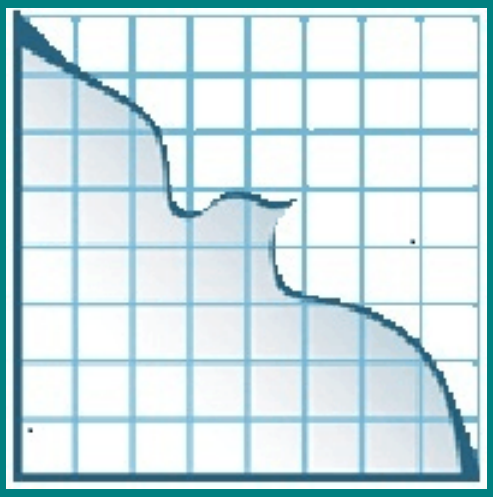
The Economics of Peace and Security Journal



The Economics of Peace and Security Journal — ISSN 1749-852X — http://www.epsjournal.org.uk

THE ECONOMICS OF PEACE AND SECURITY JOURNAL

A journal of Economists for Peace and Security

Editorial Offices

The Managing Editor
c/o Levy Institute, Box 5000
Annandale-on-Hudson, NY 12504, USA
Email: ManagingEditor@epsjournal.org.uk

The Economics of Peace and Security Journal — ISSN 1749-852X — http://www.epsjournal.org.uk

Aims and Scope

The Economics of Peace and Security Journal (EPSJ) addresses economic aspects of peace and security, ranging from the interpersonal and communal domains to transboundary and global affairs. Our scope includes all violent and nonviolent conflict affecting human and nonhuman life as well as their implications for our common habitat, Earth. Special attention is paid to constructive proposals for nonviolent conflict resolution and peacemaking. While open to noneconomic approaches, most contributions emphasize economic analysis of causes, consequences, and possible solutions to mitigate conflict and violence. Contributions are scholarly or practitioner-based. Written and edited to fit a general-interest style, EPSJ is aimed at specialist and nonspecialist readers alike, including policy analysts, policy and decisionmakers, national and international civil servants, members of the armed forces and of peacekeeping services, the business community, members of nongovernmental organizations and religious institutions, and any other interested parties. No responsibility for the views expressed by the authors in this journal is assumed by the editors, by EPS Publishing, or by Economists for Peace and Security.

Economists for Peace and Security

Economists for Peace and Security (EPS) is a network of affiliated organizations. Each is legally independent and determines its own membership criteria and activities. A group of prominent individuals serve as trustees for EPS. They are: Clark Abt, George Akerlof*, Oscar Arias*, Kenneth J. Arrow*, William J. Baumol, Barbara Bergmann, Robert J. Gordon, Sir Richard Jolly, Eric Maskin*, Daniel L. McFadden*, Roger Myerson*, George A. Papandreou, Robert Reich, Thomas Schelling*, Amartya Sen*, William Sharpe*, Robert M. Solow*, and Joseph E. Stiglitz* (*Nobel Laureate). Late trustees: Andrew Brimmer, Robert Eisner, John Kenneth Galbraith, Sir Clive Granger*, Robert Heilbroner, Michael Intriligator, Walter Isard, Lawrence R. Klein*, Wassily Leontief*, Robert S. McNamara, Franco Modigliani*, Douglass C. North*, Robert J. Schwartz, Jan Tinbergen*, James Tobin*, and Dorrie Weiss. For more information about EPS and its affiliates, please visit http://www.epsusa.org.

The Economics of Peace and Security Journal — ISSN 1749-852X — http://www.epsjournal.org.uk

VOL. 11, NO. 2 (2016) – CONTENTS

SYMPOSIUM: THE NEW SIPRI MILITARY EXPENDITURE DATA

The Economics of Peace and Security Journal — ISSN 1749-852X — http://www.epsjournal.org.uk

Snakes and ladders: The development and multiple reconstructions of the Stockholm International Peace Research Institute's military expenditure data

Sam Perlo-Freeman and **Elisabeth Sköns**

Sam Perlo-Freeman is Head of the Military Expenditure Project at the Stockholm International Peace Research Institute (SIPRI), Stockholm, Sweden. He may be reached at perlo-freeman@sipri.org. He will shortly take up a position at the World Peace Foundation at Tufts University, Boston, MA, USA, as Project Manager for Global Arms and Corruption. Elisabeth Sköns is a Senior Associate Fellow at the Stockholm International Peace Research Institute, Stockholm, Sweden. She may be reached at eskons@sipri.org.

Abstract

The Stockholm International Peace Research Institute's military expenditure database is the only long-run, consistent dataset on military expenditure with global coverage. Even though SIPRI's military expenditure data collection dates back almost to the organization's beginning in 1966, until recently, consistent data series for most countries have only been available as from 1988 onward. As this article discusses, the history of SIPRI's military expenditure project includes a number of breaks, the result of staff transitions and failures of record-keeping. As a result, reconstructing the data has been necessary on a number of occasions. The most recent such effort has now succeeded in extending the data backward from 1988 for the great majority of countries—in most cases at least to the 1960s, and for some countries as far back as 1959. This article sets out this history of advances, setbacks, and reconstructions and the methodologies used. In particular, the results of the latest reconstruction effort are presented, and thoughts for future developments laid out.

Military expenditure data has been a core topic for the Stockholm International Peace Research Institute (SIPRI) ever since its establishment in 1966. The rationale behind the Institute's founding was the provision of impartial data and information on armaments to be used as a solid basis for disarmament proposals and negotiations. The initial idea for SIPRI's creation came from the Swedish ambassador to the nuclear disarmament negotiations in Geneva in the 1960s—Alva Myrdal—and was focused on the provision of data on nuclear weapons. However, by the time SIPRI was established, the mission of impartial data provision also encompassed biological and chemical weapons, international arms transfers, and military expenditures. Thus, during SIPRI's first years, an intensive process was set in motion to gather, conceptualize, process, and document data on various aspects of armaments.

Although the Institute's flagship publication, the *SIPRI Yearbook*, has included tables of military expenditure data in all but two volumes (1993 and 1994), until recently SIPRI's online military expenditure database only provided data as from 1988 onward. This is the result of various historical hiccups, mishaps, and personnel transitions that happened along the way. As a result, it has been necessary to recreate and reconstruct the data collection three times: In 1979, the data was reconstructed back to 1950. In 1997–1998, a 10-year series (for 1988–1997) was reconstructed. Finally, in 2015, a reconstruction of the data before 1988 was completed, fulfilling a long-standing goal of the military expenditure project and meeting widespread demand among researchers for long data series on military expenditure. This extended dataset, which in some cases goes back as far as 1949, and to at least 1957 for a majority of countries that were independent political entities at the time, is as available as a beta version on request from SIPRI. It is intended for a final version to be made freely available online in November 2016.

This article describes the history of SIPRI's military expenditure data collection efforts, the sources and methods used, problems encountered, and the three data reconstruction efforts that we have led over the years. The following sections describe the initial founding of the project, the first two reconstructions led by Elisabeth Sköns, and the most recent reconstruction led by Sam Perlo-Freeman. This includes a statistical presentation of the degree of success the project has enjoyed, along with priorities for future development.

How the SIPRI military expenditure project started

As mentioned, military expenditure data collection was one of the main objectives of the establishment of SIPRI itself in 1966 and part of the broader project of publishing an annual record, the *SIPRI Yearbook*. The first *Yearbook* (1968/1969) presented

its aim as "to produce a factual and balanced account of a controversial subject—the arms race and attempts to stop it." It was designed to fill a gap: "Until now there has been no authoritative international source which provided—in one place—an account of recent trends in world military expenditure, the state of the technological arms race, and the success or failure of recent attempts at arms limitations or disarmament."[1]

Purpose of the data

Initially, the purpose of the collection of "military expenditure material" was presented in rather modest language, "to answer questions about long- and short-term trends in military expenditure, in individual countries, regions and the world as a whole." Subsequently, the aim of the military expenditure data was presented in "opportunity cost" terms, i.e., to indicate opportunities forgone by allocating government expenditure for military purposes. Later, a budget priority rationale was added, i.e., that comparison of data on military and nonmilitary expenditure can be used also as an indicator of governments' political priorities between various purposes.[2]

From the outset, there was a clear statement about the limitations of the data: "Because of differences in coverage and the difficulty of finding appropriate exchange rates, expenditure figures are often unsuitable for cross-country comparisons ... They do, however, provide a good basis for commenting on the rate at which military expenditure is rising."[3]

Methods

The purpose of presenting the military expenditure data has had some impact on the definition and methods used for collecting and processing the data. The definition of military expenditure has consistently been based on the understanding of military expenditure data as an indicator of inputs—of financial resources—into the military sector rather than of outputs—such as military capability or strength. For example, military aid is included in the data for the donor country and excluded from that of the recipient country. In practice, the lack of detailed data makes implementing such principles challenging, and thus the definition has served primarily as a guideline for the collection and processing of the data.

From the very beginning, military expenditure data were shown not only in local currency at current prices, but also in U.S. dollars at constant prices and exchange rates—and a few years later, also as a share of national product. Due to fundamental differences between market and centrally planned economies, comparison of military expenditure across countries and over time was a specific challenge during the cold war period. This meant that there was no standardized system of exchange rates and price indices. For Warsaw Pact countries, Western economists developed approximate currency conversion rates and price indices, some of which were used by SIPRI.

Written by the two most recent primary participants in the effort, this article reviews the history of the Stockholm International Peace Research Institute's military expenditure dataset.

While there were problems to apply a standardized definition of military expenditure to all countries, and while cross-country comparisons of military expenditure continue to involve numerous conceptual issues, one thing that could be applied was consistency over time. This was from the beginning, and remains now, the main principle in the data collection and processing.

Sourcing of data must have been a considerable challenge during the first years. According to the earlier *Yearbooks*, the sources on military expenditure data included primarily the United Nations (*United Nations Statistical Yearbook*, UNSY), publications by NATO for NATO countries, the U.S. Agency for International Development (USAID) for developing countries, and the *Statesman's Yearbook*. In exceptional cases, data were consulted from other military expenditure data collections such as those of the International Institute for Strategic Studies (IISS) and the U.S. Arms Control and Disarmament Agency (ACDA) but, in general, these were avoided since these do not always use open sources.

The first reconstruction of data series

When Elisabeth Sköns arrived at SIPRI as a student in late 1978 to compile a set of tables on military expenditure, there was virtually nothing to inherit apart from the *SIPRI Yearbook* itself, and a small box of cards with information of the sources used for some countries. In addition, she received a set of instructions from Frank Blackaby who had directed the data collection processes and preparations for the first *Yearbooks* , a pile of empty paper worksheets, and a calculator. For each country, she started two work sheets, one for the military expenditure data from all the sources she could identify (with one column for the final SIPRI data series), and one worksheet for calculations, converting military expenditure figures into calendar years (when applicable), constant dollars, and shares of GDP.

During the 1980s, the number and quality of sources used for SIPRI's military expenditure data collection expanded significantly, partly because additional existing sources were

identified and partly because new sources emerged. These included (1) the International Monetary Fund's *Government Finance Statistics Yearbook* (GFSY), which began publication in 1977, providing data on government expenditures, including a one-liner for "Defense," (2) IMF country reports, and (3) the World Bank's *World Tables*, which had long series of data for developing countries. The central statistics office in Stockholm also had a great variety of statistics on exchange from other countries, which often had military expenditure data, even for Middle Eastern countries. Some national statistical offices also produced statistics for other countries. Most important among those was *Statistik des Auslandes*, published by Germany's Statistisches Bundesamt (the National Statistics Office or Agency) in Wiesbaden, Germany. Another useful source was U.S. State Department reports to Congress, which presented justifications for U.S. development aid to individual recipients, along with background information including military expenditure data.

The use of these standardized sources largely precluded any recalculations of the data to adhere to the SIPRI definition of military expenditure. In exceptional cases, when alternative series were available, the guideline definition could serve as a basis for choice between series.

During the 1980s and early 1990s, great efforts were also made to identify and use primary sources, i.e., national budgets and government expenditure accounts. The limited staff resources in the military expenditure project constrained such efforts. However, when a major discrepancy between national data and the SIPRI guideline definition was identified, an effort was made to initiate special studies. One example of this was a commissioned study on Israel to identify and subtract military aid received from official military expenditure figures. A similar in-house effort was made for Egypt.[4]

One of the most detailed data collections on military expenditure of developing countries emerged in the early 1980s. This was the seminal data compendium by Nicole Ball, a U.S. American researcher, who set out to create a solid empirical base for her line of argument in the debate on the relation between defense and development in developing countries. Her collection also became a useful source for SIPRI.[5]

The second reconstruction

In 1997–1998, a second major effort to reconstruct SIPRI's military expenditure data was required. This was because the project had experienced a number of difficulties since 1987. First, due to the lack of reliable data for Russia and China and due to the concern that the lack of cross-country comparability of the data compromised the validity of regional totals, the practice of aggregating country data on military expenditure into regional and world totals was abandoned in 1987.[6]

Second, due to a staffing transition, the military expenditure project did not produce any data at all in 1993 and 1994. More importantly, no background material (sources of data and calculations of figures) was left behind for the years 1985–1997. Thus there was a need for a comprehensive restart of SIPRI's military expenditure database. The reconstruction, carried out by Elisabeth Sköns, who returned to the project for this purpose, included the following steps.

First, SIPRI's guideline definition of military expenditure, based on the NATO definition, was revisited. As mentioned, because of both conceptual issues and data availability, the definition was difficult to apply in practice. One difficult issue concerned the inclusion of the cost of paramilitary forces "when they are judged to be trained and equipped for military operations."[7] Assessment of this criterion requires specific knowledge on the respective paramilitary forces. The inclusion of retirement pensions also presents a problem, in particular for countries with a social security system that does not include pension fees in personnel costs.

Second, to identify and assess various sources of military expenditure for each of the 158 countries then covered in the tables a priority list of data sources was established. Priority one was accorded to primary sources, i.e., official national government data, including responses to SIPRI Questionnaires requesting data in standardized form, and government reports to the United Nations and the Organization for Security and Co-operation in Europe (OSCE). Priority two was secondary sources reproducing data provided by governments, such as the GFSY, the UNSY, NATO, and a few others. Finally, priority three sources consisted of specialist journals and newspapers.[8]

Third, the project started to build up a network of experts to assist SIPRI both in gathering official public expenditure data and in conducting targeted studies to recalculate official government expenditure data into military expenditure series more closely matching the SIPRI guideline definition. The most important examples were the studies to develop a method of calculation and a first 10-year series of military expenditure estimates for the former Soviet Union and Russia produced by Julian Cooper in 1998 and for China produced by Shaoguang Wang in 1999. These two series were necessary also to enable the production of a series for total world military expenditure. Much later, Prof. Nurhan Yentürk produced a detailed series of estimates for Turkey.[9]

Fourth, in regard to processing of the data, given the practical difficulties in producing military expenditure series according to a common definition, the overarching principle for producing the SIPRI series continued to be as far as

possible to achieve consistency and comparability over time.

While cross-country comparisons were advised against, it was realized that such comparisons were made nevertheless. Thus, the issue of conversion rates had to be resolved. Since the official exchange rates did not accurately reflect the price ratios of their economies, for countries in transition from a centrally planned to a market economy (primarily the former Warsaw pact countries), GDP-based purchasing power parity (PPP) rates were used for the conversion from local currencies to U.S. dollars.[10]

Additionally an effort was made to look into the option of using GDP-based PPP's for all countries. A World Bank-commissioned project to produce PPP rates had made progress. In particular, the country coverage had been greatly expanded, although based on a short-cut method. According to the World Bank, the quality of the PPP rates had also been improved.[11]

A comparison of military expenditure by market exchange rates and PPP rates for selected countries was presented in the 1999 *Yearbook*. This showed that for developing countries and countries in transition the choice of conversion rate had a huge impact on the calculated level of military expenditure in U.S. dollars. At the same time, using GDP-based PPP rates for translating military expenditure data into a common currency involved significant uncertainties in interpretation and large margins of error. Nonetheless, and primarily for transparency and educational reasons, the 2003 *Yearbook* started to present data for the largest spenders at both market exchange rates and at PPP rates.[12]

Fifth, to facilitate the generation and analysis of the data, computerization of the data collection was initiated in 1998, and a database was created, albeit a very rough and rudimentary one.

Extending the data back before 1988

Ever since the 1997–1998 reconstruction of the military expenditure database back to 1988, it has been an important aspiration of the project to extend the data back further, if possible to around 1950. The major problem was always resourcing, in particular staff time, to go through the vast archives of military expenditure source material collected by SIPRI over the years, and to analyze these sources to produce consistent long-term series.

After assuming responsibility for the military expenditure project in 2009, Sam Perlo-Freeman made backdating data a high priority. After two unsuccessful funding applications, the opportunity to start the process came in 2010 when a Ph.D. defense economics student (Jennifer Brauner), who wanted extended data for the Middle East for her work, came to SIPRI as an intern to work on gathering the data herself. After she had gone through and documented all available archival sources, she and Perlo-Freeman went through the resulting data and found that it was indeed possible to construct consistent series for most countries in the region going back to the 1970s, the 1960s, and even earlier. Following this pilot work, SIPRI sought other students and researchers interested in pursuing the backdating effort for other regions.[13]

This continued, intermittently, up to spring 2015, when Latin America was the last region covered. This was followed by gathering of additional economic data, data entry, error-checking, and the production of usable data sheets. The dataset was then sent in summer 2015 for "alpha testing" by a group of defense economists and other academic experts. The initial research results produced by this group were discussed, along with issues relating to the data itself, at a January 2016 workshop organized by SIPRI and funded by the Swedish Riksbankens Jubileumsfond. (The other articles in this symposium are based on the work presented at this workshop.) This process led to further improvements in some of the data series, prior to the release of the "beta" version of the dataset in April 2016. As mentioned SIPRI hopes to publicly launch a final version, which will be available online, in November 2016.[14]

Sources and methodological difficulties

A wide variety of sources have been used in reconstructing the extended dataset. As mentioned, source use was ranked by priority. The most important sources, by category, are domestic sources, IMF data, UN data, NATO data, expert analyses, and other statistical sources.

