, pp. 25, 60; Pritchard, 2007, pp. 76, 77; and Wit, Poneman, and Gallucci, 2004, pp. 3, 9, 25.

[15] These initiatives occurred in 1972, 1974, 1975, 1977, and 1995. Annual exercises with Country F were introduced in 1976 to reassure Country F after the United States had abandoned the Republic of Vietnam (Mazarr, 1997, pp. 20, 25, 27, 28, 29; Pyle, 2007, p. 350; Thomas C. Reed and Danny B. Stillman, *The Nuclear Express: A Political History of the Bomb and Its Proliferation*, Minneapolis, Minn.: Zenith Press, 2009; and Wit, Poneman, and Gallucci, 2004, pp. 1, 11).

[16] Hyung-Jin Kim, "South Korea, US Sign Cost-Sharing Deal for American Troops," Associated Press, February 10, 2019; Mark E. Manyin, Emma Chanlett-Avery, Mary Beth D. Nikitin, Ian E. Rinehart, and Brock R. Williams, *U.S.-South Korea Relations*, Washington, D.C.: Congressional Research Service, R41481, October 2015, p. 17; W. G. Park, *A Challenge for the ROK-U.S. Alliance: Defense Cost Sharing*, Seoul: Handong Global University, 2013, p. 5; and U.S. Senate Committee on Armed Services, *Inquiry into U.S. Costs and Allied Contributions to Support the U.S. Military Presence Overseas*, Washington, D.C.: U.S. Government Printing Office, Report 113-12, April 15, 2013.

U.S. forces, as well as negotiations pertaining to transferring wartime operational control of joint forces to Country F.[17]

In Country G, the United States has provided military assistance to the fight against communist, separatist, and Islamist insurgencies since Country G gained full independence from the United States in 1946. When the Cold War ended, Country G sought to extract larger lease payments for the use of U.S. installations, which had been holding China in check. Washington balked. By 1992, U.S. forces had been withdrawn from Country G. Beijing exploited the ensuing security vacuum in the South China Sea by moving forces to the Spratly Islands, Scarborough Shoal, and elsewhere. Country G invited U.S. forces to return shortly thereafter,[18] both to help suppress an Islamist insurgency and as a check against Chinese revisionism.[19]

Adding to concern about the rising DPRK and Chinese threat profiles, NATO's support of the 2001 U.S. intervention in Afghanistan revealed alarming shortcomings in members' military preparedness and will to fight.[20] NATO allies maintaining armies of 2 million could not or would not deploy and sustain more than 45,000 troops outside Europe.[21] There were shortages of helicopters; transport aircraft; and intelligence, surveillance, and reconnaissance (ISR) aircraft.[22] The allies were unable to maintain the equipment and associated systems in the field. And various allies and partners imposed 80 different restrictions on the positioning and use of NATO forces.[23] Key players were unwilling to participate in combat operations, leaving just a handful of the 44 participating nations responsible for an overwhelming share of combat.[24] The March to October 2011 intervention in Libya only heightened alarm about NATO's weakness. Half of the allies did not participate in combat, and only eight of the then-26 NATO members participated in the air campaign.[25] There were shortages of deploy-

---

[17] The transfer of operational control to Country F has repeatedly been delayed. The United States and Country F first agreed to transfer wartime operational control of forces in Country F to the country's government in 2007. In 2010, the transfer was postponed until 2015. In October 2014, Country F and the United States agreed to delay the transfer for a second time and adopt an approach whereby transfer would take place only once certain conditions had been fulfilled by Country F's armed forces (Chanlett-Avery and Rinehart, 2016, p. 27; Manyin et al., 2015, pp. i, 17).

[18] Armando J. Heredia, "Analysis: New U.S. Philippine Basing Deal Heavy on Air Power, Light on Naval Support," *USNI News*, March 22, 2016; Thomas Lum and Ben Dolven, *The Republic of the Philippines and U.S. Interests—2014*, Washington, D.C.: Congressional Research Service, R43498, May 2014, pp. i, 10, 12, 13; and Lum and Dolven, 2018.

[19] Zack Cooper and Jake Douglas, "Successful Signaling at Scarborough Shoal?" *War on the Rocks*, May 2, 2016; Jane Perlez, "Asian Leaders at Regional Meeting Fail to Resolve Disputes over South China Sea," *New York Times*, July 12, 2012; Jane Perlez, "In Victory for Philippines, Hague Court to Hear Dispute over South China Sea," *New York Times*, October 30, 2015; and Jane Perlez, "New Chinese Vessels Seen Near Disputed Reef in South China Sea," *New York Times*, September 5, 2016.

[20] Joachim Krause and Charles K. Mallory IV, eds., *Afghanistan, Pakistan and Strategic Change: Adjusting Western Regional Policy*, Abingdon, England: Routledge, 2014.

[21] The 45,000 NATO troops deployed represented 2 percent of total NATO active-duty forces ("Libya War Exposes 'NATO's Chronic Weaknesses,'" *Mail & Guardian*, June 10, 2011).

[22] Vincent Morelli and Paul Belkin, *NATO in Afghanistan: A Test of the Transatlantic Alliance*, Washington, D.C.: Congressional Research Service, RL33627, December 2009, p. 18; and "Libya War Exposes 'NATO's Chronic Weaknesses,'" 2011.

[23] Morelli and Belkin, 2009, pp. 10–11.

[24] Morelli and Belkin, 2009, p. 2. See also Henrik Larsen, *NATO in Afghanistan: Democratization Warfare, National Narratives, and Budgetary Austerity*, Cambridge, Mass.: Harvard Kennedy School of Government, December 2013.

[25] "Libya War Exposes 'NATO's Chronic Weaknesses,'" 2011.

able fighter aircraft and targeting specialists.[26] NATO was heavily dependent on the United States for ISR aircraft, suppression of enemy air defenses, aerial refueling, and precision-guided munitions. NATO could sustain only half of its previous aircraft sortie rate without U.S. support.[27] And, after just two and a half months of conflict, the munitions stocks of two key NATO allies were almost exhausted.[28]

As mentioned, in 2011, U.S. Secretary of Defense Gates publicly warned of the potential consequences of NATO's weaknesses. According to Gates, the majority of NATO members were contributing insufficient resources to the alliance. Personnel costs were squeezing out much-needed investment. A two-tier NATO was emerging. Core members were willing and able to pay the price, bear the burdens of alliance commitments, and participate in combat. However, Gates said, peripheral members were unwilling to share in the risks and costs; they preferred instead to enjoy NATO's security guarantee while specializing in humanitarian development, peacekeeping, and "talking tasks." Gates warned that U.S. domestic support for NATO was falling. Although a few smaller states did punch above their weight, if the others did not shape up, Gates presciently asserted, "future U.S. political leaders may not consider the returns from the U.S. investment in NATO worth the costs."[29]

Historically, shifts in regional threat profiles have had the greatest effect in boosting allied contributions to the collective defense. In Europe, the 1948 and 1961 Berlin crises, the 1956 Hungarian revolution, the 1968 Soviet invasion of Czechoslovakia, Moscow's 1976 decision to deploy intermediate-range SS-20 nuclear missiles in Eastern Europe, and the 1979 Soviet invasion of Afghanistan led to significant NATO rearmament. In Asia, the 1951–1953 Korean War and 1955–1975 Vietnam War also played significant roles.[30] The 1991 Gulf War, the 1994 and 2005 DPRK nuclear crises, and Chinese revisionism in the East and South China Seas that climaxed in 2010–2011 provided the impetus for Country H rearmament. And recent events in Europe and the Middle East may have caused NATO members to recal-

---

[26] Eric Schmitt, "NATO Sees Flaws in Air Campaign Against Qaddafi," *New York Times*, April 14, 2012.

[27] Joint Analysis and Lessons Learned Centre, *Operation Unified Protector: Lessons from National Military Perspectives*, Lisbon: North Atlantic Treaty Organization, February 27, 2012; Clara M. O'Donnell and Justin Vaïsse, *Is Libya NATO's Final Bow?* Washington, D.C.: Brookings Institution, December 2, 2011; and Todd R. Phinney, "Reflections on Operation Unified Protector," *Joint Force Quarterly*, No. 73, April 2014.

[28] Karen DeYoung and Greg Jaffe, "NATO Runs Short on Some Munitions in Libya," *Washington Post*, April 15, 2011; "Libya War Exposes 'NATO's Chronic Weaknesses,'" 2011.

[29] Gates, 2011. See also Robert M. Gates, "Secretary of Defense Speech: Munich Conference on Security Policy," Washington, D.C.: U.S. Department of Defense, February 11, 2007; and "Libya War Exposes 'NATO's Chronic Weaknesses,'" 2011.

[30] For more on the Korean War, see W. G. Beasley, *Japanese Imperialism, 1894–1945*, Oxford, United Kingdom: Oxford University Press, 1987; Bruce Cumings, *The Korean War: A History*, 1st ed., New York: Modern Library, 2010; Peter Duus, *The Abacus and the Sword: The Japanese Penetration of Korea, 1895–1910*, Berkeley, Calif.: University of California Press, 1995; David Halberstam, *The Coldest Winter: America and the Korean War*, 1st ed., New York: Hyperion, 2007; Max Hastings, *The Korean War*, London: Michael Joseph, 1987; and Don Oberdorfer, *The Two Koreas: A Contemporary History*, New York: Basic Books, 2001.

For more on the Vietnam War, see Bernard B. Fall, *Street Without Joy*, Mechanicsburg, Pa.: Stackpole Books, 1961; Sam Adams, *War of Numbers: An Intelligence Memoir*, 1st ed., South Royalton, Vt.: Steerforth Press, 1994; George W. Allen, *None So Blind: A Personal Account of the Intelligence Failure in Vietnam*, Chicago: Ivan R. Dee, 2001; David Halberstam, *The Best and the Brightest*, 1st ed., New York: Random House, 1972; Robert S. McNamara and Brian VanDeMark, *In Retrospect: The Tragedy and Lessons of Vietnam*, 1st ed., New York: Vintage Books, 1995; Ronald H. Spector, *United States Army in Vietnam—Advice and Support: The Early Years, 1941–1960*, Washington, D.C.: Center of Military History, United States Army, 1985; and Harry G. Summers, *On Strategy: A Critical Analysis of the Vietnam War*, New York: Presidio Press, 1982.

culate their strategy: Russia invaded Georgia in 2008 and Ukraine in 2014, annexing Crimea and launching a proxy separatist conflict in Eastern Ukraine. In June 2014, an Islamic State was declared in Syria and Iraq. The Kremlin intervened in the Syrian civil war starting in September 2015. Coming one after another, these developments in the Pacific Basin, Europe, and the Middle East created the impression that the international order that had prevented global conflict since World War II was under assault. These events may have provided NATO members with renewed incentives to rearm and to shift away from the expeditionary operations that had been a primary focus for a decade after the September 11, 2001, terrorist attacks and to shift back toward a primary emphasis on territorial defense.[31]

In light of these events, critics questioned whether the United States and its allies were doing enough to defend the international order; whether the Cold War system of alliances was obsolete and ill-suited to meeting the new challenges posed by rogue states, proliferation, terror, and economic predation and coercion; whether the United States could still afford its alliances; and whether allies benefit from them disproportionately. In July 2016, Donald Trump, then the Republican Party's nominee for the U.S. presidency, asserted not just that allies were not paying their fair share but that they were not paying what they had already promised. "We have many NATO members that aren't paying their bills," he said. After stating that the U.S. commitment to defend countries under Article 5 of the 1949 North Atlantic Treaty might become contingent on allies' defense spending, President Trump subsequently declined to say whether the United States would honor the commitment for countries that had not fulfilled their obligations.[32]

As President, Trump continued to elevate the burdensharing issue to the very top of the U.S. foreign policy agenda, and the 2018 NDS reflected this new emphasis. It focused on

- preparing the United States for a new era of great-power competition
- improving the robustness, capability, and extent of the international alliance networks that have characterized the post–World War II international order
- developing incentives for allies to make greater contributions to addressing four potential warfights brought about by the renewed great-power competition.[33]

Assumptions and Bedeviling Issues Embedded in the Burdensharing Debate

As part of this study, we reviewed academic and nonacademic literature on burdensharing published from 1960 to 2019. The literature included academic papers, recent think tank publications, DoD reports to Congress, NATO publications, and comparisons of various combat models.[34] The academic work focuses almost exclusively on Europe and NATO and on who

[31] Mazarr, Priebe, et al., 2016, p. ix.

[32] Michael D. Shear, Mark Landler, and James Kanter, "In NATO Speech, Trump Is Vague About Mutual Defense Pledge," *New York Times*, May 25, 2017; and Calamur Khrishadev, "NATO, Shmato?" *The Atlantic*, July 21, 2016.

[33] DoD, 2018. The four potential warfights identified in the 2018 NDS are with China, Russia, Iran, and the DPRK.

[34] The combat modeling literature reviewed included Jerome J. Burke, Grant Sharp, Alfred Kaufman, and Patricia Cohen, *Assessment of Naval Core Capabilities*, Washington, D.C.: Institute for Defense Analyses, IDA Document D-3713, January 2009; Brian Benjamin Crisher and Mark Souva, "Power at Sea: A Naval Power Dataset, 1865–2011," *International Interactions*, Vol. 40, No. 4, 2014; T. N. Dupuy, *Numbers, Predictions and War: Using History to Evaluate Combat Factors and*

free-rides and why. Bilateral alliances, such as those in the Pacific, are largely explored through the lens of specific conflicts or of cost-sharing for basing U.S. troops.

Thus, before we began our literature review, we had to answer one question: Which countries should be subject to the burdensharing question? In this study, we examine the alliance system represented by 35 European and Asian countries with whom the United States has legally binding collective defense treaties.[35] Because of the salience of China and the obligations imposed by the 1979 Taiwan Relations Act, our analysis includes Taiwan among the 35 allies.[36] Our review of the burdensharing literature yielded valuable insights into burdensharing metrics and revealed four common assumptions and five issues that complicate the debate.

The first assumption that analysts and policymakers sometimes make is that U.S. allies accept that the United States is uniquely positioned to be the leader responsible for identifying and forging consensus around alliance goals.[37] An important unstated, and perhaps unshared, corollary is that Washington might be willing to modify, share, or reduce its political leadership role if allies assume a greater share of the burden of providing a collective defense.

The second common assumption is that strong political consensus exists among the allies on the perceived threats faced, objectives pursued, and strategies being implemented.[38] It is not clear that allies in Asia share the U.S. perception of the threat posed by Russia or that allies in Europe share the U.S. perception of the threat posed by China.[39] Furthermore, differing geography, threat perceptions, and fiscal constraints have led to differing allied force postures and capabilities. For example, an island state is bound to invest relatively more in naval and air forces than in land forces; a country on a plain at a historical invasion crossroads and with a perception of threat from a major neighboring state is bound to invest more in land forces than in naval forces.[40]

The third common assumption is that alliance ties are equal across alliances, but they are not. Self-executing defense alliances that do not need the approval of a legislative body, such

---

Predict the Outcome of Battles, Fairfax, Va.: HERO Books, 1985; James W. Harris, Jr., "The Sortie Generation Rate Model," in E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes, eds., *Proceedings of the 2002 Winter Simulation Conference*, 2002; David R. Hogg, *Correlation of Forces: The Quest for a Standardized Model*, Fort Leavenworth, Kan.: U.S. Army Command and General Staff College, February 4, 1993; and Andrew James Zanella, *Combat Power Analysis Is Combat Power Density*, Fort Leavenworth, Kan.: U.S. Army Command and General Staff College, May 17, 2012.

[35] For reasons of analytical tractability, we excluded the 16 states party to the September 2, 1947, Inter-American Treaty of Reciprocal Assistance (the Rio Pact).

[36] As noted in Chapter 2 of Dean, Frühling, and Taylor, 2016, "The Taiwan Relations Act requires the U.S. Government both to provide arms and services of a defense nature to Taiwan and [to] maintain U.S. military capacity to resist coercion of Taiwan by China."

[37] A further embedded assumption is that the United States is capable of playing that role.

[38] Alexander Mattelaer, "U.S. Leadership and NATO: Revisiting the Principles of NATO Burden-Sharing," *Parameters*, Vol. 46, No. 1, Spring 2016.

[39] At the December 4, 2019, NATO summit in London, the assembled heads of state and government formally recognized that the rise of China represented both challenges and opportunities that the allies had to address together (NATO, "London Declaration: Issued by the Heads of State and Government Participating in the Meeting of the North Atlantic Council in London 3–4 December 2019," December 4, 2019b).

[40] See, for example, Edward Hunter Christie, "The Demand for Military Expenditure in Europe: The Role of Fiscal Space in the Context of a Resurgent Russia," *Defence and Peace Economics*, Vol. 30, No. 1, 2019. We are grateful to Thomas Szayna for highlighting these implications of differing geography and assumed sources of future threats.

as the U.S. Congress, to be triggered (e.g., the August 24, 1949, North Atlantic Treaty) have greater deterrent value than those that are not self-executing (e.g., the 1951 Australia, New Zealand, United States Security Treaty). Reciprocal defense treaties involving a mutual obligation to intervene in defense of the other party (e.g., the North Atlantic Treaty and the 1953 Mutual Defense Treaty Between the United States and the Republic of Korea) are of higher quality than those that do not have such an obligation (e.g., the 1960 Treaty of Mutual Cooperation and Security Between the United States and Japan). Treaties with an agreed specific geographic area of applicability (e.g., the North Atlantic Treaty) are of higher quality than treaties in which the area of applicability has deliberately been left vague or is overly large (e.g., the Australia, New Zealand, United States Security Treaty). And alliances that have an agreed strategic concept, permanent political and military decisionmaking forums, and a permanent multinational command structure are likely to have greater deterrent credibility than alliances that lack these elements. Defense treaties that do not provide all of the benefits just enumerated could be revised to provide one or more of these missing features.[41]

The fourth common assumption is that all allied nations—big or small, rich or poor—should pay the same 2 percent of their national income toward the collective defense, which is effectively a regressive tax.

In addition, we identified five issues that bedevil the burdensharing debate:

1. **Definitions.** Does the burden encompass just peacetime deterrence, or does it include contributions to ongoing military operations and combat? In measuring the burden, are stakeholders more concerned about inputs to creating a collective defense (the traditional U.S. position) or the outputs that help achieve the objective (the traditional European position), or are both equally important? In this study, we examine the twin burdens of maintaining peacetime deterrence and contributing to ongoing military interventions required to (re)establish international security; we also measure both the inputs and the outputs involved.
2. **Scope.** Is the burden narrowly defined by being limited to providing collective defense in a given region, or does it extend to providing collective defense of the entire postwar international order? If the burden is purely regional, then on what basis are costs of capabilities that are shared with other alliances (e.g., strategic lift or infrastructure in the United States) divided? In this report, we avoid that conundrum by analyzing allies' share of the burden of providing the essential collective defense element of the post–World War II international order in Europe and Asia.
3. **Dimensionality.** How can stakeholders avoid reducing defense inputs, defense outputs, and various national defense providers into measures that do not capture the nuances involved? To address this concern, we elaborate a nested, multi-attribute Burdensharing Index.
4. **Mode of analysis.** In adopting a primarily quantitative approach to measuring allies' share of the burden, how can one be sure not to miss important qualitative considerations? To avoid this potential pitfall, we designed a survey instrument to capture important qualitative aspects of allies' contributions to the common defense (see Appendix C).

[41] Brett V. Benson and Joshua D. Clinton, "Assessing the Variation of Formal Military Alliances," *Journal of Conflict Resolution,* Vol. 60, No. 5, 2016; Chanlett-Avery and Rinehart, 2016, p. 1; Dean, Frühling, and Taylor, 2016, Chapter 1; Lum and Dolven, 2014, p. 12; and Renouf, 1979, pp. 145, 151.

5. **Efficiency.** Are allied financial contributions put to the most efficient use? Would allies contribute more if their publics felt that their defense funds were better spent? As part of this analysis, we examined private-sector techniques that might help improve the efficiency with which existing resources are used before the United States requests additional funds from allied treasuries and taxpayers.

Understanding Free-Riding

Free-riding means enjoying a public good without paying for it. *Public goods* can be physical structures, such as highways and sidewalks, or intangible services, such as national defense. In contrast to private goods, such as a candy bar, public goods have two important features:

1. **Nonexcludability.** This feature means that it is almost impossible to prevent individuals who did not contribute to public goods from enjoying the benefits. For example, once a freeway or sidewalk has been built, all citizens may use it, regardless of whether they paid their taxes. Thus, public goods are nonexcludable. A candy bar, however, is excludable because one must pay for it in order to be allowed to consume it.[42]
2. **Nonrivalry.** Another feature of a public good is that one person's consumption of it does not affect another's opportunity to use it. For example, one person's consumption of cable television or a movie does not reduce another person's ability to do so. These goods are nonrivalrous, whereas a candy bar is rivalrous because once one person consumes it, nobody else can.[43]

Because people cannot be excluded from consuming a public good, and because nonrivalry means that there is no scarcity of it, people frequently feel no compunction to pay for public goods. As a result, public goods are produced at lower quantities than private goods are.

Economists consider defense—and, by extension, collective defense alliances—to be public goods. Nuclear deterrence, of the kind practiced between the Soviet Union and the United States during the Cold War, can be considered a *pure public good* because it meets the two conditions of being nonexcludable and nonrivalrous. However, not all goods involved in providing a collective defense are pure public goods. Figure 2.1 illustrates how variations in excludability and rivalry can alter the nature of a public good; examples are shown in purple.

NATO's program for the Airborne Warning and Control System (AWACS) is an example of a good that meets only one of the two conditions.[44] It is a nonexcludable resource; that is,

[42] Tolls are an example of a method by which a nonexcludable good (a highway) can be made excludable.

[43] This notion is called the Samuelson Rule, named after Paul Samuelson, who rigorously articulated the concept (Paul A. Samuelson, "The Pure Theory of Public Expenditure," *Review of Economics and Statistics*, Vol. 36, No. 4, November 1954). See also Todd Sandler, "Intergenerational Public Goods: Strategies, Efficiencies, and Institutions," in Inge Kaul, Isabelle Grunberg, and Marc A. Stern, eds., *Global Public Goods: International Cooperation in the 21st Century*, New York: Oxford University Press, 1999; and Todd Sandler, "Intergenerational Public Goods: Transnational Considerations," *Scottish Journal of Political Economy*, Vol. 53, No. 3, July 2009. For more on existential risks and transgenerational, global public goods, see the work of analysts at the Future of Humanity Institute, especially Nick Bostrom, "Existential Risk Prevention as Global Priority," *Global Policy*, Vol. 4, No. 1, March 2013.

[44] The NATO AWACS program involves 17 nations that participate from four air bases, from which 23 E-3A and E-3D aircraft are flown.

every NATO member can benefit from it. However, because the number of AWACS aircraft is limited, allies may have to compete for the resources to be used for purposes that they prefer. The aircraft are thus potentially rivalrous and are therefore a *common-pool resource*. And because the aircraft are a scarce rivalrous resource, alliance leaders could decide to exclude free-riders from using the aircraft, which would make them more like private goods. (This is why the AWACS program is positioned close to the private goods quadrant in Figure 2.1.) If leaders begin to treat some collective defense goods as common-pool resources, it might lead to larger numbers of such goods being produced.

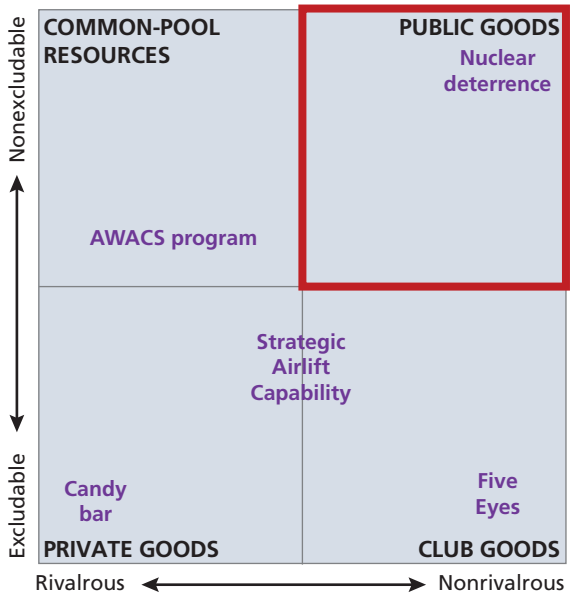
Alliance leaders could also create or convert collective defense goods to *club goods*, which are shared only by members of a small group and are thus not available to all allies (the bottom right quadrant in Figure 2.1). The Five Eyes intelligence-sharing agreement (among Australia, Canada, New Zealand, the United Kingdom, and the United States) and NATO's Strategic Airlift Capability are examples of club goods; by design, certain other alliance members are excluded from using the goods. In addition, the Strategic Airlift Capability includes but a single Boeing C-17 Globemaster III aircraft, and if the 12 states that own it disagree on how to use it, that creates rivalry. Because it is potentially both excludable and rivalrous, the Strategic Airlift Capability comes close to being a private good (the bottom-left quadrant in Figure 2.1).

Theories Relevant to Burdensharing

Our review of the burdensharing literature identified three principal schools of thought: the realist school, collective action theory, and the joint product model.

Realist school adherents draw on (1) structural realist international relations theory, introduced by Kenneth Waltz, and (2) neorealism, developed from the foundations of classical realism by Stephen Walt and others. This school assumes that, in the absence of any real

Figure 2.1
Public Versus Private Goods



order in the international system, states are self-interested. Given the international system's lack of a contract enforcement mechanism, states will seek to avoid overdependence on a protecting power because they will fear abandonment. The protecting nuclear power (the United States) might renege on its commitment to inflict nuclear punishment in response to an attack on an ally. States can help assure their self-preservation by spending more on defense, irrespective of security guarantees made by allies. According to this school, the greater the state's fear of abandonment, the more likely it is to take the initiative and increase defense spending on its own.[45]

Collective action theory was developed in the 1960s and was heavily influenced by the work of Mancur Olson and Richard Zeckhauser.[46] This theory stems from Olson's seminal 1971 work, *The Logic of Collective Action: Public Goods and the Theory of Groups*. According to Olson, "unless the number of individuals in a group is quite small, or unless there is coercion or some other special device by which to make individuals act in their common interest, rational, self-interested individuals will not act to achieve their common or group interests."[47] In larger groups, that willingness is hampered by the free-rider problem, or the tendency of some recipients of a public good to make use of that good without contributing to its cost. The theory's main observation is that larger nations will bear a disproportionate share of the burden of mounting a collective defense because smaller nations, as rational actors, will obtain most or all of what they need from what their larger allies are already purchasing for themselves. Over the past five decades, *The Logic of Collective Action* has come under scrutiny by a whole subfield of alliance theory that it spawned. That body of literature has identified some problems with the theory's original formulation, especially as it pertains to access to information.[48]

Finally, according to the joint product model, nations will free-ride less when they reap most of the benefits of their own defense spending and can, to some degree, keep others from

---

[45] See Kenneth N. Waltz, *Theory of International Politics*, Long Grove, Ill.: Waveland Press, 1979; and Stephen M. Walt, *The Origins of Alliances*, Ithaca, N.Y.: Cornell University Press, 1987. The main concepts of realism underpin much of contemporary international relations theory, are widely accepted, and are not that controversial. The relevance of neorealism has nonetheless also been the subject of lengthy debate (Robert O. Keohane, *Neorealism and Its Critics*, New York: Columbia University Press, 1986). For a more anarchic worldview, see Glenn Snyder, "The Security Dilemma in Alliance Politics," *World Politics*, Vol. 36, No. 4, July 1984. For this argument in relation to NATO, see Avery Goldstein, "Discounting the Free Ride: Alliance and Security in the Postwar World," *International Organizations*, Vol. 49, No. 1, Winter 1995.

[46] Mancur Olson and Richard Zeckhauser, "An Economic Theory of Alliances," *Review of Economics and Statistics*, Vol. 48, No. 3, August 1966.

[47] Mancur Olson, *The Logic of Collective Action: Public Goods and the Theory of Groups*, Cambridge, Mass.: Harvard University Press, 1971, p. 2.

[48] For scholars who have examined and questioned collective action theory, see Todd Sandler and Jon Cauley, "On the Economic Theory of Alliances," *Journal of Conflict Resolution*, Vol. 19, No. 2, June 1975; William R. Gates and Katsuaki L. Terasawa, "Commitment, Threat Perceptions, and Expenditures in a Defense Alliance," *International Studies Quarterly*, Vol. 36, No. 1, March 1992; John R. Oneal, "The Theory of Collective Action and Burden Sharing at NATO," *International Organization*, Vol. 44, No. 3, Summer 1990; and others as summarized in John R. Oneal and Paul F. Diehl, "The Theory of Collective Action and NATO Defense Burdens: New Empirical Tests," *Political Research Quarterly*, Vol. 47, No. 2, June 1994. See also Lars Udehn, "Twenty-Five Years with 'The Logic of Collective Action,'" *Acta Sociologica*, Vol. 36, No. 3, 1993.

Joel R. Hillison is one author who disputes Olson and Zeckhauser's claim. Hillison argues that, as NATO's membership has grown, smaller states have not necessarily contributed less relative to their larger allies (Joel R. Hillison, *Stepping Up: Burden Sharing by NATO's Newest Members*, Carlisle Barracks, Pa.: U.S. Army War College Press, November 10, 2014, pp. 5–6). See also Todd Sandler and Keith Hartley, *The Political Economy of NATO: Past, Present and into the 21st Century*, Cambridge, United Kingdom: Cambridge University Press, 1999; and Ethan Spangler, "Allies with Benefits: US Effect on European Demand for Military Expenditures," *Defence and Peace Economics*, Vol. 29, No. 7, 2018.

benefiting from their spending. Under the joint product model, these benefits are excludable. Allies will likely increase defense spending when benefits are excludable and when other allies also increase their spending. In their exploration of the joint product model, James C. Murdoch and Todd Sandler found that allied spending on conventional defense increased after NATO's shift to a doctrine of flexible response. This doctrine (of preparing for tactical and conventional, rather than just nuclear, responses to war) expanded opportunities for allies other than the United States to contribute territorial defense forces, from which they derived a large national benefit and from which other allies could be excluded.[49]

Both the collective action theory and the joint product model reaffirm the fact that excludability and rivalry lie at the root of the free-rider problem. Because not all defense goods are pure public goods, it may be possible to exploit differing degrees of excludability and rivalry in various elements of the collective defense good by unbundling it into several constituent goods.

A similar strategy was used after the U.S. airline industry was deregulated in 1978 and airline executives unbundled the air travel good in order to boost profitability. After deregulation, air travel became an almost indistinguishable commodity product. The primary competition was over price, and customers started driving airline profits almost to zero. However, airline leaders discovered that some of the unbundled constituent goods of the bundled air travel product, such as checked baggage, in-flight meals, drinks, and early boarding, are excludable. Airlines were therefore able to boost profitability by charging extra for these unbundled, excludable goods. Other unbundled constituent goods, such as middle-row seats, were rivalrous in the sense that customers wanted to avoid them. So, airlines were able to boost profitability further by making customers pay extra to avoid middle seats. By exploiting the excludability and rivalry of the unbundled constituents of the bundled air travel good, airlines were able to boost profitability in what is otherwise a commodity industry.

A similar transformation might be achievable by unbundling the collective defense good into its constituent parts. Some constituent defense goods, such as the AWACS program, will be rivalrous. Rivalry can be exploited by telling under-contributing allies that, unless they make greater contributions to the alliance, they will have the lowest priority when it comes to using those resources or deciding how those resources will be used.[50] Other constituent goods, such as strategic airlift and the Five Eyes intelligence-sharing examples given earlier, will be excludable. Excludability can be exploited by denying under-contributing allies access to those goods or by creating different categories of access to those goods, depending on the level of an alliance member's contributions. In both cases, under-contributing allies might be induced to increase contributions to the alliance in order to obtain the access and the priority of usage for resources that they desire, thereby alleviating (but not remedying) the free-rider problem.

[49] James C. Murdoch and Todd Sandler, "Complementarity, Free Riding, and the Military Expenditures of NATO Allies," *Journal of Public Economics*, Vol. 25, No. 1–2, November 1984, p. 85; Alexander Lanoszka, "Do Allies Really Free Ride?" *Survival*, Vol. 57, No. 3, May 2015, p. 134; and Gates and Terasawa, 1992, pp. 102–103.

[50] Top alliance command billets and an ally's share of total joint command staff positions are further examples of rivalrous defense goods whose distribution could be exploited in a similar fashion.

Applying Assurance Contracts to Burdensharing

Allies have no assurance that other allies with differing preferences will contribute their fair share toward acquiring defense goods that, following the approach outlined in the previous section, are deliberately created as or converted to common-pool resources or club goods.[51] Differing preferences can take many forms, including the differing threat perceptions noted earlier or differing budget constraints. Assurance contracts are a potential vehicle by which to create additional common-pool resources or club goods in a way that sidesteps the free-rider problem.

Assurance contracts are the mechanism used by crowdfunding websites, such as gofundme.com or kickstarter.com. Under such contracts, a target level of contributions or contributors must be reached or the project does not proceed, and no one is charged until all necessary funds are pledged.[52]

A variant of assurance contracts, dominant assurance contracts, was proposed in a 1998 paper by economist Alexander Tabarrok. Under a dominant assurance contract, an organizer pays potential contributors a fee in return for agreeing to participate. If the target sum is reached, the organizer is paid a reward as compensation for the initiative, risk, and efforts that she undertook. If the target is not reached, the potential contributors keep the fee that they were paid. Game theory suggests that a player will always benefit by agreeing to participate if he thinks a project has merit, despite the coordination challenges.[53]

A further possibility is to organize assurance contracts in a manner akin to an insurance policy with a high deductible. For example, suppose a country decides not to contribute $200 million to an assurance contract among ten allies to acquire additional strategic airlift aircraft, but the country then faces an emergency in which it urgently needs airlift. Under a high-deductible-like policy, the country would be offered use of the aircraft for, say, $150 million for a set amount of time. If the nonparticipating state needs to use the aircraft more than once, it would turn out to have been cheaper for that country to have subscribed to the contract from the beginning. The size of the payment is designed to make it highly advantageous for allies to subscribe initially and punitive not to do so, and this might incentivize other allies to join future assurance contracts. In this arrangement, the high-deductible assurance contract exploits the defense good's excludability to make joint allied defense acquisitions more attractive.

Furthermore, there does not need to be a one-size-fits-all approach to assurance contracts. A deliberately progressive form of taxation could be applied by setting a lower contribution level for smaller or poorer nations and a higher contribution level for larger or richer nations.

---

[51] See Amartya K. Sen, "Isolation, Assurance and the Social Rate of Discount," *Quarterly Journal of Economics*, Vol. 81, No. 1, February 1967; and Alexander Tabarrok, "The Private Provision of Public Goods via Dominant Assurance Contracts," *Public Choice*, Vol. 96, No. 3–4, 1998.

[52] See Mark Bagnoli and Barton L. Lipman, "Provision of Public Goods: Fully Implementing the Core Through Private Contributions," *Review of Economic Studies*, Vol. 56, No. 4, October 1989; Earl R. Brubaker, "Free Ride, Free Revelation, or Golden Rule?" *Journal of Law and Economics*, Vol. 18, No. 1, 1975; and Thomas R. Palfrey and Howard Rosenthal, "Participation and the Provision of Discrete Public Good: A Strategic Analysis," *Journal of Public Economics*, Vol. 24, No. 2, July 1984.

[53] Tabarrok, 1998.

Applying Private-Sector Management Practices

Benchmarking

In a 2010 study published by management consultancy McKinsey and Company and commissioned by DoD's Defense Business Board, Scott Gebicke and Samuel Magid applied a common private-sector management technique termed *benchmarking* to defense performance.[54] Benchmarking involves comparing one's own performance, as measured by key performance indicators, to that of one's peers or competitors. Private-sector executives attempt to match at least the average, and sometimes the top-quartile, levels of performance of their peer enterprises. Gebicke and Magid applied the benchmarking technique to three key budget areas of defense: spending on personnel, equipment procurement, and maintenance. They also examined the numbers of active, deployable, and deployed forces for several countries.

In 2018, NATO spent $408 billion on personnel. Important allies spent almost two-thirds of their defense budgets on personnel, whereas others spent about one-third. If countries that spent almost two-thirds on personnel could reduce personnel spending to the NATO average level (52 percent), they could save up to $7 billion per year. Non-U.S. NATO members could use these savings to boost investment in major equipment by up to 10 percent. According to the McKinsey study, if the share of personnel expenditures in the aggregate alliance-wide defense budget could be reduced to match top-quartile NATO performance (40 percent), then up to $25 billion in annual savings might be generated.[55] Those savings could be used to boost investment in major equipment by up to 39 percent.[56]

Gebicke and Magid suggested that the same efficiencies might apply to combat troops. To compare countries, the authors calculated the tooth-to-tail ratio—wherein the tooth is the percentage of combat troops on the front lines and the tail is the percentage of troops who supply or support them. The authors estimated that the average tooth-to-tail ratio for the countries they examined was 26 percent. However, their data set covers only 19 of the 35 allies under consideration in this study. But if some more-capable countries were to achieve the 26-percent average ratio, then up to 250,000 additional active-duty troops might be made available for combat. If such countries were to achieve the top-quartile performance of 30 percent, then up to an additional 400,000 combat troops might be made available.[57]

It is possible that similar results could be achieved by managing the number of troops that can be deployed and sustained. Were more-reliable data available, such a capacity utiliza-

---

[54] Scott Gebicke and Samuel Magid, *Lessons from Around the World: Benchmarking Performance in Defense*, San Francisco, Calif.: McKinsey and Company, Spring 2010. For more on benchmarking, see Raul Valdes-Perez, "Smart Benchmarking Starts with Knowing Whom to Compare Yourself To," *Harvard Business Review*, October 30, 2015.

[55] Gebicke and Samuel Magid, 2010.

[56] The greatest savings could come from improved performance by just seven allies (NATO, "Defence Expenditure of NATO Countries (2011–2018)," press release, PR-CP(2019)034, March 14, 2019a, pp. 6, 12).

[57] For comparison, NATO deployed just 45,000 troops to Afghanistan. The greatest improvements could be achieved by just seven allies (Gebicke and Magid, 2010, p. 7; International Institute for Strategic Studies [IISS], *The Military Balance*, Vol. 117, No. 1, February 13, 2017, pp. 43, 46, 85, 96, 98, 102, 108, 111, 130, 133, 135, 138, 157, 161, 241, 270, 278, 302). See also Jacques S. Gansler and William Lucyshyn, *Improving the DoD's Tooth-to-Tail Ratio*, College Park, Md.: University of Maryland, UMD-AM-14-007, February 2014. Not all of the savings need to be invested in additional personnel.

tion measure (deployments versus deployability) might usefully be included in the Burdensharing Index.[58]

Segmenting Defense Contractors

The 2018 NDS calls for selective interdependence with allies in certain capability areas.[59] The United States might be able to achieve both cost savings and greater allied contributions to the joint defense by treating separate allied defense industries as one theoretical allied defense industrial base. The total market of allied weapon manufacturers could then be segmented into high-, medium-, and low-end producers. Although significant political resistance from domestic U.S. defense contractors might have to be overcome, under this approach, the United States could deliberately rely on lower-cost allied producers for the supply of small- to medium-scale weapon systems—for example, handguns, short-range air defenses (SHORAD), and the Man-Portable Air-Defense System. This could allow the United States to reap cost savings that are potentially unavailable in its domestic defense industry and focus the time and the resources saved on joint development and production with high-end allied manufacturers of the high-value-added systems required for the potential future warfights identified in the NDS. Because of the potential high-technology spin-off benefits for the respective private sectors and defense industries, co-development and co-production opportunities of this kind could be used as incentives by which to elicit greater contributions from key allies.[60] (The specific new technologies that are most needed for NDS objectives are discussed in Chapter Four, and the candidate technologies that might be considered most desirable to the collective defense are presented in Table 4.4.)

The reliability of the McKinsey study (upon which most of the suggested efficiency improvements are based) is open to question because the authors do not provide a rigorous definition of their terms or document the methods by which they arrived at their conclusions. Nonetheless, their methodology and findings are eye-opening and are simply too important to ignore. Even if the study's findings are off by an order of magnitude, they still suggest that significant scope probably exists to make more-efficient use of existing defense resources. Unfortunately, according to outside experts, "DoD has yet to fully embrace the efficiency-based reforms introduced within the private sector."[61] For DoD to be able to benchmark and manage to average or top-quartile performance in the military sector, the existing definitions and data-gathering methodologies that are already applied to NATO allies should be extended to the

---

[58] Indications are that, in 2010, the forces of two major NATO allies and the United States were overstretched, with deployed troops exceeding 40 percent of those deployable (Gebicke and Magid, 2010, p. 10; IISS, 2017, pp. 43, 46, 85, 96, 98, 102, 108, 111, 130, 133, 135, 138, 157, 161, 241, 270, 278, 302). The available data do not allow the Burdensharing Index to give credit to countries that are overstretched because of their overseas deployments. NATO data on allied deployability and sustainability proved to be of quite limited use. Because each member compiles and supplies data to NATO based on its own definitions of deployability and sustainability, the data supplied are not comparable. There are indications that this lack of comparability is willful. If comparable NATO standards existed, members might run the risk of being held to those standards. For these reasons, we were unable to include measures of deployability and sustainability in the Burdensharing Index, despite our strong desire to do so.

[59] DoD, 2018, p. 11.

[60] The United States already engages in limited-scope co-development and co-production of weapon systems of this kind with several allies.

[61] Gansler and Lucyshyn, 2014, p. vi.

Asian allies,[62] and all allies should agree on the definitions of additional key performance indicators.[63] Gathering the data needed to implement this approach would require repeated and consistent resources. However, the potential efficiency gains highlighted in this section indicate that the potential savings may warrant the additional expense and effort.[64]

Conclusions

The fact that burdensharing and free-riding have remained issues since the inception of the U.S.-led global alliance system at the end of World War II demonstrates that there are no easy answers to the conundrum. The analysis presented in this chapter suggests five different, but potentially mutually reinforcing, approaches that might elicit greater allied contributions to the collective defense of the international order in Europe and Asia. None of the measures suggested is easy to implement. In fact, implementing any one of them could be quite difficult and could generate significant acrimony and pushback from U.S. allies. Many could be seen more as theoretical than as realistic policy options. However, if policymakers truly wish to mitigate the free-rider problem, there appear to be few alternatives to achieving a more equitable division of labor and adapting to the changed economic and strategic balance. Individually or in combination, the measures proposed could help assuage, but not resolve, a chronic and considerable source of U.S. discontents. Based on the analysis in this chapter, the five proposed measures are to update alliance treaties and associated architecture, unbundle the collective defense good, use assurance contracts, benchmark allied performance, and segment allied defense contractors.

Update Alliance Treaties and Associated Architecture

The alliances that provide an essential deterrent and enforcement mechanism for the international order established after World War II were concluded in the 1940s and 1950s. Although it would be far from easy, it is conceivable that those treaties and associated organizations and practices can be updated to reflect changes in the international strategic balance that have taken place since they were created more than 60 years ago. Modifications that could, in theory, strengthen the U.S. alliance system and improve both deterrence of U.S. opponents and allied burdensharing include the following:

- Where areas of geographical applicability are unclear or undefined, define them.
- For any alliance treaties that are not self-executing, upgrade them to be self-executing.

---

[62] In particular, the allies should organize and present budget data according to a uniform standard, such as that of NATO, that would allow consistent comparisons of personnel and major equipment spending in Europe and Asia. In addition, the allies could extend data on joint command billets and the freedom-of-movement scores that U.S. Army Europe developed for the European theater to include freedom-of-movement scores for allied countries in the Pacific theater.

[63] Indicators that would benefit from common definitions include active-duty combat troops, active-duty support troops, deployability, and sustainability.

[64] If the allies extend some key performance indicators to Asian allies and reach agreement on the definitions of the four additional indicators (as noted) with an initially limited number of key allies, those would be important first steps to achieving efficiencies. Data for each of these indicators could then be collected and collated annually. With the data in hand, by mutual agreement, the allies could make a joint effort to manage their defense establishments in a way that targets average or top-quartile performance in each category.

- For treaties that are not reciprocal, upgrade them to involve reciprocal security guarantees.
- Put in place standing multinational political and military consultative structures.
- Elaborate joint strategic concepts.
- Agree in advance on procedures for wartime operational control.
- In a stepwise fashion, make bilateral treaty arrangements multilateral.

Our primary purpose in suggesting changes to alliance treaties and their associated architectures is to boost the credibility of those alliances as deterrent mechanisms by which to enforce the post-war international order in Europe and Asia in the face of increasing challenges by revisionist, illiberal, authoritarian regimes. However, the inherent complexities and sensitivities of revisiting treaties makes this a challenging option and one that would require sustained diplomatic efforts.

Unbundle the Collective Defense Good

Theory indicates that, because not all defense goods are pure public goods, alliance leaders could unbundle the collective defense good. Doing so would make available two key levers that leaders could exploit in order to elicit greater allied contributions to the common defense:

- Excludability could be exploited to create allied club goods, such as the following:
  - upgraded dispersal airfields, which yield a large private benefit to the host state while satisfying a key requirement for future warfights
  - improvements to the national transportation network adjacent to key geographic chokepoints that must be forced in times of war
  - strategic airlift assets and intelligence-sharing arrangements for which the level of access depends on an ally's level of contribution.

  The third example is the harshest. As a practical matter, limiting access to intelligence could be difficult, and maybe impossible, to implement and could lead to significant allied blowback and the loss of intelligence flowing to the United States.
- Rivalry could be exploited to create additional allied common-pool resources. For example, top- and staff-level allied joint command structure billets could be allocated in a manner that brings each ally's billet share more closely in line with its burdenshare. And additional contributions of strategic airlift, heavy unmanned aerial vehicles (UAVs), and maritime patrol aircraft could be generated using a rivalry approach.

Use Assurance Contracts

The United States could use crowdsourcing in the form of dominant assurance contracts to create club goods and common-pool resources. The contracts could be structured similarly to a high-deductible insurance policy. The United States could ask allies to subscribe to club goods and common-pool resources, and the prices that a nonsubscribing ally would have to pay to subsequently use those goods and resources could be set at levels that make it highly advantageous to subscribe and punitive not to do so. Subscription rates could be set to reflect allies' differing levels of national income.

Benchmark Allied Performance

It is probably possible that allies could make more-intensive use of existing resources before asking for additional resources from the United States or other allies. Resources that are cur-

rently captured by inefficient management practices could be liberated if the United States and its allies in Europe and Asia were to agree to benchmark certain key military performance indicators and make a concerted effort to manage those indicators toward average or top-quartile performance in the allied peer group.

Candidate key performance indicators include personnel spending, number of active-duty combat troops and active-duty combat service support troops (to benchmark and manage allied tooth-to-tail ratios), and deployability (to identify and manage pockets of allied slack and overstretch). In addition, the United States and its allies should elaborate a common definition of sustainability and extend accounting practices used for NATO to cover key Asian allies too.

Segment Allied Defense Contractors

The United States might be able to achieve both cost savings and greater allied contributions to the joint defense by treating separate allied defense industries as one theoretical allied defense industrial base. Although significant political resistance from domestic defense contractors might have to be overcome, the consolidated base could then be segmented conceptually in a manner that allows the United States to pursue its goals more effectively. For example, the United States could

- divide the total allied defense industrial base into high-, medium-, and low-end sectors
- reap cost savings unavailable in the United States by depending on low- and medium-end allied weapon manufacturers to supply light and medium weapons to the U.S. armed forces
- apply the cost savings to joint research, development, and production partnerships with high-end allied defense manufacturers to create higher-value-added new technologies, such as those envisioned in the 2018 NDS.

The United States and its allies could employ any of the methods outlined here to incentivize greater allied contributions to collective defense. However, historically, changes in regional threat profiles and balances of power have led to the largest changes in allied contributions. Thus, being well prepared to exploit any spikes in regional threat profiles or shifts in balances of power when they occur might be the best way of obtaining greater allied contributions.

CHAPTER THREE

The Burdensharing Index

Our review of the burdensharing literature informed our development of an expansive set of potential metrics for inclusion into a nested, multi-attribute Burdensharing Index. This chapter outlines how we constructed such an index to assist policymakers and analysts in exploring the extent and type of allied contributions to the collective defense. We define those contributions as efforts designed to defend and enforce the U.S.-led international order in Europe and Asia. After outlining the index's purpose, design, and components, we demonstrate how the resultant overall burdensharing index score can serve as a top-level composite measure akin to a stock market index, such as that offered by Standard & Poor's 500 Index. We also introduce a second top-level measure, the burdensharing ratio, which adjusts the burdensharing index score to account for each nation's level of relative wealth. These two top-level measures, along with the underlying aggregated data, serve as a starting point for analyzing allied contributions to burdensharing with a higher level of granularity.

Purpose, Design, and Components

Why an index? As a concept, burdensharing is inherently abstract. It is difficult to observe or measure how and how much each ally contributes to the collective defense of the international order. Simple statistics, such as the percentage of a nation's GDP it dedicates to its defense budget, may relay one meaningful aspect of burdensharing for the purposes of debate at the political level. But only a more structured and systematic set of measures has the potential to reveal the complexity of allied contributions to collective security and ways that the United States could motivate allies to optimize those contributions.

Because each ally's share of the burden of mounting a collective defense is not directly observable, we chose to construct an index that would capture the essential contributions that each ally makes. An *index* is a mathematical tool that allows us to abstract from reality while still capturing the most-essential elements of that reality. An index can be particularly helpful when measuring a large phenomenon, such as the valuation of the stock market, for which it is unrealistic to expect to be able to measure every single component.

Our purpose in constructing the Burdensharing Index was to produce a tool that would be helpful when analyzing the extent of existing allied contributions to collective defense. The index can also be used to identify which countries could contribute more—and the specific capabilities that they could contribute—to satisfying the requirements of potential future

warfights identified in the NDS.[1] When selecting factors and metrics to include in the index, our chief criteria were that the measures be complete and accurate, comparable across allies, and relevant to the NDS and that the elements selected must allow the index to be parsimonious and cost-effective (for data-gathering and periodically refreshing the data gathered).[2]

The number of factors and metrics included in the Burdensharing Index is large enough to account for many of the ways that a state can contribute to collective defense but small enough to retain a manageable, understandable structure. However, as with any conceptual simplification, the index omits some important data and distorts others, as described later.

Through our review of the historical literature and of more recent scholarly and government publications, we identified more than a dozen factors and more than 100 metrics for potential inclusion in the index. For more detail on these components, our selection criteria, the limitations of the data, and the definitions used, see Appendix A. It explains how we sought to measure preparedness, personnel, and the various defense and nondefense contributions that allies make, including to peacekeeping, global allied troop deployments, and other regional security arrangements. For the worksheets that constitute the Burdensharing Index itself, see Appendix B. As depicted in simplified form in Figure 3.1,[3] the Burdensharing Index consists of the following core elements:

- *factors:* categories of allied contributions (e.g., ground forces, preparedness); three of the index's four tiers comprise factors
- *metrics:* the quantitative or qualitative measurements constituting a factor (e.g., share of total alliance helicopters, share of total deployed forces)
- *vectors:* groups of factors or metrics
- *weights:* a coefficient used to denote the relative importance of each factor and metric.

At its lowest (right-most) level, the index consists of 45 metrics (the metrics form the first tier of the index; not all of them are depicted in the simplified structure in the figure). Working leftward in Figure 3.1, at the next level, these metrics are grouped into vectors that represent nine quantifiable factors involved in providing collective defense (the second tier of the index). In the third tier of the index, those nine quantifiable factors are then grouped into further vectors that represent factors of military preparedness and deployments. And in the fourth tier of the index, the factors distinguish between the inputs and the outputs involved in providing collective defense. The inputs and outputs form a vector that is combined to yield a single *burdensharing index score* (or *share of burden* in the figure).

Three considerations guided the Burdensharing Index's design. First, we aimed to provide an analytically and conceptually complete picture of burdensharing. As long as it could be measured with relative ease and fidelity, no major aspect of how allies contribute to collective security (i.e., the factors) would be excluded. Second, although our approach to including

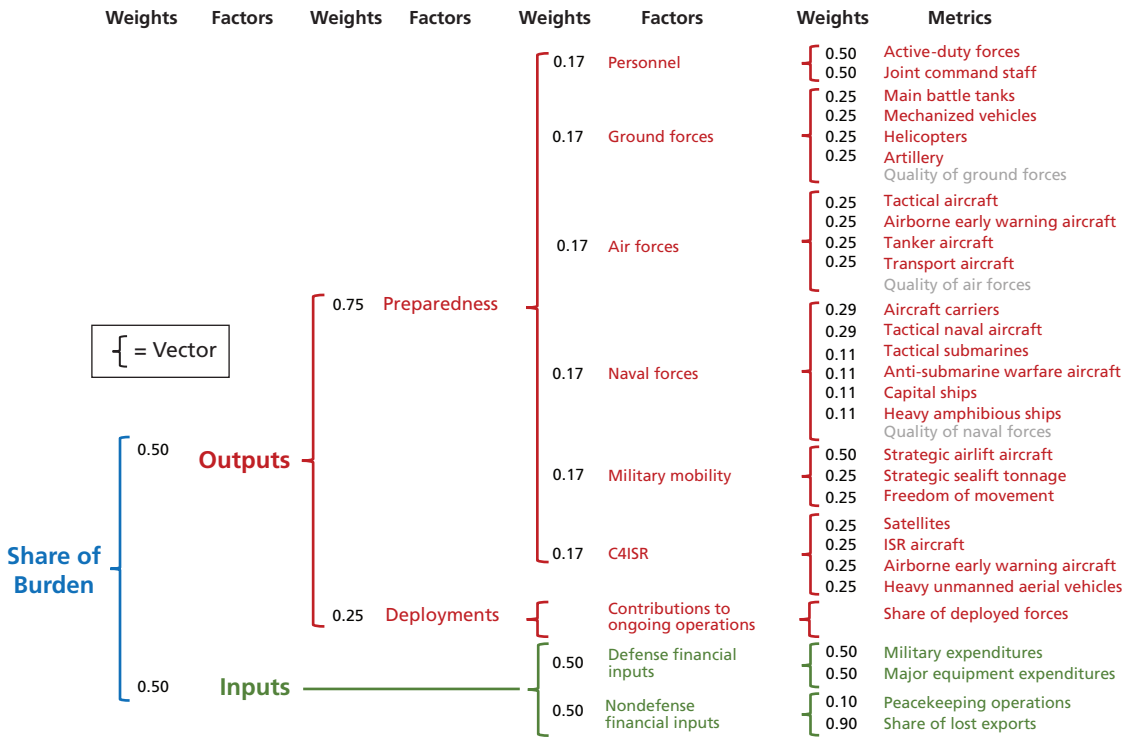
---

[1] The NDS reflects U.S. strategic priorities. The fact that these priorities may not always coincide with those of U.S. allies means that the requests generated by this mapping exercise can, at best, yield results only once the requests have been passed through the filter of each ally's own strategic priorities.

[2] The version of the Burdensharing Index published in this report uses data from 2017. Although we used more than a dozen sources, the primary source was IISS's *The Military Balance* (IISS, 2017). All sources are specified in Appendix B. Note that because IISS categories change over time, the printed version of 2017's edition of *The Military Balance* must be used to replicate these data.

[3] The detailed structure of the index is provided in Appendix A, Figure A.1.

Figure 3.1
Simplified Structure of the Burdensharing Index



NOTES: Red items represent outputs; green items represent inputs. Gray items are not yet included in the index. The index's structure has been simplified here for purposes of exposition. C4ISR = command, control, communications, computers, intelligence, surveillance, and reconnaissance.

factors was inclusive and broad, we restricted the number of metrics to no more than seven per factor and, in most cases, five or fewer. Including more than a handful of metrics per factor would begin to transform this effort from a relatively straightforward, parsimonious tool accessible to policymakers into a complex, labor-intensive modeling effort. And third, the tool should be customizable by future users. Therefore, we ensured that the Excel spreadsheet that houses the tool has a method to toggle and adjust weights for factors and metrics. This enables any interested party to conduct analysis based on differing assumptions about how burdensharing should be represented.

In constructing the Burdensharing Index, we reviewed the 2018 NDS, associated and derivative documents, and concepts of operation. This review highlighted the importance of C4ISR to the U.S. concepts of operation for potential major warfights. For this reason, we chose to include C4ISR as a separate preparedness factor of the Burdensharing Index.

Ultimately, the extent to which defense products and services meet policymaker objectives (*outcomes*) also matters a great deal. After all, national security inputs and outputs serve the primary purpose of deterrence and, failing that, the enforcement and defense of the nonaggression and territorial integrity principles underpinning the international order. All of the considerations involved in how allies might contribute to any potential conflict, however, cannot be relayed in an index that, by definition, is a simplified abstraction from reality designed to cap-

ture reality's most-important elements and serve as a point of departure for informed analysis and policy debate.

Notwithstanding this inherent limitation, the version of the Burdensharing Index included in this report could do more to anticipate outcomes by incorporating experts' qualitative judgments about the expected combat proficiency of allied armies, navies, and air forces. The inputs and capability outputs measured by the index begin to answer the question of how much each ally contributes. A full understanding of burdensharing, however, also requires measuring how valuable the contributions are. Put another way, an ally might possess military forces, but how proficient is the ally expected to be in employing those forces in combat? Additional information on a survey instrument designed to capture such qualitative combat proficiency ratings is included in Appendix C.[4] As mentioned earlier, the political ramifications of administering and incorporating the survey would likely be controversial, so DoD might wish to administer the survey separately, on a confidential basis, and integrate results into a restricted-circulation version of the Burdensharing Index.

Further Caveats

Although we believe that the Burdensharing Index included in this report presents an accurate overall picture of allied contributions, it also suffers from known shortcomings, for reasons explained in detail in Appendix A. Specifically, *the index does not*

- include nuclear weapons, which the majority of allies do not possess and which most U.S. policymakers prefer allies not to develop
- distinguish between differing levels of allied combat proficiency
- account for various forms of host-nation support[5]
- include data on deployability or sustainability

[4] Time and resource constraints prevented us from administering the survey and incorporating its results in this iteration of the index. The fact that the index does not incorporate qualitative assessments of allied combat proficiency is a significant limitation that policymakers and analysts should consider when using the index.

[5] Several countries make significant contributions to host-nation support. Allies argue that they do not receive adequate credit for the host-nation support that they provide to U.S. forces. Such support is not always an act of altruism, however. It can be motivated by the fear of abandonment created by large geographical distances separating allies. Host-nation support can be viewed as an attempt to mitigate that risk by paying for local basing of the ally's troops (Stephen M. Walt, "Why Alliances Endure or Collapse," *Survival*, Vol. 39, No. 1, 1997). Measuring host-nation support is a complex task that involves both qualitative and quantitative aspects, such as cash contributions or reimbursements; military construction funded by the host nation; renovation, repair, and routine maintenance of DoD facilities performed at the host nation's expense; utilities, fuel, or security provided by the host nation; laundry, custodial, transportation, food, and other contracted services provided by the host nation; participation in exercises; provision of training facilities; and nonmilitary support to DoD operations. We thank Office of the Secretary of Defense colleague Kennan Hedrick for these observations. A previous comprehensive RAND review of the overseas basing of U.S. military forces concluded that no consistently gathered data set of host-nation support exists. For this reason, we have deferred incorporating host-nation support until further research and analysis yield a consistently gathered data set (Michael J. Lostumbo, Michael J. McNerney, Eric Peltz, Derek Eaton, David R. Frelinger, Victoria A. Greenfield, John Halliday, Patrick Mills, Bruce R. Nardulli, Stacie L. Pettyjohn, Jerry M. Sollinger, and Stephen M. Worman, *Overseas Basing of U.S. Military Forces: An Assessment of Relative Costs and Strategic Benefits*, Santa Monica, Calif.: RAND Corporation, RR-201-OSD, 2013, Chapter Seven). See also Japanese Ministry of Defense, *Defense of Japan 2016*, Tokyo, 2016, Part II, Chapter 4; George R. Packard, "The United States–Japan Security Treaty at 50: Still a Grand Bargain?" *Foreign Affairs*, Vol. 89, No. 2, March/April 2010; and U.S. Senate Committee on Armed Services, 2013.

- include complete data on freedom of movement or joint command billets in the Pacific region
- include cyber forces or the services of nondefense intelligence agencies
- include more than a cursory estimate of net exports lost as a result of UN-imposed sanctions[6]
- include allied diplomatic conflict prevention or conflict management efforts
- provide longitudinal data that might permit analysis of historical trends (in its current iteration, the Burdensharing Index provides just a cross-sectional snapshot of the United States' alliances in NATO and Asia in one year, 2017)[7]
- adequately distinguish among such a disparate group of countries (some countries are so small that their burdensharing contribution will remain miniscule, no matter how much more they spend on defense).

Thus, analysts and policymakers should use caution when considering the results of the Burdensharing Index presented in this report.

---

[6] See Appendix A for a discussion of the issues associated with developing a high-fidelity estimate of total allied net exports lost as a result of sanctions imposed on Russia and Iran. Our primary source for calculating each ally's share of total exports lost in this manner was United Nations Conference on Trade and Development, "UNCTADSTAT Data Center," web tool, undated.

[7] After the conclusion of the study, we conducted a longitudinal analysis of burdensharing using almost exactly the same methodology. The longitudinal analysis (1) included allies in the Gulf Cooperation Council and in Latin America that were not included in this report and (2) dropped several metrics referred to in the report for which data were unavailable earlier than 2017. The preliminary results suggest that, after spiking to 42 percent in 2000, the U.S. share of the burden declined to 37 percent in 2017, close to its previous 1989 level of 36 percent. NATO allies' share of the burden increased over the same period, from 17 percent in 1989 to 23 percent in 2000 and back down to 21 percent in 2017. Asian allies' share almost doubled, rising from 5 percent to 9 percent over the same period. Contributions from all 17 allies in the Rio Pact (e.g., Argentina, Brazil, Honduras, and Uruguay) and all six in the Gulf Cooperation Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates) remained largely unchanged, rising from 3 percent to 4 percent and from 2 percent to 3 percent, respectively. Russia's share of the total burden borne by the protean group of U.S. strategic competitors declined by more than two-thirds, from 26 percent in 1989 to 7 percent in 2017. China's share, by contrast, tripled, from 3 percent to 9 percent. Because different sets of countries were compared using a subset of the metrics elaborated in this report, the results presented in this footnote are not strictly comparable with those presented in the body of the report. Furthermore, they are unverified and preliminary. However, they may help give an initial sense both of the likely historical trends in burdensharing and of the potential value of conducting a full-blown longitudinal analysis using the burdensharing methodology described in this report.

CHAPTER FOUR

Using the Burdensharing Index

In this chapter, we present and explain the top-level measures of the Burdensharing Index: each ally's burdensharing index score and burdensharing ratio. We proceed by ranking all 35 NATO and Asian allies according to these scores. We then use the scores to group allies into a nine-part taxonomy, which helps us identify allies that potentially require urgent measures to increase their contributions, as well as allies whose capabilities might need to be upgraded. In addition to providing a top-level view of allies' contributions to the collective defense, the Burdensharing Index allows us to drill down into the individual military capabilities that the allies supply. Drawing on previous RAND research on force posture requirements, we identify demand signals—that is, the military capabilities that are required to succeed in the potential warfights noted in the 2018 NDS. We then compare the supply of existing military capabilities with the demand for both existing and new technologies required by the potential warfights. This approach yields a list of investments that the United States could request of allies, prioritized by country and capability. In the next chapter, we illustrate how the United States could use co-development and co-production, common-pool resources, and club goods to incentivize allies to contribute more.

Important Information About Individual Countries in the Burdensharing Index and Data Limitations

This work is intended to advance theory on burdensharing and provide a starting point for DoD deliberations on this complex topic. To help illustrate how the Burdensharing Index could assist in future policy deliberations but, at the same time, avoid depicting scores and rankings about any single ally, we have anonymized data about individual countries. In their current form, those scores and rankings are not suitable for informing judgments about a given ally. Among the key limitations noted in this report is one of data currency: Because the majority of this project was conducted in 2018, it relies on data primarily from 2017, which were the most current data available at the time that our results were presented to DoD. Many nations, including the United States, have since begun to invest in new capabilities while reorienting their forces toward threats from highly capable nation-states. In this report, we describe additional caveats and make recommendations for how DoD could build on the Burdensharing Index presented in this report.

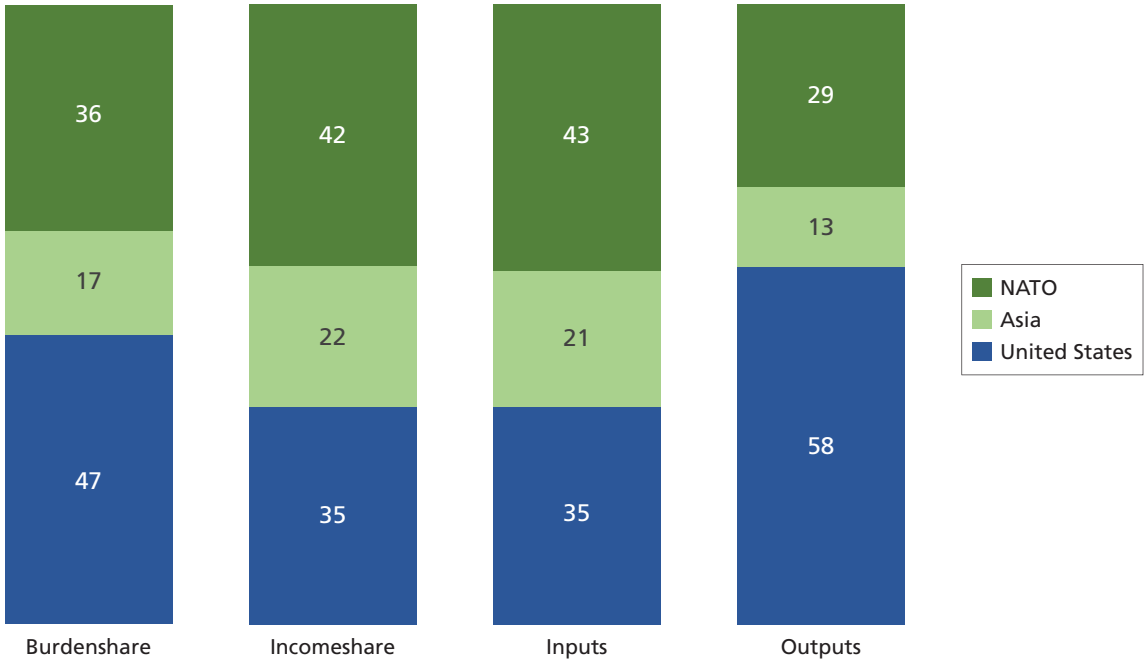
Results from the Burdensharing Index

In this section, we present results from the Burdensharing Index, including the top-level measures and preparedness estimates. As noted in Chapter One, policymakers should resist the temptation to interpret a nation's burdensharing index score as a singular determinant of whether an ally contributes enough. The scores should be interpreted in the context of each ally's unique situation and the broader national security context. The index is an exploratory tool that can only assist in the judgment and critical thinking required to address such an inherently complex, politically sensitive issue as burdensharing. To promote a greater focus on the methodology proposed, as opposed to a focus on the country rankings that result (given the limitations of the Burdensharing Index in its current form), country names have been anonymized (e.g., *Country XD*).

The data presented in this report have been double- and, in some cases, triple-checked. Our results are most sensitive to countries' share of total allied net exports lost as a result of UN sanctions imposed on Russia and Iran, the discount applied to conscripted active-duty personnel numbers, and aspects of military preparedness—principally, C4ISR and military mobility. Errors or changes in single data points outside of the first two of these key drivers are unlikely to materially alter the country rankings or overall findings of this report. We present a limited number of counterintuitive results, and the majority of those results are accounted for by the fact that, when calculating countries' share of the burden of mounting a collective defense, we chose to include the exports that countries lost as a result of sanctions.

As shown in Figure 4.1, in the baseline case, the United States' NATO and Asian allies account for about 54 percent of the total burden of mounting a collective defense (the *burden-*

Figure 4.1
Percentage of Burdenshare, Incomeshare, Inputs, and Outputs for NATO Allies, Asian Allies, and the United States



NOTE: Because of rounding, totals might not sum exactly to 100.

share, reflecting the burdensharing index score), whereas they account for about 65 percent of total alliance GDP (the *incomeshare*).[1] (Note that these numbers, as well as those in the figure, are rounded, so totals might not always sum exactly.) By comparison, the United States' burdenshare is about 47 percent and its incomeshare is about 35 percent. And while NATO and Asian allies account for about 65 percent of the total inputs to the collective defense, they account for only about 43 percent of total outputs, suggesting that they may be less effective at converting inputs into outputs than the United States is.

Each ally's burdensharing index score can be disaggregated as shown in Figure 4.2, which breaks down Country PJ's score. In particular,

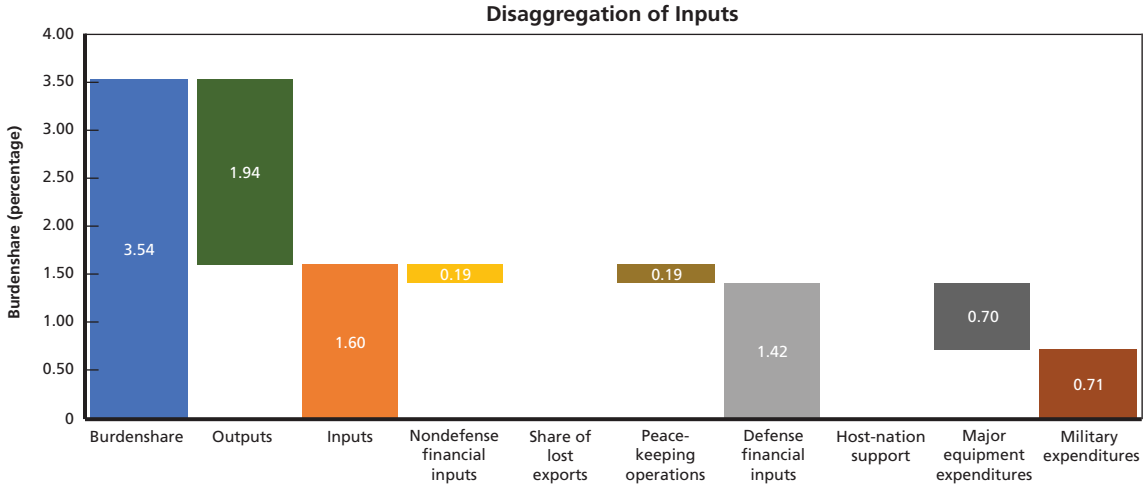
- Country PJ's score of 3.54 percent comprises 1.60 percentage points of inputs and 1.94 percentage points of outputs.
- Fully 1.42 percentage points of the 1.60 points for inputs are accounted for by defense financial inputs, which are split almost evenly between military expenditure and major military equipment expenditure (see the top panel in Figure 4.2).
- Country PJ's share of UN peacekeeping operations accounts for just 0.19 percentage points of the 1.60 input points, and because Country PJ has not suffered a significant loss of net exports to Russia and Iran as a result of UN economic sanctions, it gets no credit for its contribution to collective security from the share of lost exports category.
- The middle chart in Figure 4.2 shows that Country PJ's 1.94 percentage points of outputs derives primarily from its military preparedness (1.56 points).
- The three top components of Country PJ's military preparedness are military mobility, personnel, and naval forces. The other components are ground forces, air forces, and C4ISR.
- Deployments or contributions to ongoing operations account for 0.38 percentage points of Country PJ's score.
- The bottom chart in Figure 4.2 shows that Country PJ's largest deployments are to the EUCOM area of responsibility; the country's deployments to the CENTCOM, PACOM, AFRICOM, NORTHCOM, and SOUTHCOM areas of responsibility are lower.

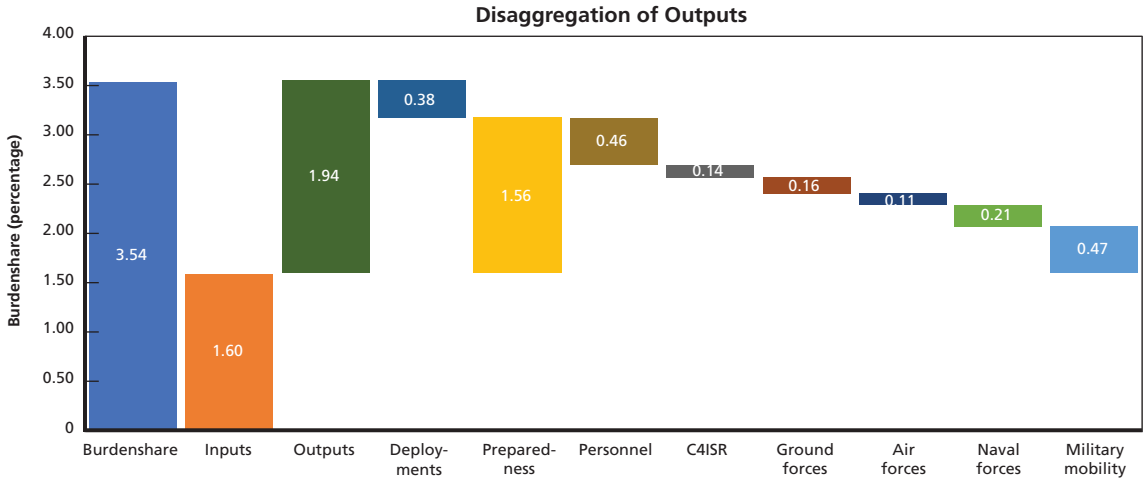
As noted earlier, the Burdensharing Index's output factor is a combination of the preparedness and deployment factors. Figure 4.3 shows how the index can be broken down to show regional contributions to each of the component factors of preparedness. Whereas NATO and Asian allies contribute the majority of personnel and ground forces, the United States provides the majority of air forces, naval forces, and C4ISR.[2]

[1] The baseline case uses our chosen weights for the factors and metrics (see Figure 3.1).

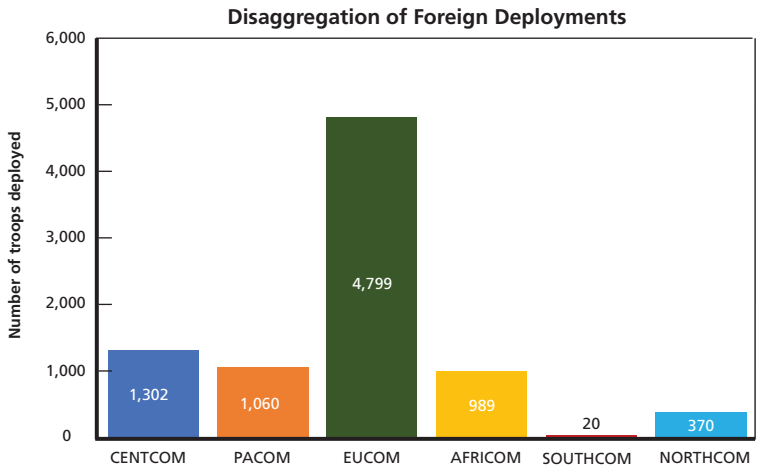
[2] *Military mobility* is a combination of strategic airlift, strategic sealift, and a freedom-of-movement score. Because imputed NATO average values have been used in lieu of missing Asian and U.S. freedom-of-movement data, it is not possible to arrive at strong conclusions based on differing regional military mobility scores.

Figure 4.2
Breakdown of Country PJ's Burdensharing Index Score





Country PJ	
BURDENSHARE	3.54
INPUTS	1.60
Defense financial inputs	1.42
Military expenditures	0.71
Equipment expenditures	0.70
Host-nation support	0.00
Nondefense financial inputs	0.19
Peacekeeping operations	0.19
Share of lost exports	0.00
OUTPUTS	1.94
Preparedness	1.56
Personnel	0.46
C4ISR	0.14
Ground forces	0.16
Air forces	0.11
Naval forces	0.21
Military mobility	0.47
Deployments	0.38



NOTE: Because of rounding, totals might not sum exactly. AFRICOM = U.S. Africa Command; CENTCOM = U.S. Central Command; EUCOM = U.S. European Command; NORTHCOM = U.S. Northern Command; PACOM = U.S. Indo-Pacific Command; SOUTHCOM = U.S. Southern Command.

Figure 4.3
Breakdown of Military Preparedness for NATO Allies, Asian Allies, and the United States

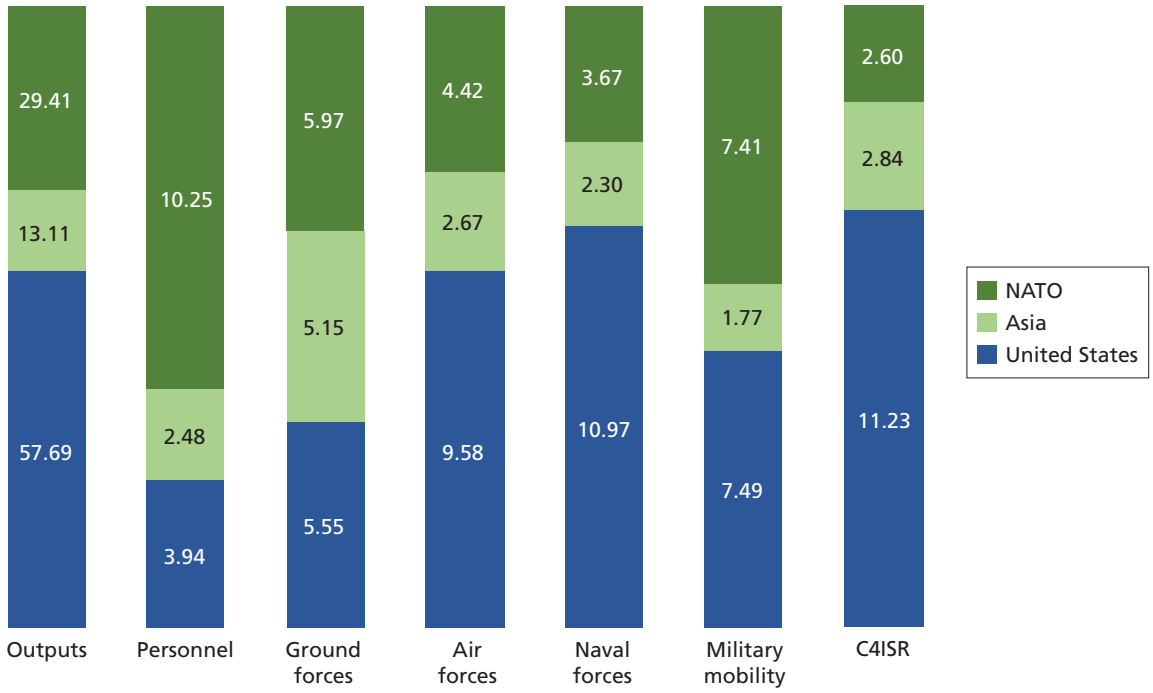


Figure 4.4 gives an ordinal ranking of all 35 U.S. allies' *burdensharing index scores*; as noted, the burdenshare represents the percentage of the total burden of collective defense that each ally provides. We divide the allies into three tiers:

- Tier A allies bear more than 3 percent of the burden.
- Tier B allies bear between 2 percent and 3 percent of the burden.
- Tier C allies bear less than 2 percent of the burden.

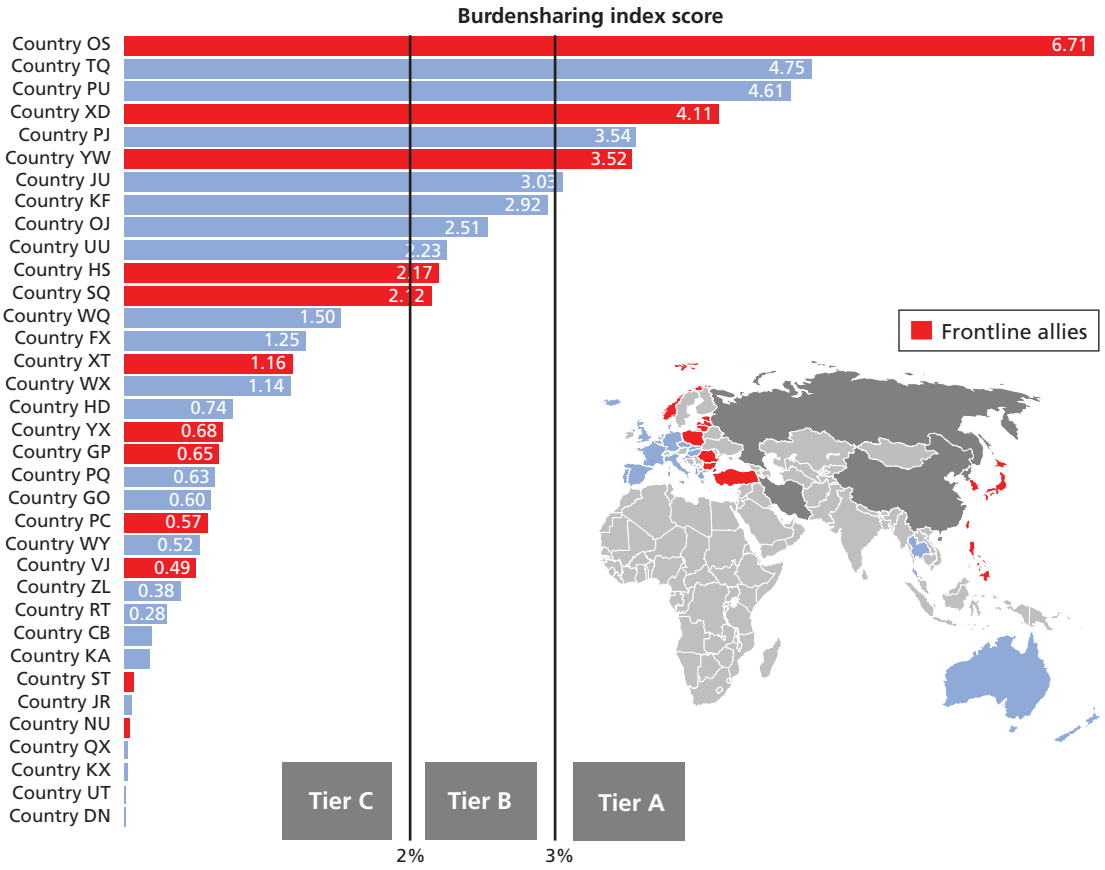
Of the 35 allies, seven fall into Tier A, five into Tier B, and 23 into Tier C. There is a gap between the seven Tier A allies and the remaining countries. The figure also distinguishes the countries that we consider to be on the *front lines*—that is, allies that share a land or sea border with or have major territorial disputes or political tensions with Russia, China, Iran, or the DPRK.