Domestic sources of data, such as government budget and expenditure documents, responses to SIPRI questionnaires and other requests for information, and national statistical yearbooks, account for 28 percent of all data points before 1988. As primary, official data, these are the most preferred sort of data to use, where available. The IMF's *Government Finance Statistics Yearbook* (GFSY) and other IMF publications account for 21 percent of all data points before 1988. The GFSY (and the online GFS database covering the period from 1990 onward) presents expenditure data reported by governments back to 1970, using the IMF/World Bank Classification of the Functions of Government (COFOG), one of which is defense. The availability of this data is patchy—and particularly weak in recent years. Moreover, the COFOG definition of defense does not correspond to SIPRI's definition of military expenditure. In particular, the former excludes military pensions. Nonetheless, for earlier periods it is often one of the best data sources readily available.[15]

The *United Nations Statistical Yearbook* (UNSY), and the *UN Statistical Yearbook for Asia and the Pacific*, also account for 21 percent of all data points before 1988 as well. UNSY used to provide data on countries' military spending, along with a range of other data. Where both sources are available, UNSY most often agrees with GFSY. *NATO* data on the military expenditure of its member states account for 17 percent of the pre-1988 data, and 55 percent of the data for European countries. NATO uses a definition of military expenditure very close to SIPRI's.[16]

Expert budget analyses and estimates account for 6 percent of data points before 1988. Most of these (72 percent) are expert analyses of national budgets and expenditure and thus are closely based on primary, domestic sources, but often including items of expenditure outside the official defense budget. The remainder are estimates by U.S. analysts for some former Warsaw Pact nations. *Statistik des Auslandes*, a German publication that used to give statistical data on countries worldwide, provides 4 percent of data points before 1988. This source also often, but not always, agrees with GFSY where both are available. Finally, other sources, including the U.S. Arms Control and Disarmament Agency (ACDA), the *Europa Yearbook*, media sources, other secondary sources, and unidentified sources from previous SIPRI worksheets, account for 3 percent of the pre-1988 data points.

Over the past two decades, the proportion of countries producing military expenditure data has increased modestly, from 88 percent in 1994 to 94 percent in 2014, although this may be as much a matter of greater accessibility of data via the internet as of increased transparency. Moreover, while there still are major problems with transparency in many countries, the general quality of the data that is available has greatly increased in many cases. Detailed budget documents are frequently made available online, along with reporting of past expenditure. It is much more often possible to find information on spending on military pensions and on paramilitary forces. Ironically, the improved quality of data now available creates challenges for extending the data backward in time, namely how to connect the current series to older, often lower-quality data, in a consistent manner![17]

It is, therefore, rarely possible to find a single data source that covers the entire period of available data for a single country. Even developed countries with strong, transparent reporting systems, have frequently changed their methods of reporting and accounting. It has almost always been necessary to combine data from more than one source, and sometimes several, to obtain long time series of data. To try to ensure consistency over time, a number of key principles, based closely on the sources and methods for military expenditure data developed during the 1997–98 reconstruction, were applied.[18]

First, wherever possible, we tried to use data series that overlapped in their time coverage, so that the extent to which they agree with each other on overlapping years can be assessed. Second, if overlapping series could not be found, we would look for evidence that separate series represented the same concept of military spending, for example the Ministry of Defense budget (an institutional definition) or a functional definition based on COFOG. Third, in a small number of cases—and where this did not give unexpected jumps or dips in real values—we have combined series even without clear evidence of interconsistency. Fourth, where different series did overlap in their time coverage, we would combine the series as they stood if the difference between them on the transition year was less than about 3 percent. In some cases, if we had several years of overlap and a variable relation between them (i.e., sometimes one series was higher, sometimes the other), we would also combine them directly. Where series overlapped, but one was consistently higher than the other (by more than 3 percent), we would apply a percentage change estimate, adjusting one of the series (usually the older) upward or downward by a fixed percentage to bring the two series into agreement on the transition year between them. This continues to be the practice used by SIPRI for combining military expenditure data series from at least the 1979 reconstruction. This factor is more significant, the older are the data. While 16 percent of data points from 1988 onward are estimates of one sort or another, or are marked as "highly uncertain," 37 percent of the data before 1988 are classified in this way (and 26 percent of the entire dataset).[19]

In a number of cases the use of percentage change estimates may give rather uncertain results, as this method relies on the assumption that the later series—were are available—would have followed the same trend as the older series. Alternatively, supposing that the later series includes a component such as pensions that is absent from the earlier series, the method assumes that this component follows the same trend as the rest of military spending. This may not be correct, and the greater the proportionate adjustment made to the older series, and the more years for which the percentage change estimate is made, the greater the likely margin of error. There are 9 countries where, at some point, a greater than 50 percent adjustment has been made to the raw data to produce the estimate, including one where the raw data has been more than doubled. In a further 14 cases, an adjustment of between 30–50 percent has at some point been made to the raw data.[20]

Nonetheless, series based on percentage change estimates are at least correctly measuring the trend in some definition of

military expenditure (assuming that the source data accurately reflects the definition of military spending it purports to measure). The series as a whole, therefore, can be taken as a reasonable index of trends over time, while also reflecting the approximate absolute level of military spending based on the best available data.

Importantly, that a series for a country does *not* involve estimates does not necessarily mean that the data is of a higher quality. If all the available sources for a country agree exactly with each other, for example, it probably means that they all originate from the same official source, which may itself be unreliable for the usual reasons—omission of elements of military spending from the definition (e.g., pensions), extra-budgetary and off-budget sources of military spending, poor monitoring and reporting of actual expenditure, and so on. This, however, is an unavoidable feature of working with military expenditure data. Ultimately, the reliability of SIPRI data is always dependant on the reliability of official sources (or occasionally estimates based on these sources), as SIPRI does not make use of intelligence-based or other non-open sources.

Results of the backdating exercise

The backdating effort was carried out without external funding, relying on volunteer interns, guest researchers, and unfunded SIPRI staff time. Thus, its scale and ambition was necessarily limited, relying on sources already available in SIPRI's archives, including media clippings, correspondence with data providers, questionnaire responses, official documents obtained from various sources, and reference works such as the IMF's GFSY and the UN's UNSY. In particular, this meant that backdating attempts could not be made for the USSR and China, as to produce meaningful estimates for these two key countries would require dedicated expert studies.

Nonetheless, we were able to extend the series at least to some degree for the great majority of countries. However, the extent of the backdating is highly variable. Table 1 shows, for various points in time, the total number of countries in the SIPRI database that were independent at the time, and the proportion of these countries for which we now have, respectively, local currency and constant USD2014 military expenditure data. (The first year of the published SIPRI database, 1988, is given as a reference point.) There is thus a steady fall-off of data availability, with the decline particularly steep over the 1950s. The first year for which half of countries have constant price data is 1957.[21]

The regions of best data availability are consistently Europe and the Americas. The (combined) region of Asia and Oceania has the highest proportion of countries where little or no backdating was possible. For African and Middle Eastern countries a small portion could be taken back before the mid-1960s.

Table 1: Data availability by year

		Proportion (in percent)	
Year	*No. of countries*	*Local currency, current prices*	*US dollar, constant prices*
1988	144	88	82
1980	142	83	77
1975	140	76	69
1970	131	74	66
1965	124	68	57
1960	109	63	51
1955	85	45	36
1950	83	34	22

As mentioned, the reliability of the data is constrained by the quality of the sources we have to work with. Problems such as off-budget spending on arms imports, or of military expenditure hidden in other budget lines, are in most cases not solvable, especially when the only available sources are secondary ones such as GFSY and UNSY. In recent times, primary source data is much more readily available compared to the backdated data. Even so, these problems have not necessarily gone away. The other major factor limiting data quality is, as discussed, the high prevalence of percentage change estimates in the older data. Nonetheless, the method used for these gives good grounds to believe that the resulting series provide a reasonably consistent measure of the trend in military expenditure within each country, as has always been the primary goal of SIPRI military expenditure data. The standing warnings on the uncertainties involved in comparing data across countries, however, perhaps carry even greater force when considering countries where estimates have been used for a long period and/or involve a large adjustment to the older data.[22]

Future improvements

As a beta version, the extended SIPRI dataset is a work in progress, and we hope for further improvements before the planned public release in September 2016, and indeed beyond this. The data could be improved in many ways. First and foremost, we should like to find data sources for missing years. This may include sources that are available in printed form but not online, or which require direct, and in some cases personal, contact with national authorities to obtain. SIPRI has limited resources with which to pursue such sources, and it therefore

greatly welcomes contributions from interested data users who may be able to access sources in their own countries.

Second, we would like to improve upon existing sources, for instance replacing secondary sources such as the IMF's GFSY with primary sources, or obtaining sources of data for omitted elements of military spending such as military pensions. (Some of the cases where very large percentage change adjustments have been made arise when military pensions are omitted from earlier sources, and they represent a very substantial proportion of the total for the years in which they are included.) Third, we would like to obtain new and updated studies for the USSR/Russia and China. This would require research by scholars with expert knowledge of these countries and, in the case of the USSR, probably access to declassified Soviet archives. This would therefore require funding. And fourth, we would like to obtain additional sources of economic data. The gap between the availability of current price local currency data and constant U.S. dollar data shown in Table 1 is due to gaps in consumer price inflation data. While we have found some additional national sources to supplement international online sources such as the IMF's and the World Bank's, it is likely that further searches of domestic sources could uncover more data. Again, SIPRI greatly welcomes contributions of data from anyone with access to such sources.

Beyond improvements to the military expenditure data itself, the SIPRI military expenditure project has two major outstanding priorities for further expanding the database. First is the provision of disaggregated military expenditure data, initially probably for a shorter (maybe 10-year) period, breaking down spending by function, e.g., personnel, operations and maintenance, procurement, R&D, construction, and others, where this information is available. This is the subject of frequent requests for information to SIPRI, which at present we are unable to fulfill. As with the backdated military expenditure data itself, SIPRI has a large collection of source material, but producing such data would involve considerable conceptual work to take account of different national systems of classifying and reporting military expenditure. A large amount of time would also be required to go through these sources for all countries and construct consistent data series. Second, as a complement to the military expenditure data, SIPRI would like to compile data on civil security expenditure, to reflect a broader security concept and the increasingly blurred boundaries between military and civil security in many contexts. Both of these potential projects have been the subject of grant applications but—once again—as yet without success.

Various other extensions and deepening of the data can be envisaged. For example, we would like to see detailed studies of spending on paramilitary forces, ensuring comprehensive coverage, separating out spending on such forces (which not all countries would include in their military expenditure), and identifying more clearly the military role such forces fulfill. Similarly, a detailed survey of military pensions spending, providing comprehensive data, and identifying the different funding systems in use across countries would be important. To accomplish all, or any, of these potential projects will of course depend on resource availability.

Conclusion

SIPRI's military expenditure data collection effort was initiated 50 years ago. Commencing during the cold war-era, in an environment of a low level of trust between the two adversary blocs—the East and the West—it was one of the projects that contributed to the provision of a factual and balanced account of trends in the cold war arms race, and attempts to stop it, from an authoritative international source. Over time, new uses and approaches to analysis of military expenditure data have developed. SIPRI's military expenditure database has become an instrument of transparency, both between and within countries (especially in countries with a low degree of openness in security matters), and a source of data for academic research on the determinants and effects of resource allocation for military purposes. Over time, the demand for SIPRI's data has increased immensely and they have become the prime source of data globally in its field.

With the broader objectives and the increasing use of the SIPRI military expenditure data, the quality requirements of the data have increased. SIPRI has met these requirements to its best ability in spite of very limited resources. Fund raising for an ongoing project with the characteristics of a global public good (everyone wants to use, no one wants to fund) has been difficult.

Some of the key principles behind the credibility of SIPRI's military expenditure work have been:

- The importance of making clear methodological choices and to be entirely transparent about these (e.g., consistency over time is first priority);
- The use of open sources of data, carefully recorded so as to be able to provide detailed information to users—and to subsequent data collectors;
- Concentrating on doing a few things well rather than spreading efforts too broadly;
- Explaining and educating data users about the limitations associated with military expenditure data.

While these principles have been employed throughout most of

the project's existence, there have been several mishaps and hiccups, as has been documented in this article. The history of the military expenditure database has thus been something of a game of "snakes and ladders," where years of progress have sometimes been undermined by major personnel transitions, failures of record keeping, and lack of adherence to sound methodological practices. Fortunately, and thanks largely to the extensive volunteer efforts of interns and guest researchers, these setbacks have now largely been rectified. As a result, the SIPRI database on military expenditure is able to continue to fulfill its role as a vital resource for researchers, policymakers, diplomats, civil society, media, and many others. At the same time, with additional resources, it would be possible to achieve a number of improvements and expansions of the data that would make additional major contributions to the research and analysis of questions related to the military sector.

Notes

1. Quotes: Nield (1969, p. 5).

2. Modest language quote: Blackaby (1969, p. 194, n. 1). Opportunity cost: Huisken (1973).

3. Blackaby (1969, p. 194, n. 1).

4. Israel: Rivlin (1983).

5. Ball (1983a; 1983b).

6. Tullberg and Hagmeyer-Gaverus (1987, p. 119).

7. SIPRI Military Expenditure Database. Sources and Methods. Last updated 5 April 2016. See https://www.sipri.org/databases/milex/sources-and-methods#definition-of-military-expenditure.

8. Sköns, *et al*. (1998, p. 240).

9. Cooper (1998, pp. 243–259); Wang (1999, pp. 334–349); Yentürk (2014). Numerous other experts have contributed data, estimates, and/or advice over the years, including Wael Abdul-Shafi (Iraq, Libya, Yemen), David Darchiasvili (Georgia), Dimitar Dimitrov (Bulgaria), Paul Dunne, Iñigo Guevara y Moyano (Mexico, Honduras), Gülay Günlük-Senesen (Turkey), Iduvina Hernández (Guatemala), Shir Hever (Israel), Nazir Kamal, Eugene Kogan (Georgia), Armen Koutoumdjian (Chile), Pavan Kumar (India), Guy Lamb (South Africa), Elina Noor (Indonesia), Tamara Pataraia (Georgia), Pere Ortega (Spain), Jamie Polanco (Colombia), Thomas Scheetz (Argentina, Guatemala, Paraguay), Ron Smith, Tasheen Zayouna (Iraq), and Ozren Zunec (Croatia).

10. Sköns, *et al*. (1998, p. 242).

11. Kravis and Lipsey (1990).

12. Comparison of selected countries: Sköns, *et al*. (1999, p. 332). Nonetheless: Sköns, *et al*. (2003, p. 305).

13. The other interns and guest researchers who worked on this, and without whom the project could not have been carried out, were Elena Deola, Lidwina Gundacker, Julius Heß, Giulia Tamagni, and Mehmet Uye.

14. Swedish Riksbankens Jubileumsfond: "Expert workshop on SIPRI's new extended military expenditure data series." http://anslag.rj.se/en/fund/51062 [accessed 21 September 2016].

15. IMF Government Finance Statistics Yearbook: Various editions 1977-2014. http://www.imfbookstore.org/SearchResult.asp?SEL=IMF.43&Type=RLMc. United Nations Statistics Division: Classification of the Functions of Government. http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=4 and http://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=4&Lg=1&Co=02.1.0.

16. United Nations: http://unstats.un.org/unsd/publications/statistical-yearbook/ and http://www.unescap.org/resources/statistical-yearbook-asia-and-pacific-2015. NATO: http://www.nato.int/cps/en/natohq/topics_49198.htm?.

17. Modest increase in reporting countries: The figure actually declines to 87 percent in 2015, but that is common with the most recent year of data as for some countries data is only available with a one-year's delay.

18. Principles applied: http://www.sipri.org/research/armaments/milex/milex_database/copy_of_sources_methods.

19. Not all figures that are marked as SIPRI estimates are based on this percentage change approach. In some cases, estimates have been made of additional elements of spending outside the defense budget—such as arms imports—based on other information. In some cases, such as China, SIPRI's entire data series from 1989–2015 consists of estimates of a number of different extra-budgetary items, in addition to the official defense budget and other publicly-available elements of military spending.

20. Nine countries: They are Brazil, Colombia, Kuwait, Lebanon, Lesotho, Nigeria, the Philippines, Trinidad and Tobago, and Uruguay.

21. In fact, 1960 shows a significant drop in availability compared to 1959 as a large number of African countries became independent in 1960, yet data for this year is only available for a few.

22. Problems not necessarily gone away: For example, a recent Nigerian government inquiry found that between 2007 and 2015 there had been around USD6 billion worth of "extra-budgetary interventions" for arms purchases. A significant portion of this was misappropriated by senior officials, however, and never led to any arms deliveries.

References

Ball, N. 1983a. *Third-World Security Expenditure: A Statistical Compendium*. Stockholm: Swedish National Defence Research Institute.

Ball, N. 1983b [2014]. *Security and Economy in the Third World*. Princeton, NJ: Princeton University Press.