Next, we calculate each ally's *burdensharing ratio* (denoted as R_i), which represents the ratio of the ally's percentage of the total burden of collective defense (B_i) to the ally's percentage share of all 35 allies' combined GDP (or *incomeshare*, denoted as S_i). In mathematical form,

$$R_i = \frac{B_i}{S_i}. \tag{4.1}$$

If an ally's burdensharing ratio is equal to 1.00, then the ally's share of the burden is exactly equal to its share of total allied GDP. One could argue that an ally with such a ratio is making a contribution to collective defense that is commensurate with its national spending

Figure 4.4
Burdensharing Index Scores for U.S. Allies



NOTES: The bar chart excludes the United States, whose burdensharing index score is 46.50 percent. North America is not depicted on the map inset.

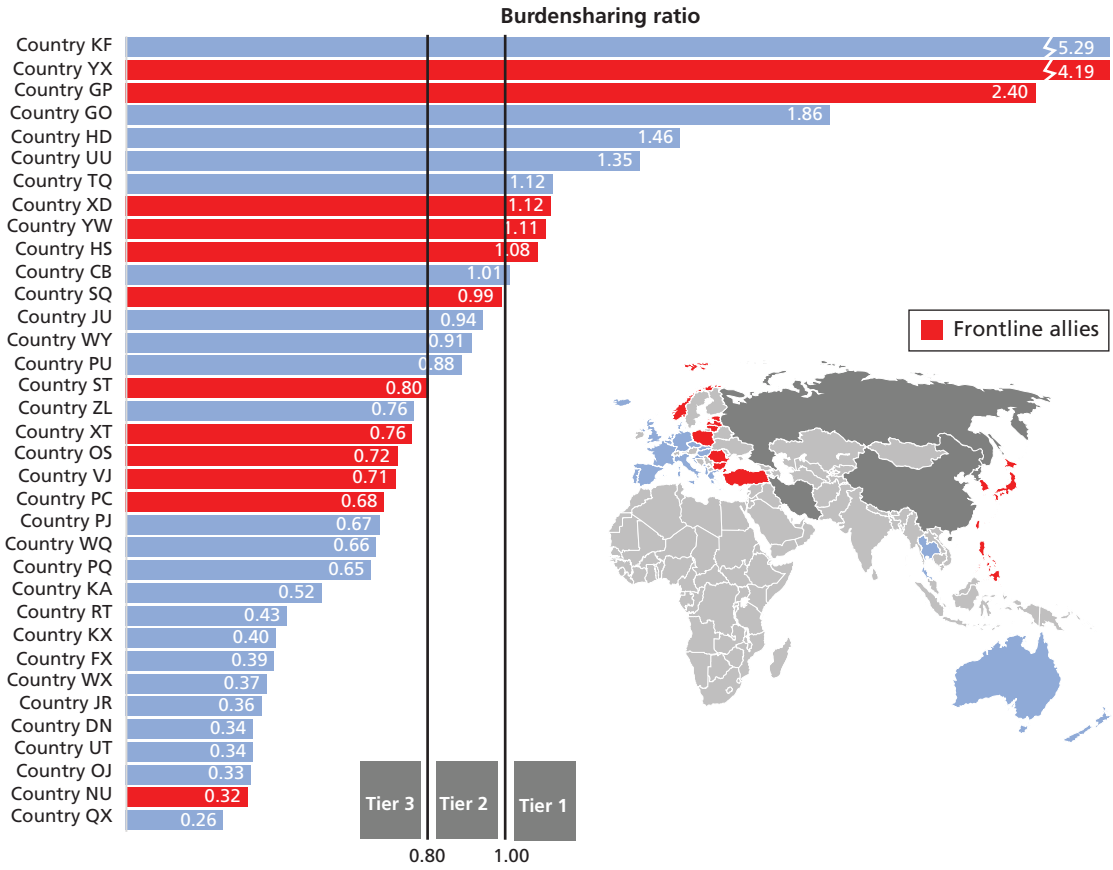
power. If an ally's burdensharing ratio is greater than 1.00, then the ally's share of the burden exceeds its share of total allied income, and one could argue that it is contributing more than its fair share. The opposite is true for allies whose ratio is less than 1.00.

Considering the burdensharing ratios, we divide the allies into three tiers:

- Tier 1 allies have a ratio equal to or greater than 1.00.
- Tier 2 allies have a ratio between 0.80 and less than 1.00.
- Tier 3 allies have a ratio less than 0.80.

Figure 4.5 shows how all 35 of the allies compare by this score. Mostly (but not exclusively) due to the impact of UN sanctions imposed on Russia and Iran, the list of 11 countries that contribute their share or more of total allied GDP (Tier 1) contains a few surprises (i.e., nations that might not look as favorable if considering the traditional metric of 2 percent of GDP spent on defense). Only three of the Tier A countries identified earlier (in terms of capability) are Tier 1 contributors by this score. Five countries, including one Tier A country, fall into Tier 2. And the other three Tier A countries according to burdensharing index score, along with 16 other allies, fall into the lowest contribution tier.

Figure 4.5
Burdensharing Ratios for U.S. Allies



NOTES: The burdensharing ratios for Country KF (5.29) and Country YX (4.19) are off the scale to allow for better distinction between the remaining allies. The bar chart excludes the United States, whose burdensharing ratio is 1.32. North America is not depicted on the map inset.

A Taxonomy of Allies

The two sets of tiers identified for allies' burdensharing index scores and burdensharing ratios allow us to elaborate a nine-part taxonomy of allies' capability and contribution, depicted in Table 4.1. For example, a country that falls into Tier B based on its burdensharing index score and Tier 2 based on its burdensharing ratio would fall into the B2 category of capability and contribution.

The results of this categorization are most notable for the large membership of the bottom-right C3 bin, comprising 16 countries that are both Tier C and Tier 3. It is worth noting that one relatively wealthy major ally and four frontline states are in this category. Because (1) these countries' capabilities are relatively limited, (2) their share of the burden amounts to less than their share of total alliance GDP, and (3) they are either frontline states or economies of significant size, the United States may wish to prioritize taking steps to increase the capabilities and contributions of these countries to move them into higher categories. If this finding holds even after some of the index's limitations are addressed and after closer scrutiny on a nation-by-

Table 4.1
Taxonomy of Allies' Capability and Contribution

		Burdensharing Ratio		
		Tier 1	**Tier 2**	**Tier 3**
Burdensharing Index Score	Tier A	• 2 NATO allies (1) • 1 Asian ally	• 2 NATO allies	• 1 NATO ally • 1 Asian ally
	Tier B	• 3 NATO allies (1)	• 1 Asian ally (1)	• 1 NATO ally
	Tier C	• 5 NATO allies (2)	• 2 NATO allies (1)	• 12 NATO allies (3) • 4 Asian allies (1)

NOTE: The numbers in red in parentheses indicate the number of frontline states in that category.

nation basis, the policy option of taking urgent measures could be appropriate. The taxonomy suggests two further generic policy priorities:

- targeting other, wealthy, under-contributing allies with requests and incentives designed to improve their burdensharing ratios
- taking steps that would increase the military capabilities of three frontline states categorized as C1 and C2 enough to move them from Tier C to Tier B.

Although the taxonomy allows us to identify allies that are potentially under-contributing, among other insights, it is important to acknowledge the limitations involved in comparing such a disparate group of countries. For example, some U.S. allies are so small that, no matter how much more they might spend on defense, their contribution to overall alliance capabilities would remain miniscule.

One possible operational implementation of the three capability tiers (Tiers A, B, and C) introduced earlier is to consider some Tier A allies to be potential global partners in enforcing the post–World War II international order. These countries have the resources, capabilities, and interests required to be global partners to the United States. The remaining members of Tier A and members of Tier B could be considered regional contributors—that is, countries that have substantial resources but primarily regional interests. Tier C allies could be considered local contributors—that is, countries whose main contributions to the alliance are infrastructure, airspace access, and the supply of some forces for territorial defense.

Under this operational implementation, countries with a limited or no military can be assessed in terms of their true value to the alliance—namely, basing for air and naval assets and sensor platforms—or in terms of what it is feasible for them to contribute without stressing interoperability considerations that would apply only to the major Tier A and Tier B alliance members. To the extent that countries create additional capabilities by changing their level of contributions (from Tier 3 to Tier 2 and from Tier 2 to Tier 1), movement between capability categories (Tiers A, B, and C) might eventually be possible.[3]

We do not expect all countries to be capable of fielding full-spectrum military capabilities. The analysis that follows departs from the military capabilities that allies have already decided to acquire on their own initiative, given the geographic and security realities that confront them. The Burdensharing Index simply measures those capabilities. In our analysis, we

[3] The authors are grateful to Thomas Szayna for suggesting this operational interpretation of the taxonomy.

attempt to leverage the information about existing allied capabilities to help us identify what additional investments the United States could request that allies make in order to better prepare the alliance to succeed in the potential warfights noted in the 2018 NDS.

Demand Signals Based on Potential Warfights

The 2018 NDS identifies four potential warfights (with China, Russia, Iran, and the DPRK) that the United States and its allies might face in the coming years.[4] These warfights generate demand signals about the capabilities that will be most needed from allies to achieve U.S. strategic goals in future. In this study, we assume that enforcement of the post–World War II international order in Europe and Asia is the principal objective of the 2018 NDS and that strategies aiming to strengthen U.S. and allied collective defenses are directed toward this end. In this section, we identify and summarize the demand signals generated by the four potential warfights, drawing on a body of work at RAND and elsewhere on future allied force posture requirements.[5]

China

Beijing is seeking to change the balance of power in the Western Pacific in a way that allows it to seize the strategic initiative and create conditions under which an invasion of Taiwan might succeed. Between 2000 and 2014, Beijing increased its military spending by almost 500 percent and significantly upgraded its military capabilities. China has built a capability to strike U.S. expeditionary forces by gaining sea control in the first island chain and holding U.S. assets in the second island chain at risk (see Figure 4.6). China also seeks to (1) limit the flow of U.S. aircraft into the region, which raises the price to the United States of establishing air superiority, and (2) prevent U.S. information superiority by degrading the quality, timeliness, and reliability of U.S. C4ISR, as well as U.S. in-theater communications—in part by being able to carry out a first strike against U.S. space-based assets.

These developments have generated new requirements for a potential warfight with China. Enhanced capabilities to strike China early in a conflict (before the United States establishes air or information superiority or sea control) will be needed. These capabilities include more ISR and new remote sensors; long-range anti-ship missiles (LRASMs); and smart standoff weapons, such as anti-ship cruise missiles (ASCMs). Resilient basing will also be required. Such basing comprises more-survivable (hardened) bases and ships, dispersal airfields

---

[4] DoD, 2018.

[5] Scott Boston, Michael Johnson, Nathan Beauchamp-Mustafaga, and Yvonne K. Crane, *Assessing the Conventional Force Imbalance in Europe: Implications for Countering Russian Local Superiority*, Santa Monica, Calif.: RAND Corporation, RR-2402, 2018; Paul K. Davis, J. Michael Gilmore, David R. Frelinger, Edward Geist, Christopher K. Gilmore, Jenny Oberholtzer, and Danielle C. Tarraf, *Exploring the Role Nuclear Weapons Could Play in Deterring Russian Threats to the Baltic States*, Santa Monica, Calif.: RAND Corporation, RR-2781-RC, 2019; Karl P. Mueller, "Filling the Baltic Gap: Or How I Learned to Stop Worrying and Love the d6," *BATTLES Magazine*, No. 11, 2014; David Ochmanek, *Restoring U.S. Power Projection Capabilities: Responding to the 2018 National Defense Strategy*, Santa Monica, Calif.: RAND Corporation, PE-260-AF, 2018; Ochmanek et al., 2017; David A. Shlapak, *The Russian Challenge*, Santa Monica, Calif.: RAND Corporation, PE-250-A, 2018; David A. Shlapak and Michael Johnson, *Reinforcing Deterrence on NATO's Eastern Flank: Wargaming the Defense of the Baltics*, Santa Monica, Calif.: RAND Corporation, RR-1253-A, 2016; and Julianne Smith and James Hendrix, *Assured Resolve: Testing Possible Challenges to Baltic Security*, Washington, D.C.: Center for a New American Security, April 2016.

Figure 4.6
The First and Second Island Chains

and forward-deployed airfield repair units, and more use of long-range platforms (e.g., heavy bombers) and survivable platforms (e.g., submarines). The warfight might also require a more robust, layered regional missile defense capability, consisting of Terminal High Altitude Area Defense (THAAD), Standard Missile-3, Aegis Ashore, and Patriot systems. However, cruise missile defenses and terminal SHORAD are likely to be more cost-effective. A capability for rapid suppression of enemy air defenses will be required as well, which involves improved jamming capabilities, improved air-to-air missiles, a new advanced anti-radiation guided missile – extended range (AARGM-ER), an ability to mount kinetic attacks on Chinese air-surveillance

radars, and radars that track surface-to-air missiles. Furthermore, the United States and its allies will need an enhanced ability to sustain the common operating picture, potentially using swarming UAVs. In addition, they will need improved cyber-warfare capabilities, including greater robustness and resilience for U.S. networks; the ability to degrade Chinese networks; long-endurance, space-independent UAVs; improved anti-satellite capabilities (e.g., against highly elliptical orbit and geosynchronous earth orbit targets); and regular higher-tempo training, including while operating in a low-bandwidth environment. Finally, the warfight will require partner networks that are more robust, capable, and extensive. This will mean strengthening existing alliances and developing new military-to-military partnerships.

Russia

Russia seeks to maintain a privileged status along its periphery, using force if necessary to keep neighboring states under its influence. Russia is trying to create a geographical buffer between Russia and the West and to weaken and discredit NATO, and Moscow has adopted a more confrontational, antagonistic security policy toward these ends. In particular, Russia has

- improved the manning, training, and readiness of its ground and air forces
- made significant investments in integrated air-defense systems, artillery, precision-strike systems, and nuclear infrastructure modernization
- rolled out a new strategic concept for Next Generation Warfare
- stated its intent to rely on its asymmetric advantage in nonstrategic nuclear weapons to offset NATO's advantage in conventional forces
- developed and may be on the cusp of a large-scale deployment of ground-launched cruise missiles in Europe in order to achieve a capability to execute precision deep strikes against key NATO rear-area infrastructure
- demonstrated an ability to conduct sustained maneuver operations, employing sophisticated reconnaissance systems to carry out precision strikes
- leveraged its shorter lines of communication compared with those of NATO.

These developments have changed the balance of power on NATO's Baltic and Black Sea flanks and pose risks to other potential trouble spots (e.g., Moldova). They highlight what some analysts describe as a gap between the United States' security commitments to Europe and its regional military posture. While engaging in a post–Cold War drawdown from 340,000 to 63,000 forward-based U.S. troops, NATO added 13 members without notable changes in its military posture. Significant ongoing efforts are underway and will need to be maintained in order to deny Moscow a low-cost, low-risk theory of victory for interventions along NATO's flanks. NATO could strengthen its deterrent posture with a combination of one or more of the following adaptations: increasing heavy ground forces, increasing air defense assets, improving supply and sustainment, reducing vulnerability to deep strikes in rear areas, and retrofitting armored vehicles with reactive armor. A warfight with Russia will also require ISR and artillery capable of locating and attacking long-range rocket artillery, as well as surface-to-air missile radars and launchers. Greater numbers of SHORAD, Multiple-Launch Rocket Systems (MLRSs), and Army Tactical Missile Systems will be required as well. Air forces will require

large stocks of new anti-armor munitions and more in-theater stocks of them.[6] C4ISR will need to be hardened, expanded, and protected by credible countermeasures, such as cyber or jam-resistant communications; additional UAVs and maritime patrol aircraft; additional E-3, E-8, and RC-135 airborne control and signals intelligence platforms; and improved anti-satellite capabilities (e.g., against highly elliptical orbit and geosynchronous earth orbit targets). Some analysts also propose that NATO position itself to be able to make a nonescalatory response to Russian first use of nuclear weapons by fielding modernized, low-yield, air- and sea-deliverable nonstrategic nuclear weapons.[7]

Iran

Tehran's development of ballistic missiles, use of proxy forces against the United States and its allies, and continuing quest for regional hegemony have created additional potential warfighting requirements. The U.S. strategic goals in the Middle East are to keep the Strait of Hormuz open for oil shipments to Europe and Asia, deter Iranian aggression against members of the Gulf Cooperation Council, and assure partners and allies that the United States will bolster regional security.[8] To achieve these goals, the United States and its allies and partners will need to maintain adequate strategic airlift, strategic sealift, and aerial refueling capability; protect deploying forces and bases by developing a network of hardened strong points and command centers that are dispersed and largely out of Iran's range; accumulate adequate stocks of in-theater air-delivered munitions to ensure suppression of enemy air defenses and achieve air superiority; be able to deploy significant mine-clearing capabilities; and suppress missiles and establish sea control by emplacing cost-effective, active ballistic missile defense systems, as well as conventional ASCM and missile counterforce capabilities.

Democratic People's Republic of Korea

The DPRK's aggressive, risk-taking profile has become a more acute threat to the ROK and Japan now that Pyongyang has acquired nuclear weapons and the means to deliver them to high-priority targets. Poor-quality DPRK conventional forces and sharpened ROK retaliatory policy toward DPRK provocations have raised the escalation risks. To blunt a DPRK invasion requires an improved counter-battery fire (CBF) capability and an improved ability to defend against chemical, biological, radiological, and nuclear attacks. In addition, the following capabilities are required to mitigate the DPRK nuclear threat: enhanced ISR to track nuclear assets; rapid precision strike for missions to kill mobile nuclear transporter-erector-launcher vehicles; aircraft with long dwell times for boost-phase intercept (BPI) technology; multi-layered ballistic missile defenses involving forward-deployed THAAD, Standard Missile-3, Aegis Ashore, Patriot, and BPI systems; and modernized, low-yield, air- or sea-deliverable nonstrategic nuclear weapons.

---

[6] Examples include high-speed anti-radiation missiles, advanced medium-range air-to-air missiles, joint air-to-surface standoff missiles (and their extended-range variants), sensor-fused weapons (under the pre-planned product improvement program), and miniature air-launched decoys.

[7] Mueller, 2014; Shlapak, 2018; Shlapak and Johnson, 2016.

[8] The 2018 NDS, the focus of this report, does not emphasize counterterrorism; instead, it focuses on potential major, conventional warfights. So, although counterterrorism activities will be a continuing source of demand for U.S. and allied activities, these requirements do not figure into the demand signals described here.

Matching Demand and Supply

The four potential warfights identified in the 2018 NDS generate two types of demand signals for future capabilities: signals that affect existing capabilities and signals that relate to new (as yet undeveloped) capabilities. Table 4.2 provides a prioritized summary of the capabilities that translate to these demand signals and the potential warfights that likely require each.

Existing Capabilities

As highlighted in Table 4.2, more tanker aircraft are required for all four potential warfights. In Figure 4.7, we drill down into the Burdensharing Index to show allies' percentage share of total alliance tanker aircraft. The countries furthest to the right along the horizontal axis have the largest number of related aircraft. In this case, all but six allies are clustered on the vertical axis, indicating that those allies have no such capability or equipment. The horizontal red line indicates the boundary that needs to be reached for a country to have an overall burdensharing ratio of 1.00. As described earlier, countries above the red line are contributing more than their percentage share of total alliance GDP to the total burden of providing a collective defense; countries below the red line are not.

Table 4.2
Prioritized Demand Signals, by Potential Warfight

	Potential Warfight			
Capability	**China**	**Russia**	**Iran**	**DPRK**
Required in all four potential warfights				
Forward-deployed munitions (standoff anti-armor, precision-guided artillery)	x	x	x	x
Airfield damage repair	x	x	x	x
Strategic sealift	x	x	x	x
Strategic airlift	x	x	x	x
Tanker aircraft	**x**	**x**	**x**	**x**
High-end long-range, low-observable UAVs (RQ-170)	x	x	x	x
Space-independent UAVs	x	x	x	x
Required in three potential warfights				
LRASM, shorter-range ASCM	x	x	x	
Longer-range, fast-flying anti-radiation missiles (AARGM-ER)	x	x	x	
SHORAD (Indirect Fire Protection Capability – Increment 2, Norway's National Advanced Surface-to-Air Missile System)	x	x	x	
Hardened, dispersed basing	x	x	x	
Special operations forces		x	x	x
Required in two potential warfights				
Air-to-air missiles – extended range (AAM-ERs)	x	x		
Space resiliency measures (stealth, rapid reconstitution, distribution)	x	x		
Cyber or jam-resistant communications	x	x		

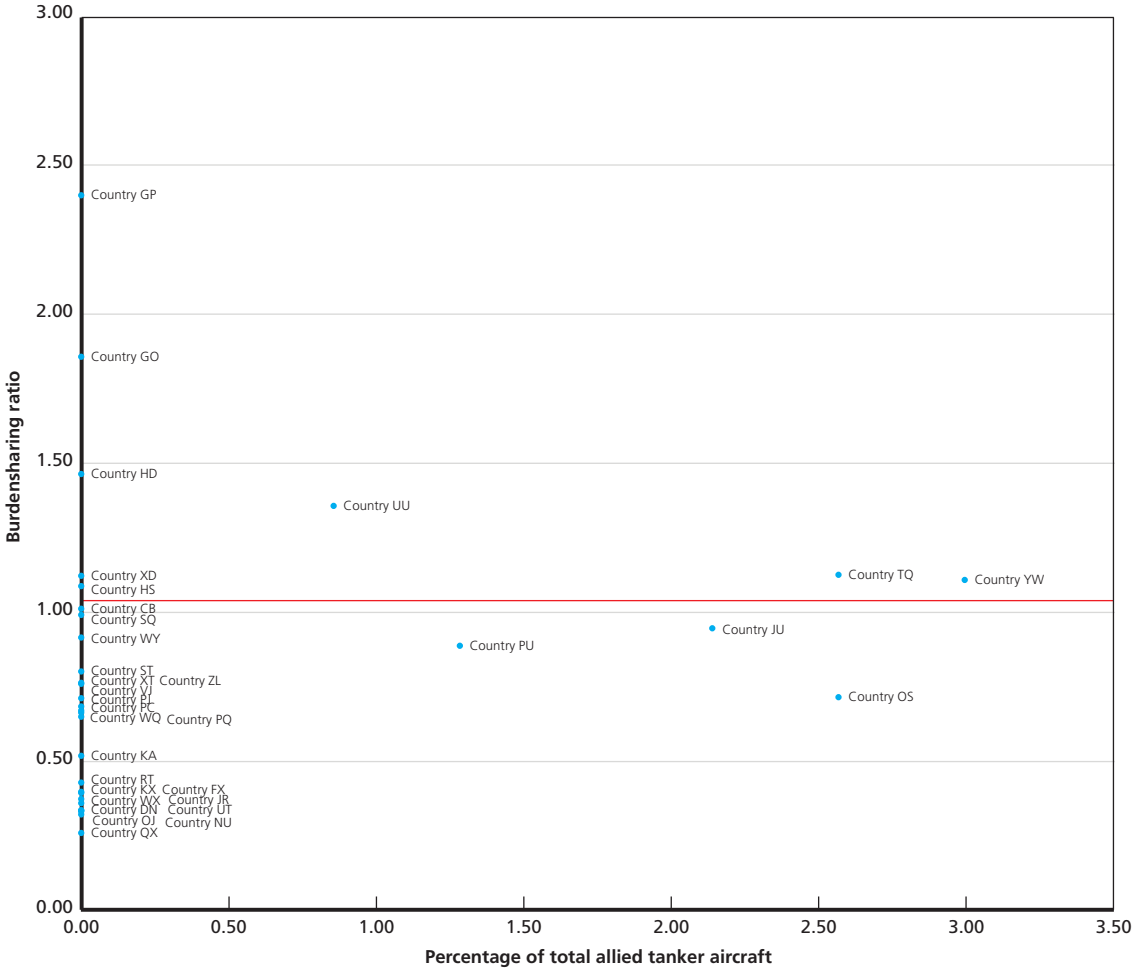
Table 4.2—Continued

Capability	Potential Warfight			
	China	Russia	Iran	DPRK
Low-bandwidth training	x	x		
Standoff attack weapons (joint air-to-surface standoff missile – extended range)	x	x		
CBF and associated radars		x		x
Modern, low-yield, air-deliverable nonstrategic nuclear weapons		x		x
Rapid precision counterstrike force (long-range Army Tactical Missile Systems)		x		x
Active protection for armor		x		x
Low-end ISR aircraft to kill transporter-erector-launcher vehicles (Predator, Reaper, Global Hawk)			x	x
Required in one potential warfight				
Large-diameter unmanned underwater vehicles	x			
Armored brigade combat team equipment sets that are forward-deployed or rotationally deployed (or stationed)		x		
Artillery fire brigades (including forward-deployed)		x		
Corps or armored division headquarters that are forward-deployed for planning purposes		x		
Unattended ground sensors		x		
Mine countermeasure vessels and helicopters			x	
BPI (long-range air-to-air missiles on airframes with high loiter or dwell time)				x
Enhancements to homeland ballistic missile defense (ground-based Interceptors)				x

SOURCES: Boston et al., 2018; Davis et al., 2019; Mueller, 2014; Ochmanek, 2018; Ochmanek et al., 2017; Shlapak, 2018; Shlapak and Johnson, 2016; Smith and Hendrix, 2016.

U.S. decisionmakers can use charts like this to help determine which allies might be asked to invest in which capabilities to satisfy potential warfighting requirements. The best candidate to increase investments will be the ally that (1) is most capable in the area in question (toward the right of the horizontal axis) while (2) having the lowest burdensharing ratio (toward the bottom of the vertical axis). In the case of the tanker aircraft capability represented in Figure 4.7, that country is Country OS. The next-best candidate is the country that has the capability and has the next-lowest burdensharing ratio; in Figure 4.7, that country is Country JU. We would continue in this manner to select Country PU. Because Country YW, Country TQ, and Country UU are already contributing more than their share of total allied GDP to the burden of mounting a collective defense, they are the last countries we would recommend asking for additional investments in tanker aircraft. Effectively, when creating a prioritized list of allies to ask for additional tanker aircraft capabilities, we start with the ally that falls on the bottom-right corner of the chart and systematically work our way toward the top-left corner. To assist further analysis, we assign points to the allies selected in this way. The first ally selected gets ten points, the second gets nine points, and so on.

Figure 4.7
Identifying Candidate Allies That the United States Could Ask to Increase Investments in Tanker Aircraft



NOTES: The burdensharing ratios of outliers Country KF and Country YX have been set to 1.00 in order to maintain a visually useful vertical scale. Those countries do not appear on the chart. The United States' share of tanker aircraft is 88.00 percent.

In Panel A of Table 4.3, we show the results from the exercise just demonstrated, but for seven key existing capabilities (the columns). In each column, the top country listed is the ally that would be the best candidate (highest priority) to make additional investments in that capability area (based on existing capabilities), and that ally is assigned ten points. The bottom country listed represents the lowest-priority ally for that capability area. Not all areas have ten capable allies.

We include the artillery capability to identify which allies might contribute additional artillery fire brigades and the CBF capability and associated radars. We include main battle tanks (MBTs) to identify allies that might contribute further armored brigade combat teams and that might retrofit armored vehicles with reactive armor.

Panel B of Table 4.3 performs a cross-walk of Panel A, sorting the allies by those targeted for the most additional investment requests (at the top) to those targeted for the least (at the

Table 4.3
Identifying Candidate Allies That the United States Could Ask to Increase Investments in Key Existing Military Capabilities

	Airlift	Sealift	Tankers	UAVs	Satellites	Artillery	MBTs	Score
Panel A								
Points								
10	**PJ**	**PJ**	OS	PQ	OS	SQ	OS	
9	OJ	ZL	JU	OJ	OJ	WX	SQ	
8	PU	OS	PU	PU	PU	PC	PC	
7	FX	OJ			FX	OS	WX	
6	WQ	WY				**PJ**	JU	
5	JU	VJ				XT	OJ	
4		PU				JU	**PJ**	
3		WX				PU	PU	
2		PQ				WY	WQ	
1		FX				ST	WY	
Panel B								
Country								
OS		8	10		10	7	10	45
PU	8	4	8	8	8	3	3	42
OJ	9	7		9	9		5	39
PJ	**10**	**10**				**6**	**4**	**30**
JU	5		9			4	6	24
WX		3				9	7	19
SQ						10	9	19
PC						8	8	16
FX	7	1			7			15
PQ		2		10				12
WY		6				2	1	9
ZL		9						9
WQ	6						2	8
VJ		5						5
XT						5		5
ST						1		1

bottom), by total combined score. Within each row, the scores in each column indicate that country's relative priority for the United States in requesting each capability. So, we can tell from Panel B that Country PJ is the fourth-highest priority overall when asking allies to augment existing capabilities, and sealift and airlift are the two most-important existing capabilities that the United States might ask Country PJ to strengthen.

New Capabilities

Table 4.4 shows a prioritized list of 11 potential warfight–related capabilities that are new, not reflected in the Burdensharing Index, or both. The priority scores were derived from the frequency with which these requirements were mentioned in the force posture literature cited earlier. Allies might play a role in providing these capabilities.

In Figure 4.8, the horizontal axis shows each country's share of total allied arms sales, which we use as a proxy measure for the sophistication of an ally's defense industrial base.[9] As before, the vertical axis plots the countries' burdensharing ratios, so allies above the red line are contributing more than their share of total allied GDP to the burden of providing a collective defense.

Our assumption when discussing new capability requirements is that allies will want to participate in the co-development and co-production of these capabilities because doing so could place their civilian and defense industries in an improved position for international competition. We therefore consider co-development and co-production to be incentives that the United States could use to elicit greater allied contributions to the common defense. In this case, the operating principle adopted is to treat co-development and co-production first as a means of rewarding contributors and then as a way of eliciting greater contributions.

In identifying the best candidates for opportunities to co-develop and co-produce new capabilities, we modified the approach that we used for identifying the best candidates to ask to augment existing capabilities (as described earlier).[10] First, we sought to allocate the highest-priority capabilities (from Table 4.4) to countries that contribute more than their share of the

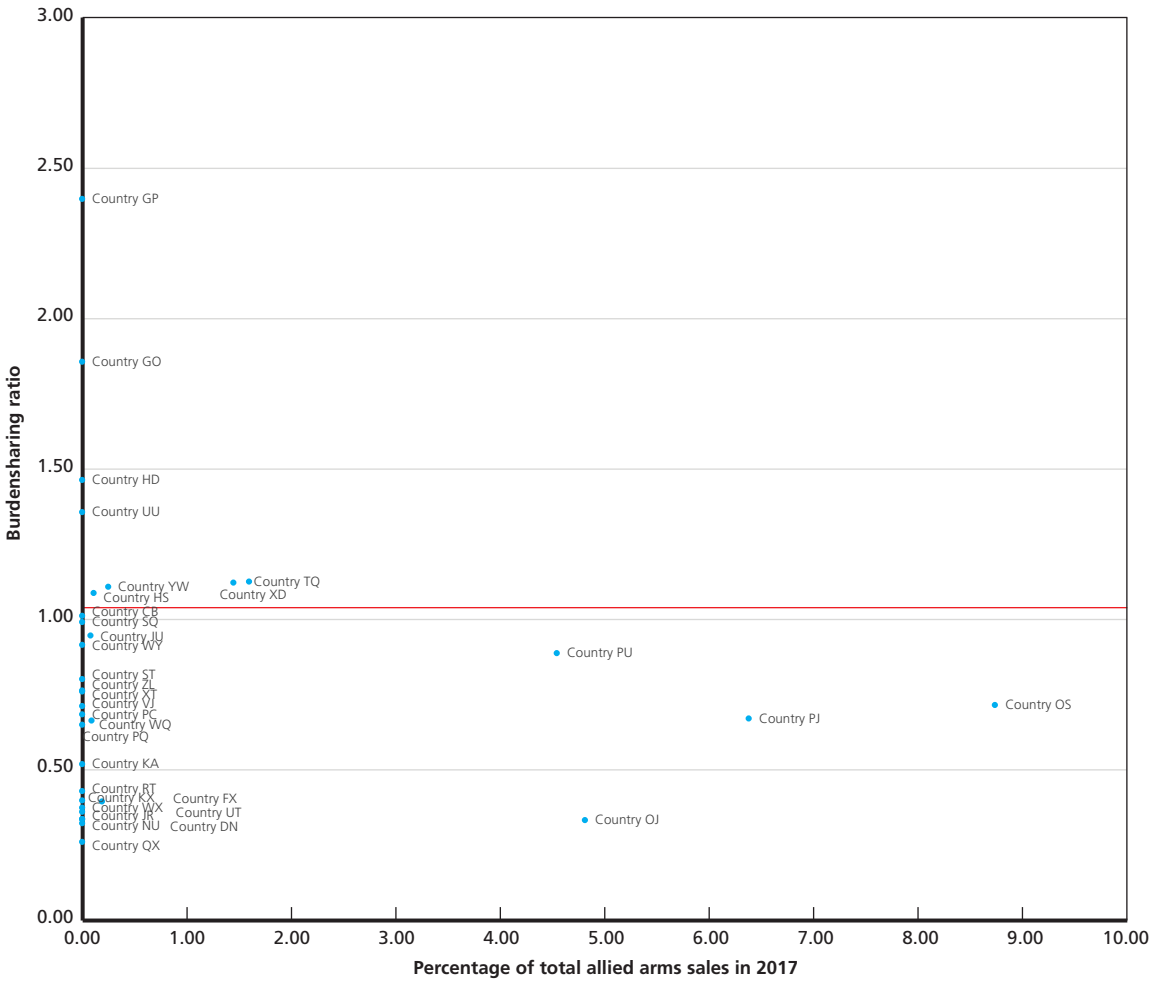
Table 4.4
New Capability Requirements, by Priority

Capability	Score
Improved ISR, including long-range, low-observable, space-independent UAVs	9
Terminal and mobile SHORAD	6
BPI	5
Cruise and long-range anti-ship missiles (ASMs)	4
Smart standoff weapons (LRASMs)	3
AARGM-ERs	3
Improved mine countermeasures	2
AAM-ERs	2
MLRSs with area munitions	2
Improved CBF	1
Aerial mines, including shallow-water, precision-guided mines	1

[9] The arms sale data are for 2017, as reported in Stockholm International Peace Research Institute (SIPRI), "SIPRI Military Expenditure Database," web tool, undated-a.

[10] The approach described here to prioritize countries for new capabilities can serve only as a general guideline. It is not only possible but indeed highly probable that co-development and co-production decisions will ultimately be made as much on the basis of intensive inter-allied bargaining as on the basis of objective factors of the kind described in this report.

Figure 4.8
Identifying Candidate Allies That the United States Could Ask to Increase Investments in New Military Capabilities



burden, such as Country XD and Country TQ. Second, according to the principle previously described, we worked from the bottom right toward the top left of Figure 4.8. We applied two additional filters. First, capabilities that would be of interest only to specific countries were first assigned to those countries. Then, when matching countries and capabilities by moving northwest from the bottom-right quadrant of Figure 4.8, we skipped assigning a capability to the next country in line when we judged that the capability in question would not be of interest to that country.

As before, the first country selected for a given capability was assigned ten points, the second country was assigned nine points, and so on; see Table 4.5 for the results. The table shows that Country OJ, Country PJ, and Country OS are the highest-priority allies for co-development and co-production of new capabilities.

Table 4.5
Identifying Candidate Allies to Co-Develop and Co-Produce New Capabilities

Country	ISR	SHORAD	BPI	ASMs	LRASMs	AARGM-ERs	Mine Counter-measures	AAM-ERs	MLRSs	CBF	Aerial Mines	Score
OJ	10	9		1	8	5	4	6	6	7	8	64
PJ	9	8		10	7	4	3	5	5	6	7	64
OS	8	7		9	10	3	2	4	4	5	6	58
TQ		10		2	9		5	7	7	8	9	57
FX	6	5		7	5	9	10	2	2	3	4	53
PU	7	6		8	6	10	1	3	3	4	5	53
JU	3	2		4	2	6	7	8	9	10	1	52
YW	4	3		5	3	7	8	9	10	1	2	52
WQ	5	4		6	4	8	9	10	1	2	3	52
XD			10	3			6		8	9	10	46

Panel B of Table 4.3 and Table 4.5 can be combined to yield a single prioritized list of capability requests, as reflected in Table 4.6, where these requests have been prioritized both by and within countries. We can see from the table that, because it is in the fourth row, Country PJ is the fourth-highest priority for U.S. requests for additional investment in existing capabilities or co-development and co-production of new capabilities. The scores in each column of the fourth row show that the highest-priority requests of Country PJ are sealift, ASMs, additional ISR, airlift, and SHORAD.

The requests target allies that have already, on their own initiative and for their own reasons, decided to acquire a leading share of total allied capability in areas that the United States would like to augment to better prepare for potential future warfights. Our overriding focus is on making targeted requests of the Tier A and Tier B countries that can serve as regional and global U.S. partners in enforcing the post–World War II international order.

Table 4.6
Prioritized Burdensharing Requests of Allies

	Existing Capabilities							New Capabilities											
Country	Airlift	Sealift	Tankers	UAVs	Satellites	Artillery	MBTs	ISR	SHORAD	BPI	ASMs	LRASMs	AARGM-ERs	Mine Counter-Measures	AAM-ERs	MLRSs	CBF	Aerial Mines	Score
OJ	9	7		9	9		5	10	9		1	8	5	4	6	6	7	8	103
OS		8	10		10	7	10	8	7		9	10	3	2	4	4	5	6	103
PU	8	4	8	8	8	3	3	7	6		8	6	10	1	3	3	4	5	95
PJ	**10**	**10**				**6**	**4**	**9**	**8**		**10**	**7**	**4**	**3**	**5**	**5**	**6**	**7**	**94**
JU	5		9			4	6	3	2		4	2	6	7	8	9	10	1	76
FX	7	1			7			6	5		7	5	9	10	2	2	3	4	68
WQ	6						2	5	4		6	4	8	9	10	1	2	3	60
TQ									10		2	9		5	7	7	8	9	57
YW								4	3		5	3	7	8	9	10	1	2	52
XD										10	3			6		8	9	10	46
WX		3				9	7												19
SQ						10	9												19
PC						8	8												16
PQ		2		10															12
WY		6				2	1												9
ZL		9																	9
VJ		5																	5
XT						5													5
ST						1													1

CHAPTER FIVE

Conclusion

The Burdensharing Index that we constructed shows that the United States clearly is the dominant contributor and contributes more than its share of total allied GDP to the alliance system whose purpose is to defend and enforce the post–World War II liberal international order in Europe and Asia. However, that is far from the whole picture. Although there is room for improvement among all allies (particularly those in Asia), the United States bears only slightly less than half of the total burden of providing the collective defense. The European and Asian allies supply a greater share of total allied personnel and ground forces than the United States does, whereas the United States supplies a greater share of total allied air forces, naval forces, and C4ISR. Of the 35 allies examined in this report, seven fall into Tier A (provide more than 3 percent of the total allied burden), five fall into Tier B (provide between 2 percent and 3 percent), and 23 fall into Tier C (provide less than 2 percent). Three of the seven Tier A allies can be considered Tier 1 contributors, as defined in this report. Among the 35 allies, 11 fall into Tier 1 (burdensharing ratio is at least 1.00), five fall into Tier 2 (burdensharing ratio is at least 0.80 but less than 1.00), and 19 fall into Tier 3 (burdensharing ratio is less than 0.80).

Policy Options

When we group allies into nine categories based on their burdensharing index scores and their burdensharing ratios (see the taxonomy in Table 4.1), three potential policy priorities emerge: urgent measures, selective upgrades, and targeted requests.

Urgent Measures

As calculated in the version of the Burdensharing Index in this report, a major ally and four frontline states fall into the lowest category of capability and contribution (C3). These countries have relatively limited capabilities, and their share of the burden amounts to less than their share of total alliance GDP. If these findings hold even after some of the index's limitations are addressed and after closer scrutiny on a nation-by-nation basis, a policy option of taking urgent measures to redress these shortcomings could be appropriate.

Selective Upgrades

Three further frontline states fall into Tier C of allied military capabilities. The United States might seek consensus among its allies about the need to assist those states to move from Tier C to Tier B. In both of these first two policy options (urgent measures and selective upgrades), DoD might identify affordable upgrades that it could field in these states

(with support from the local armed forces) that would significantly improve their defense postures in the context of combined operations with allies. For example, DoD could deploy unattended ground sensors and jam-resistant data links and provide underwater sensors to improve maritime domain awareness.[1]

Targeted Requests

Prior research has identified the military capability and technology requirements for the potential warfights noted in the NDS.[2] The Burdensharing Index allows us to drill down to the level of individual capabilities. Although the index's primary and stand-alone purpose is one of measurement, we can use the index to match NDS-generated demand signals with allied supplies of military capabilities. Doing so allows us to identify (1) targeted requests for investment in existing capabilities that the United States can ask of capable, wealthy, under-contributing allies and (2) opportunities for allies to co-develop and co-produce new capabilities, all of which are designed to help achieve the goals articulated in the 2018 NDS (see Table 4.6).