Blackaby, F. 1969. "Section 1. Military Expenditure and the Trade in Arms." *SIPRI Yearbook of World Armaments and*

Disarmament 1968/69. Stockholm: Almqvist & Wiksell.
Cooper, J. 1998. "The Military Expenditure of the USSR and the Russian Federation, 1987–97." *SIPRI Yearbook 1998*. Oxford, UK: Oxford University Press.
Nield, R. 1969. "Preface." *SIPRI Yearbook of World Armaments and Disarmament 1968/69*. Stockholm: Almqvist & Wiksell.
Huisken, R. 1973. "The Meaning and Measurement of Military Expenditure." SIPRI Research Report. No. 10. Uppsala: Almqvist & Wiksell. http://books.sipri.org/product_info?c_product_id=289 [accessed 21 September 2016].
Kravis, I.B. and R.E. Lipsey. 1990. "The International Comparison Program: Current Status and Problems." NBER Working Paper No. 3304. Cambridge, MA: National Bureau of Economic Research.
Rivlin, P. 1983. "The Burden of Defence: The Case of Israel." Appendix 7D. *SIPRI Yearbook 1983*. Oxford, UK: Oxford University Press. http://books.sipri.org/product_info?c_product_id=27 [accessed 21 September 2016].
Sköns, E. *et al*. 1998. "Sources and Methods for Military Expenditure Data." Appendix 6C. *SIPRI Yearbook 1998*. Oxford, UK: Oxford University Press.
Sköns, E., *et al*. 1999. "Sources and Methods for Military Expenditure Data." Appendix 7C. *SIPRI Yearbook 1999*. Oxford, UK: Oxford University Press.
Sköns, E. *et al*. 2003. "Military Expenditure." *SIPRI Yearbook 2003*. Oxford, UK: Oxford University Press.
Tullberg, R. and G. Hagmeyer-Gaverus. 1987. "World Military Expenditure." *SIPRI Yearbook 1987: World Armaments and Disarmament*. Oxford, UK: Oxford University Press.
Wang, S. 1999. "The Military Expenditure of China, 1989–98." *SIPRI Yearbook 1999*. Oxford, UK: Oxford University Press.
Yentürk, N. 2014. "Measuring Turkish Military Expenditure." *SIPRI Insights on Peace & Security*. No. 2014/1. http://books.sipri.org/product_info?c_product_id=474 [accessed 22 September 2016].

Some exercises with SIPRI's military expenditure alpha (α) data: Same story for Greece and Turkey?

Gulay Gunluk-Senesen

Gulay Gunluk-Senesen is Professor of Public Finance, Faculty of Political Sciences, Istanbul University, Istanbul, Turkey. She may be reached at gulaygs@istanbul.edu.tr.

Abstract

The purpose of this article is to assess the Stockholm International Peace Research Institute's (SIPRI) updated military expenditure data for Greece and Turkey. Testing for data reliability involves two stages. First, for 1949–2014, the time pattern of Turkish military expenditure is explored by comparing national military budget data with the updated SIPRI data. Second, the new data for 1980–2001 are used to replicate an earlier study on possible action-reaction military spending behavior between Greece and Turkey. The findings still hold when the analysis is based on SIPRI's updated data.

The motivation for this article stems from the availability of an extended military expenditure data series with improved quality from the Stockholm International Peace Research Institute (SIPRI). In regard to Turkey, the first purpose of this article is to compare SIRPI's new data series to Turkish national data sources. Second, the new data are then employed to replicate aspects of an earlier study. This involves, in particular, a reestimation of possible action-reaction military spending behavior between Greece and Turkey, 1980–2001. The exercises presented in this article are based on SIPRI's alpha (SIPRI-α) data made available to a select cohort of researchers in 2015.[1]

Comparing Turkish national budget data with SIPRI-α data

For Turkey, publicly available national military spending data include the budgets of the Ministry of Defense, the Gendarmerie, and the Coast Guard. Until Turkey adopted the functional government budget classification (COFOG) of the EU in 2006, data for the latter two were lumped in with those for the Ministry of Defense. This traditional set of expenditure data for Turkish military institutions is available as from 1924 onward. SIPRI's military expenditure data come in a broader context and, for any country, are higher than national data due to the inclusion of additional military-related activities, thus widening coverage beyond national military budget data. SIPRI's main source is NATO's dataset, constructed from reports by member country governments. Military-related data except for the budgets of the Defense Ministry, Gendarmerie, and Coast Guard is undisclosed information and, until 2006, Turkish budget classifications did not even allow for partly cross-checking SIPRI (or NATO) figures. Recent improvements in data quality notwithstanding, approximating SIPRI (or NATO) figures from Turkish national numbers still is a demanding issue.[2]

Figure 1 (on the next page) shows the ratio of SIPRI-α data to Turkish national military budget data for 1949 to 2014. The ratio is almost always greater than 1. Until 1974, this was on the order of 10 to 20 percent larger; thereafter on the order of 30 to 50 percent. Quite apart from issues related to the more inclusive nature of SIPRI's data—e.g., the magnitude of certain SIPRI components (pensions, procurement, other off-budget items added to the military budget) may have changed—discrepancies between the Turkish military budget data (Ministry of Defense, the Gendarmerie, and the Coast Guard) and the SIPRI data could be due to a number of other issues. Thus, the SIPRI-α coverage (degree of inclusion) might have been revised or reorganizations in the Turkish military and paramilitary structure might have led to related financing mechanisms beyond the military budget. The simple ratio presentation of the two series in Figure 1 provides some insight into the potential information gain afforded by SIPRI's coverage as well as into peculiarities of Turkish military spending.

In Figure 1, the data points for 1949, 1955, and 1958 are unusual in that SIPRI-α military expenditure data for Turkey are either equal to or below the national data. Starting in 1974, the Cyprus conflict between Greece and Turkey certainly triggered extra Turkish military spending as well as ambiguities in spending items and the estimation of their size for 1975–1979. Turkish military rule from 1980–1983 and the economic crisis of 1979–1981 could also help to account for the observed data fluctuations. From the mid-1980s onward, the margin by which the SIPRI-α data exceed the Turkish national data fluctuates less and a declining trend is noticeable:

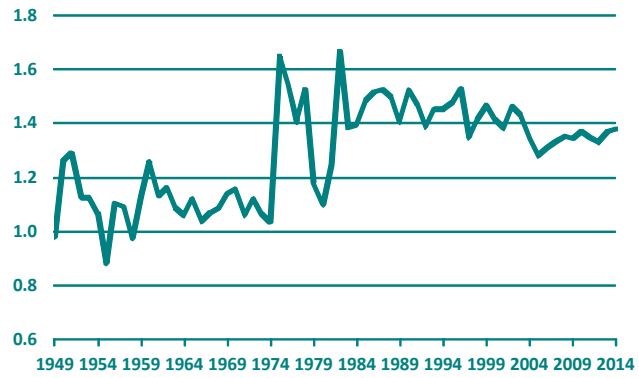


Figure 1: Ratio of SIPRI-α to Turkish national military budget data (both in current TRY). *Sources*: See endnote 2.

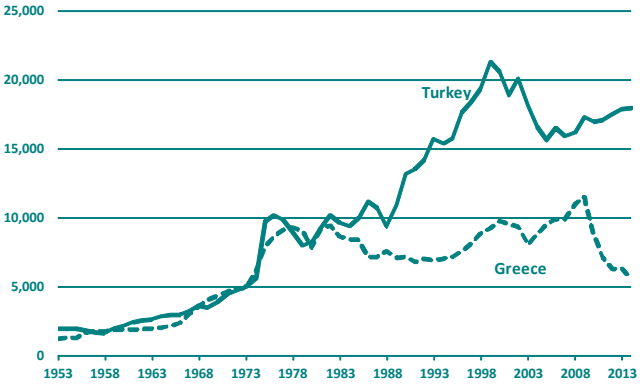


Figure 2: SIPRI-α military expenditure for Greece and Turkey, 1953-2014 (measured in constant USD2011). *Source*: www.sipri.org/databases/milex.

The SIPRI-α data suggest a ratio of generally greater than 1.4 until 2003, and less than 1.4 thereafter.[3]

The figure prompts two questions. First, does the method used to construct SIPRI's α-series differ for the pre-1974 and post-1981 periods? To my knowledge, there exists no explicit SIPRI-specific revision, so going through the underlying NATO dataset might provide answers but this falls outside the scope of this article. The second question is whether Turkish military expenditure beyond the traditional institutional budgets—defense, gendarmerie, and Coast Guard—increased over the past three decades. With reservations, the question is answered in the affirmative since this period coincides with Turkey's ambitious arms industry modernization program, initiated in 1985 and financed by the off-budget Defense Industry Support Fund (DISF). However, attributing the data discrepancy solely to DISF would not be justified without a detailed analysis of the component breakdown of related SIPRI-α data, which also is beyond the scope of this article.[4]

Greece and Turkey: Military expenditure over six decades

Turn now to the second purpose of the article, a comparison of the military expenditure of Greece and Turkey. Even though both countries joined NATO in 1952, the pair became a popular dyad in conflict studies as bilateral relations between Greece and Turkey oscillated between tension and détente until the year 2000. A large arms race-related literature accumulated, which resorted extensively to SIPRI as a major data source. Overall, the literature's findings are inconsistent, causality remains undetermined, and the issue of whether or not an arms race existed has not been resolved. Since 2000s both countries' threat perceptions of each other have changed, in part due to changes in political and economic factors both in the national and international domains, and an era characterized by rapprochement and even cooperation emerged.[5]

Capturing these oscillations, Figure 2 shows Greek and Turkish military expenditure measured in constant USD2011 prices. Despite the scale differences in population and economic heft between the two countries, simple visual inspection favors the arms race argument to hold for the three decades between 1953 and 1982. Over the past three decades, however, a different relationship structure appears to prevail. A military expenditure gap opened and then widened rapidly due to increases in Turkish military spending relative to the comparatively "stagnant" military spending of Greece. Nevertheless, the simple correlation coefficient for the whole period between these two data series is quite high (r=0.81) and statistically significantly different from zero. Note that this coefficient is valid for linear relationships only. It does not imply causality but does imply movement in generally similar directions.

The validity of SIPRI's data is widely accepted, almost without criticism. Following the principle of "first validity, then reliability," the availability of the SIPRI-α data thus presents an opportunity to test its reliability. In this vein, the following replicates a previous study regarding Greek–Turkish bilateral relations.

Greek and Turkish relative military expenditure positions, 1979–2001

Reliability in scientific research refers to consistency of measurement. The new SIPRI-α data provide an opportunity to challenge, or affirm, research based on the "old" SIPRI data. Thus, an analysis by Gunluk-Senesen (2004) used SIPRI's military expenditure data for Greece and Turkey (in constant USD1990). The data was assembled by Christos Kollias and shared with Gunluk-Senesen, so I refer to this dataset here as CK$1990. It covers the 1979–2001 period. The specific research question is whether the findings of the 2004 paper still

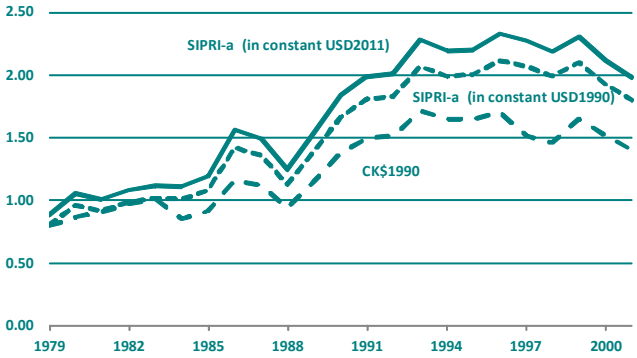


Figure 3: Ratios of Turkish to Greek military expenditure, alternative series (1979–2001). *Sources*: SIPRI-α at www.sipri.org/databases/milex; CK$1990 in Kollias (2004) and Kollias and Paleologou (2002).

hold when employing the SIPRI-α data. The first order of business is to plot the relevant data. Thus, Figure 3 shows the ratio of Turkish to Greek military expenditure in CK$1990 data (the bottom line) along with the SIPRI-α data for base year 2011 (the top line). It is a simple matter to rebase the SIPRI-α data to 1990, thus eliminating the base year difference (the middle line).

Visually, the overall match between the CK$1990 and the SIPRI-α $1990 series is quite close.[6] However, there are some peculiarities. In the CK$1990 series, Greek military spending is above Turkey's—the ratio is less than one—for 1979–1982, 1984, 1985, and 1988. Then Turkey's spending overtakes Greece's by a significant margin as from 1989 onward. In contrast, the SIPRI-α $1990 data show that Greek spending exceeded Turkey's only through 1982 and held essentially at parity in the mid-1980s. This likely is to due data revisions for Greece and could suggest a different interpretation of the countries' bilateral relations. Another peculiarity is that the SIPRI-α $2011 series results in higher ratios than the SIPRI-α $1990 series. For example, take the year 1993: The MilExTR/MilExGR ratios are 2.3, 2.1, and 1.7 for the SIPRI-α $2011, SIPRI-α $1990, and the CK$1990 data, respectively. This again could imply changes in interpretations that are based on the CK$1990 data.

Likely revisions, especially for Greece, are obvious from the summary data in Table 1 which shows the simple correlation coefficient (r) and the Pearson rank correlation (ρ) values for the ratios, absolute levels, and percentage changes of military expenditure among the different series. Correlations for the ratios depicted in Figure 3 are very close to unity. The series move in the same directions. Correlations for percentage changes in military expenditure are similar and relatively high for Greece and Turkey. However, both simple and rank

Table 1: Correlation coefficients I (1979–2001)

Correlation coefficients	*Data series: SIPRI-α $2011 (or $1990) and CK$1990*
Simple *r* for milexTR/milexGR	0.98
Rank ρ for milex	Turkey: 0.99 Greece: 0.65
Simple *r* for milex	Turkey: 0.99 Greece: 0.62
Simple *r* for percent change in milex, 1980–2001	Turkey: 0.89 Greece: 0.85

Note: All coefficients are statistically significantly different from zero at the 0.01 level.

Table 2: Correlation coefficients II (1979–2001)

Indicator	*Stat.*	*CK$1990*	*SIPRI-α $2011*	*SIPRI-α $1990*
Milex 1979–2001	*r*	0.70*	0.24	0.17
	ρ	0.56*	0.08	0.08
Percent change in milex, 1980–2001	*r*	0.11	0.04	0.04
	ρ	–0.07	0.04	0.04

Note: * 0.01 level. The CK$1990 column is repeated from Gunluk-Senesen (2004).

correlations for Greece are much *lower* while those for Turkey are almost unity. The implication again is that the data for Greece are revised in the SIPRI-α data set. Hence previous findings based on CK$1990 data, both in our specific case and in the literature more generally, may need to be reconsidered.

Retesting the action-reaction hypothesis: Different stories with different data?

I now turn to exploring whether these likely corrections for the Greek data cast a shadow on the hypothesis tests in Gunluk-Senesen (2004), which were based on the CK$1990 data, regarding the action-reaction military expenditure behavior of the Greek-Turkish dyad. Simple reasoning suggests that threat perceptions within the dyad will be reflected in their concurrent military expenditure, arms imports, and military equipment spending, or possibly with a time lag. I elaborate

bilateral responses here only for military expenditure in accordance with the available SIPRI-α data. Recognition of long-term considerations for military capacity building notwithstanding, analyses with lagged responses in Gunluk-Senesen (2004) are not repeated here due to space and scope considerations. I emphasize that focusing on quantitative aspects involves contesting inferences from the statistical tests conducted with different data sets. There certainly will be some variations in the values of the test statistics due to different units of measurement (that is, base years) but this is not the main issue at hand here.

Table 2 lists the correlations of the CK$1990 series with the new SIPRI-α series (either base year 1990 or base year 2011). Both the simple and rank correlations between the military expenditure series of Greece and Turkey are statistically significant with the CK$1990 data, implying a concurrent response to variations in threat perceptions as observed in Gunluk-Senesen (2004). Running the correlations with the SIPRI-α data, however, one comes to a different conclusion: The coefficient values now are low and statistically insignificant (revision of the data for Greece might be the underlying reason here again). The correlation coefficients for the *percentage changes* in the military expenditure series are insignificant with all three data series, casting doubt on the presence of any mutual concurrent responses.

The final exercise in this article regarding action-reaction behaviors takes into account the nature of Greek-Turkish bilateral relations, 1980–2001. As Gunluk-Senesen (2004) showed, relations improved in 11 years (1982, 1988–1992, 1995, and 1998–2001) and deteriorated, with different intensities, in the other 11 years (1980–1981, 1983–1987, 1993–1994 and 1996–1997).[7] Splitting the 22 years of data into the two subsets of "harmony" and "conflict," respectively, the following null hypothesis is tested: There is no difference between the military expenditure (in levels and percentage changes) of Greece (Turkey) in more relaxed relative to more tense times with Turkey (Greece). Both nonparametric and parametric test results for central locations and dispersion are shown in Table 3 for Greece and in Table 4 for Turkey.[8]

In Table 4, when using the SIPRI-α $2011 data, neither Turkey's level of nor percentage change in military expenditure in years of relative harmony with Greece are statistically different from more conflictual years. This finding is consistent with the inference drawn in Gunluk-Senesen (2004) which used the CK$1990 data. Only the variance test results for Greece differs (in Table 3), an outcome which once more might be attributed to SIPRI-α data revision for Greece. The variance is greater in conflict years. Nevertheless, the findings based on the SIPRI-α data do not support the hypothesis of an arms (military expenditure) race between Greece and Turkey.

Table 3: Greek reaction to bilateral relations with Turkey, 1980–2001 (significance levels; p-values)

	CK$1990 data		*SIPRI-α $2011 data*	
Test	Milex	Percent change milex	Milex	Percent change milex
Mann-Whitney U	0.13	0.56	0.62	0.34
Means	0.06	0.84	0.25	0.38
Variance	0.003	0.06	0.09	0.02

Notes: The CK$1990 series is taken from Gunluk-Senesen (2004). Findings using SIPRI-α $2011 are essentially equal to those using SIPRI-α $1990.

Table 4: Turkish reaction to bilateral relations with Greece, 1980–2001 (significance levels; p-values)

	CK$1990 data		*SIPRI-α $2011 data*	
Test	Milex	Percent change milex	Milex	Percent change milex
Mann-Whitney U	0.08	0.70	0.07	0.87
Means	0.08	0.76	0.11	0.97
Variance	0.99	0.93	0.33	0.17

Notes: The CK$1990 series is taken from Gunluk-Senesen (2004). Findings using SIPRI-α $2011 are essentially equal to those using SIPRI-α $1990.