Recommendations

In Chapter Two, we identified five approaches that might elicit greater allied contributions to the collective defense and help the United States achieve these policy options. Those approaches are updating alliance treaties and associated architecture, unbundling the collective defense good (to exploit excludability and rivalry), using assurance contracts, benchmarking allied performance, and segmenting allied defense contractors.

As we noted earlier, these potential methods for achieving the policy options are very difficult to implement, but there appear to be few alternatives if policymakers truly wish to mitigate the free-rider problem, achieve a more equitable division of labor, and reflect the ways in which the economic and strategic balance have changed since the end of World War II.

Our primary recommendation in this report is that DoD should systemize the Burdensharing Index methodology presented here to develop an analytically informed, policy-relevant, and enduring approach for incentivizing greater allied contributions. In addition, DoD should populate the index with data biennially to provide an improved basis on which to formulate policies toward key allies. As part of such an effort, DoD should take the following steps to remedy some of the shortcomings in the Burdensharing Index:

- Administer the surveys of differing levels of allied force quality and combat proficiency (included in Appendix C).
- Mount a systematic effort to measure host-nation support.
- Include measures of allied diplomatic conflict prevention and conflict management efforts.
- Agree with allies on common definitions of *deployability* and *sustainability*, and gather consistent and complete data for all allies.

---

[1] Ochmanek, 2018; Ochmanek et al., 2017.

[2] Boston et al., 2018; Davis et al., 2019; Mueller, 2014; Ochmanek, 2018; Ochmanek et al., 2017; Shlapak, 2018; Shlapak and Johnson, 2016; Smith and Hendrix, 2016.

- Conduct a complete gravity-method analysis of net exports lost as a result of UN sanctions.
- Construct freedom-of-movement measures and gather joint billet data for the Pacific theater, using existing NATO and U.S. methodologies.
- Extend the data set to include other important partners and de facto allies.
- Gather longitudinal data that would allow the analysis of historical trends.
- Include functionality to enable a focus on a single region or potential adversary, such as China or Russia.
- Perhaps most importantly, initiate an effort alongside allies to socialize and refine the Burdensharing Index's methodology, data categorization, and data collection.

Once the Burdensharing Index is updated to reflect such data, the analysis described in this report could be performed again to yield an updated, more-refined, and potentially more-reliable set of conclusions and policy recommendations.

As noted, the Burdensharing Index presented here is an abstraction from reality that suffers from shortcomings but can serve as a point of departure for further analysis. Policymakers should resist the temptation to depict the allied burdensharing index scores and burdensharing ratios that the index generates as definitive stand-alone judgments about the contributions of any single U.S. ally or group of U.S. allies. The index serves as an exploratory tool that can only assist in the judgment and critical thinking required to address such an inherently complex, politically sensitive issue as burdensharing.

APPENDIX A

Definition of the Burdensharing Index

As described in the main report, we developed a nested, multi-attribute Burdensharing Index that allows policymakers and other stakeholders to perform a more sophisticated exploration of allied burdensharing than is possible when focusing on an isolated statistic (e.g., defense spending as a percentage of GDP).

When selecting factors and metrics to be included in the index, we had five chief criteria. Two of the five relate to data access: The metrics had to be complete and accurate, and obtaining the data had to be cost-effective. These criteria necessarily limited some aspects of the index's design. For example, we excluded information on deployability and sustainability because readily accessible, official data were unreliable or incomplete. Host-nation support funding, cyberspace forces, and spending on the services of nondefense intelligence organizations were excluded for similar reasons. Next, we required that the index's measures be comparable across the allies examined in this study. The main military capabilities omitted from the index as a result of this criterion are nuclear weapons and their delivery systems.[1] Next, we sought to include measures of allied national security and defense establishments that were relevant to 2018 NDS objectives.[2] And finally, we sought to create an index that was parsimonious rather than overly broad or complicated; doing so allows the index to be relatively straightforward and accessible to policymakers.

The baseline scheme by which we weighted factors and metrics in the index favors simplicity. Unless a compelling rationale existed to elevate the importance of any factor or metric over others, all hold equal weight. For example, the input and output factors each contribute 50 percent toward the top-level burdensharing index score. As an example, at a lower level in the index's structure, the ground forces factor comprises one metric each to account for each nation's share of total allied MBTs, mechanized vehicles, helicopters, and artillery. Each of these four metrics accounts for 25 percent of the ground forces factor's value. In a couple of instances, unique circumstances or NDS-specific considerations caused us to use an adjusted weighting scheme; where we divert from equal weighting, we note it in this appendix.

[1] Only three of the 35 allies examined possess nuclear weapons, and only a handful of the others provide dual-capable aircraft capable of delivering low-yield nonstrategic nuclear weapons. Although other allies provide infrastructure and support that enable an effective deterrent posture, the complexity of these issues makes it impractical to compare related metrics in an index.

[2] For example, we excluded information about allied overseas development assistance. Although promoting growth and opportunity in the developing world represents an aspect of collective security, it does not maintain, in any direct sense, a high degree of relevance to the potential warfights identified in the NDS.

Input Factors, Metrics, and Weights

Table A.1 provides an overview of the input factors and metrics included in the Burdensharing Index. The measure for military expenditures, either as a stand-alone figure or as a percentage of GDP, is the measure most closely associated with the burdensharing debate from the late 1940s to the present. Because we adjust for countries' relative wealth using the other top-level measure, the burdensharing ratio, we include each ally's share of total absolute alliance military expenditures. We also include major equipment spending, given the trend in some militaries to overspend on personnel and underspend on major equipment, which includes research and development.[3] As with other aspects of this index, these two factors are not mutually exclusive—major equipment expenditures are included in overall military expenditures. These items are grouped together as defense financial inputs.

The metrics discussed so far relate to government defense expenditures, but allies may also contribute to the burden of collective defense through economic and other policy choices; sanctions imposed on a competitor or adversary represent arguably the foremost example. When a group of states imposes sanctions on an adversary, some states will forgo more net trade income than others will. If the intent of the sanctions relates to modifying an opponent's behavior in the security sphere, then voluntarily disengaging from trade could be considered an important contribution to collective defense.[4] We assessed the share of net exports lost as a result of UN sanctions on Russia and Iran. There are 11 UN sanctions regimes in force, but

Table A.1
Input Factors and Metrics

Factor	Factor	Metric
Defense financial inputs	Military expenditures	• Share of total allied military expenditure
	Major equipment expenditures	• Share of allied military expenditure on major equipment only
	Host-nation support	
Nondefense financial inputs	Peacekeeping operations	• Share of allied dollar contributions to UN peacekeeping operations
	Share of lost exports	• Share of total allied net exports lost as a result of UN sanctions imposed on Russia
		• Share of total allied net exports lost as a result of UN sanctions imposed on Iran

NOTE: Factors in gray are not incorporated into the Burdensharing Index presented in this report.

[3] Data on major equipment expenditures were unavailable for the seven Asian allies. Data for the 28 NATO countries were taken from NATO, 2019a.

[4] For a discussion about using forgone trade as a burdensharing metric and a summary of recent forgone trade with Russia and Iran, see Kathleen H. Hicks, Jeffrey Rathke, Seamus P. Daniels, Michael Matlaga, Laura Daniels, and Andrew Linder, *Counting Dollars or Measuring Value: Assessing NATO and Partner Burden Sharing*, Washington, D.C.: Center for Strategic and International Studies, July 2018, pp. 21–26.

we chose these two because they are arguably the most consequential to maintaining the international order in Europe and the Middle East. We did not include sanctions on the DPRK, because there were no available data on the pre-sanctions baseline level of bilateral trade, so we could not calculate forgone allied trade revenue.

In addition to participating in sanctions, states can make a policy choice to contribute to UN peacekeeping operations, which help defend the international order. The peacekeeping operations metric included in the Burdensharing Index represents each ally's percentage contribution to the total absolute dollar value of all 35 allies' contributions to these operations.[5]

For these nondefense financial inputs, we divert from equal weighting and use a baseline scheme of 10 percent for peacekeeping operations and 90 percent for share of lost exports. This weighting reflects the ratio of the absolute dollar value of allied peacekeeping operation contributions to the estimated absolute dollar value of total allied net export earnings forgone as a result of sanctions on Russia and Iran.

Output Factors, Metrics, and Weights

The two major factors that feed into the outputs factor in the Burdensharing Index are preparedness and deployments. Preparedness represents military preparedness as a function of personnel, ground forces, air forces, naval forces, military mobility, and C4ISR. We weight preparedness at 75 percent and deployments at 25 percent. Although contributions to ongoing operations (the lone subfactor for deployments) provide tangible contributions to collective security, this index is primarily based on allies' preparedness to contribute to the four potential warfights identified in the 2018 NDS.

Table A.2 provides an overview of the output factors and metrics included in the Burdensharing Index. When measuring personnel, we use active-duty forces because reserves are not easily comparable. We discount conscripted troop numbers to reflect their lower quality. We also include joint command billets, which represent an important qualitative aspect of a defense alliance—the ability to operate effectively as part of a joint allied command structure—and therefore merit inclusion in the index.

[5] The primary source for data on UN peacekeeping operation expenditures was United Nations General Assembly, "Approved Resources for Peacekeeping Operations for the Period from 1 July 2018 to 30 June 2019," New York, A/C.5/71/24, June 30, 2017.

Table A.2
Output Factors and Metrics

Factor	Factor	Metric
Preparedness		
Personnel	Active-duty forces	• Share of allied active-duty forces (discounted for conscription)
	Joint command billets	• Share of allied joint command billets
Ground forces	Numbers of ground forces	• Share of allied MBTs (age-adjusted) • Share of allied mechanized vehicles (age-adjusted) • Share of allied helicopters (excludes non-army systems) • Share of allied artillery (excludes mortars)
	Quality of ground forces	• Technology rating • Training rating • Sustainability rating • Interoperability rating
Air forces	Numbers of air forces	• Share of allied tactical aircraft (adjusted for age and training hours) • Share of allied airborne early warning aircraft • Share of allied tanker aircraft • Share of allied transport aircraft
	Quality of air forces	• Technology rating • Training rating • Sustainability rating • Interoperability rating
Naval forces	Numbers of naval forces	• Share of allied aircraft carriers • Share of allied tactical naval aircraft (excludes rotary wing) • Share of allied tactical submarines • Share of allied anti-submarine warfare aircraft (excludes rotary wing) • Share of allied capital ships (cruisers, destroyers, frigates) (age-adjusted) • Share of allied heavy amphibious ships
	Quality of naval forces	• Technology rating • Training rating • Sustainability rating • Interoperability rating
Military mobility		• Share of allied strategic airlift aircraft • Share of total allied deadweight strategic sealift tonnage • Freedom of movement • Ground accessibility • Air • Sea accessibility • Diplomatic clearance times
C4ISR		• Satellites (ISR, electronic intelligence, surveillance, early warning) • ISR aircraft • Airborne early warning aircraft • Heavy UAVs
Deployments		
Contributions to ongoing operations		• Share of allied personnel deployed, respectively, to AFRICOM, CENTCOM, EUCOM, NORTHCOM, PACOM, and SOUTHCOM areas of responsibility

NOTE: Factors and metrics in gray are not incorporated into the Burdensharing Index presented in this report.

The two subordinate factors for ground forces relay a sense of an ally's share of the total quantity of a particular capability (numbers of ground forces) and how well that capability could be employed in combat (quality of ground forces). MBTs and mechanized vehicles are age-adjusted; age is used here as a proxy for capability (i.e., older equipment is considered less capable).

Analysts may assess the quality of ground forces on a spectrum.[6] At one end, less-capable militaries are able to perform simple functions in relatively permissive environments. At the other end of the spectrum, advanced militaries possess the warfighting competencies necessary to execute sophisticated tasks in challenging conditions. Given the inherent complexity involved in identifying where on such a spectrum a given ally's military may reside, we developed but did not administer separate survey instruments for the three force types considered: ground, air, and naval.[7] For each type of force, we designed a survey instrument that experts can use to define the quality of allied forces (i.e., combat proficiency) across four dimensions: technology, training, sustainability, and interoperability. Technology reflects the kinds of systems that an ally possesses and their level of modernity. Training conveys the scale and complexity of operations that an ally's armed forces are prepared for. Sustainability indicates the forces' degree of self-reliance and logistical capacity, including the ability to maintain and deploy ready units. Finally, interoperability indicates the forces' compatibility and aptitude for operations with coalition partners. As explained in Chapter One, the quality-based factors and metrics were not incorporated in the version of the Burdensharing Index included in this report.[8]

The two subordinate factors for air forces relay a sense of an ally's share of the total quantity of a particular capability (numbers of air forces) and how well that capability could be employed in combat (quality of air forces). We include tactical aircraft (fighters, bombers, and multi-role), airborne early warning aircraft, tanker aircraft, and transport aircraft. In an attempt to capture differences in quality, we adjust total tactical aircraft numbers both by average aircraft age and by average training hours. Airborne early warning aircraft are deliberately double-counted in the Burdensharing Index (as part of air forces and C4ISR) because they serve two functions:

- an airborne control function that is a force multiplier in coordinating activities and in establishing the effective number of allied aircraft that are aloft at any time
- an early warning function that is an important component of C4ISR.

The share of total allied transport aircraft counted here reflects the total number of platforms available to transport freight by air. (The military mobility factor describes those airframes' degree of access to the desired airspace.) To assess the quality of allied air forces, we use

---

[6] The concept of a spectrum for the quality of military forces is borrowed from Michael D. Swaine and Ashley J. Tellis, *Interpreting China's Grand Strategy: Past, Present, and Future*, Santa Monica, Calif.: RAND Corporation, MR-1121-AF, 2000; and Ashley J. Tellis, Janice Bially, Christopher Layne, Melissa McPherson, and Jerry M. Sollinger, *Measuring National Power in the Postindustrial Age: Analyst's Handbook*, Santa Monica, Calif.: RAND Corporation, MR-1110/1-A, 2000.

[7] Although the terms *ground*, *air*, and *naval* relate to both force types and domains, there is a conceptual difference between these. For example, aircraft operating from ships are designed to be employed in the air domain but belong to a naval force. For the purposes of this questionnaire, we consider quality and proficiency by force type, not domain.

[8] For further details on the survey instruments, see Appendix C.

the same approach as that described for ground forces (and those metrics are not incorporated into this version of the index).

The two subordinate factors for naval forces relay a sense of an ally's share of the total quantity of a particular capability (numbers of naval forces) and how well that capability could be employed in combat (quality of naval forces). We include aircraft carriers, tactical naval aircraft, tactical submarines, anti-submarine warfare aircraft, capital ships (cruisers, destroyers, and frigates), and heavy amphibious ships. Capital ship numbers are adjusted for age. Because of the preeminent role of carrier operations in naval warfighting doctrine and the complexity of such operations, we double-weight carriers and carrier-based tactical aircraft versus other forces. To assess the quality of naval forces, we use the same approach as that described for ground and air forces (and those metrics are not incorporated into this version of the index).

Within the military mobility factor, the metrics for the share of total allied strategic airlift aircraft and the share of total allied deadweight strategic sealift tonnage are designed to measure the strategic lift resources that each ally and the alliance as a whole can bring to bear. As the buildup to the 1991 war to liberate Kuwait revealed, it can take months to transport division-size equipment sets by sea from the United States to a crisis region. Strategic airlift resources that can move global reaction forces to a crisis region expeditiously are therefore highly valued. For this reason, we attach double the weight to strategic airlift (50 percent) that we attach to strategic sealift (25 percent). The remaining 25 percent of the military mobility factor comes from a freedom-of-movement score. This score is an equally weighted measure of freedom of access to the road (ground) transport network, airports, and seaports.[9]

The C4ISR factor consists of four metrics: share of total allied satellites, share of total allied ISR aircraft, share of total allied airborne early warning aircraft, and share of total allied heavy UAVs. As explained earlier, airborne early warning aircraft are deliberately double-counted (here and as part of air forces) because of the dual role that they perform.

The index represents deployments using a single factor: contributions to ongoing operations, measured as the share of allied personnel sent to each of the six combatant command areas of responsibility. Share of personnel was chosen as the sole metric for these contributions because the numbers of such personnel are comparable across allies. The allied aircraft and naval vessels contributed vary not just in numbers but also in quality and are therefore not strictly comparable.

The data presented in this report have been double- and, in some cases, triple-checked. Our results are most sensitive to countries' share of total allied net exports lost as a result of UN sanctions imposed on Russia and Iran, the discount applied to conscripted active-duty personnel numbers, and aspects of military preparedness—principally, C4ISR and military mobility. Errors in single data points outside of the first two of these key drivers are unlikely to materially alter the country rankings or overall findings of this report. We present a limited number

[9] The freedom-of-movement score also notionally includes a metric for diplomatic clearance times, which represents the number of days it usually takes an allied government to grant diplomatic clearance for the transit of military units or equipment across its territory. In other words, the metric represents the delay occasioned by the need to receive such clearance. This metric is not included in the current version of the Burdensharing Index.

Note also that freedom-of-movement scores were available only for the European theater; thus, in this index, such scores for the seven Asian allies and the United States are set to the European (NATO) average. In a future iteration of the index, freedom-of-movement scores could be constructed for each of the Asian allies based on the objective conditions in those countries. The lack of full freedom-of-movement scores is another reason to treat the results of this iteration of the Burdensharing Index with caution when considering policy options.

of counterintuitive results, and the majority of those results are accounted for by the fact that, when calculating countries' share of the burden of mounting a collective defense, we chose to include the exports that countries lost as a result of sanctions.

Calculating the Burdensharing Index Score

The Burdensharing Index's primary outcome measure is each ally *i*'s percentage share of the total burden of providing a collective defense (B_i). We calculate the scores, and most other measures in the index, to be values between 0.00 and 1.00, which we multiply by 100 to get the percentage. In aggregate, the individual burdensharing index scores of the United States and the 35 European and Asian allies under scrutiny in this report sum to 1.00 (or 100 percent). That is,

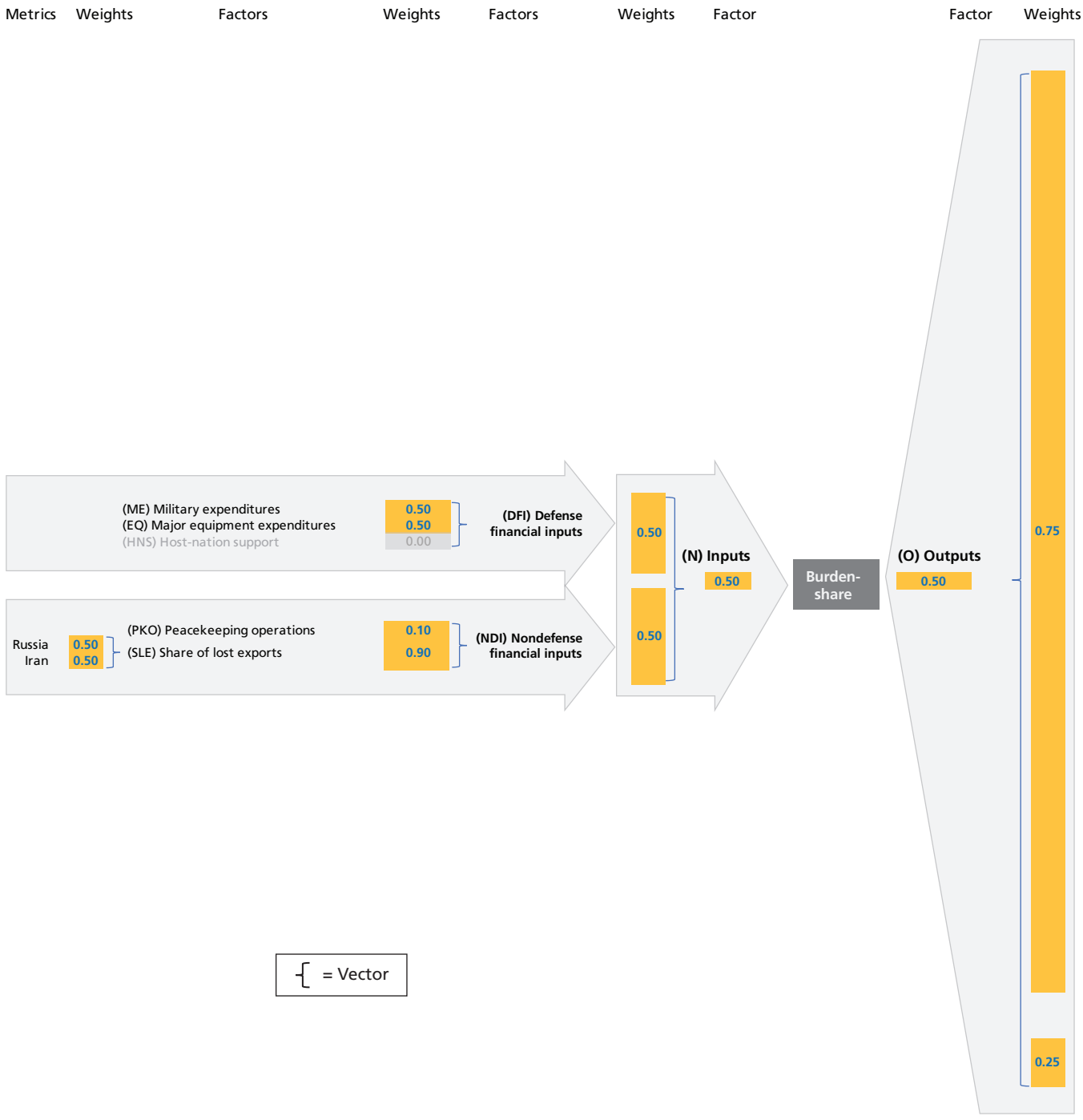
$$\sum_{i=1}^{36} B_i = 1.00. \tag{A.1}$$

This holds true at each of the subordinate levels of the nested Burdensharing Index. For example, all 36 countries' shares of the total inputs to providing a collective defense sum to 100 percent, as do all countries' shares of the total outputs. Because all of these measures sum to 100, they can be subtotaled to allow comparison of regional contributions to the total burden of providing a collective defense.

Generic Index Specification

We now provide a formal mathematical definition of the Burdensharing Index structure and the baseline weights used for each of the metrics and factors that constitute the index; a diagram of the index is given in Figure A.1. Table A.3 summarizes the variables and parameters used in calculating the index.

Figure A.1
Full Structure and Weights of the Burdensharing Index



NOTE: Factors and metrics in gray are not incorporated into the Burdensharing Index presented in this report.

Figure A.1—Continued

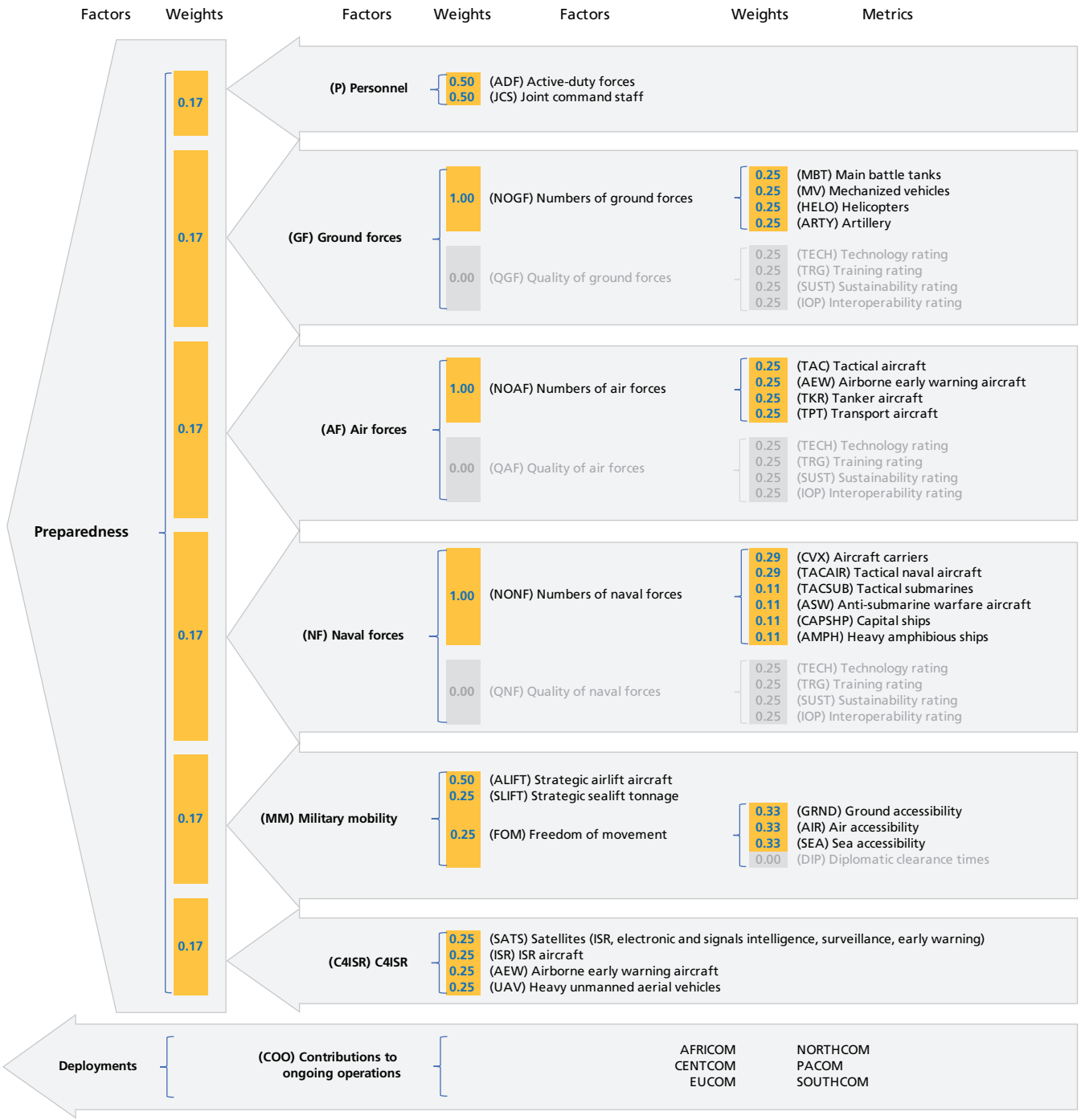


Table A.3
List of Variables and Parameters

Variable	Definition	Domain
N	Value of all inputs	$\mathbb{R}$
O	Value of all outputs	$\mathbb{R}$
X_F	Value of financial input factors	$\mathbb{R}$
$X_{F'}$	Value of nonfinancial input factors	$\mathbb{R}$
Y_i	Output factors such that $i = \{P, GF, AF, NF, NUC, MM, COO\}$	$\mathbb{R}$
d	Defense financial inputs	$\mathbb{R}^n$
d'	Nondefense financial inputs	$\mathbb{R}^n$
δ	Defense financial input factors	$\mathbb{R}^n$
δ'	Nondefense financial input factors	$\mathbb{R}^n$
f	Financial inputs	$\mathbb{R}^n$
f'	Nonfinancial inputs	$\mathbb{R}^n$
$\mathbf{x}$	Input vector	$\mathbb{R}^n$
$\mathbf{y}$	Output vector	$\mathbb{R}^n$
Ω_d	Weights on defense financial input factors	$\mathbb{R}^n$
$\Omega_{d'}$	Weights on nondefense financial input factors	$\mathbb{R}^n$
Ω_δ	Weights on defense financial inputs	$\mathbb{R}^n$
$\Omega_{\delta'}$	Weights on nondefense financial inputs	$\mathbb{R}^n$
$\Omega_{f'}$	Weights on nonfinancial inputs	$\mathbb{R}^n$
Ω_x	Weights on inputs	$\mathbb{R}^n$
Ω_y	Weights on outputs	$\mathbb{R}^n$
x_d	Individual defense input, $x_d \in \mathbf{d}$	$\mathbb{R}$
$x_{d'}$	Individual nondefense input, $x_{d'} \in \mathbf{d'}$	$\mathbb{R}$
x_i^δ	Individual defense input factor, $x_i^\delta \in \boldsymbol{\delta}$	$\mathbb{R}$
$x_i^{\delta'}$	Individual nondefense input factor, $x_i^{\delta'} \in \boldsymbol{\delta'}$	$\mathbb{R}$
$x_i^{f'}$	Individual nonfinancial input factor, $x_i^{f'} \in \mathbf{f'}$	$\mathbb{R}$
ω_d	Weight on defense financial inputs, $\omega_d \in \boldsymbol{\Omega}_\mathbf{d}$	$\mathbb{R}^n$
$\omega_{d'}$	Weight on nondefense financial inputs, $\omega_{d'} \in \boldsymbol{\Omega}_{\mathbf{d'}}$	$\mathbb{R}^n$
ω_i^δ	Weight on defense financial input factors, $\omega_i^\delta \in \boldsymbol{\Omega}_\delta$	$\mathbb{R}^n$
$\omega_i^{\delta'}$	Weight on nondefense financial input factors, $\omega_i^{\delta'} \in \boldsymbol{\Omega}_{\delta'}$	$\mathbb{R}^n$
$\omega_i^{f'}$	Weight on nondefense financial input factors, $\omega_i^{f'} \in \boldsymbol{\Omega}_{\mathbf{f'}}$	$\mathbb{R}^n$

In participating in a collective defense, a country can contribute financial inputs that are part of its formal defense budget (d) and financial inputs that are not part of the defense budget (d'). We calculate the value of these financial input factors F as follows:

$$X_F = \begin{bmatrix} \omega_d \\ \omega_{d'} \end{bmatrix}^T \begin{bmatrix} x_d \\ x_{d'} \end{bmatrix} = \mathbf{\Omega}_{\mathbf{f}} \times \mathbf{f}. \tag{A.2}$$

Input factors x_d and $x_{d'}$ are calculated from a weighted sum of metrics, as follows:

$$x_d = \begin{bmatrix} \omega_1^{\delta} \\ \omega_2^{\delta} \\ \vdots \\ \omega_n^{\delta} \end{bmatrix}^T \begin{bmatrix} x_1^{\delta} \\ x_2^{\delta} \\ \vdots \\ x_n^{\delta} \end{bmatrix} = \mathbf{\Omega}_{\boldsymbol{\delta}} \times \boldsymbol{\delta} \text{ and } x_{d'} = \begin{bmatrix} \omega_1^{\delta'} \\ \omega_2^{d'} \\ \vdots \\ \omega_n^{\delta'} \end{bmatrix}^T \begin{bmatrix} x_1^{\delta'} \\ x_2^{\delta'} \\ \vdots \\ x_n^{\delta'} \end{bmatrix} = \mathbf{\Omega}_{\boldsymbol{\delta}'} \times \boldsymbol{\delta}'. \tag{A.3}$$

Similarly, a country can contribute nonfinancial inputs. We estimate the weighted value of nonfinancial inputs, F', as a function of a vector of nonfinancial contributions, $\mathbf{f'}$, as follows:

$$X_{F'} = \begin{bmatrix} \omega_1^{f'} \\ \omega_2^{f'} \\ \vdots \\ \omega_n^{f'} \end{bmatrix}^T \begin{bmatrix} x_1^{f'} \\ x_2^{f'} \\ \vdots \\ x_n^{f'} \end{bmatrix} = \mathbf{\Omega}_{\mathbf{f}'} \times \mathbf{f}'. \tag{A.4}$$

Using Equations A.2 and A.4, the value of all inputs, N, is determined as follows:

$$N = \begin{bmatrix} \omega_n \\ \omega_{n'} \end{bmatrix}^T \begin{bmatrix} X_F \\ X_{F'} \end{bmatrix} = \mathbf{\Omega}_{\mathbf{x}} \times \mathbf{x}. \tag{A.5}$$

Furthermore, a country's contribution toward a collective defense comes in the form of military preparedness. Preparedness (Π) is a combination of the following output factors: personnel (P), ground forces (GF), air forces (AF), naval forces (NF), military mobility (MM), and C4ISR ($C4ISR$). Similar to how we calculate input factors X_F and $X_{F'}$ in Equations A.2 and A.4, we determine the value of output factors as follows:

$$Y_i = \mathbf{\Omega}_{\mathbf{y}} \times \mathbf{y} \;\forall\; i = \{P, GF, AF, NF, MM, C4ISR\}. \tag{A.6}$$

Note that Equation A.6 represents six different equations, where the value of personnel, ground forces, air forces, naval forces, military mobility, and C4ISR outputs are each the product of a vector of weights $\mathbf{\Omega}_{\mathbf{y}}$ and a vector of output factors $\mathbf{y}$. We also add the deployments factor, represented by contributions to ongoing operations (*COO*). Then, using Equation A.6, the value of all outputs, *O*, is determined as follows:

$$O = \begin{bmatrix} \omega_{P} \\ \omega_{GF} \\ \omega_{AF} \\ \omega_{NF} \\ \omega_{MM} \\ \omega_{C4ISR} \\ \omega_{COO} \end{bmatrix}^{T} \begin{bmatrix} Y_{P} \\ Y_{GF} \\ Y_{AF} \\ Y_{NF} \\ Y_{MM} \\ Y_{C4ISR} \\ Y_{COO} \end{bmatrix} = \mathbf{\Omega}_{\mathbf{y}} \times \mathbf{y}. \tag{A.7}$$

Additionally, we assume that all weights ω sum to 1, such that

$$\mathbf{I}\mathbf{\Omega}_{i} = \mathbf{I}. \tag{A.8}$$

Thus, from Equations A.5 and A.7, we can estimate a country's burdensharing index score (B_i) as an index of inputs *N* and outputs *O* as follows:

$$B_{i} = \begin{bmatrix} \omega_{N} \\ \omega_{O} \end{bmatrix}^{T} \begin{bmatrix} N \\ O \end{bmatrix} = \mathbf{\Omega}_{\mathbf{b}} \times \mathbf{b}, \tag{A.9}$$

where $\mathbf{b}$ is the vector of burdens and $\mathbf{\Omega}_{\mathbf{b}}$ is the vector of weights on those burdens. The calculation of the burdensharing index score (B_i) in Equation A.9 is general; it is agnostic to which input and output factors are used and what their assigned weights should be.

Detailed Index Specification

In this section, we offer an initial set of factors, metrics, and weights to consider. First, we provide a list of input factors and metrics. The defense financial inputs (*DFI*) factor includes each ally's share of total alliance military expenditures (*ME*), major equipment expenditures (*EQ*), and host-nation support (*HNS*). The nondefense financial inputs (*NDI*) factor comprises the share of total allied peacekeeping operations (*PKO*) and the share of lost exports as a result of UN sanctions (*SLE*). Thus, each input is given as follows:

$$DFI = \begin{bmatrix} ME \\ EQ \\ HNS \end{bmatrix}, \text{ and } NDI = \begin{bmatrix} PKO \\ SLE \end{bmatrix}. \tag{A.10}$$

Input factors *DFI* and *NDI* are calculated from a weighted sum of defense budget and nondefense budget metrics as follows:[10]

$$DFI = \begin{bmatrix} 0.50 \\ 0.50 \\ 0.00 \end{bmatrix}^T \begin{bmatrix} ME \\ EQ \\ HNS \end{bmatrix}, \text{ and } NDI = \begin{bmatrix} 0.10 \\ 0.90 \end{bmatrix}^T \begin{bmatrix} PKO \\ SLE \end{bmatrix}. \quad \text{(A.11)}$$

As of 2020, the UN imposes economic sanctions on 11 countries.[11] One way of measuring the trade lost as a result of the sanctions is to use a general equilibrium gravity framework to estimate what the trade flows between countries would have been in the absence of sanctions and compare those theoretical projected flows with actual flows. Julian Hinz estimated the value of trade lost when sanctions were imposed on Russia, Iran, and Myanmar in this manner.[12] Unfortunately, Hinz's estimates do not extend to all 35 U.S. allies under consideration in this analysis, making alliance-wide comparisons impossible. We deliberately employ a cursory or naïve-analysis approach to estimate the share of total exports lost by allies when imposing sanctions in two of the most important recent cases—Russia and Iran. We do this because we did not have sufficient time and resources to commission a full gravity-method analysis and because ignoring the effect of sanctions when calculating the Burdensharing Index would materially degrade the results.[13]

For each country *j*, we examine the year-to-year change in constant 2017 U.S.-dollar net exports from that country to Russia or Iran for each of the years (*i* to *n*) during which UN sanctions were in force through 2017. We then calculate that country's aggregate loss of net exports ALE_j to Russia or Iran during that period. Allied countries that experienced a decline in aggregate net exports are deemed to have made a contribution to the regimes of sanctions imposed on these two countries. Allied countries that show no loss or an increase are deemed not to have contributed to economic sanctions. We then calculate the value of the total allied loss in net exports to Russia (TLE_R) and to Iran (TLE_I) of all of the allied countries that expe-

[10] In this equation, host-nation support has a weight of 0.00, indicating that it is not incorporated in the version of the index presented in this report. As explained in Chapter Three, measuring host-nation support is a complex task, and a comprehensive RAND review of the overseas basing of U.S. military forces concluded that no consistently gathered data set of host-nation support exists (Lostumbo et al., 2013, Chapter Seven). For this reason, we did not include such support in the index at this time.

[11] The countries are Central African Republic, Democratic Republic of the Congo, Eritrea, Guinea-Bissau, Iraq, Libya, Mali, Somalia, South Sudan, Sudan, and Yemen.

[12] Julian Hinz, *The Cost of Sanctions: Estimating Lost Trade with Gravity*, Kiel, Germany: Kiel Institute for the World Economy, November 2017.

[13] Japan, for example, had been a top consumer of Iranian oil exports until 2011, when it significantly curtailed imports in step with international sanctions. Japan's crude oil imports from Iran fell by roughly 40 percent in 2012 and declined a further 6 percent in 2013 and 5 percent in 2014 (Chanlett-Avery et al., 2015, p. 14).

rienced such a decline and then express each contributing country *j*'s share of total lost exports SLE_j as a percentage, as follows:[14]

$$SLE_j = \frac{ALE_j}{TLE_R \text{ or } TLE_I}. \tag{A.12}$$

Specifically,

$$ALE_j = \sum_{i=1}^{n} (X_{j,R \text{ or } I} - M_{j,R \text{ or } I})_{i-1} - (X_{j,R \text{ or } I} - M_{j,R \text{ or } I})_i, \tag{A.13}$$

and

$$TLE = \sum_{j=1}^{m} ALE_j, \tag{A.14}$$

where i = beginning year of sanctions; n = ending year of sanctions; j = 1 to m = the universe of the United States plus its European and Asia allies, plus Taiwan; X = exports; M = imports; R = Russia; and I = Iran.

Clearly, the year-to-year change in net exports from allied countries to Russia and Iran depends on macroeconomic factors beyond the mere presence or absence of multilateral UN economic sanctions. Such factors can include international commodity prices (e.g., crude oil), interest rates, inflation, and exchange rates. However, the degree to which the results of this naïve analysis broadly coincide with those of the general equilibrium gravity methodology is notable.[15]

The Burdensharing Index's input factor (N) is calculated by combining the defense financial inputs (DFI) and nondefense financial inputs (NDI) factors as follows:

$$N = \begin{bmatrix} 0.50 \\ 0.50 \end{bmatrix}^T \begin{bmatrix} DFI \\ NDI \end{bmatrix}. \tag{A.15}$$

Having outlined the subfactors that combine to form the input factor N, we next describe the subfactors that combine to yield the output factor O. Outputs have two primary factors: preparedness and deployments. Within preparedness (Π), the first subfactor is personnel (P), which is calculated as follows:

$$Y_P = \begin{bmatrix} 0.50 \\ 0.50 \end{bmatrix}^T \begin{bmatrix} ADF' \\ JCS \end{bmatrix}, \tag{A.16}$$

[14] Of all the variables included in the Burdensharing Index, share of lost exports is the only one that is not cross-sectional. To capture the cumulative effect of sanctions over time as part of a country's contribution to the burden of mounting a collective defense, we had to take a longitudinal approach to this metric.