Conclusion

Until the year 2000, tension, negotiation, and rapprochement oscillated in Greek–Turkish relations, a once popular research dyad among scholars of political science, international relations, and political economy. A good portion of the vast arms race literature focused on this dyad. (The Cyprus conflict, which peaked in 1974, has remained as a source of conflict.) However, a rich variety of econometric models have not resulted in coherent empirical findings, leaving the arms race issue inconclusive. For both countries, a complex set of other factors—e.g., nonbilateral economic and internal and external political factors—emerged as more determinative for military expenditure in general and arms spending in particular. That

said, empirical work meant to contribute to attempts to generalize from case-specific findings is conditioned on the availability and quality of the underlying data. In this regard, SIPRI data have long been a common source for empirical research. Thus, the extended and updated SIPRI-α military expenditure data series offers opportunities for improved empirical research. This can, however, challenge earlier findings and the accumulated knowledge in the field.

With this background in mind, this article first cross-checked SIPRI's data with the national military budget data for Turkey and then employed the new data to retest an action-reaction hypothesis first published in Gunluk-Senesen (2004). That study failed to find evidence for an action-reaction pattern, a finding confirmed in the current article.

Since data is the main focus in this article, two issues are worth noting for future research on military expenditure: First, a comparison of the new SIPRI-α data and the national military budget data for Turkey suggests that cross-checks with national data generally could be quite useful not merely to show up limitations of national data but, more importantly, to query the extent of transparency in national data. This information is crucial for research in peace and security economics. This point may also be relevant for work on international comparisons which use, or will use, the SIPRI-α dataset. SIPRI has been providing internationally comparable and standardized data. For many years now, it has been the most reliable and most resorted to data source among researchers but an exploratory understanding of its coverage and structure at national levels would further improve our knowledge of the political and economic processes that generate these data. That said, if SIPRI made available a country-by-country breakdown of the *components* of military expenditure (e.g., personnel versus nonpersonnel spending), our understanding not only of SIPRI's methods but of patterns of resource allocation for military purposes would surely be improved. This would also serve to reinforce the validity of related SIPRI datasets.

Second, and more germane to the specific analyses carried out in this article, I note that the military expenditure data for Greece in the SIPRI-α dataset was revised for one or more years for the 1979–2001 sample. This suggests that comparative analyses for other countries and longer time spans should cross-check earlier research findings as well, both a challenge and an opportunity to improve our work. Appreciating that these and other issues can be addressed with SIPRI's policy of open data access, I expect to see future comparative research notes similar to the present article.

Notes

This article is a revised version of the presentation at the SIPRI Expert Workshop on Military Expenditure (Stockholm, 28-29 January 2016). I thank the organizers, especially Sam Perlo-Freeman and Noel Kelly. Comments by workshop participants and of this journal''s editors and referees are gratefully acknowledged.

1. Updated and extended SIPRI data: https://www.sipri.org/databases/milex [accessed 16 September 2015]

2. COFOG: http://ec.europa.eu/eurostat/statistics-explained/index.php/Government_expenditure_by_function_%E2%80%93_COFOG [accessed 12 June 2016]. Internal and external security functions and institutions in Turkey: See Ayman and Gunluk-Senesen (2016). Turkish national military expenditure data: Gunluk-Senesen (2002, 2010); Gunluk-Senesen and Kirik (2016); Maliye Bakanligi (1993); https://www.muhasebat.gov.tr/content/duyuru/kurulus-bazinda-odenek-ve-harcamalar-tablosu/169150; https://www.muhasebat.gov.tr/content/duyuru/kurulus-bazinda-odenek-ve-harcamalar-tablosu/155612; http://www.bumko.gov.tr/TR,4461/butce-gider-gelir-gercekl esmeleri-1924-2012.html [accessed 22 June 2016]. SIPRI methodology: Perlo-Freeman, *et al*. (2015, pp. 400-402). Estimations for Turkish data with SIPRI methodology since 2006: Yenturk (2014).

3. The Cyprus conflict: Dokos and Tsakonas (2003); Kollias and Gunluk-Senesen (2003); Sonmezoglu and Ayman (2003).

4. DISF: Ayman and Gunluk-Senesen (2016); Gunluk-Senesen (1993); http://www.turksavunmasanayi.gov.tr/en/file/under secretariat-for-defence-industries-stratejic-plan-2012-2016 [accessed 22 June 2016]. A similar, and if possible deeper, comparative data analysis for countries other than Turkey might generate interesting research related to questions of (de)militarization, arming, military burden, and the like. Any such research would likely carry implications for SIPRI-α methodology and data.

5. Arms race literature: For assessments see, e.g., Brauer (2003); Gunluk-Senesen (2004); Kollias, Paleologou and Stergiou (2016). Greek-Turkish relations in the 2000s: Ayman and Gunluk-Senesen (2016); Kollias, Paleologou and Stergiou (2016). SIPRI (2015) does not mention Greece and Turkey among states in conflict.

6. The correlation coefficient (r) between the SIPRI-α $2011 and the SIPRI-α $1990 series of ratios is unity. The CK$1990 ratio data is highly correlated with both of these series, r being equal to 0.982 and 0.978, respectively (see Table 1).

7. Chronology of major relations between Greece and Turkey: Gunluk-Senesen (2004), Table 1 and endnote 13 therein.

8. Significance levels of tests: Newbold, Carlson, and Thorne (2003); http://stattrek.com/online-calculator/t-distribution.aspx ; http://stattrek.com/online-calculator/f-distribution.aspx [accessed 3 July 2016].

References

Ayman, G. and G. Gunluk-Senesen. 2016. "Turkey's Changing Security Perceptions and Expenditures in the 2000s: Substitutes or Complements?" *Economics of Peace and Security Journal*. Vol. 11, No. 1, pp. 35-45. http://dx.doi.org/10.15355/epsj.11.1.35

Brauer, J. 2003. "Turkey and Greece: A Comprehensive Survey of the Defence Economics Literature," pp. 193-241 in C. Kollias and G. Gunluk-Senesen, eds. *Greece and Turkey in the 21st Century. The Political Economy Perspective*. New York: Nova Science Publishers.

Dokos, T. and P. Tsakonas. 2003. "Greek–Turkish Relations in the Post-Cold War Era," pp. 9-35 in C. Kollias and G. Gunluk-Senesen, eds. *Greece and Turkey in the 21st Century. The Political Economy Perspective*. New York: Nova Science Publishers.

Gunluk-Senesen, G. 1993. "An Overview of the Arms Industry Modernization Programme in Turkey," pp. 521-532 [Appendix 10E] in *SIPRI Yearbook 1993, World Armaments and Disarmament*. New York: Oxford University Press.

Gunluk-Senesen, G. 2002. Türkiye'de Savunma Harcamalari ve Ekonomik Etkileri (1980–2001), Istanbul: TESEV.

Gunluk-Senesen, G. 2004. "An Analysis of the Action-Reaction Behaviour in Defense Expenditures of Turkey and Greece." *Turkish Studies*. Vol. 5, No. 1, pp.78-98. http://dx.doi.org/10.1080/14683849.2004.9687243

Gunluk-Senesen, G. 2010. "Turkey's Defense Expenditures in the 2000s," pp. 143-150 in A. Bayramoglu and A. Insel, eds. *Almanac Turkey 2006-2008: Security Sector and Democratic Oversight*. Istanbul: TESEV.

Gunluk-Senesen, G. and H. Kirik. 2016. "The AKP Era: Democratization or Resecuritization? An Assessment of the Institutional and Budgetary Reflections." *Research and Policy on Turkey*. Vol. 1, No. 1, pp. 75-87. http://dx.doi.org/10.1080/23760818.2015.1099783

Kollias, C. 2004. "The Greek-Turkish Rapprochement, the Underlying Military Tension and Greek Defense Spending." *Turkish Studies*. Vol. 5, No. 1, pp. 99–116. http://dx.doi.org/10.1080/14683849.2004.9687244

Kollias, C. and S.M. Paleologou. 2002. "Is There a Greek–Turkish Arms Race? Some Further Empirical Results from Causality Tests." *Defence and Peace Economics*. Vol. 13, No. 4, pp. 321–328. http://dx.doi.org/10.1080/10242690212357

Kollias, C. and G. Gunluk-Senesen, eds. 2003. *Greece and Turkey in the 21st Century: Conflict or Cooperation?* New York: NovaScience.

Kollias, C., S.M. Paleologou and A. Stergiou. 2016. "Military Expenditure in Greece: Security Challenges and Economic Constraints." *Economics of Peace and Security Journal*. Vol. 11, No. 1, pp. 28-34. http:// dx.doi.org/10.15355/epsj.11.1.28

Maliye Bakanligi.1993. Savunma ve Guvenlik Hizmetleri (1924–1993). Ankara.

Newbold, P., W.L. Carlson, and B. M. Thorne. 2003. *Statistics for Business and Economics*. London: Prentice Hall.

Perlo-Freeman, S., M. Carriera, A. Fleurant, N. Kelly, P.D. Wezeman, and S. Wezeman. 2015. "Military Expenditure Data, 2005-2014," pp. 373-402 in *SIPRI Yearbook 2015: Armaments, Disarmament and International Security*. Oxford, UK: Oxford University Press.

[SIPRI] Stockholm International Peace Research Institute. 2015. *SIPRI Yearbook 2015: Armaments, Disarmament and International Security*. Oxford, UK: Oxford University Press.

Sonmezoglu, F. and G. Ayman. 2003. "The Roots of Conflict and the Dynamics of Change in Turkish–Greek Relations," pp. 37-48 in C. Kollias and G. Gunluk-Senesen, eds. *Greece and Turkey in the 21st Century. The Political Economy Perspective*. New York: Nova Science Publishers.

Yenturk, N. 2014. "Measuring Turkish Military Expenditure." SIPRI Insights on Peace and Security.http://books.sipri.org/files/insight/SIPRIInsight1401.pdf [accessed 9 September 2016].

Greece, Portugal, Spain: New evidence on the economic effects of military expenditure using the new SIPRI data

Eftychia Nikolaidou

Eftychia Nikolaidou is Associate Professor of Economics at the University of Cape Town, Cape Town, South Africa. She may be reached at efi.nikolaidou@uct.ac.za.

Abstract

This article first compares old with newly updated and extended SIPRI military expenditure data for Greece, Portugal, and Spain. Using the new data to confirm or reject earlier findings, it then replicates a Solow growth model application employed in a 2012 study by Dunne and Nikolaidou. In addition, the article provides new evidence on the military expenditure–economic growth nexus for these three countries using the extended data that now cover the post-global financial crisis and European debt crisis years. The use of the new SIPRI data does not lead to rejection of the earlier findings for Greece and Portugal but does reject the formerly negative and statistically significant effect of military burden on growth for the case of Spain.

Newly revised and extended military expenditure data made available by the Stockholm International Peace Research Institute (SIPRI) provide both an opportunity and a potential challenge to researchers who have analyzed the relation between military spending and economic growth. The potential challenge lies in that the new data—for many countries extended from 1988 back to the early 1950s—may possibly lead to revisions of the research community's earlier findings. The opportunity lies in the ability to identify and possibly establish more stable, statistically robust relationships between military spending and economic growth over a much longer time period than was hitherto possible.

In 2012, J. Paul Dunne and Eftychia Nikolaidou published an analysis of the effects of military burden, that is, the ratio of military expenditure over GDP, on economic growth focusing on the 15 core European Union countries. The availability of SIPRI's revised and extended data makes it worthwhile to reinvestigate their paper by focusing on three of these countries, namely Greece, Portugal and Spain.[1]

These three countries are particularly interesting cases for such a study for a number of reasons. First, in comparison to other EU countries, their military expenditure data has seen the most revisions in the new SIPRI data. Second, characterized as "peripheral European economies," they share similar economic features and have suffered the most from the recent economic and debt crises. Third, all three emerged from military dictatorships in the mid-1970s and Greece in particular (followed by Portugal) has been a big defense spender since then, a factor that has partly contributed to the Greek debt crisis.[2]

This article, then, first compares the old SIPRI military data series with the revised ones to identify common patterns in the data revisions. Second, to test the validity of earlier findings it replicates the growth model used in Dunne and Nikolaidou (2012), for the same time period (1960–2007), but employing the new military expenditure data. Third, the article provides new empirical evidence for the same model but over the extended time frame 1960–2014 which therefore includes the post-crisis years. And, fourth, the article explicitly accounts for the impact of the global financial crisis and the European debt crisis on these economies' growth through the use of dummy variables. The final section summarizes and concludes this article.

Greece, Portugal, Spain: Evolution of military expenditure

Within the European Union and the eurozone, interesting variations in military burden and economic performance exist. The European debt crisis brought to the front the vulnerabilities of the so-called peripheral EU countries: Greece, Portugal, and Spain. All three are economically weak and Greece and Portugal in particular have been high-level military spenders for a long period (Greece after the collapse of its military junta in 1974 and Portugal for the duration of its own military regime which collapsed in 1975).[3]

All three are members of the EU, the eurozone, and NATO. Sharing many similarities in terms of economic performance, they show differences in their patterns of military expenditure. Throughout the 1960s and into the early- to mid-1970s, all showed high rates of economic growth (7.6, 6.0, and 7.8 percent, respectively, for Greece, Portugal, and Spain; see Figure 1) when, with the onset of the first global oil crisis, the three economies entered a deep recession as did most western,

industrialized economies. The recession coincided with the collapse of the dictatorships in all three countries as well and, in the case of Greece, 1974 was, moreover, the year of the conflict with Turkey over the island of Cyprus. The transition toward parliamentary democracy led to internal political and economic changes and a desire for international recognition. All three joined the then-European Community as a means of strengthening their economic and political situation. When they did join, however, their relative economic backwardness made them the EU's poorest countries. The 1970s crises led to a huge drop in investment for all three of the countries (see Figure 2) and substantial increases in government debt after 1975, a problem that has become more serious over the last two decades, especially for Greece.[4]

As Figure 1 shows, the GDP growth averages even in the late 1970s were still relatively high, certainly when compared to the poor performance that was to follow in the 1980s. (Greece, especially, turned in an average growth rate record of only 0.78 percent.). The 1990s found all three economies in an equally uninspiring situation as in the 1980s and in the next decade (the 2000s) growth rates averaged 2.8 percent for Greece and Spain while Portugal experienced a much lower rate of only 0.94 percent for the decade. For all three countries, and particularly for Greece and Portugal, the economic situation deteriorated tremendously with the onset of the 2008 global financial crisis and the ensuing European debt crisis. Greece and Portugal signed a bail-out package offered by the EU, the European Central Bank, and the International Monetary Fund. Spain, a much larger and stronger economy in comparison to Greece and Portugal, avoided the deep recession—and the bail-out package. All countries suffered a big reduction in gross domestic investment after the crisis, the most profound decrease faced by Greece (Figure 2).[5]

Turn now to the countries' military expenditure. Figure 3 shows clear differences in the evolution of the countries' military burden (the ratio of military expenditure to GDP). Throughout the period, Spain carried the lowest burden among the three countries, averaging around 2 percent of GDP. An increase to about 3 percent occurred by the mid-1980s, due to a push to develop an indigenous arms industry and the subsequent expansion of arms production. In Greece and Portugal, things are quite different. Clearly visible, 1974 was a critical year for both countries. Portugal had a high military burden (higher than Greece) for the years prior to 1974 and after that a dramatically decreased one, with the opposite pattern observed for Greece. The reduction of the Portuguese military burden after 1974 is attributed to the end of its dictatorship but most importantly to the fall of its colonial empire. For Greece, the Turkish invasion of Cyprus in 1974

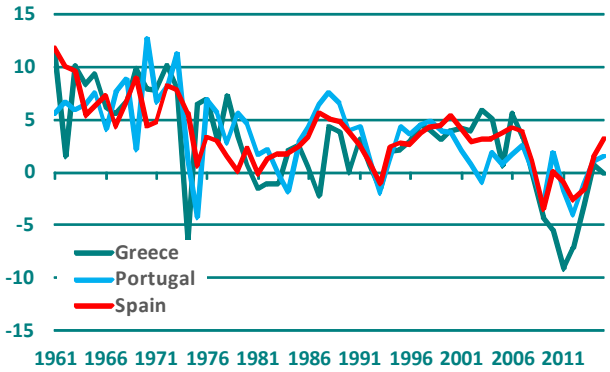


Figure 1: GDP growth (percent) for Greece, Portugal, and Spain, 1961-2015. *Note*: Growth rates are calculated from figures in constant USD2010. *Source*: World Bank.

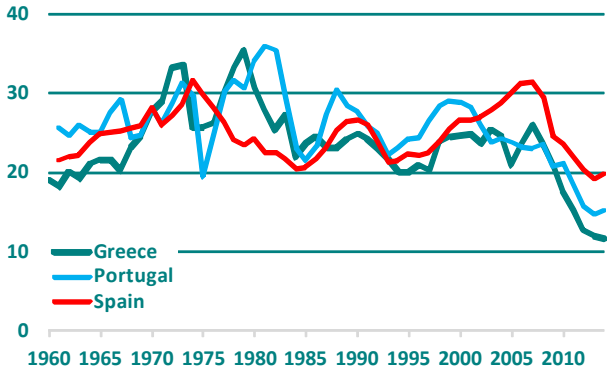


Figure 2: Investment as a share of GDP. *Source*: World Bank.

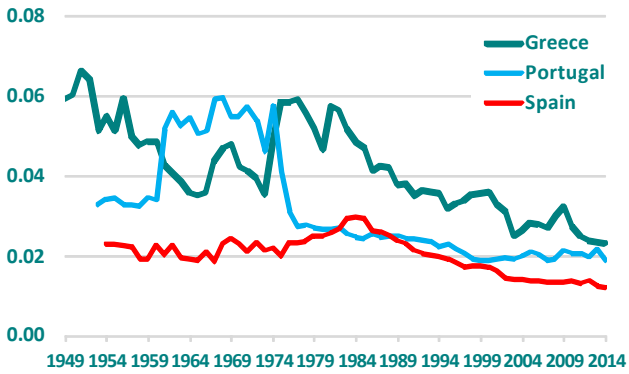


Figure 3: Military burden for Greece, Portugal, and Spain (new SIPRI data). *Source*: SIPRI.

marked a huge increase in military burden. This has remained high ever since then due to continuing disagreements and conflicts with its neighbor. Greece continued excessive military spending up until and even shortly after the onset of the Greek

debt crisis. After 2008 both Greece and Portugal saw dramatic decreases in their military expenditure. This descriptive record of interesting patterns is particularly valuable to analyze when revised and longer time series are available.[6]

Brief literature review

The theoretical analysis of military expenditure remains a difficult task given the complex nature of this type of spending (a combination of economic, political, strategic, cultural, psychological, and moral aspects). In the relevant literature, most of the empirical work is based on either a Keynesian or neoclassical framework. More recent work uses exogenous and endogenous growth models.