[15] See Figure B.4 in Appendix B for the calculation of the share of total exports lost.

where the personnel factor (Y_p) is a combination of each country's percentage share of total adjusted active-duty forces (ADF') and each country's percentage share of occupied (as opposed to allocated) joint command staff positions (JCS). According to the literature, conscripted troops have a lower average level of education; receive lower levels of aggregate training; experience higher turnover (i.e., lower reenlistment rates); and suffer from lower unit cohesiveness, discipline, and productivity.[16] Consequently, where a country employs conscription (indicator variable $CON = 1$), that country's number of active-duty forces (ADF) is discounted by 30 percent. We use a discount rate of 30 percent because that was the percentage of conscripted troops that the U.S. Army rejected for being militarily useless during the Vietnam War.[17] The adjusted active-duty forces metric (ADF') is calculated by expressing each country's share of the total remaining U.S., NATO, and Asian-ally active-duty forces after this adjustment as a percentage, as follows:

$$ADF'_i = \frac{ADF_i \times (1-(CON \times 0.30))}{\sum_{i=1}^{n} ADF_i \times (1-(CON \times 0.30))}. \tag{A.17}$$

The ground forces factor (Y_{GF}) is a combination of the share of the total numbers of ground forces (NO_{GF}) and of the quality (i.e., expected combat proficiency) of those ground forces (Q_{GF}):[18]

$$Y_{GF} = \begin{bmatrix} 1.00 \\ 0.00 \end{bmatrix}^T \begin{bmatrix} NO_{GF} \\ Q_{GF} \end{bmatrix}. \tag{A.18}$$

[16] Robbie Asher, *Draft or Volunteer Army: Our Nation's Best Interest*, Carlisle Barracks, Pa.: U.S. Army War College, February 2008, pp. 12–15; Curtis L. Gilroy and Cindy Williams, *Service to Country: Personnel Policy and the Transformation of Western Militaries*, Cambridge, Mass.: MIT Press, 2006; Colby K. Krug, *Sustaining the Quality of the All-Volunteer Force: A Cost-Effective Approach*, Fort Leavenworth, Kan.: U.S. Army Command and General Staff College, May 26, 2016, pp. 9, 31; John T. Warner and Paul F. Hogan, *Walter Oi and His Contributions to the All-Volunteer Force: Theory, Evidence, Persuasion*, Arlington, Va.: CNA Corporation, September 23, 2014, pp. 7, 12, 16; and Cindy Williams, ed., *Filling the Ranks: Transforming the U.S. Military Personnel System*, Cambridge, Mass.: MIT Press, April 2004.

[17] Krug, 2016, pp. 7, 11. During World War II, the U.S. Army, which was just emerging from the Great Depression, rejected 40 percent of conscripted recruits because of malnutrition and other factors relating to physical and mental health.

[18] As noted earlier, a weight of 0.00 indicates that the corresponding element of the index is not incorporated into the Burdensharing Index presented in this report. In this case, a survey of experts at 21 DoD components that regularly train allied forces would provide the best measure of the quality of ground forces. The same is true for the factors representing the quality of air forces and the quality of naval forces. See Appendix C.

The numbers of ground forces factor (NO_{GF}) is a combination of the country's percentage share of all allied age-adjusted MBTs (MBT'); age-adjusted mechanized vehicles (MV');[19] attack helicopters ($HELO$); and towed and self-propelled artillery and MLRSs ($ARTY$):

$$NO_{GF} = \begin{bmatrix} 0.25 \\ 0.25 \\ 0.25 \\ 0.25 \end{bmatrix}^{T} \begin{bmatrix} MBT' \\ MV' \\ HELO \\ ARTY \end{bmatrix}. \tag{A.19}$$

Some of the mechanized vehicles and MBTs in allied inventories are extremely old. To adjust for age, one could weight, for example, the numbers of armored personnel carriers and infantry fighting vehicles in a given ally's mechanized vehicle park by the following factor:

$$\omega^{age} = 1 - \left(\frac{\text{average age of ally's MVs}}{\text{oldest average age}} \right). \tag{A.20}$$

This calculation yields a weight that ranges from 0.00 to 1.00. However, this weighting fails to take into account the fact that even a 60-year-old mechanized vehicle has some residual military value; that is, the bottom of the weight range cannot be zero. The ratio of youngest average age to oldest average age may indicate by what amount the actual average equipment age range deviates from a strict 0.00 to 1.00 scale. It may be used as an estimate of the residual utility of the oldest average-age vehicle park in the allied inventory to give the following factor by which to weight the age of each ally's vehicle park:[20]

$$\omega^{age^*} = \left(\frac{\text{youngest average age}}{\text{oldest average age}} \right) + \left(1 - \left(\frac{\text{average age}}{\text{oldest average age}} \right) \right). \tag{A.21}$$

[19] *Mechanized vehicles* are defined as the items listed under the following categories in the 2017 edition of *The Military Balance* (IISS, 2017):

- armored personnel carrier: lightly armored combat vehicle designed and equipped to transport an infantry squad, either unarmed or armed with a cannon of less than 20-mm caliber
- infantry fighting vehicle: armored combat vehicle designed and equipped to transport an infantry squad, armed with a cannon of at least 20-mm caliber
- light tank: armored, tracked combat vehicle armed with a turret-mounted gun of at least 75-mm caliber and with a combat weight of less than 25 metric tons
- wheeled assault gun: armored, wheeled combat vehicle armed with a turret-mounted gun of at least 75-mm caliber and with a combat weight of at least 15 metric tons
- airborne combat vehicle: armored vehicle designed to be deployable by parachute alongside airborne forces
- amphibious assault vehicle: armored vehicle designed to have an amphibious ship-to-shore capability
- armored utility vehicle: armored vehicle not designed to transport an infantry squad but capable of undertaking a variety of other utility battlefield tasks, including light reconnaissance and light transport.

[20] We calculated the weights used in the index using the average age of each ally's armored personnel carrier and infantry fighting vehicle parks. Other mechanized vehicles or MBTs are not adjusted for age.

Applying this weight to the total number of each ally's mechanized vehicles (*MV*) yields the share of total U.S., NATO, and Asian-ally age-adjusted mechanized vehicles (*MV′*), as follows:

$$MV_i' = \frac{MV_i \times \omega^{age^*}}{\sum_{i=1}^{n} MV_i \times \omega^{age^*}}. \tag{A.22}$$

Numbers of ground forces say little about qualitative factors, such as the expected proficiency with which an ally is capable of employing those forces in combat. As explained earlier (and further in Appendix C), the quality of an ally's ground forces (Q_{GF}) is a function of those forces' technological level (*TECH*), scope and scale of training (*TRG*), ability to sustain themselves in combat (*SUST*), and ability to interoperate (*IOP*) with other allied forces:

$$Q_{GF} = \begin{bmatrix} 0.25 \\ 0.25 \\ 0.25 \\ 0.25 \end{bmatrix}^T \begin{bmatrix} TECH \\ TRG \\ SUST \\ IOP \end{bmatrix}. \tag{A.23}$$

The air forces factor (Y_{AF}) is a combination of the numbers of air forces (NO_{AF}) and the quality of those air forces (Q_{AF}):

$$Y_{AF} = \begin{bmatrix} 1.00 \\ 0.00 \end{bmatrix}^T \begin{bmatrix} NO_{AF} \\ Q_{AF} \end{bmatrix}. \tag{A.24}$$

Numbers of air forces (NO_{AF}) is a combination of each ally's percentage share of total U.S., NATO, and Asian-ally tactical aircraft adjusted for age and total training hours (*TAC′*), airborne early warning aircraft (*AEW*), airborne tanker aircraft (*TKR*), and transport aircraft (*TPT*):

$$NO_{AF} = \begin{bmatrix} 0.25 \\ 0.25 \\ 0.25 \\ 0.25 \end{bmatrix}^T \begin{bmatrix} TAC' \\ AEW \\ TKR \\ TPT \end{bmatrix}. \tag{A.25}$$

As in the case of mechanized vehicles, allied tactical aircraft are weighted for age. An additional weight is used to account for flight training hours. Taking 140 flight training hours per year as a minimum requirement,[21] we construct the training-hours weight as follows:

$$\omega^{trg} = \frac{\text{national training hours}}{140}. \tag{A.26}$$

For countries that hit the 140-hour norm, the resulting weight of 1.00 has no effect on the age-adjusted number of aircraft. For countries that exceed the minimum required hours, a weight that is greater than 1.00 results, pushing up the age-adjusted number of aircraft. Conversely, a weight that is less than 1.00 results for countries whose training hours fell below the minimum requirement. Applying these two weights to the total number of each ally's tactical aircraft (*TAC*) yields the share of total U.S., NATO, and Asian-ally tactical aircraft adjusted for age and training hours (*TAC′*), as follows:

$$TAC_i' = \frac{TAC_i \times \omega^{age^*} \times \omega^{trg}}{\sum_{i=1}^{n} TAC_i \times \omega^{age^*} \times \omega^{trg}}. \tag{A.27}$$

The quality of allied air forces, especially their combat proficiency, matters; it is calculated in the same way as the quality of ground forces (see Equation A.23).

The naval forces factor (Y_{NF}) is a combination of the numbers of naval forces (NO_{NF}) and the quality of those naval forces (Q_{NF}):

$$Y_{NF} = \begin{bmatrix} 1.00 \\ 0.00 \end{bmatrix}^T \begin{bmatrix} NO_{NF} \\ Q_{NF} \end{bmatrix}. \tag{A.28}$$

Numbers of naval forces (NO_{NF}) is a combination of each ally's percentage share of total U.S., NATO, and Asian-ally aircraft carriers (*CVX*), tactical naval aircraft (*TACAIR*),[22] tactical submarines (*TACSUB*), anti-submarine warfare aircraft (*ASW*), capital ships (*CAPSHP*), and heavy amphibious ships (*AMPH*). Capital ship numbers were adjusted for age (*CAPSHIP′*). In a reflection of the preeminent role that carrier-borne operations continue to play in naval doctrine, the weights assigned to carriers and tactical naval aircraft are each

[21] John Venable, "Fighter Pilots Aren't Flying Enough to Hone the Skills of Full-Spectrum War," *Defense One*, November 21, 2016. In three cases, where data were missing, we assume 140 hours of flight training, thereby giving the training weight a value of 1.00 (i.e., no influence on the outcome). Where IISS gave a range of training hours, we use the midpoint.

[22] Numbers of tactical naval aircraft were not adjusted for age or for average training hours.

double the weights assigned to submarines, anti-submarine warfare aircraft, capital ships, and heavy amphibious ships:

$$NO_{NF} = \begin{bmatrix} 0.29 \\ 0.29 \\ 0.11 \\ 0.11 \\ 0.11 \\ 0.11 \end{bmatrix}^{T} \begin{bmatrix} CVX \\ TACAIR \\ TACSUB \\ ASW \\ CAPSHP' \\ AMPH \end{bmatrix}. \tag{A.29}$$

As in the cases of ground forces and air forces, the quality of allied naval forces matters; it is calculated in the same way as the quality of ground forces (see Equation A.23).

The military mobility factor (Y_{MM}) is a combination of each ally's percentage share of total U.S., NATO, and Asian-ally strategic airlift aircraft (*ALIFT*), deadweight tonnage of strategic sealift (*SLIFT*), and a freedom-of-movement (*FOM*) score:

$$Y_{MM} = \begin{bmatrix} 0.50 \\ 0.25 \\ 0.25 \end{bmatrix}^{T} \begin{bmatrix} ALIFT \\ SLIFT \\ FOM \end{bmatrix}. \tag{A.30}$$

Freedom of movement (*FOM*) is a combination of each ally's percentage share of the total accessible allied national territory (*GRND*), airspace (*AIR*), and seaports (*SEA*), as well as diplomatic clearance times (*DIP*). Ease of access to allied road and rail networks are equally weighted in assessing the accessibility of allies' national territory.[23] The accessibility of airports of debarkation, the ease of obtaining overflight and landing rights, and air traffic control clearance are all equally weighted in assessing the accessibility of allied airspace. No freedom-of-movement data are available for the seven Asian allies or the United States. In these cases, the NATO average for ground, air, and sea freedom-of-movement scores is used as a placeholder until such scores can be produced. Diplomatic clearance times are not incorporated into the Burdensharing Index at this time, so they are weighted at 0.00. The freedom-of-movement score is calculated as follows:

$$FOM = \begin{bmatrix} 0.33 \\ 0.33 \\ 0.33 \\ 0.00 \end{bmatrix}^{T} \begin{bmatrix} GRND \\ AIR \\ SEA \\ DIP \end{bmatrix}. \tag{A.31}$$

[23] For the raw data relied on for these calculations, see M. Mamur, *Freedom of Movement Assessment (Ground): Moving Towards a Military Schengen Zone*, Wiesbaden, Germany: U.S. Army Europe, 2016.

The C4ISR factor (*C4ISR*) is a combination of each ally's share of total U.S., NATO, and Asian-ally ISR, electronic intelligence, surveillance, and early warning satellites (*SATS*); ISR aircraft (*ISR*); airborne early warning aircraft (*AEW*); and heavy UAVs (*UAV*).

$$Y_{C4\,ISR} = \begin{bmatrix} 0.25 \\ 0.25 \\ 0.25 \\ 0.25 \end{bmatrix}^{T} \begin{bmatrix} SATS \\ ISR \\ AEW \\ UAV \end{bmatrix}. \tag{A.32}$$

Together, these six output subfactors—personnel, ground forces, air forces, naval forces, military mobility, and C4ISR—combine to yield the preparedness factor (Π) as follows:

$$\Pi = \begin{bmatrix} 0.17 \\ 0.17 \\ 0.17 \\ 0.17 \\ 0.17 \\ 0.17 \end{bmatrix}^{T} \begin{bmatrix} Y_{P} \\ Y_{GF} \\ Y_{AF} \\ Y_{NF} \\ Y_{MM} \\ Y_{C4\,ISR} \end{bmatrix}. \tag{A.33}$$

In the deployments factor, there is only one subfactor: contributions to ongoing operations (*COO*) in the form of overseas deployments. To obtain a useful measure of allied contributions in this area, we exclude troops deployed to a country's own overseas sovereign territory. The measure does count each ally's number of personnel deployed to AFRICOM, CENTCOM, EUCOM, NORTHCOM, PACOM, and SOUTHCOM areas of responsibility.

Combining allied military preparedness (Π) and deployments (in the form of contributions to ongoing operations), each ally's share of total allied military outputs (*O*) contributed to mounting a collective defense is determined as follows:

$$O = \begin{bmatrix} 0.75 \\ 0.25 \end{bmatrix}^{T} \begin{bmatrix} \Pi \\ COO \end{bmatrix}. \tag{A.34}$$

Thus, the allies' shares of all inputs (*N*) and outputs (*O*) contributed to mounting a collective defense are combined to yield a vector of each ally's burdensharing index score (B_i) as follows:

$$B_i = \begin{bmatrix} 0.50 \\ 0.50 \end{bmatrix}^{T} \begin{bmatrix} N \\ O \end{bmatrix} = \boldsymbol{\Omega}_{\mathbf{b}} \times \mathbf{b}. \tag{A.35}$$

Calculating the Burdensharing Ratio

In addition to calculating each ally's burdensharing index score, we calculate a burdensharing ratio as the other top-level measure of the index. For the burdensharing ratio, we first must calculate a given country *i*'s incomeshare—that is, its share of total alliance income or spending power (S_i). Incomeshare is determined by the country's national GDP_i as a share of total allied $\overline{GDP}$, as follows:

$$S_i = GDP_i / \overline{GDP}. \tag{A.36}$$

This allows us to examine the ratio of each ally *i*'s percentage share of the burden of mounting a collective defense (B_i) to that ally's percentage share of total alliance income (S_i). Thus, the burdensharing ratio (R_i) for each ally is determined as follows:

$$R_i = \frac{B_i}{S_i}. \tag{A.37}$$

If the value of an ally's burdensharing ratio is equal to 1.00, then that ally's share of the burden of mounting a collective defense is exactly equal to the ally's share of total allied income. As mentioned in Chapter Four, one could argue that an ally with such a ratio is making a contribution to collective defense that is commensurate with its national spending power. If an ally's burdensharing ratio is greater than 1.00, then the ally's share of the burden exceeds its share of total allied income, and one could argue that it is contributing more than its fair share. The opposite is true for allies whose ratio is less than 1.00. When an ally's share is 0.00, it is considered to be free-riding; when it is more than nothing but less than 1.00, the ally is considered to be cheap-riding.

Attempts to Reduce Complexity

In the foregoing definition of the Burdensharing Index, we identified nine key input and output factors and 45 associated metrics for use in constructing the Burdensharing Index. One of our goals was that the index be parsimonious, so in an attempt to reduce the number of variables, we examined the correlations between each metric. Metrics that are more than 90 percent correlated with one another could be considered redundant, and redundant metrics could be eliminated. After our analysis, only two pairs of variables identified for inclusion in the index were 90 percent or more correlated with one another: the numbers of artillery pieces and MBTs and the numbers of destroyers and tactical naval aircraft. We retained these metrics, given the marginal gains to be had by dropping them.

Simulation and Sensitivity Analysis

We used Monte Carlo simulation software repeatedly to substitute different values for each of the baseline weights described in this appendix and observed the ensuing variation in each ally's burdensharing index score and burdensharing ratio.[24]

As shown in Table A.4 and in Figure A.2, in 95 percent of the cases, the European (NATO) and Asian allies' combined burdensharing index score was between 50 percent and 57 percent. By way of comparison, the allies' combined share of total alliance income was 65 percent. In all but 5 percent of the cases, the United States' burdensharing index score lay between 43 percent and 50 percent, whereas its share of total alliance income was 35 percent. The NATO allies' combined burdensharing index score was between 34 percent and 38 percent; their share of total income was 43 percent. The Asian allies' combined burdensharing index score lay between 16 percent and 19 percent, while their share of total income was 22 percent.

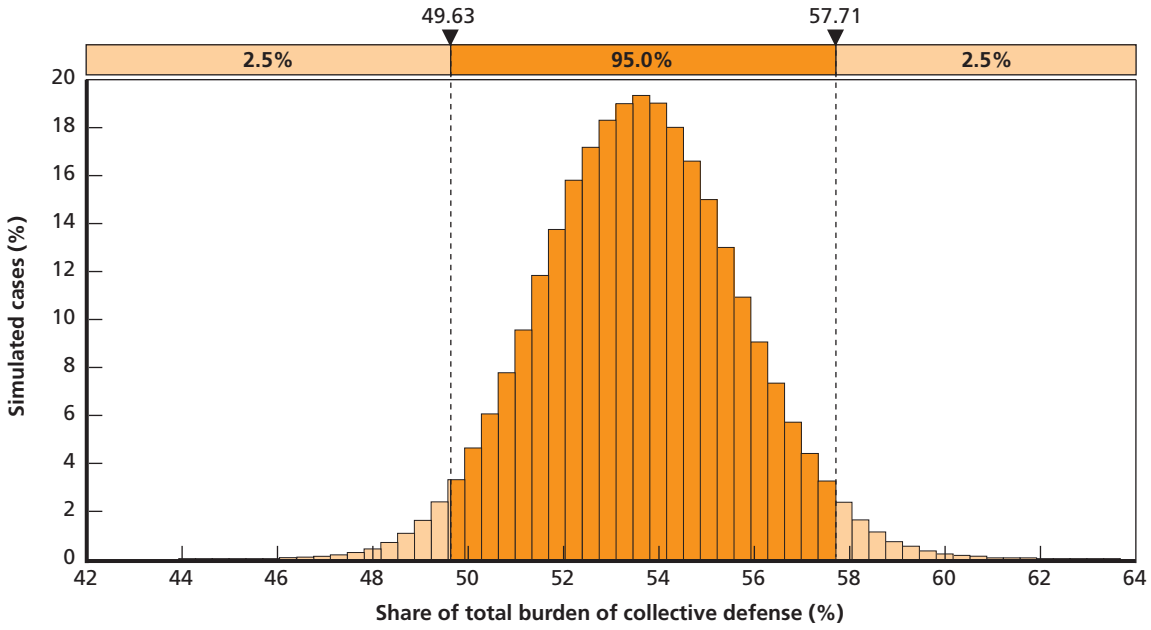
If we take the mean burdensharing index score as a benchmark, then the burdensharing ratio of the NATO and Asian allies' combined contribution to the burden of mounting a collective defense is 0.83; for the United States, it is 1.32. With a combined burdensharing ratio of 0.77 versus NATO allies' combined ratio of 0.86, Asian allies as a group appear to have the most room for improvement.

Table A.4
Simulation Results

Description	5th Percentile	Mean	95th Percentile	Standard Deviation
Burdensharing index score				
NATO + Asian allies	50.25	53.62	57.05	2.063
NATO allies	34.42	36.36	38.33	1.190
Asian allies	15.81	17.24	18.71	0.8812
United States	43.09	46.50	49.85	2.053
Burdensharing ratio				
NATO + Asian allies	0.7770	0.8289	0.8820	0.03189
NATO allies	0.8136	0.8594	0.9062	0.02814
Asian allies	0.7063	0.7704	0.8359	0.03937
United States	1.2200	1.3167	1.4110	0.05813

[24] We used Latin Hypercube Sampling and a Mersenne Twister random-number generator with an initial fixed seed value of 1 to draw 500,000 random weight values from normally distributed samples as follows: defense financial inputs mean = 0.50, standard deviation = 0.05; preparedness mean = 0.75, standard deviation = 0.075; C4ISR mean = 0.17, standard deviation = 0.017; satellites mean = 0.25, standard deviation = 0.025; strategic airlift mean = 0.50, standard deviation = 0.0608; air accessibility mean = 0.33, standard deviation = 0.033; aircraft carriers mean = 0.29, standard deviation = 0.05; adjusted tactical aircraft mean = 0.25, standard deviation = 0.05; MBT mean = 0.25, standard deviation = 0.05; conscription discount mean = 0.70, standard deviation = 0.07.

Figure A.2
Simulation Results: Total Allied Share of Burden



We conducted a sensitivity analysis of all of the weights used to construct the Burdensharing Index. To do this, we flexed each weight by the same amount while holding all of the other weights constant and then observed that weight's influence on the Burdensharing Index calculated. Share of lost exports was the most influential input, and the discount applied for conscripted troops was the next most influential. These were followed by C4ISR, military mobility, naval forces, defense financial inputs (military spending), air forces, and ground forces.

We drew random weights from a normal distribution with a mean equal to the baseline weight for share of lost exports (0.9) and a standard deviation of 10 percent on either side of this value. Doing so showed that the weight attached to the share of lost exports can have a high impact on the burdensharing index score of countries with a high share of lost exports, such as Country TQ and, to a lesser extent, Country OS. In nine out of ten cases, a 10-percent increase or decrease in the weight attached to Country TQ's share of exports lost as a result of UN sanctions imposed on Russia and Iran led to somewhere between a 26-percent increase (from 4.75 percent to 5.00 percent) and a 33-percent decrease (from 4.75 percent to 4.51 percent) in Country TQ's burdensharing index score. In the most-extreme cases, Country TQ's score fell 39 percent (to 4.06 percent from 4.75 percent) and rose 19 percent (to 5.42 percent from 4.75 percent). The corresponding changes in Country OS's burdensharing index score were more modest. In nine out of ten cases, Country OS's score changed by ±2 percent, ranging from 6.55 percent to 6.85 percent. In the most-extreme cases, Country OS's score fell to 6.27 percent from 6.70 percent and rose to 7.13 percent from 6.70 percent.

We found that, when calculating the preparedness factor, the weights with the most influence were those for C4ISR, military mobility, naval forces, ground forces, and then air forces (in that order; throughout this paragraph, we list the metrics in descending order of influence). For the C4ISR factor, the weights were most influenced by heavy UAVs, ISR air-

craft, airborne early warning aircraft, and then satellites. Weights for strategic airlift, strategic sealift, and then freedom of movement had the greatest influence on the military mobility factor. The naval forces factor was most influenced by weights for tactical naval aircraft, capital ships, aircraft carriers, anti-submarine warfare aircraft, tactical submarines, and then heavy amphibious ships. The ground forces factor was most heavily influenced by weights for helicopters, MBTs, artillery, and then mechanized vehicles. Finally, weights for tanker aircraft, adjusted tactical aircraft, transport aircraft, and then airborne early warning aircraft had the greatest influence on the air forces factor.

APPENDIX B

Burdensharing Index: Raw Data

The Burdensharing Index described in this report is contained in a spreadsheet, and in this appendix, we reproduce each worksheet of the index.[1] Readers can view the baseline values for inputs, outputs, burdenshare, incomeshare, burdensharing ratio, and so forth for each country and can drill down into each of the factors to see the calculated values for each metric. In addition, this appendix provides more-detailed information about the data sources used. On each worksheet, some columns' headings are shaded in black, which indicates that these values are the results of the raw data and calculations presented in the unshaded columns to their left.

As noted elsewhere, this work is intended to advance theory on burdensharing and provide a starting point for DoD deliberations on this complex topic. Data about individual nations are included to help illustrate how the Burdensharing Index could assist in future policy deliberations, but depicted scores and rankings are not suitable for informing judgments about any single ally; thus, the country names are anonymized. We provide additional information about the index's limitations and caveats, as well as recommendations for ways to improve it, in the main report.

[1] Because the time and resources to thoroughly stress test the electronic model and subject it to external review were not available, we have made only these images of the worksheets available at this time.

Figure B.1
Calculation of Burdenshare

Weights	0.50	0.50				
Country	INPUTS (I)	OUTPUTS (O)	BURDENSHARE (B)	"Efficiency" (I/O)	INCOMESHARE (ι)	BURDENSHARE RATIO (B:ι)
U.S.	35.32	57.69	46.50	1.63	35.32	1.32
Country WQ	1.36	1.63	**1.50**	1.19	2.26	0.66
Country OS	10.03	3.39	**6.71**	0.34	9.39	0.72
Country KA	0.22	0.12	**0.17**	0.56	0.33	0.52
Country XT	1.74	0.58	**1.16**	0.33	1.53	0.76
Country XD	4.55	3.68	**4.11**	0.81	3.67	1.12
Country SQ	2.46	1.77	**2.12**	0.72	2.14	0.99
Country WX	1.02	1.26	**1.14**	1.23	3.06	0.37
TOTAL E ASIA wo U.S.	**21**	**13**	**17**	**0.61**	**22**	**0.8**
TOTAL E ASIA w U.S.	**57**	**71**	**64**	**1.24**	**58**	**1.10**
Country KX	0.01	0.05	**0.03**	7.74	0.07	0.40
Country PQ	0.75	0.51	**0.63**	0.68	0.97	0.65
Country GP	1.08	0.22	**0.65**	0.20	0.27	2.40
Country FX	0.84	1.66	**1.25**	1.96	3.19	0.39
Country CB	0.19	0.17	**0.18**	0.88	0.18	1.01
Country RT	0.26	0.31	**0.28**	1.18	0.67	0.43
Country ZL	0.19	0.58	**0.38**	3.08	0.50	0.76
Country ST	0.03	0.08	**0.06**	2.39	0.07	0.80
Country PU	4.92	4.30	**4.61**	0.88	5.21	0.88
Country OJ	2.15	2.86	**2.51**	1.33	7.57	0.33
Country KF	3.63	2.21	**2.92**	0.61	0.55	5.29
Country HD	1.24	0.25	**0.74**	0.20	0.51	1.46
Country UT	0.00	0.02	**0.01**	8.89	0.03	0.34
Country TQ	6.35	3.15	**4.75**	0.50	4.23	1.12
Country NU	0.02	0.04	**0.03**	2.36	0.10	0.32
Country YX	1.28	0.07	**0.68**	0.06	0.16	4.16
Country QX	0.03	0.03	**0.03**	1.23	0.11	0.26
Country DN	0.00	0.01	**0.01**	6.26	0.02	0.34
Country UU	3.65	0.82	**2.23**	0.22	1.65	1.35
Country VJ	0.41	0.58	**0.49**	1.40	0.69	0.71
Country HS	3.11	1.23	**2.17**	0.39	2.00	1.08
Country WY	0.44	0.59	**0.52**	1.35	0.57	0.91
Country PC	0.45	0.69	**0.57**	1.53	0.84	0.68
Country GO	0.99	0.20	**0.60**	0.20	0.32	1.86
Country JR	0.02	0.07	**0.05**	3.98	0.13	0.36
Country JU	4.45	1.61	**3.03**	0.36	3.22	0.94
Country YW	3.60	3.44	**3.52**	0.95	3.18	1.11
Country PJ	3.21	3.88	**3.54**	1.21	5.31	0.67
TOTAL NON-U.S. NATO	**43**	**29**	**36**	**0.68**	**42**	**0.86**
TOTAL U.S.+NATO	**79**	**87**	**83**	**1.10**	**78**	**1.07**
TOTAL ASIA, NATO wo U.S.	**65**	**43**	**54**	**0.66**	**65**	**0.83**
TOTAL ASIA, NATO w U.S.	**100**	**100**	**100**	**1.00**	**100**	**1.0**

NOTE: All cells on this worksheet are derived from other worksheets. The entire sheet is therefore locked and no cells can be altered

Figure B.2
Calculation of Incomeshare

Country	GDP	POP	GDP/CAP	INCOMESHARE	GROSS CAPITAL	Share
U.S.	**$ 18,560**	**323,995,528**	**$ 57,285**	**35**	**52,849,892**	**29**
Country WQ	$ 1,189	22,992,654	$ 51,712	2.26	3,944,976	2.14
Country OS	$ 4,932	126,702,133	$ 38,926	9.39	18,236,474	9.91
Country KA	$ 175	4,474,549	$ 39,065	0.33	459,617	0.25
Country XT	$ 802	102,624,209	$ 7,814	1.53	2,084,501	1.13
Country XD	$ 1,929	50,924,172	$ 37,880	3.67	6,839,375	3.72
Country SQ	$ 1,125	23,464,787	$ 47,944	2.14	3,412,746	1.85
Country WX	$ 1,610	68,200,824	$ 23,607	3.06	3,705,161	2.01
TOTAL E ASIA wo U.S.	**$ 11,762**	**399,383,328**	**$ 246,948**	**22**	**38,682,850**	**21**
TOTAL E ASIA w U.S.	**$ 30,322**	**723,378,856**	**$ 304,233**	**58**	**91,532,742**	**50**
Country KX	$ 34	3,038,594	$ 11,258	0.07	112,793	0.06
Country PQ	$ 509	11,409,077	$ 44,579	0.97	2,300,616	1.25
Country GP	$ 143	7,144,653	$ 20,029	0.27	312,399	0.17
Country FX	$ 1,674	35,362,905	$ 47,338	3.19	6,097,225	3.31
Country CB	$ 94	4,313,707	$ 21,847	0.18	411,751	0.22
Country RT	$ 351	10,644,842	$ 32,964	0.67	1,733,171	0.94
Country ZL	$ 265	5,593,785	$ 47,338	0.50	1,079,511	0.59
Country ST	$ 39	1,258,545	$ 30,750	0.07	150,939	0.08
Country PU	$ 2,737	66,836,154	$ 40,951	5.21	12,076,728	6.56
Country OJ	$ 3,979	80,722,792	$ 49,292	7.57	15,146,735	8.23
Country KF	$ 291	10,773,253	$ 26,965	0.55	2,004,816	1.09
Country HD	$ 268	9,874,784	$ 27,099	0.51	1,065,812	0.58
Country UT	$ 16	335,878	$ 48,083	0.03	59,351	0.03
Country TQ	$ 2,221	62,007,540	$ 35,818	4.23	13,027,931	7.08
Country NU	$ 51	1,965,686	$ 25,879	0.10	308,636	0.17
Country YX	$ 86	2,854,235	$ 30,057	0.16	257,047	0.14
Country QX	$ 59	582,291	$ 100,877	0.11	180,698	0.10
Country DN	$ 11	644,578	$ 16,460	0.02	27,886	0.02
Country UU	$ 866	17,016,967	$ 50,885	1.65	3,507,223	1.91
Country VJ	$ 365	5,265,158	$ 69,267	0.69	1,294,501	0.70
Country HS	$ 1,052	38,523,261	$ 27,308	2.00	2,073,987	1.13
Country WY	$ 297	10,833,816	$ 27,423	0.57	1,937,155	1.05
Country PC	$ 441	21,599,736	$ 20,417	0.84	1,631,990	0.89
Country GO	$ 169	5,445,802	$ 31,051	0.32	522,356	0.28
Country JR	$ 66	1,978,029	$ 33,432	0.13	338,292	0.18
Country JU	$ 1,690	48,563,476	$ 34,800	3.22	8,438,931	4.59
Country YW	$ 1,670	80,274,604	$ 20,804	3.18	4,605,441	2.50
Country PJ	$ 2,788	64,430,428	$ 43,271	5.31	11,811,327.00	6.42
TOTAL NON-U.S. NATO	**$ 22,230**	**609,294,576**	**$ 1,016,243**	**42**	**92,515,249**	**50**
TOTAL U.S.+NATO	**$ 40,790**	**933,290,104**	**$ 1,073,528**	**78**	**145,365,141**	**79**
TOTAL ASIA, NATO wo U.S.	**$ 33,991**	**1,008,677,904**	**$ 1,263,192**	**65**	**131,198,098**	**71**
TOTAL ASIA, NATO w U.S.	**$ 52,551**	**1,332,673,432**	**$ 1,320,476**	**100**	**184,047,990**	**100**

SOURCES:
GDP = Central Intelligence Agency (CIA), The World Factbook 2017, McLean, Va., July 18, 2018, accessed October 31, 2018.
POP = CIA, 2018, accessed October 31, 2018.
Gross capital = Robert C. Feenstra, Robert Inklaar, and Marcel P. Timmer, "The Next Generation of the Penn World Table," American Economic Review, Vol. 105, No. 10, 2015, pp. 3150–3182, database accessed January 23, 2019.

NOTES: Cells cannot be altered. GDP = gross domestic product; POP = population; GDP/CAP = GDP per capita, or GDP/population; incomeshare = share of total allied GDP; gross capital = capital stock at current purchasing power parities (in 2011 $U.S. millions).

Figure B.3
Calculation of the Inputs Factor

Weights				0.50			0.50		0.00	0.50		0.10	0.90	0.50	
Country	MILEX	GDP	ME/GDP	Share	ME	EQUIP	EqSpend	Share	EQ	HNS Share HNS	DFI	PKO	Share	PKO	SLE	NDI	INPUTS
U.S.	$ 606	$ 18,560	3.26%	58	29	25.41	$ 154	67	33	0	62	28.43	37	4	5	8	35
Country WQ	$ 28	$ 1,189	2.34%	2.65	1.32	15.00	$ 4	1.81	0.90	0	2.23	2.34	3.06	0.31	0.20	0.50	1.36
Country OS	$ 46	$ 4,932	0.94%	4.41	2.21	15.00	$ 7	3.02	1.51	0	3.71	9.68	12.69	1.27	15.08	16.35	10.03
Country KA	$ 2	$ 175	1.40%	0.23	0.12	15.00	$ 0	0.16	0.08	0	0.20	0.27	0.35	0.04	0.21	0.24	0.22
Country XT	$ 4	$ 802	0.49%	0.37	0.19	15.00	$ 1	0.25	0.13	0	0.31	0.03	0.04	0.00	3.15	3.16	1.74
Country XD	$ 39	$ 1,929	2.00%	3.68	1.84	15.00	$ 6	2.51	1.26	0	3.10	2.04	2.67	0.27	5.73	6.00	4.55
Country SQ	$ 10	$ 1,125	0.92%	0.98	0.49	15.00	$ 2	0.67	0.34	0	0.83	0.00	0.00	0.00	4.09	4.09	2.46
Country WX	$ 6	$ 1,610	0.38%	0.58	0.29	15.00	$ 1	0.40	0.20	0	0.49	0.06	0.08	0.01	1.55	1.56	1.02
TOTAL E ASIA wo U.S.	$ 136	$11,762	1.15%	13	6	15.00	$ 20	9	4	0	11	14.42	19	2	30	32	21
TOTAL E ASIA w U.S.	$ 741	$30,322	2.44%	71	35	23.51	$ 174	76	38	0	73	42.85	56	6	35	40	57
Country KX	$ 0	$ 34	0.45%	0	0.01	8.92	$ 0	0.01	0.00	0	0.01	0.00	0.00	0.0	0	0.00	0.01
Country PQ	$ 5	$ 509	0.97%	0	0.24	3.42	$ 0	0.07	0.04	0	0.27	0.89	1.16	0.1	1	1.22	0.75
Country GP	$ 1	$ 143	0.46%	0	0.03	3.47	$ 0	0.01	0.00	0	0.04	0.01	0.02	0.0	2	2.13	1.08
Country FX	$ 17	$ 1,674	1.03%	2	0.82	13.06	$ 2	0.98	0.49	0	1.31	2.92	3.83	0.4	0	0.38	0.84
Country CB	$ 1	$ 94	0.96%	0	0.04	10.58	$ 0	0.04	0.02	0	0.06	0.03	0.04	0.0	0	0.32	0.19
Country RT	$ 2	$ 351	0.60%	0	0.10	11.75	$ 0	0.11	0.05	0	0.15	0.28	0.36	0.0	0	0.37	0.26
Country ZL	$ 4	$ 265	1.56%	0	0.20	11.50	$ 0	0.21	0.10	0	0.30	0.58	0.77	0.1	0	0.08	0.19
Country ST	$ 1	$ 39	1.41%	0	0.03	13.94	$ 0	0.03	0.02	0	0.04	0.04	0.05	0.0	0	0.03	0.03
Country PU	$ 61	$ 2,737	2.22%	6	2.89	25.03	$ 15	6.60	3.30	0	6.19	6.28	8.23	0.8	3	3.64	4.92
Country OJ	$ 47	$ 3,979	1.18%	4	2.24	11.93	$ 6	2.44	1.22	0	3.46	6.39	8.37	0.8	0	0.84	2.15
Country KF	$ 6	$ 291	2.10%	1	0.29	12.77	$ 1	0.34	0.17	0	0.46	0.47	0.62	0.1	7	6.80	3.63
Country HD	$ 1	$ 268	0.46%	0	0.06	8.17	$ 0	0.04	0.02	0	0.08	0.05	0.06	0.0	2	2.39	1.24
Country UT	$ 0	$ 16	0.13%	0	0.00	0.00	$ -	0.00	0.00	0	0.00	0.02	0.03	0.0	0	0.00	0.00
Country TQ	$ 28	$ 2,221	1.28%	3	1.35	9.72	$ 3	1.20	0.60	0	1.95	3.75	4.91	0.5	10	10.74	6.35
Country NU	$ 0	$ 51	0.67%	0	0.02	13.60	$ 0	0.02	0.01	0	0.03	0.02	0.03	0.0	0	0.01	0.02
Country YX	$ 1	$ 86	0.66%	0	0.03	21.55	$ 0	0.05	0.03	0	0.05	0.02	0.03	0.0	3	2.51	1.28
Country QX	$ 0	$ 59	0.62%	0	0.02	33.33	$ 0	0.05	0.03	0	0.04	0.06	0.08	0.0	0	0.01	0.03
Country DN	$ 0	$ 11	0.72%	0	0.00	0.00	$ -	0.00	0.00	0	0.00	0.00	0.00	0.0	0	0.00	0.00
Country UU	$ 10	$ 866	1.21%	1	0.50	11.16	$ 1	0.51	0.25	0	0.75	1.48	1.94	0.2	6	6.54	3.65
Country VJ	$ 7	$ 365	2.02%	1	0.35	22.48	$ 2	0.72	0.36	0	0.71	0.85	1.11	0.1	0	0.11	0.41
Country HS	$ 13	$ 1,052	1.20%	1	0.60	33.06	$ 4	1.81	0.90	0	1.50	0.25	0.33	0.0	5	4.72	3.11
Country WY	$ 4	$ 297	1.47%	0	0.21	8.73	$ 0	0.17	0.08	0	0.29	0.39	0.51	0.1	1	0.59	0.44
Country PC	$ 3	$ 441	0.68%	0	0.14	19.65	$ 1	0.25	0.13	0	0.27	0.06	0.07	0.0	1	0.63	0.45
Country GO	$ 1	$ 169	0.69%	0	0.06	18.28	$ 0	0.09	0.05	0	0.10	0.10	0.13	0.0	2	1.89	0.99
Country JR	$ 0	$ 66	0.74%	0	0.02	1.86	$ 0	0.00	0.00	0	0.03	0.08	0.11	0.0	0	0.01	0.02
Country JU	$ 17	$ 1,690	1.00%	2	0.81	14.82	$ 3	1.09	0.54	0	1.35	2.44	3.20	0.3	7	7.56	4.45
Country YW	$ 18	$ 1,670	1.06%	2	0.84	25.13	$ 4	1.93	0.96	0	1.80	0.20	0.27	0.0	5	5.40	3.60
Country PJ	$ 60	$ 2,788	2.14%	6	2.84	21.75	$ 13	5.64	2.82	0	5.66	5.77	7.56	0.8	0	0.76	3.21
TOTAL NON-U.S. NATO	$ 309	$ 22,230	1.39%	29	15	18.17	$ 56	24	12	0	27	33.44	44	4	55	60	43
TOTAL U.S.+NATO	$ 915	$ 40,790	2.24%	87	44	22.96	$ 210	91	46		89	61.87	81	8	60	68	79
TOTAL ASIA, NATO wo U.S.	$ 445	$ 33,991	1.31%	42	21	17.21	$ 77	33	17		38	47.85	63	6	85	92	65
TOTAL ASIA, NATO w U.S.	$ 1,051	$ 52,551	2.00%	100	50	21.94	$ 230	100	50		100	76.29	100	10	90	100	100

SOURCES:
MILEX: SIPRI, undated-a, accessed May 31, 2019.
GDP: CIA, 2018, accessed May 31, 2019.
EQUIP, EqSpend: NATO, 2019a, pp. 6, 12.
PKO: United Nations General Assembly, "Effective Rates of Assessment for Peacekeeping Operations, 1 January 2016 to 31 December 2018," New York, A/70/331/Add.1, December 28, 2015.

NOTES: MILEX = military expenditures (constant 2017 $U.S. billions); GDP = gross domestic product ($ billions); ME/GDP = military expenditures as a percentage of GDP; ME = military expenditures; EQUIP = percentage of defense spending spent on equipment; EqSpend = dollar value of equipment spending; EQ = equipment; HNS = host-nation support; DFI = defense financial inputs; PKO = peacekeeping operations, using effective rate for 2018; SLE = share of lost exports; NDI = nonfinancial defense inputs; orange = imputed values/placeholders.

Figure B.4
Calculation of the Share of Lost Exports

Weights	0.50	0.50					
	"Naïve" Analysis					(Hinz, 2017) Analysis	
Country	**Russia**	**Iran**	**SLE**	**INCOMESHARE**	**Ratio**	**Russia**	**Iran**
U.S.	9	1	5.21	35	0.15	0.30	0.11
Country WQ	0	0	0.22	2.26	0.10	-0.48	0.56
Country OS	8	26	16.75	9.39	1.79	-1.95	-4.51
Country KA	0	0	0.23	0.33	0.70	-0.08	
Country XT	1	6	3.50	1.53	2.30		
Country XD	0	13	6.36	3.67	1.73		-5.11
Country SQ	0	9	4.55	2.14	2.13		
Country WX	3	0	1.72	3.06	0.56		
TOTAL E ASIA wo U.S.	**13**	**53**	**33.34**	**22.38**	**1.49**	**-2.51**	**-9.06**
TOTAL E ASIA w U.S.	**23**	**55**	**38.55**	**57.70**	**0.67**	**-2.21**	**-8.95**
Country KX	0	0	0.00	0.07	0.02		
Country PQ	2	0	1.23	0.97	1.27	-2.80	-1.43
Country GP	4	0	2.37	0.27	8.69		
Country FX	0	0	0.00	3.19	0.00	-0.87	-0.19
Country CB	1	0	0.35	0.18	1.97		
Country RT	1	0	0.37	0.67	0.55	-2.11	-0.23
Country ZL	0	0	0.00	0.50	0.00	-1.27	-0.13
Country ST	0	0	0.02	0.07	0.33		
Country PU	2	4	3.13	5.21	0.60	-4.67	-6.35
Country OJ	0	0	0.00	7.57	0.00	-23.22	-7.67
Country KF	7	8	7.49	0.55	13.55		
Country HD	5	0	2.65	0.51	5.21	-2.30	
Country UT	0	0	0.00	0.03	0.01		
Country TQ	11	12	11.39	4.23	2.70	-3.50	-4.68
Country NU	0	0	0.01	0.10	0.09		
Country YX	5	0	2.79	0.16	17.10		
Country QX	0	0	0.00	0.11	0.00		
Country DN	0	0	0.00	0.02	0.00		
Country UU	11	3	7.05	1.65	4.28	-4.12	-1.45
Country VJ	0	0	0.00	0.69	0.00	-1.05	-0.1
Country HS	10	0	5.21	2.00	2.60	-4.38	-0.29
Country WY	0	1	0.59	0.57	1.05		
Country PC	0	1	0.70	0.84	0.83		
Country GO	4	0	2.08	0.32	6.48	-1.49	-0.01
Country JR	0	0	0.00	0.13	0.00		
Country JU	9	7	8.04	3.22	2.50	-1.53	-1.69
Country YW	3	9	5.96	3.18	1.88		6.59
Country PJ	0	0	0.00	5.31	0.00	-2.54	-0.92
TOTAL NON-U.S. NATO	**77**	**45**	**61.45**	**42.30**	**1.45**	**-55.85**	**-18.55**
TOTAL U.S.+NATO	**87**	**47**	**66.66**	**77.62**	**0.86**	**-55.55**	**-18.44**
TOTAL ASIA, NATO wo U.S.	**91**	**99**	**94.79**	**64.68**	**1.47**	**-58.36**	**-27.61**
TOTAL ASIA, NATO w U.S.	**100**	**100**	**100.00**	**100.00**	**1.00**	**-58.06**	**-27.50**

SOURCES: United Nations Conference on Trade and Development, undated; Hinz, 2017.

Figure B.5
Calculation of the Outputs Factor

Weights		0.17	0.17	0.17	0.17	0.17	0.17	0.75	0.25	
COUNTRY		**P**	**GF**	**AF**	**NF**	**MM**	**C4ISR**	**PREPAR-EDNESS**	**COO**	**OUTPUTS**
U.S.		**24**	**33**	**58**	**66**	**45**	**67**	**49**	**84**	**58**
Country WQ		0.67	1.52	2.18	1.79	5.14	0.89	2.03	0.42	1.63
Country OS		2.86	3.96	5.57	5.14	2.80	6.67	4.50	0.06	3.39
Country KA		0.10	0.08	0.19	0.20	0.28	0.00	0.14	0.07	0.12
Country XT		1.45	0.45	0.31	0.42	0.57	1.42	0.77	0.00	0.58
Country XD		5.11	13.31	2.85	2.80	0.63	4.13	4.80	0.29	3.68
Country SQ		1.74	5.39	3.36	1.64	0.34	1.72	2.36	0.00	1.77
Country WX		2.93	2.08	1.54	0.49	0.85	2.18	1.68	0.00	1.26
TOTAL E ASIA wo U.S.		**15**	**31**	**16**	**14**	**11**	**17**	**17**	**1**	**13**
TOTAL E ASIA w U.S.		**39**	**64**	**73**	**78**	**56**	**84**	**66**	**85**	**71**
Country KX		0.24	0.00	0.00	0.00	0.03	0.00	0.04	0.05	0.05
Country PQ		1.43	0.39	0.59	0.12	0.68	0.49	0.62	0.18	0.51
Country GP		0.66	0.42	0.14	0.20	0.06	0.12	0.27	0.09	0.22
Country FX		2.20	0.90	1.38	0.89	6.72	0.30	2.07	0.42	1.66
Country CB		0.36	0.49	0.01	0.00	0.33	0.00	0.20	0.08	0.17
Country RT		1.23	0.48	0.45	0.00	0.02	0.00	0.36	0.14	0.31
Country ZL		0.99	0.19	0.27	0.21	2.71	0.00	0.73	0.13	0.58
Country ST		0.21	0.15	0.03	0.00	0.22	0.00	0.10	0.03	0.08
Country PU		6.98	2.70	4.13	5.16	3.87	3.51	4.39	4.03	4.30
Country OJ		8.58	2.13	1.97	0.92	4.75	1.85	3.37	1.36	2.86
Country KF		2.23	4.83	1.45	1.41	7.04	0.60	2.93	0.07	2.21
Country HD		0.82	0.42	0.10	0.00	0.04	0.00	0.23	0.32	0.25
Country UT		0.00	0.00	0.00	0.00	0.15	0.00	0.02	0.00	0.02
Country TQ		6.94	2.29	2.05	6.60	2.17	2.36	3.73	1.41	3.15
Country NU		0.22	0.03	0.00	0.00	0.07	0.00	0.05	0.01	0.04
Country YX		0.37	0.06	0.09	0.00	0.04	0.00	0.09	0.02	0.07
Country QX		0.02	0.03	0.00	0.00	0.17	0.00	0.04	0.02	0.03
Country DN		0.02	0.04	0.00	0.00	0.01	0.00	0.01	0.01	0.01
Country UU		2.42	0.81	0.61	1.15	0.99	0.00	1.00	0.29	0.82
Country VJ		1.29	0.21	0.36	0.69	1.77	0.00	0.72	0.14	0.58
Country HS		3.69	3.47	1.36	0.50	0.28	0.00	1.55	0.27	1.23
Country WY		0.99	0.30	0.37	0.43	1.65	0.83	0.76	0.08	0.59
Country PC		1.83	2.19	0.28	0.14	0.15	0.24	0.80	0.36	0.69
Country GO		0.97	0.20	0.19	0.00	0.05	0.00	0.23	0.09	0.20
Country JR		0.26	0.07	0.00	0.00	0.01	0.00	0.06	0.12	0.07
Country JU		4.33	1.65	2.83	1.73	1.05	0.24	1.97	0.54	1.61
Country YW		4.79	8.88	4.48	1.83	1.93	2.79	4.12	1.39	3.44
Country PJ		7.43	2.57	3.35	1.82	7.52	2.31	4.17	3.02	3.88
TOTAL NON-U.S. NATO		**61**	**36**	**27**	**22**	**44**	**16**	**34**	**15**	**29**
TOTAL U.S.+NATO		**85**	**69**	**84**	**86**	**89**	**83**	**83**	**99**	**87**
TOTAL ASIA, NATO wo U.S.		**76**	**67**	**42**	**36**	**55**	**33**	**52**	**16**	**43**
TOTAL ASIA, NATO w U.S.		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

SOURCES: See the respective worksheets for each factor.

NOTES: P = personnel; GF = ground forces; AF = air forces; NF = naval forces; MM = military mobility; C4ISR = command, control, communications, computers, intelligence, surveillance, and reconnaissance; COO = contributions to ongoing operations.

Figure B.6
Calculation of the Personnel Factor

Conscription Discount Weights: 0.7

COUNTRY	ADF	CON	ADF'	POP	ER	TCW	ADF/TCW	Share	P
U.S.	**1,347,300**	**0**	**1,347,300**	**323,995,528.0**	**58.80%**	**190,509,370**	**0.71%**	**31**	**24**
Country WQ	57,800	0	57,800	22,992,654.0	61.00%	14,025,519	0.41%	1	0.67
Country OS	247,150	0	247,150	126,702,133.0	57.20%	72,473,620	0.34%	6	2.86
Country KA	8,950	0	8,950	4,474,549.0	63.50%	2,841,339	0.31%	0	0.10
Country XT	125,000	0	125,000	102,624,209.0	61.00%	62,600,767	0.20%	3	1.45
Country XD	630,000	1	441,000	50,924,172.0	58.70%	29,892,489	2.11%	10	5.11
Country SQ	215,000	1	150,500	23,464,787.0	54.30%	12,741,379	1.69%	3	1.74
Country WX	360,850	1	252,595	68,200,824.0	70.60%	48,149,782	0.75%	6	2.93
TOTAL E ASIA wo U.S.	**1,644,750**	**3**	**1,282,995**	**399,383,328.0**	**60.77%**	**242,724,895**	**0.68%**	**30**	**15**
TOTAL E ASIA w U.S.	**2,992,050**		**2,630,295**	**723,378,856.0**	**59.89%**	**433,234,266**	**0.69%**	**61**	**39**
Country KX	8,000	1	5,600	3,038,594.0	42.40%	1,288,364	0.62%	0	0.24
Country PQ	29,600	0	29,600	11,409,077.0	49.00%	5,590,448	0.53%	1	1.43
Country GP	31,300	0	31,300	7,144,653.0	49.70%	3,550,893	0.88%	1	0.66
Country FX	63,000	0	63,000	35,362,905.0	60.60%	21,429,920	0.29%	1	2.20
Country CB	15,500	0	15,500	4,313,707.0	46.00%	1,984,305	0.78%	0	0.36
Country RT	21,950	0	21,950	10,644,842.0	57.00%	6,067,560	0.36%	1	1.23
Country ZL	16,000	1	11,200	5,593,785.0	58.30%	3,261,177	0.49%	0	0.99
Country ST	6,400	1	4,480	1,258,545.0	57.40%	722,405	0.89%	0	0.21
Country PU	202,950	0	202,950	66,836,154.0	49.30%	32,950,224	0.62%	5	6.98
Country OJ	176,800	0	176,800	80,722,792.0	57.70%	46,577,051	0.38%	4	8.58
Country KF	141,350	1	98,945	10,773,253.0	39.90%	4,298,528	3.29%	2	2.23
Country HD	26,500	0	26,500	9,874,784.0	51.60%	5,095,389	0.52%	1	0.82
Country UT	-	0	-	335,878.0	71.10%	238,809	0.00%	0	0.00
Country TQ	174,500	0	174,500	62,007,540.0	42.70%	26,477,220	0.66%	4	6.94
Country NU	5,310	0	5,310	1,965,686.0	54.60%	1,073,265	0.49%	0	0.22
Country YX	17,030	0	17,030	2,854,235.0	54.00%	1,541,287	1.10%	0	0.37
Country QX	900	0	900	582,291.0	55.50%	323,172	0.28%	0	0.02
Country DN	1,950	0	1,950	644,578.0	40.20%	259,120	0.75%	0	0.02
Country UU	35,410	0	35,410	17,016,967.0	59.80%	10,176,146	0.35%	1	2.42
Country VJ	24,950	1	17,465	5,265,158.0	61.40%	3,232,807	0.77%	0	1.29
Country HS	99,300	0	99,300	38,523,261.0	53.60%	20,648,468	0.48%	2	3.69
Country WY	26,900	0	26,900	10,833,816.0	52.10%	5,644,418	0.48%	1	0.99
Country PC	70,500	0	70,500	21,599,736.0	51.50%	11,123,864	0.63%	2	1.83
Country GO	15,850	0	15,850	5,445,802.0	53.40%	2,908,058	0.55%	0	0.97
Country JR	7,250	0	7,250	1,978,029.0	52.40%	1,036,487	0.70%	0	0.26
Country JU	123,200	0	123,200	48,563,476.0	47.30%	22,970,524	0.54%	3	4.33
Country YW	355,200	1	248,640	80,274,604.0	44.80%	35,963,023	0.99%	6	4.79
Country PJ	152,350	0	152,350	64,430,428.0	59.50%	38,336,105	0.40%	4	7.43
TOTAL NON-U.S. NATO	**1,851,550**	**6**	**1,684,380**	**609,294,576.0**	**51.66%**	**314,769,035**	**0.59%**	**39**	**61**
TOTAL U.S.+NATO	**3,198,850**	**6**	**3,031,680**	**933,290,104.0**	**54.14%**	**505,278,405**	**0.63%**	**70**	**85**
TOTAL ASIA, NATO wo U.S.	**3,496,300**	**9**	**2,967,375**	**1,008,677,904.0**	**55.27%**	**557,493,930**	**0.63%**	**69**	**76**
TOTAL ASIA, NATO w U.S.	**4,843,600**	**9**	**4,314,675**	**1,332,673,432.0**	**56.13%**	**748,003,301**	**0.65%**	**100**	**100**

SOURCES:
ADF = IISS, 2017.
POP = CIA, 2018, accessed October 31, 2018.
ER = International Labour Organization Department of Statistics, ILOSTAT data tool, undated.

NOTES: ADF = number of active-duty forces; CON = conscription indicator variable; ADF' = ADF discounted by conscription discount factor, where applicable; POP = total population; ER = employment ratio (proportion of a country's working-age population that is employed); TCW = total civilian workforce; ADF" = ADF discounted by conscription discount factor, where applicable, and then converted into a percentage share multiplied by the relevant weight; P = personnel.

Figure B.7
Calculation of the Ground Forces Factor

Weights			0.25						0.25			0.25			0.25			1.00			0.00	
COUNTRY	**Number**	**Share**	**MBT**	**Number**	**Avg Age**	**Weight**	**Wgtd No.**	**Share**	**MV**	**Number**	**Share**	**HELO**	**Number**	**Share**	**ARTY**	**NOGF**	**QGF**	**Wgtd No.**	**QGF**	**GF**
U.S.	**2,831**	**17**	**4**	**27,684**	**34**	**0.63**	**17,533**	**42**	**11**	**783**	**52**	**13**	**4,387**	**22**	**6**	**33**	**100**		**0**	**33**
Country WQ	59	0	0	1,714	14	0.97	1,667	4	1	22	1	0	54	0	0	1.52	100		0	1.52
Country OS	690	4	1	871	31	0.69	597	1	0	104	7	2	669	3	1	3.96	100		0	3.96
Country KA	-	-	0	93	22	0.83	78	0	0	-	-	0	24	0	0	0.08	100		0	0.08
Country XT	-	-	0	549	50	0.37	202	0	0	-	-	0	257	1	0	0.45	100		0	0.45
Country XD	2,614	16	4	3,596	35	0.62	2,236	5	1	96	6	2	5,067	26	6	13.31	100		0	13.31
Country SQ	565	3	1	2,272	48	0.41	924	2	1	96	6	2	1,880	10	2	5.39	100		0	5.39
Country WX	318	2	0	1,588	36	0.60	961	2	1	7	0	0	717	4	1	2.08	100		0	2.08
TOTAL E ASIA wo U.S.	**7,077**	**42**	**11**	**10,683**	**36**	**0.61**	**6,466**	**16**	**4**	**325**	**21**	**5**	**8,668**	**44**	**11**	**31**	**100**		**0**	**31**
TOTAL E ASIA w U.S.	**9,908**	**59**	**15**	**38,367**	**35**	**0.62**	**23,906**	**57**	**14**	**1,108**	**73**	**18**	**13,055**	**67**	**17**	**64**	**100**		**0**	**64**
Country KX	-	-	0	-	-	-	-	-	0	-	-	0	-	-	0	0.00	100		0	0.00
Country PQ	-	-	0	783	25	0.78	613	1	0	-	-	0	14	0	0	0.39	100		0	0.39
Country GP	80	0	0	297	46	0.43	129	0	0	6	0	0	96	0	0	0.42	100		0	0.42
Country FX	82	0	0	1,323	29	0.72	948	2	1	-	-	0	163	1	0	0.90	100		0	0.90
Country CB	75	0	0	495	24	0.80	396	1	0	-	-	0	113	1	0	0.49	100		0	0.49
Country RT	30	0	0	243	35	0.62	150	0	0	17	1	0	48	0	0	0.48	100		0	0.48
Country ZL	34	0	0	442	45	0.45	199	0	0	-	-	0	12	0	0	0.19	100		0	0.19
Country ST	-	-	0	172	31	0.68	118	0	0	-	-	0	66	0	0	0.15	100		0	0.15
Country PU	200	1	0	3,181	34	0.63	2,015	5	1	62	4	1	134	1	0	2.70	100		0	2.70
Country OJ	236	1	0	2,213	36	0.60	1,328	3	1	50	3	1	121	1	0	2.13	100		0	2.13
Country KF	1,341	8	2	2,816	42	0.50	1,408	3	1	28	2	0	1,187	6	2	4.83	100		0	4.83
Country HD	30	0	0	380	28	0.73	279	1	0	11	1	0	17	0	0	0.42	100		0	0.42
Country UT	-	-	0	-	30	0.70	-	-	0	-	-	0	-	-	0	0.00	100		0	0.00
Country TQ	160	1	0	1,644	20	0.87	1,425	3	1	43	3	1	376	2	0	2.29	100		0	2.29
Country NU	-	-	0	-	-	1.20	-	-	0	-	-	0	27	0	0	0.03	100		0	0.03
Country YX	-	-	0	238	60	0.20	48	0	0	-	-	0	22	0	0	0.06	100		0	0.06
Country QX	-	-	0	48	16	0.93	45	0	0	-	-	0	-	-	0	0.03	100		0	0.03
Country DN	-	-	0	8	30	0.70	6	0	0	-	-	0	30	0	0	0.04	100		0	0.04
Country UU	-	-	0	533	12	1.00	533	1	0	28	2	0	18	0	0	0.81	100		0	0.81
Country VJ	36	0	0	499	46	0.43	216	1	0	-	-	0	18	0	0	0.21	100		0	0.21
Country HS	937	6	1	1,970	30	0.70	1,379	3	1	28	2	0	607	3	1	3.47	100		0	3.47
Country WY	58	0	0	438	49	0.38	168	0	0	-	-	0	89	0	0	0.30	100		0	0.30
Country PC	460	3	1	1,768	35	0.62	1,090	3	1	-	-	0	661	3	1	2.19	100		0	2.19
Country GO	30	0	0	340	40	0.53	181	0	0	-	-	0	38	0	0	0.20	100		0	0.20
Country JR	-	-	0	115	27	0.75	86	0	0	-	-	0	18	0	0	0.07	100		0	0.07
Country JU	335	2	1	1,136	41	0.52	587	1	0	17	1	0	407	2	1	1.65	100		0	1.65
Country YW	2,485	15	4	4,783	39	0.55	2,631	6	2	64	4	1	1,982	10	3	8.88	100		0	8.88
Country PJ	227	1	0	2,013	18	0.90	1,812	4	1	50	3	1	250	1	0	2.57	100		0	2.57
TOTAL NON-U.S. NATO	**6,836**	**41**	**10**	**27,878**	**34**	**0.63**	**17,638**	**42**	**11**	**404**	**27**	**7**	**6,514**	**33**	**8**	**36**	**100**		**0**	**36**
TOTAL U.S.+NATO	**9,667**	**58**	**14**	**55,562**	**34**	**0.63**	**35,172**	**84**	**21**	**1,187**	**79**	**20**	**10,901**	**56**	**14**	**69**	**100**		**0**	**69**
TOTAL ASIA, NATO wo U.S.	**13,913**	**83**	**21**	**38,561**	**34**	**0.63**	**24,104**	**58**	**14**	**729**	**48**	**12**	**15,182**	**78**	**19**	**67**	**100**		**0**	**67**
TOTAL ASIA, NATO w U.S.	**16,744**	**100**	**25**	**49,244**	**34**	**0.63**	**41,637**	**100**	**25**	**1,512**	**100**	**25**	**19,569**	**100**	**25**	**100**	**100**		**0**	**100**

SOURCE: IISS, 2017.

NOTES: MBT = main battle tanks; MV = mechanized vehicles (armored personnel carriers + infantry fighting vehicles + light tanks + wheeled assault guns + airborne combat vehicles + amphibious assault vehicles + armored utility vehicles); HELO = attack helicopters; ARTY = towed and self-propelled artillery + Multiple-Launch Rocket Systems; NOGF = numbers of ground forces; QGF = quality of ground forces; GF = ground forces; orange = imputed value/placeholder.

Figure B.8
Calculation of the Air Forces Factor

Weights								0.25			0.25			0.25			0.25	1.00			0.00	
COUNTRY	**No. of Tactical Aircraft**	**Avg Age Years**	**Training Hours p.a.**	**Age Weight**	**Training Weight**	**Weighted No. of Aircraft**	**Share of Total Aircraft**	**ATAC**	**AEW**	**Share**	**AEW**	**No. of Tanker Aircraft**	**Share**	**TKR**	**TPT**	**Share**	**TPT**	**NOAF**	**QAF**	**Wgtd No.**	**QAF**	**AF**
U.S.	**1,411**	**36**	**160**	**0.70**	**1.14**	**1,122**	**29**	**7**	**111**	**66**	**17**	**204**	**88**	**22**	**683**	**47**	**12**	**58**	**100**	**0**	**0**	**58**
Country WQ	110	33	140	0.74	1.00	81	2.11	1	6	3.57	1	-	-	0	44	3.04	1	2.18	100	0	0	2.18
Country OS	335	39	140	0.63	1.00	211	5.49	1	17	10.12	3	6	2.58	1	59	4.08	1	5.57	100	0	0	5.57
Country KA	-	-	-	-	-	-	-	0	-	-	0	-	-	0	11	0.76	0	0.19	100	0	0	0.19
Country XT	12	12	140	1.10	1.00	13	0.34	0	-	-	0	-	-	0	13	0.90	0	0.31	100	0	0	0.31
Country XD	507	48	140	0.48	1.00	245	6.38	2	4	2.38	1	-	-	0	38	2.63	1	2.85	100	0	0	2.85
Country SQ	415	36	140	0.70	1.00	289	7.51	2	6	3.57	1	-	-	0	34	2.35	1	3.36	100	0	0	3.36
Country WX	106	41	140	0.60	1.00	64	1.67	0	2	1.19	0	-	-	0	48	3.32	1	1.54	100	0	0	1.54
TOTAL E ASIA wo U.S.	**1,485**	**41**	**143**	**0.60**	**1.02**	**903**	**24**	**6**	**35**	**21**	**5**	**6**	**3**	**1**	**247**	**17**	**4**	**16**	**100**	**0**	**0**	**16**
TOTAL E ASIA w U.S.	**2,896**	**39**	**152**	**0.65**	**1.08**	**2,025**	**53**	**13**	**146**	**87**	**22**	**210**	**90**	**23**	**930**	**64**	**16**	**73**	**100**	**0**	**0**	**73**
Country KX	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	0	0.00	100	0	0	0.00
Country PQ	59	42	165	0.59	1.18	41	1.1	0	-	-	0	-	-	0	19	1.31	0	0.59	100	0	0	0.59
Country GP	16	35	40	0.71	0.29	3	0.1	0	-	-	0	-	-	0	7	0.48	0	0.14	100	0	0	0.14
Country FX	77	34	140	0.72	1.00	56	1.5	0	-	-	0	-	-	0	59	4.08	1	1.38	100	0	0	1.38
Country CB	11	58	50	0.31	0.36	1	0.0	0	-	-	0	-	-	0	-	-	0	0.01	100	0	0	0.01
Country RT	35	18	120	1.00	0.86	30	0.8	0	-	-	0	-	-	0	15	1.04	0	0.45	100	0	0	0.45
Country ZL	30	42	165	0.59	1.18	21	0.5	0	-	-	0	-	-	0	8	0.55	0	0.27	100	0	0	0.27
Country ST	-	-	-	-	-	-	-	0	-	-	0	-	-	0	2	0.14	0	0.03	100	0	0	0.03
Country PU	273	26	180	0.86	1.29	303	7.9	2	7	4	1	3	1.29	0	46	3.18	1	4.13	100	0	0	4.13
Country OJ	211	32	140	0.76	1.00	160	4.2	1	-	-	0	-	-	0	54	3.73	1	1.97	100	0	0	1.97
Country KF	218	41	140	0.60	1.00	132	3.4	1	4	2	1	-	-	0	-	-	0	1.45	100	0	0	1.45
Country HD	14	20	50	0.97	0.36	5	0.1	0	-	-	0	-	-	0	4	0.28	0	0.10	100	0	0	0.10
Country UT	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	0	0.00	100	0	0	0.00
Country TQ	225	26	140	0.86	1.00	194	5.0	1	1	1	0	6	2.58	1	-	-	0	2.05	100	0	0	2.05
Country NU	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	0	0.00	100	0	0	0.00
Country YX	-	-	-	-	-	-	-	0	-	-	0	-	-	0	5	0.35	0	0.09	100	0	0	0.09
Country QX	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	0	0.00	100	0	0	0.00
Country DN	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	0	0.00	100	0	0	0.00
Country UU	61	41	180	0.60	1.29	47	1.2	0	-	-	0	2	0.86	0	5	0.35	0	0.61	100	0	0	0.61
Country VJ	59	42	180	0.59	1.29	44	1.2	0	-	-	0	-	-	0	4	0.28	0	0.36	100	0	0	0.36
Country HS	99	39	180	0.64	1.29	81	2.1	1	-	-	0	-	-	0	48	3.32	1	1.36	100	0	0	1.36
Country WY	30	42	180	0.59	1.29	23	0.6	0	-	-	0	-	-	0	13	0.90	0	0.37	100	0	0	0.37
Country PC	34	55	120	0.36	0.86	11	0.3	0	-	-	0	-	-	0	12	0.83	0	0.28	100	0	0	0.28
Country GO	12	35	90	0.71	0.64	5	0.1	0	-	-	0	-	-	0	9	0.62	0	0.19	100	0	0	0.19
Country JR	-	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	0	0.00	100	0	0	0.00
Country JU	165	34	180	0.72	1.29	154	4.0	1	-	-	0	5	2.15	1	75	5.18	1	2.83	100	0	0	2.83
Country YW	335	43	180	0.57	1.29	245	6.4	2	4	2	1	7	3.00	1	89	6.15	2	4.48	100	0	0	4.48
Country PJ	185	21	210	0.95	1.50	263	6.8	2	6	4	1	-	-	0	43	2.97	1	3.35	100	0	0	3.35
TOTAL NON-U.S. NATO	**2,149**	**34**	**164**	**0.72**	**1.17**	**1,818**	**47**	**12**	**22**	**13**	**3**	**23**	**10**	**2**	**517**	**36**	**9**	**27**	**100**	**0**	**0**	**27**
TOTAL U.S.+NATO	**3,560**	**35**	**162**	**0.71**	**1.16**	**2,940**	**76**	**19**	**133**	**79**	**20**	**227**	**97**	**24**	**1,200**	**83**	**21**	**84**	**100**	**0**	**0**	**84**
TOTAL ASIA, NATO wo U.S.	**3,634**	**37**	**155**	**0.67**	**1.11**	**2,721**	**71**	**18**	**57**	**34**	**8**	**29**	**12**	**3**	**764**	**53**	**13**	**42**	**100**	**0**	**0**	**42**
TOTAL ASIA, NATO w U.S.	**5,045**	**37**	**157**	**0.68**	**1.12**	**3,843**	**100**	**25**	**168**	**100**	**25**	**233**	**100**	**25**	**1,447**	**100**	**25**	**100**	**100**	**0**	**0**	**100**

SOURCE: IISS, 2017.

NOTES: TAC = number of tactical aircraft adjusted for age and training hours; AEW = airborne early warning aircraft; TKR = tanker aircraft (aircraft capable of both air-to-air refueling and military airlift); TPT = transport aircraft + transport/tanker aircraft + passenger transport aircraft; NOAF = numbers of air forces; QAF = quality of air forces; AF = air forces; orange = imputed value/placeholder.

Figure B.9
Calculation of the Naval Forces Factor

Weights			0.29			0.29			0.11				0.11			0.11			0.11	1.00		0.00	
COUNTRY	**CVX**	**Share**	**CVX**	**TacAir**	**Share**	**TACAIR**	**TacSubs**	**Share**	**TACSUB**	**Helos**	**Aircraft**	**Airframes**	**Share**	**ASW**	**CapShips**	**Share**	**CAPSHP**	**Amph**	**Share**	**AMPH**	**NONF**	**QNF Wgtd No.**	**QNF**	**NF**
U.S.	**11**	**79**	**22**	**1322**	**95**	**27**	**54**	**31**	**3**	**224**	**120**	**344**	**25**	**3**	**96**	**41**	**4**	**33**	**55**	**6**	**66**	**100**	**0**	**66**
Country WQ		-	-		-	-	6	3.49	0	24	20	44	3.15	0	12	5.09	0.55	3	5.00	1	1.79	100	0	1.79
Country OS		-	-		-	-	17	9.88	1	87	74	161	11.52	1	43	18.24	1.95	5	8.33	1	5.14	100	0	5.14
Country KA		-	-		-	-		-	0	8	6	14	1.00	0	2	0.85	0.09		-	0	0.20	100	0	0.20
Country XT		-	-		-	-		-	0		2	2	0.14	0	1	0.42	0.05	2	3.33	0	0.42	100	0	0.42
Country XD		-	-		-	-	24	13.95	1	31	16	47	3.36	0	9	3.82	0.41	3	5.00	1	2.80	100	0	2.80
Country SQ		-	-		-	-	2	1.16	0	20	12	32	2.29	0	24	10.18	1.09	1	1.67	0	1.64	100	0	1.64
Country WX		-	-		-	-		0.00	0	8	3	11	0.79	0	5	2.12	0.23	1	1.67	0	0.49	100	0	0.49
TOTAL E ASIA wo U.S.	**0**	**0**	**-**	**0**	**0**	**-**	**49**	**28**	**3**	**402**	**253**	**655**	**47**	**5**	**67**	**28**	**3**	**15**	**25**	**3**	**14**	**100**	**0**	**14**
TOTAL E ASIA w U.S.	**11**	**79**	**22**	**1322**	**95**	**27**	**103**	**60**	**6**	**626**	**373**	**999**	**71**	**8**	**121**	**51**	**5**	**48**	**80**	**9**	**78**	**100**	**0**	**78**
Country KX		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country PQ		-	-		-	-		-	0	4		4	0.29	0	2	0.85	0.09		-	0	0.12	100	0	0.12
Country GP		-	-		-	-		-	0	2		2	0.14	0	4	1.70	0.18		-	0	0.20	100	0	0.20
Country FX		-	-		-	-	1	0.6	0	37		37	2.65	0	12	5.09	0.55		-	0	0.89	100	0	0.89
Country CB		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country RT		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country ZL		-	-		-	-		-	0	9		9	0.64	0	3	1.27	0.14		-	0	0.21	100	0	0.21
Country ST		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country PU	1	7.14	2.04	42	3.02	0.86	6	3.5	0	34	12	46	3.29	0	22	9.33	1.00	3	5.00	1	5.16	100	0	5.16
Country OJ		-	-		-	-	6	3.5	0	22	8	30	2.15	0	7	2.97	0.32		-	0	0.92	100	0	0.92
Country KF		-	-		-	-	11	6.4	1	18		18	1.29	0	13	5.51	0.59		-	0	1.41	100	0	1.41
Country HD		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country UT		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country TQ	2	14.29	4.08	16	1.15	0.33	8	4.7	0	39	5	44	3.15	0	18	7.63	0.82	3	5.00	1	6.60	100	0	6.60
Country NU		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country YX		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country QX		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country DN		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country UU		-	-		-	-	4	2.3	0	12		12	0.86	0	6	2.54	0.27	3	5.00	1	1.15	100	0	1.15
Country VJ		-	-		-	-	6	3.5	0	8	4	12	0.86	0	5	2.12	0.23		-	0	0.69	100	0	0.69
Country HS		-	-		-	-	4	2.3	0	11	10	21	1.50	0	2	0.85	0.09		-	0	0.50	100	0	0.50
Country WY		-	-		-	-	2	1.2	0	5	5	10	0.72	0	5	2.12	0.23		-	0	0.43	100	0	0.43
Country PC		-	-		-	-		-	0				-	0	3	1.27	0.14		-	0	0.14	100	0	0.14
Country GO		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country JR		-	-		-	-		-	0				-	0		-	0		-	0	0.00	100	0	0.00
Country JU		-	-	13	0.93	0.27	3	1.7	0	20	11	31	2.22	0	11	4.67	0.50	3	5.00	1	1.73	100	0	1.73
Country YW		-	-		-	-	12	7.0	1	29	6	35	2.50	0	18	7.63	0.82		-	0	1.83	100	0	1.83
Country PJ		-	-		-	-	6	3.5	0	88		88	6.29	1	17	7.21	0.77		-	0	1.82	100	0	1.82
TOTAL NON-U.S. NATO	**3**	**21**	**6**	**71**	**5**	**1**	**69**	**40**	**4**	**338**	**61**	**399**	**29**	**3**	**109**	**46**	**5**	**12**	**20**	**2**	**22**	**100**	**0**	**22**
TOTAL U.S.+NATO	**14**	**100**	**29**	**1393**	**100**	**29**	**123**	**72**	**8**	**562**	**181**	**743**	**53**	**6**	**163**	**69**	**7**	**45**	**75**	**8**	**86**	**100**	**0**	**86**
TOTAL ASIA, NATO wo U.S.	**3**	**21**	**6**	**71**	**5**	**1**	**118**	**69**	**7**	**740**	**314**	**1054**	**75**	**8**	**182**	**77**	**8**	**27**	**45**	**5**	**36**	**100**	**0**	**36**
TOTAL ASIA, NATO w U.S.	**14**	**100**	**29**	**1393**	**100**	**29**	**172**	**100**	**11**	**964**	**434**	**1398**	**100**	**11**	**236**	**100**	**11**	**60**	**100**	**11**	**100**	**100**	**0**	**100**

SOURCE: IISS, 2017.

NOTES: CVX = aircraft carriers (helicopter carriers are listed under AMPH to give maximum credit to allies for like capabilities); TACAIR = tactical naval aircraft; TACSUB = tactical submarines; ASW = anti-submarine warfare aircraft; CAPSHP = capital ships (cruisers + destroyers + frigates); AMPH = heavy amphibious ships (landing helicopter assault vessels + landing helicopter docks + landing platform docks + landing ship docks + helicopter carriers); NONF = numbers of naval forces; QNF = quality of naval forces; NF = naval forces; orange = imputed value/placeholder.

Figure B.10
Calculation of the Military Mobility Factor

Weights			0.50						0.25		0.25	
COUNTRY	**Strat Airlift**	**Share**	**ALIFT**	**Tankers**	**Gen Cargo**	**Container**	**TotTons**	**Share**	**SLIFT**	**Share**	**FOM**	**MM**
U.S.	**281**	**76**	**38**	**3,877**	**2,094**	**2,906**	**8,877**	**5**	**1**	**22**	**6**	**45**
Country WQ	8.00	2.17	1	12	102		114	0.06	0	16.14	4.04	5.14
Country OS			0	9,185	2,669	710	12,564	7.12	2	4.08	1.02	2.80
Country KA			0	104	55		159	0.09	0	1.03	0.26	0.28
Country XT			0	323	1,377	306	2,006	1.14	0	1.15	0.29	0.57
Country XD			0	849	1,444	1,281	3,574	2.03	1	0.48	0.12	0.63
Country SQ			0	200	144	1,730	2,074	1.18	0	0.18	0.04	0.34
Country WX			0	3,122	389	279	3,790	2.15	1	1.26	0.32	0.85
TOTAL E ASIA wo U.S.	**8.00**	**2**	**1**	**13,795**	**6,180**	**4,306**	**24,281**	**14**	**3**	**24**	**6**	**11**
TOTAL E ASIA w U.S.	**288.96**	**78**	**39**	**17,672**	**8,274**	**7,212**	**33,158**	**19**	**5**	**47**	**12**	**56**
Country KX			0		44		44	0.02	0	0.10	0.02	0.03
Country PQ	0.06	0.02	0	4,232	59		4,291	2.43	1	0.24	0.06	0.68
Country GP			0	7	56		63	0.04	0	0.22	0.05	0.06
Country FX	7.00	1.90	1	546	1,300	15	1,861	1.05	0	22.04	5.51	6.72
Country CB			0	1,067	18		1,085	0.61	0	0.72	0.18	0.33
Country RT			0				0	0.00	0	0.09	0.02	0.02
Country ZL			0	3,600	255	11,431	15,286	8.66	2	2.18	0.54	2.71
Country ST	0.42	0.11	0	12	20		32	0.02	0	0.62	0.16	0.22
Country PU	14.00	3.80	2	3,889	97	2,341	6,327	3.59	1	4.29	1.07	3.87
Country OJ	19.00	5.15	3	476	234	9,211	9,921	5.62	1	3.07	0.77	4.75
Country KF			0	45,778	178	569	46,525	26.37	7	1.81	0.45	7.04
Country HD	0.05	0.01	0				0	0.00	0	0.12	0.03	0.04
Country UT			0		2		2	0.00	0	0.59	0.15	0.15
Country TQ			0	5,561	1,700	623	7,884	4.47	1	4.22	1.05	2.17
Country NU			0	9	43		52	0.03	0	0.27	0.07	0.07
Country YX	0.04	0.01	0	5	83	21	109	0.06	0	0.09	0.02	0.04
Country QX			0	76	19	1,117	1,212	0.69	0	0.01	0.00	0.17
Country DN			0				0	0.00	0	0.05	0.01	0.01
Country UU	0.47	0.13	0	216	4,345	766	5,327	3.02	1	0.68	0.17	0.99
Country VJ	0.38	0.10	0	6,870	436	8	7,314	4.15	1	2.74	0.69	1.77
Country HS	0.14	0.04	0	7	25		32	0.02	0	1.04	0.26	0.28
Country WY			0	557	458	9,200	10,215	5.79	1	0.83	0.21	1.65
Country PC	0.18	0.05	0	6	35		41	0.02	0	0.46	0.11	0.15
Country GO	0.06	0.02	0		3	87	90	0.05	0	0.10	0.02	0.05
Country JR			0				0	0.00	0	0.03	0.01	0.01
Country JU	3.00	0.81	0	444	187		631	0.36	0	2.20	0.55	1.05
Country YW	7.00	1.90	1	1,349	1,503	1,022	3,874	2.20	1	1.71	0.43	1.93
Country PJ	28.00	7.59	4	11,012	1,046	9,041	21,099	11.96	3	2.94	0.73	7.52
TOTAL NON-U.S. NATO	**79.80**	**22**	**11**	**85,719**	**12,102**	**45,452**	**143,273**	**81**	**20**	**53**	**13**	**44**
TOTAL U.S.+NATO	**360.76**	**98**	**49**	**89,596**	**14,196**	**48,358**	**152,150**	**86**	**22**	**76**	**19**	**89**
TOTAL ASIA, NATO wo U.S.	**87.80**	**24**	**12**	**99,514**	**18,282**	**49,758**	**167,554**	**95**	**24**	**78**	**19**	**55**
TOTAL ASIA, NATO w U.S.	**368.76**	**100**	**50**	**103,391**	**20,376**	**52,664**	**176,431**	**100**	**25**	**100**	**25**	**100**

SOURCES:
ALIFT = IISS, 2017.
SLIFT = United Nations Conference on Trade and Development, undated, accessed October 31, 2018.
FOM = Mamur, 2016.

NOTES: ALIFT = strategic airlift aircraft (fractional amounts reflect NATO sharing arrangements); SLIFT = strategic sealift tonnage; FOM = NATO freedom-of-movement score; MM = military mobility. Strategic airlift includes numbers of C-5, C-17, C-141, A-400M, An-124, An-225, Il-76, and Xian Y-20 aircraft. Shipping figures are in thousands of deadweight tons. Chinese shipping includes Hong Kong and Macao.