Supply-side models of the defense–growth relationship within the neoclassical framework derive from the aggregate production function. Models developed by Feder (1983), Ram (1986), and Biswas and Ram (1986) use military expenditure as an exogenous variable and estimate its dynamic real effects on output. While extensively employed in the literature, they have attracted substantial criticism (e.g., see Dunne, Smith, and Willenbockel, 2005) and as such other growth models were then applied in the defense economics literature, e.g., models based on Barro (1990), the augmented Solow model, Romer (2000), and Taylor (2000).

Overall, while the empirical results offer no consensus on the economic effects of military spending, the most common finding is that military burden has either no, or a negative, statistically significant effect on the economic growth of developing countries. The survey by Dunne and Tian (2013) suggests that studies using post-cold war data tend to find significant negative effects. Empirical evidence for the focal countries in this article, with the exception of Greece is limited. To my knowledge, apart from the 2012 Dunne and Nikolaidou study that includes Spain among other EU countries, there is no study on the defense–growth relationship that focuses on Spain itself. As regards Portugal, previous work is limited to the causality studies by Dunne and Nikolaidou and by Shabaz, *et al*., published in 2005 and 2013, respectively. The first study did not find a causal relationship between military expenditure and economic growth while the second concluded that military expenditure does cause economic growth, but this finding was not confirmed with the formal growth modeling approach employed in Dunne and Nikolaidou (2012). Given these inconclusive results (probably due to the use of different models, approaches, and time frames), the newly available revised SIPRI data presents researchers with an opportunity to reinvestigate the military expenditure–economic growth nexus for these counties. Thus, the next section outlines the approach and presents the empirical results.[7]

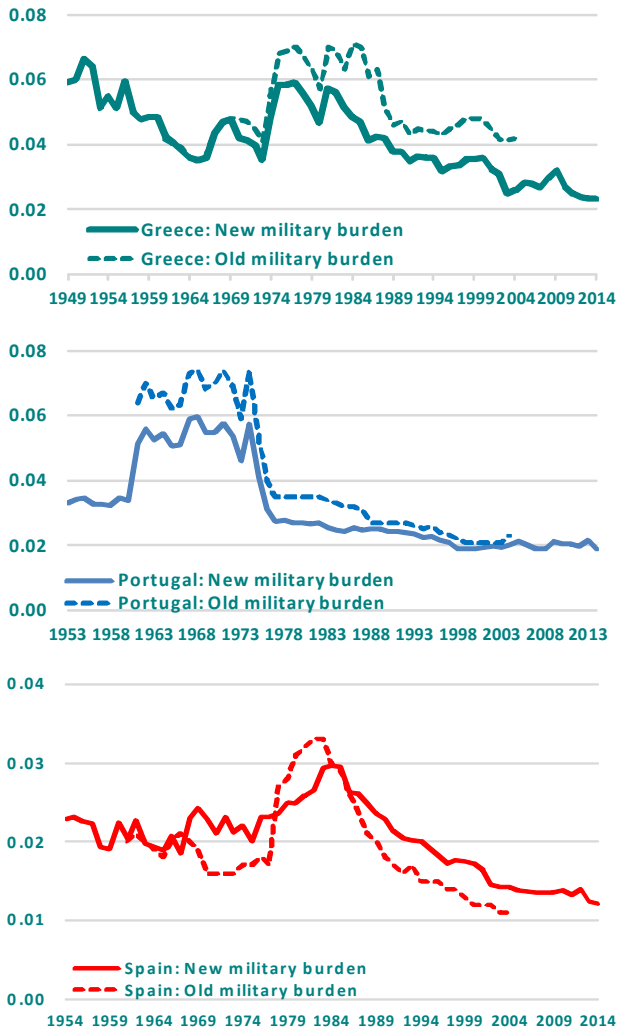


Figure 4: New and old SIPRI military expenditure (and military burden) data (Greece, Portugal, and Spain).

Data and empirical analysis

Comparing SIPRI's old and new military expenditure data for Greece, Portugal, and Spain

Comparing the old and new military expenditure and military burden data, a striking result is obtained (see Figure 4). For Greece we note a downward revision in the series after 1974, the year that saw the collapse of its dictatorship and that coincided with the Turkish invasion of Cyprus. Although the two series follow the same overall pattern, the discrepancy between the old and the revised data is particularly high over the period 1975–1986. Is this because of a change in SIPRI's military expenditure definition, a revision of Greece's GDP, or a combination of the two? This is something that SIPRI should clarify.

For Portugal, we note a similar downward revision of its numbers. In contrast to the case of Greece, though, the big downward revision concerns mainly the years of the dictatorship. After 1975, the difference between the old and revised series becomes smaller. Finally, for Spain we see both upward and downward revisions in the series. For 1968–1978 (which includes the dictatorship years in Spain) data is revised upward; then downward between 1978–1984, and upward again thereafter. There is a need for some clarity regarding these changes, particularly when the revisions go both ways (upward and downward).

Replication and new evidence

Given the revisions in the military expenditure data of the three countries, it is of interest to consider the validity of earlier work, for example the 2012 work of Dunne and Nikolaidou. They analyzed the military expenditure–economic growth relation for 15 EU countries over the period 1960–2007. Here, I replicate their model over the same period but only for Greece, Portugal, and Spain. Given that these countries also suffered the most from the recent economic and debt crises, I also provide new evidence regarding the military expenditure–economic growth nexus using the extended, post-crisis data (1960–2014). Further, I employ the same model with and without a dummy variable for the 2008 crisis (and the 1974 crisis for Greece).

The model is an augmented Solow growth model with Harrod-neutral technical progress and is specified as follows:[8]

$$dlyp = c + lyp(-1) + dliy + liy(-1) + dlmy + lmy(-1) + ngd + t,$$

where *lyp* is the logarithm of GDP per capita (in constant USD2005), *liy* is the logarithm of investment as a share of GDP, *lmy* is the logarithm of military expenditure as a share of GDP, *ngd* is the labor force growth rate + 0.05, and *t* is a time trend. The *d* in front of a variable denotes first difference, and the *l* in front of a variable denotes a logarithmic transformation. Finally, (-1) at the end of a variable refers to a one-period lag.

The key assumption is that *my* (military expenditure as a share of GDP) affects factor productivity via level effects on the efficiency parameter which controls the labor-augmenting technical change. Further, *g* is the exogenous rate of Harrod-neutral technical progress. Given the different definitions of what constitutes the labor force across countries, labor force is proxied here by population size to construct the augmented labor force growth rate (*ngd*). Technology is proxied by the time trend (*t*). Data for military burden (military expenditure over GDP) is taken from SIPRI while data for all the other variables comes from the World Bank's *World Development Indicators* database.

Table 1, Panel A: Short-run estimates for Greece

	1960–2007		*1960–2014*	
	Old	*New*	*New*	*New & dummy*
c	–0.659**	0.270*	0.298**	0.119
lyp(–1)	–0.110	–0.135*	–0.149**	–0.075
Δliy	0.235***	0.020***	0.027***	0.020***
liy(–1)	0.165**	0.011	0.013**	0.010*
Δlmy	–0.046	–0.008	–0.004	–0.001
lmy(–1)	–0.012	–0.004	–0.004	–0.007*
ngd	–0.133**	–0.001	0.001	–0.011
t	0.003	0.0003	0.001	-0.001
D08				–0.004**
D74				–0.009***
R-sq.	0.579	0.577	0.664	0.720
SER	0.029	0.002	0.003	0.003
DW	1.989	2.237	1.931	1.801

Note: *, **, and *** denote statistical significance at the 10, 5, an 1 percent levels, respectively.

Table 1, Panel B: Long-run estimates for Greece

	1960–2007		*1960–2014*	
	Old	*New*	*New*	*New & dummy*
c	–5.99	2	2	1.6
liy	1.5	0.07	0.09	0.13
lmy	–0.11	–0.03	–0.03	–0.09
lngd	–1.21	–0.001	0.001	–0.13
t	0.03	0.001	0.001	0.01
D08				–0.05
D74				–0.13

For each of the three countries, the model is estimated as a log-linear reparameterized general first-order dynamic model

with the change in the log of GDP per capita (*lyp*) as the dependent variable. Tables 1, 2, and 3 present the short- and long-run estimates, in two panels, for Greece, Portugal, and Spain, respectively. For each country, the short- and long-run estimates are presented (1) using the old SIPRI data over the period 1960–2007, (2) using the new SIPRI data over the same period, (3) using the new (revised and extended) SIPRI data over the period (1960–2014), and (4) using the revised, extended SIPRI with a dummy variable for 2008 to denote the beginning of the economic crisis (and a dummy for 1974 for Greece as well).

Start with Greece. The first two numeric columns in Table 1, Panel A (for 1960–2007) show, for most variables, slightly smaller coefficients with the new SIPRI data but the signs of all variables (apart from the constant) remain the same. As before, the expected positive sign for the investment variable and the negative signs for GDP per capita growth, population growth, and for the military burden variables hold. Statistical significance, however, vanishes for the population growth variable when the new SIPRI data are used. The variable of interest—military burden (*lmy*)—is negative and statistically insignificant with either the old or new data. A similar story applies when the new SIPRI data are used over the extended time frame (1960–2014). When including the crises dummies (D08 for the economic crisis and D74 for the Cyprus crisis), the fit of the model improves and the negative coefficient on military burden becomes statistically significant (at the 10% level). The two dummies are highly significant and of the expected negative sign. As for the calculated long-run coefficients, military burden carries a negative sign in all four specifications. Albeit not statistically significant, it is certain that military burden does *not* have a positive effect on economic growth.

Moving on to Portugal (Table 2), note the improvement in the fit of the model and a somewhat stronger statistical significance of some of the coefficients when the new SIPRI data are used. With the old data, for 1960–2007 (Panel A, first column), the only statistically significant variable is labor force growth (*ngd*), and with the expected negative sign. This is maintained in the other three specifications, which now also produce consistent estimates, signs, and statistical significance for the investment variable. When it comes to the change in military burden per se (*Δlmy*), the coefficients are negative although not statistically significant. In contrast, the lagged log of military burden, *lmy*(–1), becomes positive and statistically significant at the 10% level with the new SIPRI data for the 1960–2007 period as well as for the 1960–2014 period when the dummy variable is included in the model. However, since *lyp*(-1) is not statistically significant in the final specification

Table 2, Panel A: Short-run estimates for Portugal

	1960–2007		*1960–2014*	
	Old	*New*	*New*	*New & dummy*
c	–0.179	–0.040	–0.281	–0.010
lyp(–1)	–0.060	–0.039	–0.017**	–0.041
Δliy	0.113	0.187***	0.197***	0.193***
liy(–1)	0.015	0.062*	0.062**	0.061**
Δlmy	–0.033	–0.023	–0.030	–0.020
lmy(–1)	-0.006	0.037*	0.026	0.039*
ngd	–0.010***	–0.112***	–0.116***	–0.109***
t	0.001	0.001	0.001	0.002
D08				–0.025***
R-sq.	0.491	0.722	0.749	0.766
SER	0.027	0.021	0.020	0.020
DW	1.948	2.202	2.167	2.23

Note: *, **, and *** denote statistical significance at the 10, 5, an 1 percent levels, respectively.

Table 2, Panel B: Long-run estimates for Portugal

	1960–2007		*1960–2014*	
	Old	*New*	*New*	*New & dummy*
c	–2.98	–1.03	16.47	–0.25
liy	0.25	1.54	4.12	1.5
lmy	–0.1	1.03	1.76	1
lngd	–1.65	–2.82	–7.06	–2.75
t	0.01	0.03	0.06	0.05
D08				–0.5

in Panel B (column 4 in the panel with the long-run estimates), one cannot claim that Portuguese military burden has a long-run effect on its economic growth.

Finally, look at the short-run and long-run estimates for Spain (Table 3). As for Portugal, statistical fit and diagnostics improve when the new data are used. Using the new data over

the old sample period (Panel A, column 2) or over the extended sample, with and without the crisis dummy (columns 3 and 4) yields consistent statistically significant results (at the 1% level) and with the expected signs for the GDP per capita and the investment variables. Labor force growth (*ngd*) is statistically significant with a negative sign in all specifications apart from when the model is estimated for the full sample without the dummy variable. Interestingly enough, the negative and statistically significant effect of the lagged value of military burden found when the old data are used (column 1) completely disappears in any of the specifications with the new data. In the long-run (Panel B), the statistically significant negative effect of military burden on economic growth ceases to exist when the new SIPRI data are employed.[9]

Conclusion

The availability of revised data by SIPRI permits researchers to reinvestigate the military expenditure–economic growth relationship for many countries. In this articles, I examine the case of three peripheral EU countries, Greece, Portugal, and Spain. The main objective was to compare the coefficient estimates coming of the augmented Solow growth model published in Dunne and Nikolaidou's 2012 paper with those based on SIPRI's revised data but also to provide evidence over an extended time frame that would cover the post-crisis years. The choice of the three countries was not coincidental as they are among the EU countries with the heaviest SIPRI data revisions. In addition, they have similarities in their economic performance but also some difference in terms of their military expenditure patterns. Further, Portugal and Spain are underinvestigated in the relevant literature.

Replication of 1960–2007 period but using the new SIPRI data gave relatively consistent results for Greece in terms of the signs of the variables but smaller coefficient values. Also, there were some changes in the significance of the variables. Military burden, however, remained statistically insignificant. For Portugal, results using the new data were improved, yet military burden remains insignificant in the long-run estimates. Only for the case of Spain does the use of the revised data yield rather different results for the military burden variable. Specifically, the negative and statistically significant effect of military burden on economic growth found with the old SIPRI data, both for the short- and long-run, completely vanishes when the revised data are employed.

Results using the new SIPRI data over the extended time frame (1960–2014) are fairly consistent for all three countries regarding the effect of military expenditure on economic growth. For none of the countries do I find either a positive or negative effect that would be statistically significant. It should be mentioned that the 2008 crisis dummy does, however, show a statistically significant adverse effect on the economic growth of all three countries.

While it remains difficult to draw general conclusions, it is certain, though, that the empirical evidence using SIPRI's revised data does not point toward a positive effect of military

Table 3, Panel A: Short-run estimates for Spain

	1960–2007		*1960–2014*	
	Old	*New*	*New*	*New & dummy*
c	–0.117	0.990**	0.794*	1.069***
lyp(–1)	–0.090***	–0.184***	–0.118***	–0.184***
Δliy	0.246***	0.230***	0.303***	0.245***
liy(–1)	0.037	0.115***	0.086***	0.122***
Δlmy	–0.021	0.021	0.017	0.024
lmy(–1)	–0.026**	–0.008	0.017	0.003
ngd	–0.89**	–0.112***	–0.039	–0.089***
t	0.001	0.004***	0.002*	0.004***
D08				–0.035***
R-sq.	0.783	0.723	0.755	0.805
SER	0.013	0.013	0.014	0.013
DW	1.708	1.583	1.558	1.654

Note: *, **, and *** denote statistical significance at the 10, 5, an 1 percent levels, respectively.

Table 3, Panel B: Long-run estimates for Spain

	1960–2007		*1960–2014*	
	Old	*New*	*New*	*New & dummy*
c	–1.29	5.5	6.58	5.81
liy	0.41	0.67	0.75	0.66
lmy	–0.29	–0.04	0.17	0.02
lngd	–0.98	–0.61	–0.33	–0.48
t	0.01	0.02	0.02	0.02
D08				–0.19

expenditure on the economic growth for any of the three countries under investigation.

Notes

A version of this article was presented at SIPRI's Experts' Workshop on Military Expenditure held in Stockholm, 28-29 January 2016. The author thanks the organizers and participants.

1. Dunne and Nikolaidou (2012).

2. On the role of military expenditure in the Greek debt crisis, see Nikolaidou (2016). Some commentators include Ireland and even Italy in the "peripheral" EU but this article deals only with Greece, Portugal, and Spain.

3. Interesting variations: See Nikolaidou (2008).

4. Similarities and differences: See Dunne and Nikolaidou (2005) for a detailed overview.

5. Average growth rates: For the entire period 1961–2015 the average rates are 5.4, 5.6, and 3.9 percent, respectively, for Greece, Portugal, and Spain.

6. High Greek military burden: Nikolaidou (2008).

7. With the exception of Greece: See, e.g., Chletsos and Kollias (1995); Antonakis (1999); Kollias, Manolas, and Paleologou. (2004); Dunne and Nikolaidou (2001, 2012).

8. On the model's details see Knight, Loyaza, and Villanueva (1996) and Dunne and Nikolaidou (2012).

9. Long-run coefficients are calculated from the lagged output per capita and military burden. For instance, for the case of Spain (Table 3, Panel A, first column) –0.026/(–)(–0.090) = –0.29 is the coefficient of the military burden in the long-run. Given that both variables used to calculate the long-run coefficient were statistically significant in the short-run, the long-run result also is statistically significant.