Figure B.11
Calculation of the Freedom-of-Movement Metric

Weights			0.25	0.25	0.25	0.25					0.33	0.50	0.50				0.33				0.33		0.00		
COUNTRY	**Area**	**Ports**	**APOD**	**OVRFLT**	**LANDING**	**CLRNC**	**W Avg**	**Airspace**	**Accessible**	**Share**	**AIR**	**ROADS**	**RAIL**	**W Avg**	**Accessible**	**Share**	**GRND**	**SPOD**	**Ports**	**Share**	**SEA**	**DIP**	**DIP**	**FOM**
U.S.	**9,833,517**	**142**	**100**	**55**	**43**	**67**	**66**	**7,306,849**	**4,820,491**	**29**	**10**	**48**	**44**	**46**	**4,552,554**	**28**	**9**	**72**	**103**	**9**	**3**	**46**	**0**	**22**
Country WQ	7,741,220	50	100	55	43	67	66	5,752,157	3,794,826	22.72	7.57	48	44	46	3,583,898	22.42	7.47	72	36	3.30	1.1	46	0.00	16.14
Country OS	377,915	152	100	55	43	67	66	280,812	185,258	1.11	0.37	48	44	46	174,961	1.09	0.36	72	110	10.02	3.34	46	0.00	4.08
Country KA	268,838	23	100	55	43	67	66	199,762	131,787	0.79	0.26	48	44	46	124,462	0.78	0.26	72	17	1.52	0.51	46	0.00	1.03
Country XT	300,000	26	100	55	43	67	66	222,917	147,063	0.88	0.29	48	44	46	138,889	0.87	0.29	72	19	1.71	0.57	46	0.00	1.15
Country XD	99,720	13	100	55	43	67	66	74,098	48,884	0.29	0.10	48	44	46	46,167	0.29	0.10	72	9	0.86	0.29	46	0.00	0.48
Country SQ	35,980	5	100	55	43	67	66	26,735	17,638	0.11	0.04	48	44	46	16,657	0.10	0.03	72	4	0.33	0.11	46	0.00	0.18
Country WX	513,120	12	100	55	43	67	66	381,277	251,537	1.51	0.50	48	44	46	237,556	1.49	0.50	72	9	0.79	0.26	46	0.00	1.26
TOTAL E ASIA wo U.S.	**9,336,793**	**281**	**100**	**55**	**43**	**67**	**66**	**6,937,758**	**4,576,993**	**27**	**9**	**48**	**44**	**46**	**4,322,589**	**27**	**9**	**72**	**203**	**19**	**6**	**46**	**0**	**24**
TOTAL E ASIA w U.S.	**19,170,310**	**423**	**100**	**55**	**43**	**67**	**66**	**14,244,607**	**9,397,484**	**56**	**19**	**48**	**44**	**46**	**8,875,144**	**56**	**19**	**72**	**306**	**28**	**9**	**46**	**0**	**47**
Country KX	28,748	4	100	25	25	100	63	17,968	11,230	0.07	0.02	50	0	25	7,187	0.04	0.01	50	2	0.18	0.06	50	0.00	0.10
Country PQ	30,528	6	100	25	25	25	44	13,356	5,843	0.03	0.01	50	100	75	22,896	0.14	0.05	100	6	0.55	0.18	50	0.00	0.24
Country GP	110,879	1	100	75	75	0	63	69,299	43,312	0.26	0.09	50	50	50	55,440	0.35	0.12	50	1	0.05	0.02	50	0.00	0.22
Country FX	9,984,670	120	100	55	43	67	66	7,419,165	4,894,588	29.31	9.77	48	44	46	4,622,532	28.91	9.64	72	87	7.91	2.64	46	0.00	22.04
Country CB	55,594	21	100	25	25	25	44	24,322	10,641	0.06	0.02	50	50	50	27,797	0.17	0.06	100	21	1.92	0.64	100	0.00	0.72
Country RT	78,867	NA	100	25	25	75	56	44,363	24,954	0.15	0.05	50	0	25	19,717	0.12	0.04	0	0	0.00	0.00	0	0.00	0.09
Country ZL	43,094	68	100	100	100	100	100	43,094	43,094	0.26	0.09	50	0	25	10,774	0.07	0.02	100	68	6.21	2.07	50	0.00	2.18
Country ST	45,228	17	100	25	25	100	63	28,268	17,668	0.11	0.04	50	100	75	33,921	0.21	0.07	100	17	1.55	0.52	50	0.00	0.62
Country PU	643,801	88	100	75	25	75	69	442,613	304,296	1.82	0.61	50	100	75	482,851	3.02	1.01	100	88	8.04	2.68	0	0.00	4.29
Country OJ	357,022	59	100	100	100	100	100	357,022	357,022	2.14	0.71	50	100	75	267,767	1.67	0.56	100	59	5.39	1.8	100	0.00	3.07
Country KF	131,957	53	100	75	75	25	69	90,720	62,370	0.37	0.12	50	0	25	32,989	0.21	0.07	100	53	4.84	1.61	50	0.00	1.81
Country HD	93,028	NA	100	100	25	25	63	58,143	36,339	0.22	0.07	50	0	25	23,257	0.15	0.05	0	0	0.00	0.00	50	0.00	0.12
Country UT	103,000	30	100	100	25	100	81	83,688	67,997	0.41	0.14	0	0	0	-	0.00	0.00	50	15	1.37	0.46	0	0.00	0.59
Country TQ	301,340	108	100	75	75	100	88	263,673	230,714	1.38	0.46	50	100	75	226,005	1.41	0.47	100	108	9.86	3.29	50	0.00	4.22
Country NU	64,589	6	100	25	25	100	63	40,368	25,230	0.15	0.05	50	0	25	16,147	0.10	0.03	100	6	0.55	0.18	100	0.00	0.27
Country YX	65,300	1	100	25	25	25	44	28,569	12,499	0.07	0.02	50	0	25	16,325	0.10	0.03	100	1	0.09	0.03	100	0.00	0.09
Country QX	2,586	NA	100	25	25	25	44	1,131	495	0.00	0.00	50	100	75	1,940	0.01	0.00	0	0	0.00	0.00	50	0.00	0.01
Country DN	13,812	2	100	25	0	100	56	7,769	4,370	0.03	0.01	50	0	25	3,453	0.02	0.01	50	1	0.09	0.03	50	0.00	0.05
Country UU	41,543	19	100	75	25	75	69	28,561	19,636	0.12	0.04	50	100	75	31,157	0.19	0.06	100	19	1.73	0.58	50	0.00	0.68
Country VJ	323,802	65	100	75	75	75	81	263,089	213,760	1.28	0.43	50	50	50	161,901	1.01	0.34	100	65	5.94	1.98	0	0.00	2.74
Country HS	312,685	10	100	25	25	100	63	195,428	122,143	0.73	0.24	50	100	75	234,514	1.47	0.49	100	10	0.91	0.3	100	0.00	1.04
Country WY	92,090	40	100	75	75	75	81	74,823	60,794	0.36	0.12	50	50	50	46,045	0.29	0.10	50	20	1.83	0.61	0	0.00	0.83
Country PC	238,391	4	100	25	25	75	56	134,095	75,428	0.45	0.15	50	50	50	119,196	0.75	0.25	50	2	0.18	0.06	50	0.00	0.46
Country GO	49,035	NA	100	75	75	100	88	42,096	36,834	0.22	0.07	50	0	25	12,259	0.08	0.03	0	0	0.00	0.00	50	0.00	0.10
Country JR	20,273	1	100	25	25	0	38	7,602	2,851	0.02	0.01	50	0	25	5,068	0.03	0.01	50	1	0.05	0.02	50	0.00	0.03
Country JU	505,370	33	100	75	75	75	81	410,613	333,623	2.00	0.67	50	50	50	252,685	1.58	0.53	100	33	3.01	1	0	0.00	2.20
Country YW	783,562	33	100	25	25	25	44	342,808	149,979	0.90	0.30	50	0	25	195,891	1.23	0.41	100	33	3.01	1	0	0.00	1.71
Country PJ	243,610	75	100	75	25	100	75	182,708	137,031	0.82	0.27	50	100	75	182,708	1.14	0.38	100	75	6.85	2.28	50	0.00	2.94
TOTAL NON-U.S. NATO	**14,764,404**	**864**	**100**	**55**	**43**	**67**	**66**	**10,715,354**	**7,304,739**	**44**	**15**	**48**	**44**	**46**	**7,112,419**	**44**	**15**	**72**	**790**	**72**	**24**	**46**	**0**	**53**
TOTAL U.S.+NATO	**24,597,921**	**1,006**	**100**	**55**	**43**	**67**	**66**	**18,022,203**	**12,125,230**	**73**	**24**	**48**	**44**	**46**	**11,664,973**	**73**	**24**	**144**	**892**	**81**	**27**	**46**	**0**	**76**
TOTAL ASIA, NATO wo U.S.	**24,101,197**	**1,145**	**100**	**55**	**43**	**67**	**66**	**17,653,112**	**11,881,732**	**71**	**24**	**48**	**44**	**46**	**11,435,008**	**72**	**24**	**144**	**993**	**91**	**30**	**46**	**0**	**78**
TOTAL ASIA, NATO w U.S.	**33,934,714**	**1,287**	**100**	**55**	**43**	**67**	**66**	**24,959,961**	**16,702,223**	**100**	**33**	**48**	**44**	**46**	**15,987,562**	**100**	**33**	**217**	**1,095**	**100**	**33**	**46**	**0**	**100**

SOURCES: Mamur, 2016; CIA, 2018.

NOTES: APOD = airports of debarkation; OVRFLT = overflight rights; LANDING = landing rights; CLRNC = air traffic control clearance; SPOD = seaports of debarkation; DIP = diplomatic clearance times; FOM = freedom of movement; orange = imputed values/placeholders.

Figure B.12
Calculation of the C4ISR Factor

Weights							0.25			0.25			0.25			0.25	
COUNTRY	ISR Sats	Electronic and Signals Intelligence Sats	Surveillance Sats	Early Warning Sats	Sats	Share	SATS	ISR Aircraft	Share	ISR	AEW Aircraft	Share	AEW	Heavy UAV	Share	UAV	C4ISR
U.S.	**15**	**28**	**6**	**7**	**56**	**68**	**17**	**93**	**44**	**10.97**	**111**	**66.07**	**17**	**560**	**91**	**23**	**67**
Country WQ						-	0		0	0	6	3.57	1		-	0	1
Country OS	7				7	8.54	2	17	8	2.00	17	10.12	3		-	0	7
Country KA						-	0		0	0		-	0		-	0	0
Country XT						-	0	12	6	1.42		-	0		-	0	1
Country XD						-	0	30	14	3.54	4	2.38	1		-	0	4
Country SQ						-	0	7	3	0.83	6	3.57	1		-	0	2
Country WX						-	0	16	8	1.89	2	1.19	0		-	0	2
TOTAL E ASIA wo U.S.	**7**	**0**	**0**	**0**	**7**	**9**	**2**	**82**	**39**	**9.67**	**35**	**20.83**	**5**	**0**	**-**	**0**	**17**
TOTAL E ASIA w U.S.	**22**	**28**	**6**	**7**	**63**	**77**	**19**	**175**	**83**	**20.64**	**146**	**86.90**	**22**	**560**	**91**	**23**	**84**
Country KX						-	0		-	0		-	0		-	0	0
Country PQ						-	0		-	0		-	0	12	1.95	0	0
Country GP						-	0	1	0	0.12		-	0		-	0	0
Country FX			1		1	1.22	0		-	0		-	0		-	0	0
Country CB						-	0		-	0		-	0		-	0	0
Country RT						-	0		-	0		-	0		-	0	0
Country ZL						-	0		-	0		-	0		-	0	0
Country ST						-	0		-	0		-	0		-	0	0
Country PU	4			2	6	7.32	2	2	1	0.24	7	4.17	1	10	1.63	0	4
Country OJ	5				5	6.10	2		-	0		-	0	8	1.30	0	2
Country KF						-	0		-	0	4	2.38	1		-	0	1
Country HD						-	0		-	0		-	0		-	0	0
Country UT						-	0		-	0		-	0		-	0	0
Country TQ	5				5	6.10	2	1	0	0.12	1	0.60	0	14	2.28	1	2
Country NU						-	0		-	0		-	0		-	0	0
Country YX						-	0		-	0		-	0		-	0	0
Country QX						-	0		-	0		-	0		-	0	0
Country DN						-	0		-	0		-	0		-	0	0
Country UU						-	0		-	0		-	0		-	0	0
Country VJ						-	0		-	0		-	0		-	0	0
Country HS						-	0		-	0		-	0		-	0	0
Country WY						-	0	7	3	0.83		-	0		-	0	1
Country PC						-	0	2	1	0.24		-	0		-	0	0
Country GO						-	0		-	0		-	0		-	0	0
Country JR						-	0		-	0		-	0		-	0	0
Country JU						-	0	2	1	0.24		-	0		-	0	0
Country YW	2				2	2.44	1	10	5	1.18	4	2.38	1	10	1.63	0	3
Country PJ						-	0	12	6	1.42	6	3.57	1		-	0	2
TOTAL NON-U.S. NATO	**16**	**0**	**1**	**2**	**19**	**23**	**6**	**37**	**17**	**4.36**	**22**	**13.10**	**3**	**54**	**9**	**2**	**16**
TOTAL U.S.+NATO	**31**	**28**	**7**	**9**	**75**	**91**	**23**	**130**	**61**	**15.33**	**133**	**79.17**	**20**	**614**	**100**	**25**	**83**
TOTAL ASIA, NATO wo U.S.	**23**	**0**	**1**	**2**	**26**	**32**	**8**	**119**	**56**	**14.03**	**57**	**33.93**	**8**	**54**	**9**	**2**	**33**
TOTAL ASIA, NATO w U.S.	**38**	**28**	**7**	**9**	**82**	**100**	**25**	**212**	**100**	**25.00**	**168**	**100.00**	**25**	**614**	**100**	**25**	**100**

SOURCE: IISS, 2017.

NOTE: SATS = satellites (includes ISR, electronic and signals intelligence, surveillance, and early warning); ISR = intelligence, surveillance, and reconnaissance; AEW = airborne early warning; UAV = unmanned aerial vehicle; C4ISR = command, control, communications, computers, intelligence, surveillance, and reconnaissance.

Figure B.13
Calculation of the Contributions to Ongoing Operations Factor

Country	CENTCOM TOTAL	PACOM TOTAL	EUCOM TOTAL	AFRICOM TOTAL	SOUTHCOM TOTAL	NORTHCOM TOTAL	GRAND TOTAL	DEPLOYMENT SHARE	ADF'	DEPLOYMENT RATIO	INCOME-SHARE	RATIO
U.S.	**54,410**	**76,620**	**99,702**	**6,339**	**1,380**	**150**	**238,601**	**84**	**1,347,300**	**18%**	**35.32**	**2.39**
Country WQ	1,075	120	-	1	-	-	1,196	0.42	57,800	2%	2.26	0.19
Country OS	-	-	-	174	-	-	174	0.06	247,150	0%	9.39	0.01
Country KA	190	-	-	3	-	-	193	0.07	8,950	2%	0.33	0.21
Country XT	-	-	-	-	-	-	-	0.00	125,000	0%	1.53	0.00
Country XD	521	-	-	305	-	-	826	0.29	441,000	0%	3.67	0.08
Country SQ	-	-	-	-	-	-	-	0.00	150,500	0%	2.14	0.00
Country WX	-	-	-	10	-	-	10	0.00	252,595	0%	3.06	0.00
TOTAL E ASIA wo U.S.	**1,786**	**120**	**-**	**493**	**-**	**-**	**2,399**	**1**	**1,282,995**	**0%**	**22**	**0.04**
TOTAL E ASIA w U.S.	**56,196**	**76,740**	**99,702**	**6,832**	**1,380**	**150**	**241,000**	**85.32**	**2,630,295**	**9%**	**57.70**	**1.48**
Country KX	83	-	50	4	-	-	137	0.05	5,600	2%	0.07	0.75
Country PQ	201	-	104	205	-	-	510	0.18	29,600	2%	0.97	0.19
Country GP	160	-	76	5	-	-	241	0.09	31,300	1%	0.27	0.31
Country FX	351	-	822	13	-	-	1,186	0.42	63,000	2%	3.19	0.13
Country CB	95	-	122	7	-	-	224	0.08	15,500	1%	0.18	0.44
Country RT	317	-	30	45	-	-	392	0.14	21,950	2%	0.67	0.21
Country ZL	330	-	39	9	-	-	378	0.13	11,200	3%	0.50	0.27
Country ST	51	-	8	14	-	-	73	0.03	4,480	2%	0.07	0.35
Country PU	1,812	-	2,314	7,249	-	-	11,375	4.03	202,950	6%	5.21	0.77
Country OJ	1,532	-	1,573	724	-	-	3,829	1.36	176,800	2%	7.57	0.18
Country KF	53	-	136	2	-	-	191	0.07	98,945	0%	0.55	0.12
Country HD	331	-	571	16	-	-	918	0.32	26,500	3%	0.51	0.64
Country UT	-	-	-	-	-	-	-	0.00	-		0.03	0.00
Country TQ	2,732	-	752	512	-	-	3,996	1.41	174,500	2%	4.23	0.33
Country NU	28	-	4	5	-	-	37	0.01	5,310	1%	0.10	0.14
Country YX	29	-	20	8	-	-	57	0.02	17,030	0%	0.16	0.12
Country QX	1	-	45	2	-	-	48	0.02	900	5%	0.11	0.15
Country DN	18	-	4	3	-	-	25	0.01	1,950	1%	0.02	0.44
Country UU	288	-	256	276	-	-	820	0.29	35,410	2%	1.65	0.18
Country VJ	173	-	220	16	-	-	409	0.14	17,465	2%	0.69	0.21
Country HS	280	-	476	5	-	-	761	0.27	99,300	1%	2.00	0.13
Country WY	43	-	19	178	-	-	240	0.08	26,900	1%	0.57	0.15
Country PC	737	-	253	36	-	-	1,026	0.36	70,500	1%	0.84	0.43
Country GO	209	-	51	-	-	-	260	0.09	15,850	2%	0.32	0.29
Country JR	13	-	318	4	-	-	335	0.12	7,250	5%	0.13	0.94
Country JU	1,044	-	318	174	-	-	1,536	0.54	123,200	1%	3.22	0.17
Country YW	3,408	-	518	-	-	-	3,926	1.39	248,640	2%	3.18	0.44
Country PJ	1,302	1,060	4,799	989	20	370	8,540	3.02	152,350	6%	5.31	0.57
TOTAL NON-U.S. NATO	**15,621**	**1,060**	**13,898**	**10,501**	**20**	**370**	**41,470**	**14.68**	**1,684,380**	**2%**	**42**	**0.35**
TOTAL U.S.+NATO	**70,031**	**77,680**	**113,600**	**16,840**	**1,400**	**520**	**280,071**	**99**	**3,031,680**	**9%**	**78**	**1.28**
TOTAL ASIA, NATO wo U.S.	**17,407**	**1,180**	**13,898**	**10,994**	**20**	**370**	**43,869**	**16**	**2,967,375**	**1%**	**65**	**0.24**
TOTAL ASIA, NATO w U.S.	**71,817**	**77,800**	**113,600**	**17,333**	**1,400**	**520**	**282,470**	**100**	**4,314,675**	**7%**	**100**	**NA**

SOURCE: IISS, 2017.

NOTES: ADF' = ADF discounted by conscription discount factor, where applicable. This worksheet excludes 950 Greek troops on Cyprus; 43,000 Turkish troops on Cyprus; 3,890 British troops on Cyprus (2,260), Ascension Island (20), British Indian Ocean Territory (40), Falkland Islands (1,000), and Gibraltar (570); 7,050 French troops on French Guiana (2,100), French Polynesia (900), French West Indies (1,000), New Caledonia (1,450), and Indian Ocean (including La Reunion) (1,600).

APPENDIX C

Survey Instruments to Measure the Quality of Allied Forces

As noted in the main report, we developed a nested, multi-attribute Burdensharing Index that allows for a more sophisticated exploration of allied burdensharing than is possible by focusing on an isolated statistic (e.g., defense spending as a percentage of GDP). Most of the metrics constituting the index are quantitative; they inform the burdensharing debate by identifying how much each ally contributes.

A full understanding of burdensharing, however, also requires an answer to the following question: How valuable is each ally's contribution? An ally may possess military forces, but are they high or low quality? More specifically, with what level of proficiency might they perform in combat?

This appendix presents three survey instruments that we designed to help answer these qualitative questions. Each section that follows presents a separate, largely repetitive, stand-alone survey instrument that is intended to be administered to experts on ground, air, and naval forces, respectively. The survey instruments suggest ways that researchers might obtain reliable estimates of the relative quality of allied forces. Such estimates could be included in a future iteration of the Burdensharing Index described in this report.

Survey on Ground Forces' Quality and Combat Proficiency

RAND researchers have developed a nested, multi-attribute Burdensharing Index that enables a more sophisticated exploration of allied burdensharing than is possible by focusing on an isolated statistic (e.g., defense spending as a percentage of gross domestic product). This index incorporates data for 45 metrics—organized across nine overarching factors[1]—that collectively could inform policymakers' judgments about the share of the collective defense burden that allies and partners are shouldering, as envisioned in the 2018 U.S. National Defense Strategy. Most of the metrics are quantitative and based on data from public sources. These quantitative measures inform the burdensharing debate by beginning to identify how much each ally contributes. A full understanding of burdensharing, however, also requires identifying how valuable each ally's contribution is. Put another way, an ally may possess military forces, but are they high or low quality, and how proficient would they be in combat?

The purpose of this survey is to elicit expert judgment about the quality, and especially the combat proficiency, of allied and partner ground forces. We aim to gain higher-level insight into how well, relative to each other, these ground forces could employ personnel and equipment in operations. Respondents may include, among others, the following types of experts:

- country desk officers in planning positions at combatant commands, other joint organizations, and U.S. Army commands
- analysts tracking allied and partner ground forces
- individuals at training organizations that host allies and partners
- operators with recent experience in multinational settings.

[1] The nine factors are defense financial inputs; nondefense financial inputs; personnel; ground forces; air forces; naval forces; military mobility; command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); and contributions to ongoing operations. Each factor contains one or more metrics. For example, the naval forces factor includes such metrics as the number of capital ships, the number of tactical naval aircraft, and the proficiency of naval forces. The third metric is qualitative and will be assessed using results from the naval version of this survey.

Design

Analysts may assess armed forces' quality on a spectrum.[2] At one end, less-capable militaries are able to perform simple functions in relatively permissive environments. At the other end of the spectrum, advanced militaries possess the warfighting competencies necessary to execute sophisticated tasks in challenging conditions. Given the inherent complexity involved in identifying where on the spectrum a given ally's military may reside, we developed separate surveys for the three force types considered: ground, air, and naval.[3] Additionally, we offer a definition of force quality that incorporates four dimensions:

1. technology
2. training
3. sustainability
4. interoperability.

Table C.1 frames the spectrum of force quality along these dimensions, which are the rows. *Technology* reflects what kinds of systems an ally's ground forces possess and their level of modernity. *Training* conveys the scale and complexity of operations that the ground forces are prepared for. *Sustainability* indicates the forces' degree of self-reliance and logistical capacity, including the ability to maintain and deploy ready units. Finally, *interoperability* indicates the forces' compatibility and aptitude for operations with coalition partners.

The columns in Table C.1 offer three ratings for consideration by the survey respondent: *very proficient*, *proficient*, and *somewhat proficient*. The bulleted text items serve as attributes to illustrate where on the force-quality spectrum a given nation's ground forces could be rated across each dimension. Nations without ground forces do not require responses.

Table C.1 is representative and may be used in conjunction with the respondent's own expertise. For each dimension, a nation's ground forces do not necessarily need to exhibit every attribute in the cell to warrant the rating; each case requires judgment from individuals with relevant experience and knowledge.

[2] The concept of a spectrum for force quality and combat proficiency is borrowed from Michael D. Swaine and Ashley J. Tellis, *Interpreting China's Grand Strategy: Past, Present, and Future*, Santa Monica, Calif.: RAND Corporation, MR-1121-AF, 2000; and Ashley J. Tellis, Janice Bially, Christopher Layne, Melissa McPherson, and Jerry M. Sollinger, *Measuring National Power in the Postindustrial Age: Analyst's Handbook*, Santa Monica, Calif.: RAND Corporation, MR-1110/1-A, 2000.

[3] Although the terms *ground*, *air*, and *naval* relate to both force types and domains, there is a conceptual difference between these. For example, aircraft operating from ships are designed to be employed in the air domain but belong to a naval force. For the purposes of this questionnaire, we consider quality and proficiency by force type, not domain.

Table C.1
Spectrum of Ground Forces' Quality and Combat Proficiency

	Very Proficient	Proficient	Somewhat Proficient
Technology	• Primarily modern vehicles with add-on or reactive armor • Primarily guided rockets, missiles, and artillery with digital fires targeting and integration • Modern anti-tank guided munitions (e.g., explosively formed penetrator or top attack) • Network C4ISR with advanced digital processing	• Primarily modern vehicles without add-on or reactive armor • Mix of guided and unguided rockets, missiles, and artillery with legacy fires targeting and integration • Legacy anti-tank guided munitions • FM-based command and control and limited digital processing	• Legacy vehicles with limited or no armor • Unguided artillery or no indirect fires capability beyond mortars • No anti-tank guided munitions beyond rocket-propelled grenades and guns • FM-based command and control without digital processing
Training	• Training approaches top quality and generates capabilities to operate in ◦ coalition and joint task forces ◦ brigades with joint and combined arms capabilities ◦ contested environments (near-peer threat) ◦ nighttime in most circumstances	• Training does not approach top quality but generates capabilities to operate in ◦ joint task forces ◦ battalions with combined arms capabilities ◦ semi-contested environments (moderate threat) ◦ nighttime in some circumstances	• Training is limited to generating capabilities to operate in ◦ structures with limited or no joint integration ◦ companies with basic fire and maneuver capabilities ◦ largely permissive environments (low threat) ◦ daytime
Sustainability	• Requires no or minimal coalition assistance to deploy beyond own land borders • Can self-sustain most supplies and services for an extended duration (weeks) • 75 percent or more of units are mission-capable	• Requires some coalition assistance to deploy beyond own land borders • Can self-sustain most supplies and services for a limited duration (days) • 50–74 percent of units are mission-capable	• Requires extensive coalition assistance to deploy beyond own land borders • Is reliant on coalition-provided supplies and services at onset of operations • Less than 50 percent of units are mission-capable
Interoperability	• Leadership role and/or extensive participation in ground-intensive multinational deployments within the past 5 years • Compatibility with NATO C4ISR systems • Common tactics, techniques, and procedures (e.g., NATO) • English-language proficiency and fluency with technical terms	• Participation in ground-intensive multinational deployments within the past 5 years • Limited compatibility with NATO C4ISR systems • Some common tactics, techniques, and procedures • English-language familiarity and understanding of technical terms	• Limited or no participation in ground-intensive multinational deployments within the past 5 years • Minimal or no compatibility with NATO C4ISR systems • Limited common tactics, techniques, and procedures • English-language difficulty and limited understanding of technical terms

NOTES: The purpose of this table is to enable experts to categorize the quality and combat proficiency of ground forces from a nation of interest. **The process of rating requires a degree of judgment based on operational or research experience; some ground forces may not clearly align to one of the proficiency ratings across a given dimension.** FM = frequency modulation.

Instructions

1. **Review Table C.1.** Recall that the framing of force quality and combat proficiency is illustrative.
2. **For each nation's ground forces (rows), use Table C.3 to provide a rating across the four dimensions (columns).** To the best of your knowledge, select a number from 0.1 to 3.0 that corresponds to increasing levels of force quality and proficiency. The first row in Table C.2 shows an example of a completed rating response. Base your answers on the following scale:

   – Very proficient 2.1 to 3.0
   – Proficient 1.1 to 2.0
   – Somewhat proficient 0.1 to 1.0
   – Unable to respond Not applicable

   If you have less than moderate confidence in your answer, select *unable to respond*. Moderate confidence means that you believe that your response would be at least as accurate as one from a well-informed national security generalist. Do not conduct research; you may review on-hand references, but the purpose of this exercise is to elicit your existing knowledge.
3. **For each nation's ground forces (rows), use Table C.3 to provide text responses across the four dimensions (columns).** State the most impactful action you believe a nation's ground forces could take within the next five years to improve their force quality and combat proficiency. Assume slow to moderate growth in the budget for ground forces. If you do not have the direct knowledge to offer a judgment, state *unable to respond*. The second row in Table C.2 shows an example of a completed text response.
4. **Reexamine Table C.1.** Consider whether you need to adjust any of your responses.
5. **Fill out the comments box in Table C.4.** Provide any reasoning or considerations you may have taken into account while responding, or offer any other feedback.

Table C.2
Survey Response Example

	Dimensions of Force Quality			
Nation	**Technology**	**Training**	**Sustainability**	**Interoperability**
Nation's name	2.5	2.0	1.8	1.5
What is the most impactful action that could be taken within the next five years?	Unable to respond	More opportunities for high-end NATO exercises	Increase stocks of precision-guided ammunition	English-language training for noncommissioned officers

Survey Response Forms for Completion by Experts

Table C.3
Responses to Ground Forces Survey

	Dimensions of Force Quality			
Nation	**Technology**	**Training**	**Sustainability**	**Interoperability**
Albania				
What is the most impactful action that could be taken within the next five years?				
Australia				
What is the most impactful action that could be taken within the next five years?				
Belgium				
What is the most impactful action that could be taken within the next five years?				
Bulgaria				
What is the most impactful action that could be taken within the next five years?				
Canada				
What is the most impactful action that could be taken within the next five years?				
Croatia				
What is the most impactful action that could be taken within the next five years?				
Czech Republic				
What is the most impactful action that could be taken within the next five years?				
Denmark				
What is the most impactful action that could be taken within the next five years?				
Estonia				
What is the most impactful action that could be taken within the next five years?				
France				
What is the most impactful action that could be taken within the next five years?				

Table C.3—Continued

Nation	Dimensions of Force Quality			
	Technology	Training	Sustainability	Interoperability
Germany				
What is the most impactful action that could be taken within the next five years?				
Greece				
What is the most impactful action that could be taken within the next five years?				
Hungary				
What is the most impactful action that could be taken within the next five years?				
Italy				
What is the most impactful action that could be taken within the next five years?				
Japan				
What is the most impactful action that could be taken within the next five years?				
Latvia				
What is the most impactful action that could be taken within the next five years?				
Lithuania				
What is the most impactful action that could be taken within the next five years?				
Luxembourg				
What is the most impactful action that could be taken within the next five years?				
Montenegro				
What is the most impactful action that could be taken within the next five years?				
Netherlands				
What is the most impactful action that could be taken within the next five years?				
New Zealand				
What is the most impactful action that could be taken within the next five years?				

Table C.3—Continued

Nation	Dimensions of Force Quality			
	Technology	Training	Sustainability	Interoperability
Norway				
What is the most impactful action that could be taken within the next five years?				
Philippines				
What is the most impactful action that could be taken within the next five years?				
Poland				
What is the most impactful action that could be taken within the next five years?				
Portugal				
What is the most impactful action that could be taken within the next five years?				
Republic of Korea (South Korea)				
What is the most impactful action that could be taken within the next five years?				
Romania				
What is the most impactful action that could be taken within the next five years?				
Slovakia				
What is the most impactful action that could be taken within the next five years?				
Slovenia				
What is the most impactful action that could be taken within the next five years?				
Spain				
What is the most impactful action that could be taken within the next five years?				
Taiwan				
What is the most impactful action that could be taken within the next five years?				

Table C.3—Continued

Nation	Dimensions of Force Quality			
	Technology	Training	Sustainability	Interoperability
Thailand				
What is the most impactful action that could be taken within the next five years?				
Turkey				
What is the most impactful action that could be taken within the next five years?				
United Kingdom				
What is the most impactful action that could be taken within the next five years?				
United States				
What is the most impactful action that could be taken within the next five years?				

Table C.4
Comments for Ground Forces Survey

Survey on Air Forces' Quality and Combat Proficiency

RAND researchers have developed a nested, multi-attribute Burdensharing Index that enables a more sophisticated exploration of allied burdensharing than is possible by focusing on an isolated statistic (e.g., defense spending as a percentage of gross domestic product). This index incorporates data for 45 metrics—organized across nine overarching factors[4]—that collectively could inform policymakers' judgments about the share of the collective defense burden that allies and partners are shouldering, as envisioned in the 2018 U.S. National Defense Strategy. Most of the metrics are quantitative and based on data from public sources. These quantitative measures inform the burdensharing debate by beginning to identify how much each ally contributes. A full understanding of burdensharing, however, also requires identifying how valuable each ally's contribution is. Put another way, an ally may possess military forces, but are they high or low quality, and how proficient would they be in combat?

The purpose of this survey is to elicit expert judgment about the quality, and especially the combat proficiency, of allied and partner air forces. We aim to gain higher-level insight into how well, relative to each other, these air forces could employ personnel and equipment in operations. Respondents may include, among others, the following types of experts:

- country desk officers in planning positions at combatant commands, other joint organizations, and U.S. Air Force commands
- airmen or other personnel working at U.S. embassy country teams
- analysts tracking allied and partner air forces
- individuals at training organizations that host allies and partners
- operators with recent experience in multinational settings.

[4] The nine factors are defense financial inputs; nondefense financial inputs; personnel; ground forces; air forces; naval forces; military mobility; command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); and contributions to ongoing operations. Each factor contains one or more metrics. For example, the naval forces factor includes such metrics as the number of capital ships, the number of tactical naval aircraft, and the proficiency of naval forces. The third metric is qualitative and will be assessed using results from the naval version of this survey.

Design

Analysts may assess armed forces' quality on a spectrum.[5] At one end, less-capable militaries are able to perform simple functions in relatively permissive environments. At the other end of the spectrum, advanced militaries possess the warfighting competencies necessary to execute sophisticated tasks in challenging conditions. Given the inherent complexity involved in identifying where on the spectrum a given ally's military may reside, we developed separate surveys for the three force types considered: ground, air, and naval.[6] Additionally, we offer a definition of combat proficiency that incorporates four dimensions:

1. technology
2. training
3. sustainability
4. interoperability.

Table C.5 frames the spectrum of force quality along these dimensions, which are the rows. *Technology* reflects what kinds of systems an ally's air forces possess and their level of modernity. *Training* conveys the scale and complexity of operations that the air forces are prepared for. *Sustainability* indicates the forces' degree of self-reliance and logistical capacity, including the ability to maintain and deploy ready units. Finally, *interoperability* indicates the forces' compatibility and aptitude for operations with coalition partners.

The columns in Table C.5 offer three ratings for consideration by the survey respondent: *very proficient*, *proficient*, and *somewhat proficient*. The bulleted text items serve as attributes to illustrate where on the force-quality spectrum a given nation's air forces could be rated across each dimension. Nations without air forces do not require responses.

Table C.5 is representative and may be used in conjunction with the respondent's own expertise. For each dimension, a nation's air forces do not necessarily need to exhibit every attribute in the cell to warrant the rating; each case requires judgment from individuals with relevant experience and knowledge.

[5] The concept of a spectrum for force quality and combat proficiency is borrowed from Michael D. Swaine and Ashley J. Tellis, *Interpreting China's Grand Strategy: Past, Present, and Future*, Santa Monica, Calif.: RAND Corporation, MR-1121-AF, 2000; and Ashley J. Tellis, Janice Bially, Christopher Layne, Melissa McPherson, and Jerry M. Sollinger, *Measuring National Power in the Postindustrial Age: Analyst's Handbook*, Santa Monica, Calif.: RAND Corporation, MR-1110/1-A, 2000.

[6] Although the terms *ground*, *air*, and *naval* relate to both force types and domains, there is a conceptual difference between these. For example, aircraft operating from ships are designed to be employed in the air domain but belong to a naval force. For the purposes of this questionnaire, we consider quality and proficiency by force type, not domain.

Table C.5
Spectrum of Air Forces' Quality and Combat Proficiency

	Very Proficient	Proficient	Somewhat Proficient
Technology	• Mix of 5th-generation (e.g., F-35) and 4th-generation (e.g., F-15/16) combat aircraft • Modern radar and infrared air-to-air missiles • Global Positioning System–enabled air-to-ground munitions • Advanced early warning radars • Modern network command and control (e.g., Link 16)	• Mix of 4th-generation and legacy combat aircraft with upgrades • Mix of modern and legacy air-to-air missiles • Laser-guided or similar air-to-ground munitions • Limited quantity of advanced early warning radars • Legacy network command and control (e.g., Link 1)	• Legacy combat aircraft without upgrades • Legacy or no air-to-air missiles • Freefall air-to-ground munitions • No early warning radars • Rudimentary network command and control (e.g., land lines/runners)
Training	• Training approaches top quality and generates capabilities to operate in ◦ coalition and joint task forces ◦ large-scale and mixed formations ◦ contested environments (near-peer threat) ◦ nighttime and adverse weather	• Training does not approach top quality but generates capabilities to operate in ◦ joint task forces ◦ multiple similar formations ◦ semi-contested environments (moderate threat) ◦ limited nighttime and adverse weather	• Training is limited to generating capabilities to operate in ◦ structures with limited or no joint integration ◦ single formations ◦ largely permissive environments (low threat) ◦ daytime and fair weather
Sustainability	• Has advanced airfield operations capability across most functions • Can self-sustain all supplies and services for an extended duration (weeks) • 75 percent or more of platforms are mission-capable	• Has advanced airfield operations capability in some functions • Can self-sustain most supplies and services for a limited duration (days) • 50–74 percent of platforms are mission-capable	• Has a limited airfield operations capability • Is reliant on coalition-provided supplies and services at onset of operations • Less than 50 percent of platforms are mission-capable
Interoperability	• Leadership role and/or extensive participation in air-intensive multinational operations within the past 5 years • Compatibility with NATO C4ISR systems • Common tactics, techniques, and procedures (e.g., NATO) • English-language proficiency and fluency with technical terms	• Participation in air-intensive multinational operations within the past 5 years • Limited compatibility with NATO C4ISR systems • Some common tactics, techniques, and procedures • English-language familiarity and understanding of technical terms	• Limited or no experience in air-intensive multinational operations within the past 5 years • Minimal or no compatibility with NATO C4ISR systems • Limited common tactics, techniques, and procedures • English-language difficulty and limited understanding of technical terms

NOTES: The purpose of this table is to enable experts to categorize the quality and combat proficiency of air forces from a nation of interest. **The process of rating requires a degree of judgment based on operational or research experience; some air forces may not clearly align to one of the proficiency ratings across a given dimension.**

Instructions

1. **Review Table C.5.** Recall that the framing of force quality and combat proficiency is illustrative.
2. **For each nation's air forces (rows), use Table C.7 to provide a rating across the four dimensions (columns).** To the best of your knowledge, select a number from 0.1 to 3.0 that corresponds to increasing levels of force quality. The first row in Table C.6 shows an example of a completed rating response. Base your answers on the following scale:

   – Very proficient 2.1 to 3.0
   – Proficient 1.1 to 2.0
   – Somewhat proficient 0.1 to 1.0
   – Unable to respond Not applicable

   If you have less than moderate confidence in your answer, select *unable to respond*. Moderate confidence means that you believe that your response would be at least as accurate as one from a well-informed national security generalist. Do not conduct research; you may review on-hand references, but the purpose of this exercise is to elicit your existing knowledge.
3. **For each nation's air forces (rows), use Table C.7 to provide text responses across the four dimensions (columns).** State the most impactful action you believe a nation's air forces could take within the next five years to improve their force quality and combat proficiency. Assume slow to moderate growth in the budget for air forces. If you do not have the direct knowledge to offer a judgment, state *unable to respond*. The second row in Table C.6 shows an example of a completed text response.
4. **Reexamine Table C.5.** Consider whether you need to adjust any of your responses.
5. **Fill out the comments box in Table C.8.** Provide any reasoning or considerations you may have taken into account while responding, or offer any other feedback.

Table C.6
Survey Response Example

	Dimensions of Force Quality			
Nation	**Technology**	**Training**	**Sustainability**	**Interoperability**
Nation's name	2.5	2.0	1.8	1.5
What is the most impactful action that could be taken within the next five years?	Unable to respond	More opportunities for high-end NATO exercises	Increase stocks of precision-guided ammunition	English-language training for noncommissioned officers

Survey Response Forms for Completion by Experts

Table C.7
Responses to Air Forces Survey

	Dimensions of Force Quality			
Nation	**Technology**	**Training**	**Sustainability**	**Interoperability**
Albania				
What is the most impactful action that could be taken within the next five years?				
Australia				
What is the most impactful action that could be taken within the next five years?				
Belgium				
What is the most impactful action that could be taken within the next five years?				
Bulgaria				
What is the most impactful action that could be taken within the next five years?				
Canada				
What is the most impactful action that could be taken within the next five years?				
Croatia				
What is the most impactful action that could be taken within the next five years?				
Czech Republic				
What is the most impactful action that could be taken within the next five years?				
Denmark				
What is the most impactful action that could be taken within the next five years?				
Estonia				
What is the most impactful action that could be taken within the next five years?				
France				
What is the most impactful action that could be taken within the next five years?				

Table C.7—Continued

Nation	Dimensions of Force Quality			
	Technology	Training	Sustainability	Interoperability
Germany				
What is the most impactful action that could be taken within the next five years?				
Greece				
What is the most impactful action that could be taken within the next five years?				
Hungary				
What is the most impactful action that could be taken within the next five years?				
Italy				
What is the most impactful action that could be taken within the next five years?				
Japan				
What is the most impactful action that could be taken within the next five years?				
Latvia				
What is the most impactful action that could be taken within the next five years?				
Lithuania				
What is the most impactful action that could be taken within the next five years?				
Montenegro				
What is the most impactful action that could be taken within the next five years?				
Netherlands				
What is the most impactful action that could be taken within the next five years?				
New Zealand				
What is the most impactful action that could be taken within the next five years?				

Table C.7—Continued

Nation	Dimensions of Force Quality			
	Technology	Training	Sustainability	Interoperability
Norway				
What is the most impactful action that could be taken within the next five years?				
Philippines				
What is the most impactful action that could be taken within the next five years?				
Poland				
What is the most impactful action that could be taken within the next five years?				
Portugal				
What is the most impactful action that could be taken within the next five years?				
Republic of Korea (South Korea)				
What is the most impactful action that could be taken within the next five years?				
Romania				
What is the most impactful action that could be taken within the next five years?				
Slovakia				
What is the most impactful action that could be taken within the next five years?				
Slovenia				
What is the most impactful action that could be taken within the next five years?				
Spain				
What is the most impactful action that could be taken within the next five years?				
Taiwan				
What is the most impactful action that could be taken within the next five years?				

Table C.7—Continued

Nation	Dimensions of Force Quality			
	Technology	Training	Sustainability	Interoperability
Thailand				
What is the most impactful action that could be taken within the next five years?				
Turkey				
What is the most impactful action that could be taken within the next five years?				
United Kingdom				
What is the most impactful action that could be taken within the next five years?				
United States				
What is the most impactful action that could be taken within the next five years?				

Table C.8
Comments for Air Forces Survey

Survey on Naval Forces' Quality and Combat Proficiency

RAND researchers have developed a nested, multi-attribute Burdensharing Index that enables a more sophisticated exploration of allied burdensharing than is possible by focusing on an isolated statistic (e.g., defense spending as a percentage of gross domestic product). This index incorporates data for 45 metrics—organized across nine overarching factors[7]—that collectively could inform policymakers' judgments about the share of the collective defense burden that allies and partners are shouldering, as envisioned in the 2018 U.S. National Defense Strategy. Most of the metrics are quantitative and based on data from public sources. These quantitative measures inform the burdensharing debate by beginning to identify how much each ally contributes. A full understanding of burdensharing, however, also requires identifying how valuable each ally's contribution is. Put another way, an ally may possess military forces, but are they high or low quality, and how proficient would they be in combat?

The purpose of this survey is to elicit expert judgment about the quality, and especially the combat proficiency, of allied and partner naval forces. We aim to gain higher-level insight into how well, relative to each other, these naval forces could employ personnel and equipment in operations. Respondents may include, among others, the following types of experts:

- country desk officers in planning positions at combatant commands, other joint organizations, and U.S. Navy and Marine Corps commands
- analysts tracking allied and partner naval forces
- individuals at training organizations that host allies and partners
- operators with recent experience in multinational settings.

[7] The nine factors are defense financial inputs; nondefense financial inputs; personnel; ground forces; air forces; naval forces; military mobility; command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); and contributions to ongoing operations. Each factor contains one or more metrics. For example, the naval forces factor includes such metrics as the number of capital ships, the number of tactical naval aircraft, and the proficiency of naval forces. The third metric is qualitative and will be assessed using results from the naval version of this survey.

Design

Analysts may assess armed forces' quality on a spectrum.[8] At one end, less-capable militaries are able to perform simple functions in relatively permissive environments. At the other end of the spectrum, advanced militaries possess the warfighting competencies necessary to execute sophisticated tasks in challenging conditions. Given the inherent complexity involved in identifying where on the spectrum a given ally's military may reside, we developed separate surveys for the three force types considered: ground, air, and naval.[9] Additionally, we offer a definition of combat proficiency that incorporates four dimensions:

1. technology
2. training
3. sustainability
4. interoperability.

Table C.9 frames the spectrum of force quality along these dimensions, which are the rows. *Technology* reflects what kinds of systems an ally's naval forces possess and their level of modernity. *Training* conveys the scale and complexity of operations that the naval forces are prepared for. *Sustainability* indicates the forces' degree of self-reliance and logistical capacity, including the ability to maintain and deploy ready units. Finally, *interoperability* indicates the forces' compatibility and aptitude for operations with coalition partners.

The columns in Table C.9 offer three ratings for consideration by the survey respondent: *very proficient*, *proficient*, and *somewhat proficient*. The bulleted text items serve as attributes to illustrate where on the force-quality spectrum a given nation's naval forces could be rated across each dimension. Nations without naval forces do not require responses.

Table C.9 is representative and may be used in conjunction with the respondent's own expertise. For each dimension, a nation's naval forces do not necessarily need to exhibit every attribute in the cell to warrant the rating; each case requires judgment from individuals with relevant experience and knowledge.

[8] The concept of a spectrum for force quality and combat proficiency is borrowed from Michael D. Swaine and Ashley J. Tellis, *Interpreting China's Grand Strategy: Past, Present, and Future*, Santa Monica, Calif.: RAND Corporation, MR-1121-AF, 2000; and Ashley J. Tellis, Janice Bially, Christopher Layne, Melissa McPherson, and Jerry M. Sollinger, *Measuring National Power in the Postindustrial Age: Analyst's Handbook*, Santa Monica, Calif.: RAND Corporation, MR-1110/1-A, 2000.

[9] Although the terms *ground*, *air*, and *naval* relate to both force types and domains, there is a conceptual difference between these. For example, aircraft operating from ships are designed to be employed in the air domain but belong to a naval force. For the purposes of this questionnaire, we consider quality and proficiency by force type, not domain.

Table C.9
Spectrum of Naval Forces' Quality and Combat Proficiency

	Very Proficient	Proficient	Somewhat Proficient
Technology	• Primarily modern warships (commissioned within 20 years) • Weapons and sensors for operations across most maritime mission areas • Advanced netted command and control for sensing and effect chains with integrated fires	• Mix of modern and legacy warships • Weapons and sensors for operations across some maritime mission areas • Legacy command and control tactical data links (e.g., Link 11, Link 22) for sensing and effect chains	• Legacy warships • Weapons and sensors for limited operations across some maritime mission areas • Voice-linked command and control for sensing and effect chains
Training	• Training approaches top quality and generates capabilities to operate in ◦ coalition and joint task forces ◦ formations with full-spectrum capabilities ◦ contested environments (near-peer threat) ◦ nighttime and adverse weather	• Training does not approach top quality but generates capabilities to operate in ◦ joint task forces ◦ formations with multi-mission capabilities ◦ semi-contested environments (moderate threat) ◦ limited nighttime and adverse weather	• Training limited to generating capabilities to operate in ◦ structures with limited or no joint integration ◦ formations with single-mission capabilities ◦ largely permissive environments (low threat) ◦ daytime and fair weather
Sustainability	• Capable of out-of-area deployments (blue water capability) • Can self-sustain all supplies and services for an extended duration (weeks) • 75 percent or more of platforms are mission-capable	• Capable of in-area deployments (limited blue water capability) • Can self-sustain most supplies and services for limited duration (days) • 50–74 percent of platforms are mission-capable	• Capable of coastal deployments (green water capability) • Is reliant on coalition-provided supplies and services at onset of operations • Less than 50 percent of platforms are mission-capable
Interoperability	• Leadership role and/or extensive participation in maritime-intensive multinational deployments within the past 5 years • Compatibility with NATO C4ISR systems • Common tactics, techniques, and procedures (e.g., NATO) • English-language proficiency and fluency with technical terms	• Participation in maritime-intensive multinational deployments within the past 5 years • Limited compatibility with NATO C4ISR systems • Some common tactics, techniques, and procedures • English-language familiarity and understanding of technical terms	• Limited or no participation in maritime-intensive multinational deployments within the past 5 years • Minimal or no compatibility with NATO C4ISR systems • Limited common tactics, techniques, and procedures • English-language difficulty and limited understanding of technical terms

NOTES: The purpose of this table is to enable experts to categorize the quality and combat proficiency of naval forces from a nation of interest. **The process of rating requires a degree of judgment based on operational or research experience; some naval forces may not clearly align to one of the proficiency ratings across a given dimension.**

Instructions

1. **Review Table C.9.** Recall that the framing of force quality and combat proficiency is illustrative.
2. **For each nation's naval forces (rows), use Table C.11 to provide a rating across the four dimensions (columns).** To the best of your knowledge, select a number from 0.1 to 3.0 that corresponds to increasing levels of force quality and proficiency. The first row in Table C.10 is an example of a completed rating response. Base your answers on the following scale:

   – Very proficient 2.1 to 3.0
   – Proficient 1.1 to 2.0
   – Somewhat proficient 0.1 to 1.0
   – Unable to respond Not applicable

   If you have less than moderate confidence in your answer, select *unable to respond*. Moderate confidence means that you believe that your response would be at least as accurate as one from a well-informed national security generalist. Do not conduct research; you may review on-hand references, but the purpose of this exercise is to elicit your existing knowledge.
3. **For each nation's naval forces (rows), use Table C.11 to provide text responses across the four dimensions (columns).** State the most impactful action you believe a nation's naval forces could take within the next five years to improve their force quality and combat proficiency. Assume slow to moderate growth in the budget for naval forces. If you do not have the direct knowledge to offer a judgment, state *unable to respond*. The second row in Table C.10 shows an example of a completed text response.
4. **Reexamine Table C.9.** Consider whether you need to adjust any of your responses.
5. **Fill out the comments box in Table C.12.** Provide any reasoning or considerations you may have taken into account while responding, or offer any other feedback.

Table C.10
Survey Response Example

	Dimensions of Force Quality			
Nation	**Technology**	**Training**	**Sustainability**	**Interoperability**
Nation's name	2.5	2.0	1.8	1.5
What is the most impactful action that could be taken within the next five years?	Unable to respond	More opportunities for high-end NATO exercises	Increase stocks of precision-guided ammunition	English-language training for noncommissioned officers

Survey Response Forms for Completion by Experts

Table C.11
Responses to Naval Forces Survey

	Dimensions of Force Quality			
Nation	**Technology**	**Training**	**Sustainability**	**Interoperability**
Albania				
What is the most impactful action that could be taken within the next five years?				
Australia				
What is the most impactful action that could be taken within the next five years?				
Belgium				
What is the most impactful action that could be taken within the next five years?				
Bulgaria				
What is the most impactful action that could be taken within the next five years?				
Canada				
What is the most impactful action that could be taken within the next five years?				
Croatia				
What is the most impactful action that could be taken within the next five years?				
Denmark				
What is the most impactful action that could be taken within the next five years?				
Estonia				
What is the most impactful action that could be taken within the next five years?				
France				
What is the most impactful action that could be taken within the next five years?				
Germany				
What is the most impactful action that could be taken within the next five years?				

Table C.11—Continued

Nation	Dimensions of Force Quality			
	Technology	Training	Sustainability	Interoperability
Greece				
What is the most impactful action that could be taken within the next five years?				
Italy				
What is the most impactful action that could be taken within the next five years?				
Japan				
What is the most impactful action that could be taken within the next five years?				
Latvia				
What is the most impactful action that could be taken within the next five years?				
Lithuania				
What is the most impactful action that could be taken within the next five years?				
Montenegro				
What is the most impactful action that could be taken within the next five years?				
Netherlands				
What is the most impactful action that could be taken within the next five years?				
New Zealand				
What is the most impactful action that could be taken within the next five years?				
Norway				
What is the most impactful action that could be taken within the next five years?				
Philippines				
What is the most impactful action that could be taken within the next five years?				
Poland				
What is the most impactful action that could be taken within the next five years?				

Table C.11—Continued

Nation	Dimensions of Force Quality			
	Technology	Training	Sustainability	Interoperability
Portugal				
What is the most impactful action that could be taken within the next five years?				
Republic of Korea (South Korea)				
What is the most impactful action that could be taken within the next five years?				
Romania				
What is the most impactful action that could be taken within the next five years?				
Spain				
What is the most impactful action that could be taken within the next five years?				
Taiwan				
What is the most impactful action that could be taken within the next five years?				
Thailand				
What is the most impactful action that could be taken within the next five years?				
Turkey				
What is the most impactful action that could be taken within the next five years?				
United Kingdom				
What is the most impactful action that could be taken within the next five years?				
United States				
What is the most impactful action that could be taken within the next five years?				

Table C.12
Comments for Naval Forces Survey

Conclusion

The survey instruments presented in this appendix are largely repetitive because each survey is intended to stand on its own. The biggest differences lie in the assessment of technology and in service-specific terminology used to refer to types of operations or groups of forces. The biggest challenge in producing reliable estimates of relative allied force quality and combat proficiency to incorporate into a nested, multi-attribute Burdensharing Index lies in achieving full coverage of all allies and partners that need to be rated. Although experts at a medium-sized organization like the RAND Corporation, which has more than 1,000 researchers, may be able to provide initial rough estimates, it is unlikely that administering the surveys to members of an organization of that size will achieve adequate coverage of all allied and partner countries and armed services. The number of responses collected for each country's force types is unlikely to be large enough to place a high degree of confidence in the results. However, such estimates, in all probability, will yield an index that is better than one with no measure of relative estimated force quality and combat proficiency.

Thanks to the operational and training activities that it undertakes with U.S. allies and partners every day, DoD is a significant repository of expertise on expected allied force quality and combat proficiency. If anything other than a rough estimate of that proficiency is required, then it may be worth the time, cost, and effort to conduct a broader survey of experts at DoD components that have significant relevant subject-matter expertise. The following DoD components likely have experts with knowledge relevant to all three versions of the survey (ground, air, and naval) and who could be surveyed as part of such a broader effort:

- Office of the Secretary of Defense country desks (Pentagon)
- Joint Chiefs of Staff, Strategy, Plans, and Policy Directorate (J5) (Pentagon)
- Defense Intelligence Agency regional centers (Joint Base Anacostia-Bolling, Maryland)
- Defense Security Cooperation Agency (Arlington, Virginia)
- EUCOM, Policy, Strategy, Partnering and Capabilities Directorate (J5/8) (Stuttgart, Germany)
- PACOM, Strategic Planning and Policy Directorate (J5) (Camp H. M. Smith, Hawaii)
- CENTCOM, J5 Directorate (MacDill Air Force Base, Florida).

The following Army components likely have experts with knowledge relevant to the ground forces survey:

- Operations, Plans, and Training Directorate (G-3/5/7) (Pentagon)
- U.S. Army Europe (Wiesbaden, Germany)
- U.S. Army Pacific (Fort Shafter, Hawaii)
- 7th Army Training Command (Grafenwöhr, Germany).

The following Air Force components likely have experts with knowledge relevant to the air forces survey:

- Air Force International Affairs (Pentagon)
- U.S. Air Forces in Europe and Air Forces Africa, A5 Directorate (Ramstein, Germany)
- Pacific Air Forces, A5 Directorate (Joint Base Pearl Harbor–Hickam, Hawaii)

- U.S. Air Forces Central Command, Security Cooperation and Future Plans Directorate (A5) (Shaw Air Force Base, South Carolina)
- Euro-NATO Joint Jet Pilot Training Program and 80th Flying Training Wing (Sheppard Air Force Base, Texas)
- 414th Combat Training Squadron (Nellis Air Force Base, Nevada).

The following Navy components likely have experts with knowledge relevant to the naval forces survey:

- Office of the Chief of Naval Operations, Operations, Plans, and Strategy Directorate (N3/N5) (Pentagon)
- Naval Forces Europe – Naval Forces Africa, N5 Directorate (Naples, Italy)
- U.S. Pacific Fleet, Plans and Policy Directorate (N5) (Joint Base Pearl Harbor–Hickam, Hawaii)
- U.S. Naval Forces Central Command, N5 Directorate (Bahrain).

References

Adams, Sam, *War of Numbers: An Intelligence Memoir*, 1st ed., South Royalton, Vt.: Steerforth Press, 1994.

Allen, George W., *None So Blind: A Personal Account of the Intelligence Failure in Vietnam*, Chicago: Ivan R. Dee, 2001.

Asher, Robbie, *Draft or Volunteer Army: Our Nation's Best Interest*, Carlisle Barracks, Pa.: U.S. Army War College, February 2008.

Bagnoli, Mark, and Barton L. Lipman, "Provision of Public Goods: Fully Implementing the Core Through Private Contributions," *Review of Economic Studies*, Vol. 56, No. 4, October 1989, pp. 583–601.

Baker, Peter, "Trump Abandons Trans-Pacific Partnership, Obama's Signature Trade Deal," *New York Times*, January 23, 2017.

Ball, Desmond, *A Suitable Piece of Real Estate: American Installations in Australia*, Sydney: Hale & Iremonger, 1980.

Bartunek, Robert-Jan, "Development Aid Cannot Be Part of Defense Spending: NATO's Stoltenberg," Reuters, March 31, 2017.

Beasley, W. G., *Japanese Imperialism, 1894–1945*, Oxford, United Kingdom: Oxford University Press, 1987.

Bell, Coral, *Dependent Ally: A Study of Australia's Relations with the United States and the United Kingdom Since the Fall of Singapore*, Canberra: Department of International Relations, Australian National University, 1984.

Benson, Brett V., and Joshua D. Clinton, "Assessing the Variation of Formal Military Alliances," *Journal of Conflict Resolution*, Vol. 60, No. 5, 2016, pp. 855–898.

Boston, Scott, Michael Johnson, Nathan Beauchamp-Mustafaga, and Yvonne K. Crane, *Assessing the Conventional Force Imbalance in Europe: Implications for Countering Russian Local Superiority*, Santa Monica, Calif.: RAND Corporation, RR-2402, 2018. As of February 24, 2020: https://www.rand.org/pubs/research_reports/RR2402.html

Bostrom, Nick, "Existential Risk Prevention as Global Priority," *Global Policy*, Vol. 4, No. 1, March 2013, pp. 15–31.

Brubaker, Earl R., "Free Ride, Free Revelation, or Golden Rule?" *Journal of Law and Economics*, Vol. 18, No. 1, 1975, pp. 147–161.

Burke, Jerome J., Grant Sharp, Alfred Kaufman, and Patricia Cohen, *Assessment of Naval Core Capabilities*, Washington, D.C.: Institute for Defense Analyses, IDA Document D-3713, January 2009.

Central Intelligence Agency, *The World Factbook 2017*, McLean, Va., July 18, 2018.

Chanlett-Avery, Emma, Mark E. Manyin, Ian E. Rinehart, Rebecca M. Nelson, and Brock R. Williams, *Japan-U.S. Relations: Issues for Congress*, Washington, D.C.: Congressional Research Service, RL33436, April 2015.

Chanlett-Avery, Emma, and Ian R. Rinehart, *The U.S.-Japan Alliance*, Washington, D.C.: Congressional Research Service, RL33740, July 2016.

Christie, Edward Hunter, "The Demand for Military Expenditure in Europe: The Role of Fiscal Space in the Context of a Resurgent Russia," *Defence and Peace Economics*, Vol. 30, No. 1, 2019, pp. 72–84.

CIA—*See* Central Intelligence Agency.

Cooper, Zack, and Jake Douglas, "Successful Signaling at Scarborough Shoal?" *War on the Rocks*, May 2, 2016.

Crisher, Brian Benjamin, and Mark Souva, "Power at Sea: A Naval Power Dataset, 1865–2011," *International Interactions*, Vol. 40, No. 4, 2014, pp. 602–629.

Cumings, Bruce, *The Korean War: A History*, 1st ed., New York: Modern Library, 2010.

Davis, Paul K., J. Michael Gilmore, David R. Frelinger, Edward Geist, Christopher K. Gilmore, Jenny Oberholtzer, and Danielle C. Tarraf, *Exploring the Role Nuclear Weapons Could Play in Deterring Russian Threats to the Baltic States*, Santa Monica, Calif.: RAND Corporation, RR-2781-RC, 2019. As of February 24, 2020:
https://www.rand.org/pubs/research_reports/RR2781.html

Dean, Peter J., Stephan Frühling, and Brendan Taylor, eds., *Australia's American Alliance: Towards a New Era?* Melbourne, Australia: Melbourne University Press, 2016.

DeYoung, Karen, and Greg Jaffe, "NATO Runs Short on Some Munitions in Libya," *Washington Post*, April 15, 2011.

DoD—*See* U.S. Department of Defense.

Duke, Simon, *The Burdensharing Debate: A Reassessment*, New York: St. Martin's Press, 1993.

Dupuy, T. N., *Numbers, Predictions and War: Using History to Evaluate Combat Factors and Predict the Outcome of Battles*, Fairfax, Va.: HERO Books, 1985.

Duus, Peter, *The Abacus and the Sword: The Japanese Penetration of Korea, 1895–1910*, Berkeley, Calif.: University of California Press, 1995.

Emmott, Robin, "NATO Edges Toward Trump's Spending Demands, Germany Lags," Reuters, March 14, 2019.

Fall, Bernard B., *Street Without Joy*, Mechanicsburg, Pa.: Stackpole Books, 1961.

Feenstra, Robert C., Robert Inklaar, and Marcel P. Timmer, "The Next Generation of the Penn World Table," *American Economic Review*, Vol. 105, No. 10, 2015, pp. 3150–3182.

Fraser, Malcolm, and Cain Roberts, *Dangerous Allies*, Melbourne, Australia: Melbourne University Press, 2014.

Funabashi, Yoichi, *The Peninsula Question: A Chronicle of the Second Korean Nuclear Crisis*, Washington, D.C.: Brookings Institution Press, 2007.

Gansler, Jacques S., and William Lucyshyn, *Improving the DoD's Tooth-to-Tail Ratio*, College Park, Md.: University of Maryland, UMD-AM-14-007, February 2014.

Gates, Robert M., "Secretary of Defense Speech: Munich Conference on Security Policy," Washington, D.C.: U.S. Department of Defense, February 11, 2007.

———, "Secretary of Defense Speech: The Security and Defense Agenda (Future of NATO)," Washington, D.C.: U.S. Department of Defense, June 10, 2011.

Gates, William R., and Katsuaki L. Terasawa, "Commitment, Threat Perceptions, and Expenditures in a Defense Alliance," *International Studies Quarterly*, Vol. 36, No. 1, March 1992, pp. 101–118.

Gebicke, Scott, and Samuel Magid, *Lessons from Around the World: Benchmarking Performance in Defense*, San Francisco, Calif.: McKinsey and Company, Spring 2010.

Gilroy, Curtis L., and Cindy Williams, *Service to Country: Personnel Policy and the Transformation of Western Militaries*, Cambridge, Mass.: MIT Press, 2006.

Goldberg, Jeffrey, "The Obama Doctrine: The U.S. President Talks Through His Hardest Decisions About America's Role in the World," *The Atlantic*, April 2016.

Goldstein, Avery, "Discounting the Free Ride: Alliance and Security in the Postwar World," *International Organizations*, Vol. 49, No. 1, Winter 1995, pp. 39–71.

Halberstam, David, *The Best and the Brightest*, 1st ed., New York: Random House, 1972.

———, *The Coldest Winter: America and the Korean War*, 1st ed., New York: Hyperion, 2007.

Harris, James W., Jr., "The Sortie Generation Rate Model," in E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes, eds., *Proceedings of the 2002 Winter Simulation Conference*, 2002, pp. 864–868.

Hastings, Max, *The Korean War*, London: Michael Joseph, 1987.

Heredia, Armando J., "Analysis: New U.S. Philippine Basing Deal Heavy on Air Power, Light on Naval Support," *USNI News*, March 22, 2016.

Hicks, Kathleen H., Jeffrey Rathke, Seamus P. Daniels, Michael Matlaga, Laura Daniels, and Andrew Linder, *Counting Dollars or Measuring Value: Assessing NATO and Partner Burden Sharing*, Washington, D.C.: Center for Strategic and International Studies, July 2018.

Hillison, Joel R., *Stepping Up: Burden Sharing by NATO's Newest Members*, Carlisle Barracks, Pa.: U.S. Army War College Press, November 10, 2014.

Hinz, Julian, *The Cost of Sanctions: Estimating Lost Trade with Gravity*, Kiel, Germany: Kiel Institute for the World Economy, November 2017.

Hogg, David R., *Correlation of Forces: The Quest for a Standardized Model*, Fort Leavenworth, Kan.: U.S. Army Command and General Staff College, February 4, 1993.

IISS—*See* International Institute for Strategic Studies.

International Institute for Strategic Studies, *The Military Balance*, Vol. 117, No. 1, February 13, 2017.

International Labour Organization Department of Statistics, ILOSTAT data tool, undated. As of March 25, 2020:
https://ilostat.ilo.org/data/

Japanese Ministry of Defense, *Defense of Japan 2016*, Tokyo, August 2016.

Joint Analysis and Lessons Learned Centre, *Operation Unified Protector: Lessons from National Military Perspectives*, Lisbon: North Atlantic Treaty Organization, February 27, 2012.

Keohane, Robert O., *Neorealism and Its Critics*, New York: Columbia University Press, 1986.

Khrishadev, Calamur, "NATO, Shmato?" *The Atlantic*, July 21, 2016.

Kim, Hyung-Jin, "South Korea, US Sign Cost-Sharing Deal for American Troops," Associated Press, February 10, 2019.

Krause, Joachim, and Charles K. Mallory IV, eds., *Afghanistan, Pakistan and Strategic Change: Adjusting Western Regional Policy*, Abingdon, England: Routledge, 2014.

Krug, Colby K., *Sustaining the Quality of the All-Volunteer Force: A Cost-Effective Approach*, Fort Leavenworth, Kan.: U.S. Army Command and General Staff College, May 26, 2016.

Lanoszka, Alexander, "Do Allies Really Free Ride?" *Survival*, Vol. 57, No. 3, May 2015, pp. 133–152.

Larsen, Henrik, *NATO in Afghanistan: Democratization Warfare, National Narratives, and Budgetary Austerity*, Cambridge, Mass.: Harvard Kennedy School of Government, December 2013.

"Libya War Exposes 'NATO's Chronic Weaknesses,'" *Mail & Guardian*, June 10, 2011.

Lostumbo, Michael J., Michael J. McNerney, Eric Peltz, Derek Eaton, David R. Frelinger, Victoria A. Greenfield, John Halliday, Patrick Mills, Bruce R. Nardulli, Stacie L. Pettyjohn, Jerry M. Sollinger, and Stephen M. Worman, *Overseas Basing of U.S. Military Forces: An Assessment of Relative Costs and Strategic Benefits*, Santa Monica, Calif.: RAND Corporation, RR-201-OSD, 2013. As of February 24, 2020:
https://www.rand.org/pubs/research_reports/RR201.html

Lum, Thomas, and Ben Dolven, *The Republic of the Philippines and U.S. Interests—2014*, Washington, D.C.: Congressional Research Service, R43498, May 2014.

———, "In Focus: The Philippines," Washington D.C.: Congressional Research Service, IF10250, 2018.

Mamur, M., *Freedom of Movement Assessment (Ground): Moving Towards a Military Schengen Zone*, Wiesbaden, Germany: U.S. Army Europe, 2016.

Manyin, Mark E., Emma Chanlett-Avery, Mary Beth D. Nikitin, Ian E. Rinehart, and Brock R. Williams, *U.S.-South Korea Relations*, Washington, D.C.: Congressional Research Service, R41481, October 2015.

Mattelaer, Alexander, "U.S. Leadership and NATO: Revisiting the Principles of NATO Burden-Sharing," *Parameters*, Vol. 46, No. 1, Spring 2016, pp. 25–33.

Mazarr, Michael J., *North Korea and the Bomb: A Case Study in Nonproliferation*, New York: St. Martin's Press, 1997.

———, *Summary of the Building a Sustainable International Order Project*, Santa Monica, Calif.: RAND Corporation, RR-2397-OSD, 2018. As of February 24, 2020: https://www.rand.org/pubs/research_reports/RR2397.html

Mazarr, Michael J., Jonathan S. Blake, Abigail Casey, Tim McDonald, Stephanie Pezard, and Michael Spirtas, *Understanding the Emerging Era of International Competition: Theoretical and Historical Perspectives*, Santa Monica, Calif.: RAND Corporation, RR-2726-AF, 2018. As of February 24, 2020: https://www.rand.org/pubs/research_reports/RR2726.html

Mazarr, Michael J., Astrid Stuth Cevallos, Miranda Priebe, Andrew Radin, Kathleen Reedy, Alexander D. Rothenburg, Julia A. Thompson, and Jordan Wilcox, *Measuring the Health of the Liberal International Order*, Santa Monica, Calif.: RAND Corporation, RR-1994-OSD, 2017. As of February 24, 2020: https://www.rand.org/pubs/research_reports/RR1994.html

Mazarr, Michael J., Miranda Priebe, Andrew Radin, and Astrid Stuth Cevallos, *Understanding the Current International Order*, Santa Monica, Calif.: RAND Corporation, RR-1598-OSD, 2016. As of February 24, 2020: https://www.rand.org/pubs/research_reports/RR1598.html

McNamara, Robert S., and Brian VanDeMark, *In Retrospect: The Tragedy and Lessons of Vietnam*, 1st ed., New York: Vintage Books, 1995.

Morelli, Vincent, and Paul Belkin, *NATO in Afghanistan: A Test of the Transatlantic Alliance*, Washington, D.C.: Congressional Research Service, RL33627, December 2009.

Mueller, Karl P., "Filling the Baltic Gap: Or How I Learned to Stop Worrying and Love the d6," *BATTLES Magazine*, No. 11, 2014, pp. 53–57.

Murdoch, James C., and Todd Sandler, "Complementarity, Free Riding, and the Military Expenditures of NATO Allies," *Journal of Public Economics*, Vol. 25, No. 1–2, November 1984, pp. 83–101.

NATO—*See* North Atlantic Treaty Organization.

North Atlantic Treaty Organization, "Defence Expenditure of NATO Countries (2011–2018)," press release, PR-CP(2019)034, March 14, 2019a.

———, "London Declaration: Issued by the Heads of State and Government Participating in the Meeting of the North Atlantic Council in London 3–4 December 2019," December 4, 2019b.

Oberdorfer, Don, *The Two Koreas: A Contemporary History*, New York: Basic Books, 2001.

Ochmanek, David, *Restoring U.S. Power Projection Capabilities: Responding to the 2018 National Defense Strategy*, Santa Monica, Calif.: RAND Corporation, PE-260-AF, 2018. As of February 24, 2020: https://www.rand.org/pubs/perspectives/PE260.html

Ochmanek, David, Peter A. Wilson, Brenna Allen, John Speed Meyers, and Carter C. Price, *U.S. Military Capabilities and Forces for a Dangerous World: Rethinking the U.S. Approach to Force Planning*, Santa Monica, Calif.: RAND Corporation, RR-1782-1-RC, 2017. As of February 24, 2020: https://www.rand.org/pubs/research_reports/RR1782-1.html

O'Donnell, Clara M., and Justin Vaïsse, *Is Libya NATO's Final Bow?* Washington, D.C.: Brookings Institution, December 2, 2011.

Olson, Mancur, *The Logic of Collective Action: Public Goods and the Theory of Groups*, Cambridge, Mass.: Harvard University Press, 1971.

Olson, Mancur, and Richard Zeckhauser, "An Economic Theory of Alliances," *Review of Economics and Statistics*, Vol. 48, No. 3, August 1966, pp. 266–279.

Oneal, John R., "The Theory of Collective Action and Burden Sharing at NATO," *International Organization*, Vol. 44, No. 3, Summer 1990, pp. 379–402.

Oneal, John R., and Paul F. Diehl, "The Theory of Collective Action and NATO Defense Burdens: New Empirical Tests," *Political Research Quarterly*, Vol. 47, No. 2, June 1994, pp. 373–396.

Packard, George R., "The United States–Japan Security Treaty at 50: Still a Grand Bargain?" *Foreign Affairs*, Vol. 89, No. 2, March/April 2010, pp. 92–103.

Palfrey, Thomas R., and Howard Rosenthal, "Participation and the Provision of Discrete Public Good: A Strategic Analysis," *Journal of Public Economics*, Vol. 24, No. 2, July 1984, pp. 171–193.

Park, W. G., *A Challenge for the ROK-U.S. Alliance: Defense Cost Sharing*, Seoul: Handong Global University, 2013.

Perlez, Jane, "Asian Leaders at Regional Meeting Fail to Resolve Disputes over South China Sea," *New York Times*, July 12, 2012.

———, "In Victory for Philippines, Hague Court to Hear Dispute over South China Sea," *New York Times*, October 30, 2015.

———, "New Chinese Vessels Seen Near Disputed Reef in South China Sea," *New York Times*, September 5, 2016.

Phinney, Todd R., "Reflections on Operation Unified Protector," *Joint Force Quarterly*, No. 73, April 2014, pp. 86–92.

Pritchard, Charles L., *Failed Diplomacy: The Tragic Story of How North Korea Got the Bomb*, Washington, D.C.: Brookings Institution Press, 2007.

Przystup, James J., *The U.S.-Japan Alliance: Review of the Guidelines for Defense Cooperation*, Washington, D.C.: National Defense University, Strategic Perspectives No. 18, March 2015.

Pyle, Kenneth B., *Japan Rising: The Resurgence of Japanese Power and Purpose*, 1st ed., New York: Public Affairs, 2007.

Reed, Thomas C., and Danny B. Stillman, *The Nuclear Express: A Political History of the Bomb and Its Proliferation*, Minneapolis, Minn.: Zenith Press, 2009.

Renouf, Alan, *The Frightened Country*, Melbourne, Australia: Macmillan, 1979.

Samuels, Richard J., *Securing Japan: Tokyo's Grand Strategy and the Future of East Asia*, Ithaca, N.Y.: Cornell University Press, 2008.

Samuelson, Paul A., "The Pure Theory of Public Expenditure," *Review of Economics and Statistics*, Vol. 36, No. 4, November 1954, pp. 387–389.

Sandler, Todd, "Intergenerational Public Goods: Strategies, Efficiencies, and Institutions," in Inge Kaul, Isabelle Grunberg, and Marc A. Stern, eds., *Global Public Goods: International Cooperation in the 21st Century*, New York: Oxford University Press, 1999, pp 20–50.

———, "Intergenerational Public Goods: Transnational Considerations," *Scottish Journal of Political Economy*, Vol. 53, No. 3, July 2009, pp. 353–370.

Sandler, Todd, and Jon Cauley, "On the Economic Theory of Alliances," *Journal of Conflict Resolution*, Vol. 19, No. 2, June 1975, pp. 330–334.

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

Schmitt, Eric, "NATO Sees Flaws in Air Campaign Against Qaddafi," *New York Times*, April 14, 2012.

Sen, Amartya K., "Isolation, Assurance and the Social Rate of Discount," *Quarterly Journal of Economics*, Vol. 81, No. 1, February 1967, pp. 112–124.

Shear, Michael D., Mark Landler, and James Kanter, "In NATO Speech, Trump Is Vague About Mutual Defense Pledge," *New York Times*, May 25, 2017.

Shlapak, David A., *The Russian Challenge*, Santa Monica, Calif.: RAND Corporation, PE-250-A, 2018. As of February 24, 2020:
https://www.rand.org/pubs/perspectives/PE250.html

Shlapak, David A., and Michael Johnson, *Reinforcing Deterrence on NATO's Eastern Flank: Wargaming the Defense of the Baltics*, Santa Monica, Calif.: RAND Corporation, RR-1253-A, 2016. As of February 24, 2020:
https://www.rand.org/pubs/research_reports/RR1253.html

SIPRI—*See* Stockholm International Peace Research Institute.

Smith, Julianne, and James Hendrix, *Assured Resolve: Testing Possible Challenges to Baltic Security*, Washington, D.C.: Center for a New American Security, April 2016.

Snyder, Glenn, "The Security Dilemma in Alliance Politics," *World Politics*, Vol. 36, No. 4, July 1984, pp. 461–495.

Spangler, Ethan, "Allies with Benefits: US Effect on European Demand for Military Expenditures," *Defence and Peace Economics*, Vol. 29, No. 7, 2018, pp. 731–747.

Spector, Ronald H., *United States Army in Vietnam—Advice and Support: The Early Years, 1941–1960*, Washington, D.C.: Center of Military History, United States Army, 1985.

Stockholm International Peace Research Institute, "SIPRI Military Expenditure Database," web tool, undated-a. As of February 24, 2020:
https://www.sipri.org/databases/milex

———, "Sources and Methods," webpage, undated-b. As of August 14, 2019:
https://www.sipri.org/databases/milex/sources-and-methods

Summers, Harry G., *On Strategy: A Critical Analysis of the Vietnam War*, New York: Presidio Press, 1982.

Swaine, Michael D., and Ashley J. Tellis, *Interpreting China's Grand Strategy: Past, Present, and Future*, Santa Monica, Calif.: RAND Corporation, MR-1121-AF, 2000. As of February 24, 2020:
https://www.rand.org/pubs/monograph_reports/MR1121.html

Tabarrok, Alexander, "The Private Provision of Public Goods via Dominant Assurance Contracts," *Public Choice*, Vol. 96, No. 3–4, 1998, pp. 345–362.

Tellis, Ashley J., Janice Bially, Christopher Layne, Melissa McPherson, and Jerry M. Sollinger, *Measuring National Power in the Postindustrial Age: Analyst's Handbook*, Santa Monica, Calif.: RAND Corporation, MR-1110/1-A, 2000. As of February 24, 2020:
https://www.rand.org/pubs/monograph_reports/MR1110z1.html

Trump, Donald, "Transcript: Donald Trump's Foreign Policy Speech," *New York Times*, April 27, 2016.

Udehn, Lars, "Twenty-Five Years with 'The Logic of Collective Action,'" *Acta Sociologica*, Vol. 36, No. 3, 1993, pp. 239–261.

United Nations Conference on Trade and Development, "UNCTADSTAT Data Center," web tool, undated. As of February 24, 2020:
https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sCS_ChosenLang=en

United Nations General Assembly, "Effective Rates of Assessment for Peacekeeping Operations, 1 January 2016 to 31 December 2018," New York, A/70/331/Add.1, December 28, 2015.

———, "Approved Resources for Peacekeeping Operations for the Period from 1 July 2018 to 30 June 2019," New York, A/C.5/71/24, June 30, 2017.

U.S. Department of Defense, *Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge*, Washington, D.C., 2018.

U.S. Senate Committee on Armed Services, *Inquiry into U.S. Costs and Allied Contributions to Support the U.S. Military Presence Overseas*, Washington D.C.: U.S. Government Printing Office, Report 113-12, April 15, 2013.

Valdes-Perez, Raul, "Smart Benchmarking Starts with Knowing Whom to Compare Yourself To," *Harvard Business Review*, October 30, 2015.

Venable, John, "Fighter Pilots Aren't Flying Enough to Hone the Skills of Full-Spectrum War," *Defense One*, November 21, 2016.

Wadhams, Nick, and Jennifer Jacobs, "Trump Seeks Huge Premium from Allies Hosting U.S. Troops," *Bloomberg*, March 8, 2019.

Walt, Stephen M., *The Origins of Alliances*, Ithaca, N.Y.: Cornell University Press, 1987.

———, "Why Alliances Endure or Collapse," *Survival*, Vol. 39, No. 1, 1997, pp. 156–179.

Waltz, Kenneth N., *Theory of International Politics*, Long Grove, Ill.: Waveland Press, 1979.

Warner, John T., and Paul F. Hogan, *Walter Oi and His Contributions to the All-Volunteer Force: Theory, Evidence, Persuasion*, Arlington, Va.: CNA Corporation, September 23, 2014.

White, Hugh, "Strategic Interests in Australian Defence Policy: Some Historical and Methodological Reflections," *Security Challenges*, Vol. 4, No. 2, Winter 2008, pp. 63–79.

Williams, Cindy, ed., *Filling the Ranks: Transforming the U.S. Military Personnel System*, Cambridge, Mass.: MIT Press, April 2004.

Wit, Joel S., Daniel B. Poneman, and Robert L. Gallucci, *Going Critical: The First North Korean Nuclear Crisis*, Washington, D.C.: Brookings Institution Press, 2004.

Zanella, Andrew James, *Combat Power Analysis Is Combat Power Density*, Fort Leavenworth, Kan.: U.S. Army Command and General Staff College, May 17, 2012.

NATIONAL DEFENSE RESEARCH INSTITUTE

New security challenges from Russia, China, North Korea, and Iran have reignited the perennial debate about whether U.S. allies in the North Atlantic Treaty Organization and in Asia are contributing sufficiently to the collective defense of the post–World War II liberal international order. The debate, which had subsided after the Cold War ended, has once again become a high priority in the U.S. foreign policy agenda. However, the traditional standard for measuring allied contributions—military expenditures as a percentage of gross domestic product (GDP)—provides an incomplete analytic foundation for understanding burdensharing. At the request of the Office of the Secretary of Defense, RAND researchers reviewed the burdensharing debates and the associated literature and constructed a Burdensharing Index to aid in measurement and analysis. The index provides a more sophisticated picture of allied burdensharing than is possible when focusing solely on military spending as a percentage of GDP. The index also helps policymakers understand how they might incentivize additional allied commitments to generating the capabilities required for potential warfights, as identified in the 2018 National Defense Strategy. Although the U.S. share of the costs of collective defense in Europe and Asia is certainly disproportionate, the U.S. burden is not as lopsided as some have asserted. As estimated by the Burdensharing Index presented in this report, the United States bears slightly less than half (about 47 percent) of the total burden of providing the collective defense.

$49.95

ISBN-10 1-9774-1326-9
ISBN-13 978-1-9774-1326-0

www.rand.org

RR-4189/1-OSD