References

Antonakis, N. 1999. "Guns versus Butter: A Multisectoral Approach to Military Expenditure and Growth with Evidence from Greece, 1960-1993." *Journal of Conflict Resolution*. Vol. 43, No. 4, pp.501–520. http://dx.doi.org/10.1177/0022002799043004005

Barro, R.J. 1990. "Government Spending in a Simple Model of Endogenous Growth." *Journal of Political Economy*. Vol. 98, No. 5, pp. 103–126. http://dx.doi.org/10.1086/261726

Biswas, B. and R. Ram. 1986. "Military Expenditures and Economic Growth in LDCs: An Augmented Model and Further Evidence." *Economic Development and Cultural Change*. Vol. 34, No. 2, pp. 361–372. http://dx.doi.org/10.1086/451533

Chletsos, M. and C. Kollias. 1995. "Defense Spending and Growth in Greece, 1974-1990: Some Preliminary Econometric Results." *Applied Economics*. Vol. 27, No. 9, pp. 883–890. http://dx.doi.org/10.1080/00036849500000042

Dunne, J.P. and E. Nikolaidou. 2001. "Military Spending and Economic Growth in Greece: A Demand and Supply Model, 1960-1996." *Defence and Peace Economics*. Vol. 12, No. 1, pp. 47–67. http://dx.doi.org/10.1080/10430710108404976

Dunne, J.P. and E. Nikolaidou. 2005. "Military Spending and Economic Growth in Greece, Portugal and Spain." *Frontiers in Finance and Economics Journal*. Vol. 2, No. 1, pp. 1–17.

Dunne, J.P. and E. Nikolaidou. 2012. "Defense Spending and Economic Growth in the EU15." *Defence and Peace Economics*. Vol. 23, No. 6, pp. 537–548. http://dx.doi.org/10.1080/10242694.2012.663575

Dunne, J.P., R.P. Smith, and D. Willenbockel. 2005. "Models of Military Expenditure and Growth: A Critical Review." *Defence and Peace Economics*. Vol. 16, No. 6, pp. 449–461. http://dx.doi.org/10.1080/10242690500167791

Dunne, J.P. and N. Tian. 2013. "Military Expenditure and Economic Growth: A Survey." *Economics of Peace and Security Journal*. Vol. 8, No. 1, pp. 5–11. http://dx.doi.org/10.15355/epsj.8.1.5

Feder, G. 1983. "On Exports and Economic Growth." *Journal of Development Economics*. Vol. 12, Nos. 1–2, pp. 59–73. http://dx.doi.org/10.1016/0304-3878(83)90031-7

Knight, M., N. Loayza, and D. Villanueva. 1996. "The Peace Dividend: Military Spending Cuts and Economic Growth." *IMF Staff Papers*. No. 1577. Washington, D.C.: International Monetary Fund. http://dx.doi.org/10.2307/3867351

Kollias, C., G. Manolas, and S.M. Paleologou. 2004. "Defense Expenditure and Economic Growth in the European Union: A Causality Analysis." *Journal of Policy Modeling*. Vol. 26, No. 5, pp. 553–569. http://dx.doi.org/10.1016/j.jpolmod.2004.03.013

Nikolaidou, E. 2008. "The Demand for Military Expenditure: Evidence from the EU15, 1961-2005." *Defence and Peace Economics*. Vol. 19, No. 4, pp. 273–292. http://dx.doi.org/10.1080/10242690802166533

Nikolaidou, E. 2016. "The Role of Military Expenditure in the Greek Debt Crisis." *Economics of Peace and Security Journal*. Vol. 11, No. 1, pp. 18–27. http://dx.doi.org/10.15355/epsj.11.1.18

Ram, R. 1986. "Government Size and Economic Growth: A New Framework and Some Evidence from Cross-Section and Time-Series Data." *American Economic Review*. Vol. 76, No. 1, pp. 191–203.

Romer, P.M. 2000. "Keynesian Macroeconomics Without the LM Curve." *Journal of Economic Perspectives*. Vol. 14, No. 2, pp. 149–169. http://dx.doi.org/10.1257/jep.14.2.149

Shahbaz, M., N.C. Leitao, G.S. Uddin, M. Arouri, and F. Teulon. 2013 "Should Portuguese Economy Invest in Defense Spending? A Revisit." *Economic Modelling*. Vol. 35, pp. 805–915.

http://dx.doi.org/10.1016/j.econmod.2013.08.038
Taylor, J.B. 2000. "Teaching Modern Macroeconomics at the Principles Level." *American Economic Review*. Vol. 90, No. 2, pp. 90–94.
http://dx.doi.org/10.1257/aer.90.2.90

Investment, growth, and defense expenditure in the EU15: Revisiting the nexus using SIPRI's new consistent dataset

Christos Kollias and **Suzanna-Maria Paleologou**

Christos Kollias is Professor of Economics at the Department of Economics, University of Thessaly, Greece. The corresponding author, he can be reached at kollias@uth.gr. Suzanna-Maria Paleologou is Associate Professor of Economics at the Department of Economics, Aristotle University of Thessaloniki, Greece. She can be reached at smp@econ.auth.gr.

Abstract

Using SIPRI's new consistent database on military expenditure and employing a panel vector autoregression (PVAR) methodology, the article investigates the nexus between military expenditure and two key macroeconomic variables, namely growth rates and investment spending for the case of the EU15 countries over the period 1961–2014. The findings reported herein do not support the effective demand stimulation argument for military spending. Thus, they broadly confirm the results of earlier studies for the EU15 that used the previous version of the SIPRI dataset.

The economic ramifications of military spending is the theme of an impressively large and steadily growing body of empirical studies. Since comprehensive surveys of the literature can be found in Dunne and Uye and Dunne and Tian, we refrain from producing a literature review here. Broadly speaking, though, the discussion regarding the economic effects of military expenditure may be grouped into several categories. An obvious starting point regards the opportunity cost of the resources allocated to defense. This is especially relevant for the case of developing countries that face both, more acute resource constraints when compared to developed ones and pressing developmental challenges such as much needed public sector spending on health or education that could potentially be partially met by the resources allocated to defense uses. Apart from this guns versus butter issue, demand and supply-side effects are associated with military expenditure and the multiple channels through which it can affect an economy. Demand-side channels refer to stimulative effects of increased employment of otherwise idle or underemployed resources with the concomitant propping-up of economic activity and growth, whereas supply-side aspects point to positive externalities such as technological advances that spill over to other sectors of the economy thus increasing productivity, infrastructure creation, and human capital formation. The supply-side view is not unchallenged and critics argue with fervor that nonmilitary forms of government spending, for instance infrastructure expenditure, may very well have an equal if not greater positive impact on the economy. Furthermore, by possibly crowding out more productive forms of public expenditure as well as private sector investment, military expenditure can retard growth. In broad terms, the literature has not produced robust empirical consistency in the reported findings.[1]

The Stockholm International Peace Research Institute (SIPRI) recently revised and extended its military expenditure database. It now offers consistent estimates across countries for an appreciably longer time period—as from the early 1950s rather than as from 1988 onward—that spans both the cold war and post-cold war periods. This presents the opportunity to (re)assess the subject matter of the economic effects of military expenditure using consistent time series over a significantly longer time horizon in a statistically more robust way and leading to more reliable inferences than before. Using this new consistent database, this article addresses the issue at hand for the case of the EU15 group of countries and contributes to the literature through the extension of the time period examined. To this effect, we concentrate onto two key macroeconomic variables—economic growth and gross domestic investment—that have repeatedly featured in empirical studies that assess the economic impact of military spending. The next section of this article contains a brief descriptive and comparative presentation of the variables used in the empirical analysis. The methodology employed to probe the research question at hand is outlined in the section thereafter, and the results are presented and discussed. The final section concludes.[2]

The variables

As noted, the macroeconomic variables used in the empirical investigation are the defense burden (i.e., military expenditure as a share of GDP), the annual growth rate of GDP, and investment as a share of GDP. For each of the EU15, Table 1 shows the average, maximum, and minimum values for these

Table 1: Descriptive statistics, 1961–2014 (in percent)

	Average	*Max.*	*Min.*	*Average*	*Max.*	*Min.*	*Average*	*Max.*	*Min.*
	Belgium			Spain			Austria		
Growth	2.7	7.0	–2.3	3.5	11.8	–3.6	2.8	6.3	–3.8
Inv/GDP	23.2	27.3	18.5	24.3	31.1	19.2	25.8	32.0	21.6
Milex/GDP	2.3	3.4	1.0	2.0	3.0	1.2	1.2	1.9	0.8
	Denmark			France			Portugal		
Growth	2.3	9.3	–5.1	2.8	7.0	–2.9	3.3	12.6	–4.3
Inv/GDP	21.6	25.8	17.2	23.0	26.8	19.4	25.3	33.4	14.8
Milex/GDP	2.0	3.0	1.3	3.6	6.5	2.2	3.1	6.0	1.9
	Germany			Italy			Finland		
Growth	2.5	7.5	–5.6	2.5	8.2	–5.5	2.9	9.6	–8.3
Inv/GDP	22.1	26.6	19.1	22.4	28.3	16.6	25.3	33.0	18.6
Milex/GDP	2.6	5.2	1.2	2.2	3.4	1.5	1.6	2.5	1.2
	Ireland			Luxembourg			Sweden		
Growth	4.4	11.2	–5.6	3.7	10.0	–6.6	2.5	6.8	–5.2
Inv/GDP	22.1	31.0	14.9	20.4	27.5	14.4	23.9	29.1	19.2
Milex/GDP	1.2	1.9	0.5	0.9	1.4	0.5	2.6	4.0	1.2
	Greece			Netherlands			U.K.		
Growth	2.9	11.1	–9.1	2.9	8.6	–3.8	2.4	6.5	–4.2
Inv/GDP	24.0	35.4	11.6	23.3	29.4	17.9	20.2	26.5	16.0
Milex/GDP	3.9	5.9	2.2	2.6	4.6	1.2	4.0	6.3	2.2

Note: Growth (annual percentage change in GDP); Inv/GDP (investment ratio); Milex/GDP (military burden). *Source*: SIPRI.

variable for 1961–2014. Starting with the defense burden, the EU15 present a varied picture. Countries such as the United Kingdom, France, and Greece have on average allocated a relatively high proportion of their national income to defense: 4.0, 3.6, and 3.9 percent, respectively. Others show appreciably lower numbers: Ireland and Austria for example average 1.2, Finland 1.6, and Luxembourg only 0.9 percent. Compared to the EU15's average of 2.4 percent, the bottom panel in Figure 1 (next page) shows that in addition to France, Greece, and the U.K., Germany, the Netherlands, Portugal, and Sweden, also have on average allocated an above-average percentage of their GDP to defense. As Eftychia Nikolaidou has pointed out, there is little uniformity in the domestic and external factors that determine each country's allocation of resources to defense. A cohort of economic, political, strategic, and security factors have shaped the demand for military expenditure in each of the EU15 which explains the notable differences in their defense burdens.[3]

A similar diversity among the EU15 is observed with respect to the other two variables (Table 1 and Figure 1, top and middle panels). Compared to the group's average growth rate of 2.9 percent, clear over- and underperformers emerge (see the top panel in Figure 1). Ireland (with an average growth rate of 4.4 percent) is followed by Luxembourg (3.7), Spain (3.5), and Portugal (3.3). Others, for instance Denmark (2.3), the United Kingdom (2.4), and Germany (2.5) underperformed relative to the group's average. A similarly diverse picture holds with respect to the third variable. The group's average investment expenditure as a share of GDP was 23.1 percent. The biggest over-performers Austria (25.8 percent), followed by Portugal and Finland (25.3 percent each). The three main underperformers are the United Kingdom (20.2), Luxembourg (20.4), and Denmark (21.6).

Methods and results

To investigate the effect of military expenditure on investment and growth for the EU15, a balanced panel of time series data was constructed for the period 1961–2014. We estimate models of the form given in equations (1), (2), and (3) and the panel vector autoregression (PVAR) given in equation (7) where *inv* is investments as a share of GDP, *milex* is military spending expressed as a share of GDP and *gdp* is the economy-wide growth rate. For the same time period, we also estimate a panel of data for six countries deemed to posses a significant defense industrial base: France, Germany, Italy, Spain, Sweden, and the U.K. The effective demand stimulation argument postulates

that higher military spending can bring about increased utilization of idle or underemployed capital stock, induce investment and hence, through short-run multiplier effects, prop-up growth rates. Since such an effect would probably be more evident in countries that have a developed defense industrial base able to produce manufacturing inputs for the defense sector, our choice here is to estimate a subsample with the six mentioned countries.[4]

Pooled OLS

(1) $inv_{jt} = \alpha + \beta milex_{jt} + \gamma gdp_{jt} + \epsilon_{jt}$

Fixed Effects Panel Estimator (FE)

(2) $inv_{jt} = \alpha_j + \beta milex_{jt} + \gamma gdp_{jt} + \epsilon_{jt}$

Random Coefficient Estimator (RCE)

(3) $inv_{jt} = \alpha_j + \beta_j\, milex_{jt} + \gamma_j\, gdp_{jt} + \epsilon_{jt}$

and calculates weighted averages of the individual time series estimates $\hat{\beta}_j$ and $\hat{\gamma}_j$, namely $\tilde{\beta}_R = \sum_j w_j \hat{\beta}_j$ and $\tilde{\gamma}_R = \sum_j w_j \hat{\gamma}_j$.

To specify whether a fixed or a random effects model is more appropriate to use, we performed the Hausman test, distributed as a $\chi^2(2)$. In our case, this yield values of 40.17 for the EU15 sample and 40.03 for the EU6 and indicate that the random effects model is rejected at the 5 and 1 percent levels, respectively. This finding is consistent with the literature since random effects models are considered more appropriate than fixed effect models only when the results are used to make an inference from a sample to a population, which is not our case. Instead, we are interested in estimating the group and time effects that may exist within our sample. Parameter estimates for the Pooled OLS, FE, and RCE models are shown in Table 2. The results obtained for the EU15 show a significant positive effect of the economy's growth rate and the share of military expenditure in GDP on the share of investment in GDP only in the case of the FE and RCE methods. In the case of the EU6, the same positive effect is obtained only with the FE estimation.[5]

As noted, to further explore the relation between military expenditure and the economy, we employ a panel VAR, or PVAR, which extends Sim's traditional vector autoregression (VAR) with a panel data approach. An analysis based on VAR offers several advantages. Although, strictly speaking, atheoretical, it is a flexible method that treats all variables in the system as endogenous and independent, without worrying about the direction of causality. Each variable is explained by its own lags and by lagged values of the other variables. It is a system of equations rather than a one-equation model. Panel

Figure 1: Over- and underperformance of EU15 relative to sample averages. Top: Growth rates. Middle: Investment to GDP ratio. Bottom: Military expenditure to GDP ratio. *Source*: SIPRI and authors' calculations.

VAR allows for unobserved individual heterogeneity, improves asymptotic results, and simplifies the choice of suitable instrumental variables. The general form of a PVAR model is exemplified by Canova and Ciccarelli (2004): [6]

(4) $y_{it} = A_0\, a_{it} + L_1\, y_{it-1} + \ldots + L_p\, y_{i,t-p} + u_t$,

where y_{it} is a $K\times1$ vector of a K panel data of variables; $i = 1, \ldots, I$, a_{it} is a vector of deterministic terms such as linear trend, dummy variables, or a constant; A_0 is the associated parameter matrix; and the L's are $K\times K$ parameter matrices attached to the lagged variables $y_{i,t-p}$. The lag order (VAR order) is denoted by p. The error process, u_t, consists of three components:

(5) $u_t = \mu_i + \gamma_t + \epsilon_{it}$,

with μ_i representing the country-specific effect, γ_t capturing the time effect, and ϵ_{it} is the disturbance term. The error term u_t is assumed to have zero mean, $E(u_t) = 0$, and the time invariant covariance matrix and $u_t s$ are independent. This specification

Table 2: Estimation results, 1961–2014

	EU15		*EU6*	
	GDP growth	*Milex/GDP*	*GDP growth*	*Milex/GDP*
Pooled OLS (clustered SE's) R-squared (within)	0.334 (0.076)*** 0.20	0.458 (0.367)	0.442(0.054)*** 0.15	0.077 (0.389)
FE panel (clustered SE's) R-squared (within)	0.277 (0.035)*** 0.19	1.062 (0.121)***	0.284 (0.053)*** 0.26	0.972 (0.141)***
FE two-way estimator R-squared (within)	0.334 (0.039)*** 0.12	0.458 (0.092)*	0.112 (0.057)*** 0.23	-0.531 (0.246)
RCE (Swamy estimator of component variances)	0.289 (0.051)***	1.295 (0.408)***	0.243 (0.069)***	0.959 (0.726)
RCE two-way (Swamy estimator of component variances)	0.118 (0.053)**	-1.786 (0.803)	0.253 (0.072)**	1.125 (0.732)

Notes: With the RCE the random effects contribute only to the covariance and therefore there are no random effects sum of squares to calculate the R-squared correlation coefficient. *** statistically significant at the 1% level; S.E in parenthesis.

imposes two restrictions: It assumes common slope coefficients and it does not allow for interdependencies across units. Given these restrictions, the estimated matrices L are interpreted as average dynamics in response to shocks. As with standard VAR models, all variables depend on the past of all variables in the system, the main difference being the presence of the individual country-specific terms μ_i.

The PVAR approach is used to estimate the relation among GDP growth rates, investment, and military expenditure. In line with prior literature, the latter two are both expressed as shares of GDP. VAR modeling does not require the imposition of strong structural relationships, although theory is involved to select the appropriate normalization and to interpret the results. Another advantage is that only a minimal set of assumptions is needed to interpret the impact of shocks on each variable in the PVAR system. The reduced form VAR, once the unknown parameters are estimated, permits implementing dynamic simulations. This method only allows for the analysis of short-run adjustment effects and not of structural long-run effects. The results come in the form of impulse response functions (IRFs), and their coefficients analysis, as well as forecast error variance decompositions (FEVDs) that permit one to examine the impact of innovations or shocks to any particular variable on other variables in the system. IRFs model the dynamics of the response, the coefficients represent the average effects of IRFs and permit recognizing the significance of the overall response, while variance decompositions give information about the variation in one variable due to a shock to the others. The response corresponds to a one-time shock in other variables, holding all the other shocks constant at zero. In other words, orthogonalizing the response allows one to identify the effect of one shock at a time, while holding other shocks constant. We are particularly interested in the response of investment due to shocks in GDP growth rates and military expenditure.[7]

To obtain orthogonalized impulse response functions, we decompose the residuals in a way that makes them orthogonal. Such exercises require applying a careful VAR identification procedure. The most common way to deal with this problem is to choose a causal ordering. We adopt the Choleski decomposition of variance-covariance matrix of residuals. This process is called VAR identification and involves a particular ordering of variables in the VAR system. We allocate any correlation between the residuals to the variable that appears earlier in the ordering. The identifying assumption is that the variables that appear earlier in the system are more exogenous, and those which appear later are more endogenous. This implies that variables that appear earlier affect the following variables contemporaneously and with lags, while the variables that appear later only affect the previous variables with lag. We treat the share of military expenditure in GDP as the most exogenous variable and the share of investment in GDP as the most endogenous one. GDP growth rates are used as a buffer variable.[8]

(6) milex/GDP → GDP growth rate → investment/GDP.

As a set of endogenous equations, all variables influence

each other. The simplest three-variable PVAR model is specified and can be represented as equation (7)

$$\begin{bmatrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{bmatrix} \begin{bmatrix} \Delta \frac{milex}{gdp}_{it} \\ \Delta gdp_{it} \\ \Delta \frac{inv}{gdp}_{it} \end{bmatrix} =$$

$$\begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \end{bmatrix} + \begin{bmatrix} L_{11} & L_{12} & L_{13} \\ L_{21} & L_{22} & L_{23} \\ L_{31} & L_{32} & L_{33} \end{bmatrix} \begin{bmatrix} \Delta \frac{milex}{gdp}_{i,t-p} \\ \Delta gdp_{i,t-p} \\ \Delta \frac{inv}{gdp}_{i,t-p} \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix}$$

where y_{it} on the left-hand side of the equation is a three-variable vector including 3 endogenous variables: The share of military expenditure in GDP, GDP growth rates, and the share of investment in GDP. On the right-hand side, the 3×3 matrix L contains the coefficients of contemporaneous relationships among these three variables. As noted, we are interested in the impulse responses of the share of investment in GDP to shocks in the share of military expenditure in GDP and to shocks in GDP growth rates.

Applying the VAR technique requires some data transformations to remove trends and only keep variations. The use of panel data imposes that the underlying structure is the same for each cross-sectional unit, i.e., that the coefficients in the matrices L are the same for all countries in our sample. This constraint is violated in practice. To overcome this restriction and allow for country heterogeneity, fixed effects (μ_i) are introduced. However, fixed effects are correlated with the regressors due to lags of the dependent variables. We employ forward mean-differencing to eliminate the fixed effects. Also called a Helmert transformation, this procedure keeps the orthogonality between variables and their lags, so we can use the lags as instruments.[9]

Another issue is that of the cross-section autocorrelation being related to the common factors because panels with groups of countries sharing some homogeneity present some interdependence between them that may affect the results. To adjust for such common factors, we subtract from each series at any time the average of the group. The last transformation, time-demeaning, is performed to control for time fixed effects (γ_t). We subtract the mean of each variable calculated for each country-year. To proceed with the panel VAR estimation, stationary data are needed. Hence, the next step is to test whether the main variables of interest are stationary by applying three different panel unit root tests: The Levin, Lin, and Chu test, the Breitung test, and the Im, Pesaran, and Chin test. All are reported in Table 3. With one exception, the results suggest that the three variables of interest are stationary. The exception is the Breitung test for m_t in the EU6 panel.[10]

Table 3: Panel unit root tests

	EU15			*EU6*		
	inv	*gdp*	*milex*	*inv*	*gdp*	*milex*
Levin, Lin, Chu						
Adjusted t*	–10.307	–18.639	–8,375	–6.890	–8.794	–6.190
p-value	0.001	0.000	0.000	0.010	0.000	0.025
H_0: Panels contain unit roots. H_1: Panels are stationary. Common AR parameters.						
Breitung						
Lambda	–11.060	–11.193	–2.094	–0.346	–6.364	–0.332
p-value	0.000	0.000	0.010	0.000	0.000	0.369
H_0: Panels contain unit roots. H_1: Panels are stationary. Common AR parameters.						
Im, Pesaran, Shin						
W-t bar	–3.567	–13.978	–4.155	–1.565	–8.732	–2.467
p-value	0.000	0.000	0.000	0.085	0.000	0.006
H_0: All panels contain unit roots. H_1: Some panels are stationary. Panel-specific AR parameters.						

At this point, it should be mentioned that the presence of structural breaks in panel series data can induce behavior similar to that of an integrated process, making it difficult to differentiate between a unit root and a stationary process with a regime shift. For this reason, the panel unit root tests used here may potentially suffer from a significant loss of power if structural breaks are present in the data. In view of this, it was decided to employ the panel data unit root test based on the Lagrangian multiplier (LM) principle developed by Im and Lee. It is very flexible since it can be applied not only when a structural break occurs at a different time period in each time series, but also when the structural break occurs in only some of the time series. The proposed test is not only robust to the presence of structural breaks but also is more powerful than the popular IPS test in the basic scenario where no structural breaks are involved. Furthermore, as reported by Im and Lee, since the LM test loses little power by controlling for spurious structural breaks when they do not exist, this represents a reasonable strategy to control for breaks even when they are only at a suspicious level. Moreover, this panel LM test does not require the simulation of new critical values that depend on the number and location of breaks. The results of this testing procedure as well a more detailed discussion of the findings is

Table 4: Panel cointegration test results

Model	*ADF*
without deterministic component	–1.994
with intercept	–1.328
with trend	–0.705

Note: As the tests are one-sided, a calculated statistic smaller than the critical value leads to the rejection of the null hypothesis of no cointegration.

Table 5: Results for the three-variable PVAR model

	inv(t–1)	*gdp(t–1)*	*milex(t–1*
		EU15 (obs=765)	
inv(t)	0.109 (0.024)	0.105 (**0.000**)	–0.568 (0.138)
gdp(t)	–0.381 (**0.000**)	–0.246 (0.000)	1.233 (0.926)
milex(t)	–0.007 (0.421)	–0.005 (0.102)	0.004 (0.967)
		EU6 (obs=306)	
inv(t)	0.275 (0.000)	0.133 (**0.000**)	–0.185 (0.613)
gdp(t)	–0.666 (**0.000**)	–0.155 (0.026)	2.067 (0.026)
milex(t)	–0.004 (0.6710)	–0.009 (**0.004**)	0.126 (0.114)

Notes: p-values in parenthesis. The values in bold-type font are discussed in the text.

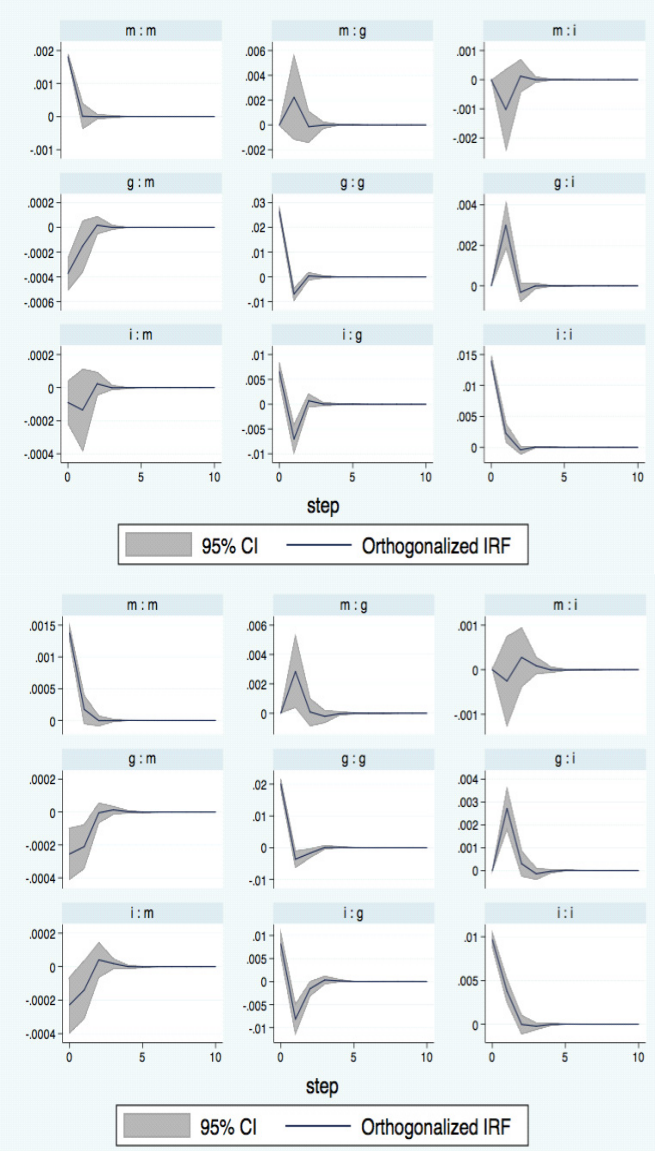


Figure 2: Impulse responses for 1-lag VAR. Top panel: EU15. Bottom panel: EU6. Note: Based on the three model selection criteria by Andrews and Lu (2001) and the overall coefficient of determination, the first-order panel VAR is the preferred model since this has the smallest MBIC, MAIC, and MQIC.

presented in the Appendix. Overall, the findings using panel data unit root tests that allow for structural breaks are in support of the already reported results of panel data unit root tests for the GDP growth rates, leading us to conclude that the series is integrated of order zero while the investment and the military expenditure series are integrated of order one.[11]

Having confirmed the nonstationarity of our investment and military expenditure series for the EU15 it is natural to test for the existence of a structural long-run relation between these series. To this effect, we compute Pedroni's cointegration test statistics using conventional (asymptotic) critical values (see Table 4). We present the results for the entire sample of the EU15. Using conventional asymptotic critical values (–1.66 at 5 percent), calculated under the assumption of cross-sectional independence (reported in Pedroni, 1999, and extracted from the standard normal distribution), the null hypothesis of no cointegration between investment and military expenditure is accepted by the test statistics only when the model has no deterministic component.[12]

The results from estimating the PVAR for the entire sample as well as the subsample are presented in Table 5. Broadly, no significant differences between the EU15 and the EU6 samples emerge. Focusing on military expenditure (column 3 in Table 5), no statistically traceable and significant impact is detected

either on the growth rates or on investment, although the respective signs could hint at effective demand stimulation and crowding-out effects which, however, are not statistically significant and hence cannot support any inference in this regard. The only noteworthy difference between the two samples is the effect that economic growth seems to exert on the defense burden in the case of the EU6 sample (column 2).

As the next step in the analysis, and prior to estimating impulse response functions (IRFs), we check the stability condition of the two estimated panel VARs. The results for the EU15 and for the EU6 subsample are shown in Figure A1 in the Appendix. The resulting graph of the eigenvalues confirm that the estimates have stationary roots since all eigenvalues lie inside the unit circle. The estimated IRFs for both samples, then, are shown in Figures 2 and include their confidence intervals represented by the lower and upper lines on the graphs. The middle lines are the actual response functions, depicting the dynamics of the response of the one variable to shocks of the other variables in the panel. Once again focusing on the effects of a shock in military expenditure, it would appear that they are short-lived. The short-run dynamics depicted by the IRFs suggest that a shock in the military spending variable brings about an increase in growth and a decrease in investment, pointing on the one hand to stimulative effects—probably via the effective demand channel—and, on the other hand, a crowding-out impact as suggested in the relevant literature.

Conclusion

The availability of longer and consistent time series on military expenditure presents the opportunity to reassess their effects on the economy. This study focused on the EU15 over the period 1961–2014 as well as on a subsample of six countries which house a comparatively sizeable defense industrial base. Based on the results of the PVAR method employed herein, it would appear that military expenditure does not exert any statistically significant and traceable effect on the economy. Hence, the effective demand stimulation argument is not supported, neither for the whole sample (the EU15) nor for the subsample (the EU6) where any such an effect, if it exists, should be more evident.

Notes

The helpful comments and constructive suggestions by two anonymous referees and valuable editorial guidance by Jurgen Brauer are gratefully acknowledged. The usual disclaimer applies.

1. Literature surveys: Dunne and Uye (2010); Dunne and Tian (2013). Multiple channels: See, e.g., Heo and Ye (2016); Dunne, Smith, and Willenbockel (2005); Drèze (2006); Dunne and Tian (2015). No robust findings: See, e.g., Alptekin and Levine (2012); Dunne and Tian (2013).

2. New SIPRI data: For an initial assessment, see Sandler and George (2016). EU15 literature: See, e.g., Kollias, Mylonidis, and Paleologou (2007); Mylonidis (2008); Kollias and Paleologou (2010); Dunne and Nikolaidou (2012); Chang, Lee, and Chu (2015).

3. Nikolaidou (2008).

4. Six countries: Hartley (2006, 2008).

5. Consistent with the literature: Murdoch, Pi, and Sandler (1997).

6. The first paper that used PVAR in Stata was Love and Zicchino (2006) who, informally, made the program routines available to other researchers. We use the STATA pvar routines by Abrigo and Love (2016) which give an updated package of programs with additional functionality, including subroutines to implement Granger (1969) causality tests and optimal moment and model selection following Andrews and Lu (2001). Sim's traditional VAR: Sims (1980).

7. In line with prior literature: See, e.g,. Dakurah, Davies, and Sampath (2001); Chen, Lee, and Chiu (2014); Chang, Lee, and Chu (2015); Dunne and Nikolaidou (2012).

8. Choleski decomposition: See Hamilton (1994) for a discussion on IRFs and derivations.

9. Fixed effects are correlated: Arellano and Bond (1991); Blundell and Bond (1998). Forward mean-differencing: Arellano and Bover (1995). Using lags as instruments: The coefficients are estimated by GMM, which, in our case, is "just identified," i.e., the number of regressors equals the number of instruments. Hence, it is equivalent to 2SLS.

10. Autocorrelation related to common factors: Levin, Lin, and Chu (2002). Panel unit root tests: Levin, Lin, and Chu (2002); Breitung (2001); Im, Pesaran, and Chin (2003).

11. LM panel unit root test: Im and Lee (2005). IPS test: Im, Pesaran, and Shin (2003).

12. Pedroni: Pedroni (1999; 2004).

References

Abrigo, M.R.M and I. Love. 2016. "Estimation of Panel Vector Autoregression in Stata: a Package of Programs." University of Hawaii. Working paper No. 16–2. http://www.economics.hawaii.edu/research/workingpapers/WP_16-02.pdf.

Alptekin, A. and P. Levine. 2012. "Military Expenditure and Economic Growth: A Meta-Analysis." *European Journal of Political Economy*. Vol. 28, No. 4, pp. 636–650. http://dx.doi.org/10.1016/j.ejpoleco.2012.07.002

Andrews, D.W.K. and B. Lu. 2001. "Consistent Model and Moment Selection Procedures for GMM Estimation with Application to Dynamic Panel Data Models." *Journal of*

Econometrics. Vol. 101, No. 1, pp. 123–164. http://dx.doi.org/10.1016/S0304-4076(00)00077-4

Arellano, M. and S. Bond. 1991. "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *Review of Economic Studies*. Vol. 58, No. 2, pp. 277–297. http://dx.doi.org/10.2307/2297968

Arellano, M. and O. Bover. 1995. "Another Look at the Instrumental Variable Estimation of Error Components Model." *Journal of Econometrics*. Vol. 68, No. 1, pp. 29–51. http://dx.doi.org/10.1016/0304-4076(94)01642-D

Blundell, R. and S. Bond. 1998. "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models." *Journal of Econometrics*. Vol. 87, No. 1, pp. 115–143. http://dx.doi.org/10.1016/S0304-4076(98)00009-8

Breitung, J. 2001. "The Local Power of Some Unit Root Tests for Panel Data," pp. 161–177 in B.H. Baltagi, T.B. Fomby, and R. Carter Hill, eds. *Nonstationary Panels, Panel Cointegration, and Dynamic Panels*. Bingley, UK: Emerald.

Canova, F. and M. Ciccarelli. 2004. "Forecasting and Turning Point Predictions in a Bayesian Panel VAR model." *Journal of Econometrics*. Vol. 120, No. 2, pp. 327–359. http://dx.doi.org/10.1016/S0304-4076(03)00216-1

Chang, T., C-C. Lee, and H-P. Chu. 2015. "Revisiting the Defense–Growth Nexus in European Countries." *Defence and Peace Economics*. Vol. 26, No. 3, pp. 341–356. http://dx.doi.org/10.1080/10242694.2013.832556

Chen, P.F., C.C. Lee, and Y.B. Chiu. 2014. "The Nexus between Defense Expenditure and Economic Growth: New Global Evidence." *Economic Modelling*. Vol. 36 (January), pp. 474–483. http://dx.doi.org/10.1016/j.econmod.2013.10.019

Dakurah, H., S. Davies, and R. Sampath. 2001. "Defense Spending and Economic Growth in Developing Countries: A Causality Analysis." *Journal of Policy Modeling*. Vol. 23, No. 6, pp. 651–658. http://dx.doi.org/10.1016/S0161-8938(01)00079-5

Drèze, J. 2006. "Military Expenditure and Economic Growth," pp. 377-381 in D.E. Clark, ed. *The Elgar Companion to Development Studies*. Cheltenham, UK: Elgar.

Dunne, J.P., R.P. Smith, and D. Willenbockel. 2005. "Models of Military Expenditure and Growth: A Critical Review." *Defence and Peace Economics*. Vol. 16, No. 6, pp. 449–461. http://dx.doi.org/10.1080/10242690500167791

Dunne, J.P. and N. Tian. 2013. "Military Expenditure and Economic Growth: A Survey." *Economics of Peace and Security Journal*. Vol. 8, No. 1, pp. 5–11. http://dx.doi.org/10.15355/epsj.8.1.5

Dunne, J.P. and N. Tian. 2015. "Military Expenditure, Economic Growth and Heterogeneity." *Defence and Peace Economics*. Vol. 26, No. 1, pp. 15–31. http://dx.doi.org/10.1080/10242694.2013.848575

Dunne, J.P. and E. Nikolaidou. 2012. "Defence Spending and Economic Growth in the EU15." *Defence and Peace Economics*. Vol. 23, No. 6, pp. 537–548. http://dx.doi.org/10.1080/10242694.2012.663575

Dunne, J.P. and M. Uye. 2010. "Military Spending and Development," pp. 293–305 in A. Tian, ed. *The Global Arms Trade: A Handbook*. London: Routledge.

Hartley, K. 2006. "Defense Industrial Policy in a Military Alliance." *Journal of Peace Research*. Vol. 43, No. 4, pp. 473–489. http://dx.doi.org/10.1177/0022343306064976

Hartley, K. 2008. "Collaboration and European Defence Industrial Policy." *Defence and Peace Economics*. Vol. 19, No. 4, pp. 303–315. http://dx.doi.org/10.1080/10242690802221585

Heo, U. and M. Ye. 2016. "Defense Spending and Economic Growth around the Globe: The Direct and Indirect Link." *International Interactions*. Vol. 42, No. 5, pp. 774–796. http://dx.doi.org/10.1080/03050629.2016.1149067

Im, K., M. Pesaran, and Y. Shin. 2003. "Testing for Unit Roots in Heterogeneous Panels." *Journal of Econometrics*. Vol. 115, No. 1, pp. 53–74. http://dx.doi.org/10.1016/S0304-4076(03)00092-7

Im, K. and J. Lee. 2005. "Panel LM Unit Root Test with Level Shifts." *Oxford Bulletin of Economics and Statistics*. Vol. 67, No. 3, pp. 393–419. http://dx.doi.org/10.1111/j.1468-0084.2005.00125.x

Kollias, C. and S.-M. Paleologou. 2010. "Growth, Investment and Military Expenditure in the European Union 15." *Journal of Economic Studies*. Vol. 37, No. 2, pp. 228–240. http://dx.doi.org/10.1108/01443581011043618

Kollias, C., N. Mylonidis, and S.-M. Paleologou. 2007. "A Panel Data Analysis of the Nexus between Defence Spending and Growth in the European Union." *Defence and Peace Economics*. Vol. 18, No. 1, pp. 75–85. http://dx.doi.org/10.1080/10242690600722636

Lee, J. and M. Strazicich. 2003. "Minimum Lagrange Multiplier Unit Root Test with Two Structural Breaks." *Review of Economics and Statistics*. Vol. 85, No. 4, pp. 1082–1089. http://dx.doi.org/10.1162/003465303772815961

Levin, A., C.-F. Lin, and C.-S. J. Chu. 2002. "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties." *Journal of Econometrics*. Vol. 108, No. 1, pp. 1–24. http://dx.doi.org/10.1016/S0304-4076(01)00098-7

Love, I. and L. Zicchino. 2006. "Financial Development and Dynamic Investment Behavior: Evidence from Panel VAR." *Quarterly Review of Economics and Finance*. Vol. 46, No. 2, pp. 190–210. http://dx.doi.org/10.1016/j.qref.2005.11.007

Murdoch, J., C.-R. Pi, and T. Sandler. 1997. "The Impact of Defence and Non-Defence Public Spending on Growth in Asia and Latin America." *Defence and Peace Economics*. Vol. 8, No. 2, pp. 205–224. http://dx.doi.org/10.1080/10430719708404876

Mylonidis, N. 2008. "Revisiting the Nexus between Military Spending and Growth in the European Union." *Defence*

and Peace Economics. Vol. 19, No. 4, pp. 265–272. http://dx.doi.org/10.1080/10242690802164801

Nikolaidou, E. 2008. "The Demand for Military Expenditure: Evidence from the EU15." *Defence and Peace Economics*. Vol. 19, No. 4, pp. 273–292. http://dx.doi.org/10.1080/10242690802166533

Pedroni, P. 1999. "Critical Values for Cointegrating Tests in Heterogeneous Panels with Multiple Regressors." *Oxford Bulletin of Economics and Statistics*. Vol. 61, No. 1, pp. 653–670. http://dx.doi.org/10.1111/1468-0084.61.s1.14

Pedroni, P. 2004. "Panel Cointegration; Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the Purchasing Power Parity Hypothesis." *Econometric Theory*. Vol. 20, No. 3, pp. 597–625. http://dx.doi.org/10.1017/S0266466604203073

Sandler, T. and J. George. 2016. "Military Expenditure Trends for 1960–2014 and What they Reveal." *Global Policy*. Vol. 7, No. 2, pp. 174–184. http://dx.doi.org/10.1111/1758-5899.12328

Schmidt, P. and P. Phillips. 1992. "LM Tests for a Unit Root in the Presence of Deterministic Trends." *Oxford Bulletin of Economics and Statistics*. Vol. 54, No. 3, pp. 257–287. http://dx.doi.org/10.1111/j.1468-0084.1992.tb00002.x

Sims, C.A. 1980. "Macroeconomics and Reality." *Econometrica*. Vol. 48, No. 1, pp. 1–48. http://dx.doi.org/10.2307/1912017

Zivot, E. and D. Andrews. 1992. "Further Evidence of the Great Crash, the Oil-Price Shock and the Unit-Root Hypothesis." *Journal of Business and Economic Statistics*. Vol. 10, No. 3, pp. 251–270.

Appendix: Panel unit root tests allowing for structural breaks

To provide for additional robustness, we compare both univariate and panel LM unit root test results with and without structural break. We begin with the Schmidt and Phillips (1992) univariate LM unit root test, without any structural change. We then move to extensions that allow for one break since our time series covers periods during which structural change may have occurred due to structural and institutional changes in the EU15 countries. In addition to the Schmidt and Phillips (1992) no-break test, we employ the univariate test and the Lee and Strazicich (2003) minimum LM unit root tests with one break to determine the structural break point in each country. After determining the optimal break point, we employ the panel LM unit root test of Im and Lee (2005). For comparison, we also show the panel LM test results without breaks.

To determine the optimal break point in the panel LM test, we utilize the univariate minimum LM unit root tests of Lee and Strazicich (2003). These tests are comparable to the corresponding Dickey and Fuller-type endogenous break tests of Zivot and Andrews (1992). The performance of the LM test is comparable to or superior to these counterpart tests in terms of size and power. In addition, the LM unit root tests are not subject to spurious rejections under the null. In each test, the break point is determined endogenously from the data via a grid search by selecting the break where the value of the unit root test statistic is at its minimum. Using the minimum LM tests of Lee and Strazicich (2003), the unit root test statistic is estimated at each break point.

The results are reported in Tables A1, A2 and A3, which, respectively, show the results for GDP growth rates and investment and military expenditure as a percentage of GDP. For the univariate LM test without break, the unit root null can be rejected at the 5 percent level of significance in five countries for the GDP growth rates (France, Greece, Ireland, Netherlands, and Spain), in fourteen countries for investment (the exception is Luxemburg), and in fourteen countries for military expenditure (all except France). After allowing for a structural break, the univariate minimum LM test rejects the unit root null in all countries for the GDP growth rates, in twelve countries (except Luxemburg, Sweden, and the U.K.) for Investment and nine countries (Austria, Denmark, Finland, Germany, Greece, Netherlands, Portugal, Spain, and Sweden) for military expenditure at the 5 percent level. Without allowing for structural breaks, the panel LM test statistic is –6.953 for the GDP growth rates, clearly indicating that the unit root null can be rejected at the 5 percent level of significance due to increased power from panel data. In addition, after allowing for structural breaks, the panel test statistic of –7.124 also strongly rejects the unit root null at the 5 percent level.

Concerning investment and the military expenditure series taken as a percentage of GDP, it appears that the panel LM test statistics, with or without a break, cannot reject the null unit root hypothesis at the 5 percent level of significance, thus providing strong evidence in favor of a unit root in these two EU15 country series.

Table A1: Panel LM unit root tests allowing for structural break for GDP growth rates

Country	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Austria	-3.514*	1	-6.818*	1	1982
Belgium	-5.272*	1	-7.428*	1	1982
Denmark	-4.419*	1	-6.931*	1	1975
Finland	-4.582*	1	-5.481*	1	2006
France	-2.825	1	-5.937*	0	1981
Germany	-5.158*	2	-6.917*	1	1982
Greece	-2.475	1	-5.050*	0	2005
Ireland	-2.593	2	-4.268*	0	2000
Italy	-3.220*	1	-6.658*	1	2006
Luxembourg	-4.853*	1	-6.243*	0	2000
Netherlands	-3.040	1	-6.003*	1	1978
Portugal	-3.215*	1	-5.756*	0	2000
Spain	-3.042	1	-3.929*	0	1976
Sweden	-4.934*	1	-5.866*	0	1978
U.K.	-4.263*	2	-5.702*	1	2001
Panel LM stat	-6.953*		-7.124*		

Notes: Column (1) Individual LM statistic without break; (2) lags; (3) individual LM statistic with break; (4) lags; (5) optimal break point. Other notes are at the end of Table A3.

Table A2: Panel LM unit root tests allowing for structural break for GDP investment (as percent of GDP)

Country	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Austria	-1.071	1	-3.363	0	1999
Belgium	-1.993	1	-3.435	1	1985
Denmark	-2.212	1	-3.261	1	1982
Finland	-2.240	1	-3.969	1	1975
France	-1.421	0	-3.554	0	1996
Germany	-2.719	2	-3.545	1	1976
Greece	-1.322	1	-2.931	0	2006
Ireland	-3.167	2	-3.162	2	1970
Italy	-1.739	1	-2.812	2	1975
Luxembourg	-3.709*	1	-4.902*	2	1970
Netherlands	-0.912	1	-2.963	0	1977
Portugal	-0.713	1	-3.437	0	1980
Spain	-2.945	2	-3.109	1	2006
Sweden	-1.987	1	-3.816*	1	1997
U.K.	-1.669	2	-3.755*	1	1989
Panel LM stat	-2.895		-2.276		

Notes: Column (1) Individual LM statistic without break; (2) lags; (3) individual LM statistic with break; (4) lags; (5) optimal break point. Other notes are at the end of Table A3.

Table A3: Panel LM unit root tests allowing for structural break for GDP military expenditure (as percent of GDP)

Country	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Austria	-0.781	1	-3.793*	1	1984
Belgium	-0.184	1	-2.103	1	1976
Denmark	-0.609	1	-3.844*	1	1971
Finland	-2.333	1	-3.746*	1	1969
France	-3.079	1	-3.169	0	2006
Germany	-1.709	2	-4.275*	1	1969
Greece	-1.270	1	-4.365*	0	1977
Ireland	-0.327	1	-3.429	1	1976
Italy	-1.071	1	-3.459	0	1975
Luxembourg	-1.221	1	-2.803	0	1970
Netherlands	-1.651	1	-3.870*	0	1969
Portugal	-1.263	1	-5.768*	0	1983
Spain	-0.497	2	-4.209*	2	1984
Sweden	-0.152	2	-3.582*	0	1991
U.K.	-1.325	2	-2.632	2	2005
Panel LM stat	0.727		–1.039		

Notes: Column (1) Individual LM statistic without break; (2) lags; (3) individual LM statistic with break; (4) lags; (5) optimal break point.

(1) All tests are one-sided so that a calculated statistic smaller than the critical value leads to the rejection of the null of a unit root. At 5 percent, the critical value for the LM test without break is –3.06. At 5 percent the critical value for the minimum LM test with one break is –3.566. (2) The critical value for the panel LM test (with or without breaks) is –1.645, with an asymptotic standard normal distribution. (3) * denotes significance at the 5 percent level. (a) Schmidt and Phillips (1992) test; (b) Lee and Strazicich (2003) test; (c) Im and Lee (2005) test.

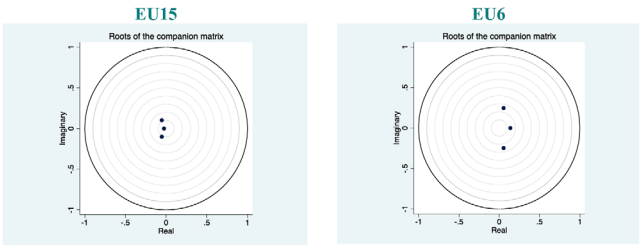


Figure A1: Stability tests.

Military expenditure and economic growth in the European Union: Evidence from SIPRI's extended dataset

Julien Malizard

Julien Malizard is Senior Researcher at the Chair of Defense Economics in the Endowment Fund of the Institute for Higher National Defense Studies (Institut des Hautes Etudes de Défense Nationale) in Paris, France. He is also a Research Fellow at the Research Unit in Theoretical and Applied Economics (GREThA), University of Bordeaux. He may be reached at julien.malizard@fdd-ihedn.fr or julien.malizard@gmail.com.

Abstract

The aim of this article is to shed light on the fiscal consequences of economic growth in the EU15 countries by disentangling military and civilian government expenditure. Given the newly available extended dataset on military expenditure provided by the Stockholm International Peace Research Institute (SIPRI), a comparison can be made to older SIPRI data. Using growth theory and panel data analysis, the results show that public spending is growth detrimental and military expenditure is less harmful than nonmilitary, civilian spending. The new data offer a richer pattern of results.

The economic crisis that began in the late 2000s has spurred economists to (re)evaluate the macroeconomic consequences of public sector spending. No consensus has emerged which makes it difficult to address policy options. For European countries, especially, estimating the influence of public expenditure is a major issue as many of them have reached public debt limits stipulated by Maastricht criterion. The subsequent fiscal consolidation then raised questions regarding the consequence of debt limits on current economic performance. The aim of this article is to provide empirical evidence of the long-run effect of public expenditure in the EU15 countries by comparing military and nonmilitary, civlian public expenditure.[1]

Military expenditure lies at the intersection of security needs and budgetary constraints: A rise in perceived threats should lead to a rise in military expenditure whereas bad economic conditions could have an adverse effect on military outlays. Recent trends in the EU15 show that following the fiscal consolidation policy, military expenditure fell by an average of 12.5 percent between 2010 and 2014, especially so in countries most severely affected by the economic crisis, i.e., Greece, Italy, Portugal, and Spain. (Among the EU15, only Sweden showed a rise in military expenditure for the 2010–2014 period.) At the same time, the EU15 are facing increased threats: For instance, the attitude of Russia appears somewhat aggressive and generates uncertainties regarding Crimea, terrorists' attacks have taken place in Paris and elsewhere in Europe, and a number of European countries are involved in the international coalition against ISIS. The nature of many of these kinds of threats is more diffuse than before so that security issues raise challenges not yet fully taken into account by European defense strategy.[2]

To deal with these events, military budgets are being increased. Thus, France decided to raise its budget by EUR3.5 billion to finance the deployment of land forces within the country. Equipment-poor Germany approved a budget increase of EUR6.2 billion for the five next years. The United Kingdom's 2015 Strategic Defence and Security Review acknowledges that the 2 percent of GDP target is necessary and commits to respect this threshold in the future. As a final example, the newly elected Finnish government imposed public spending cuts except for the military.

These choices have economic consequences. The literature on the military expenditure–economic growth relation is not entirely conclusive, in part because of differences in theoretical approaches, samples, and econometric modeling. Channels by which military expenditure may affect economic growth are numerous so that constructing a model that would encompass all the channels is very difficult to implement and estimate. Some research papers dealing with the EU15 suggest that military expenditure has an adverse influence on economic growth but generalizing across a group of countries that are fairly heterogeneous in their defense and economy policies may give one pause.[3]

In this article, I rely on growth theory as it provides a useful framework to evaluate the role of public spending. The growth effects of fiscal policy have been widely investigated, and the literature concludes that public spending exerts a negative influence on growth. However, empirical difficulties arise due to implied homogeneity which can lead to flaws in estimation.

This article studies the relation between military expenditure and economic growth for the EU15 countries. Using the newly revised and extended SIPRI military expenditure dataset, the article finds that over the 1960–2011 time period, both military and nonmilitary expenditure exert a negative effect on per capita economic growth, and nonmilitary spending more so than military spending.

To avoid this problem, some authors control for potential heterogeneity. I follow this part of the literature as it allows one to capture steady-state dynamics with a long time series panel. This point is original to the military expenditure–economic growth literature.[4]

One key issue to get comprehensive and consistent data on military expenditure. For comparative studies this requires that the definition of military expenditure is strictly identical across countries. SIPRI's data have become a standard source in the literature because its method is fully available and it uses consistent definition over time and among countries. One limitation, however, of SIPRI's original data was its relatively short time coverage, 1988–2015. This has now been rectified with data for a number of countries going back to the early 1950s, providing an opportunity to evaluate the dynamics of the military expenditure–economic growth relation in a panel data context for the EU15 countries.[5]

The remainder of this article is organized as follow. The next section presents the theoretical model and the data. The follow-on section discusses the issue of country heterogeneity and how to address it in terms of econometric method used. Results are provided in the section thereafter, and the article concludes with thoughts on future research.

Model and data

I employ a standard endogenous growth model with human capital and public expenditure. With this specification, the growth rate of GDP per capita, i.e., $ln(y_t)–ln(y_{t-1})$, is determined by physical capital (s_t), human capital (h_t), the population growth rate (n_t), military expenditure (m_t) and nonmilitary expenditure ($civil_t$).[6]

To deal with the absence of transitional dynamics in this kind of model, recent literature assumes that the model can be reparametrized as an autoregressive distributed lag (ARDL). This takes the following form:

$$(1)\ ln(y_t)–ln(y_{t-1}) = -\theta ln(y_{t-1}) + \alpha_1 ln(s_t) + \alpha_2 ln(h_t) + \alpha_3 ln(n_t) + \alpha_4 ln(m_t) + \alpha_5 ln(civil_t) + \beta_1 \Delta ln(s_t) + \beta_2 \Delta ln(h_t) + \beta_3 \Delta ln(n_t) + \beta_4 \Delta ln(m_t) + \beta_5 \Delta ln(civil_t) + \epsilon_t ,$$

where Δ denotes the first difference operator and ϵ_t the error term. As written, the equation has only one lag term but it can be augmented with ease to include more. To estimate equation (1), I assume that s_t is equal to the investment ratio.

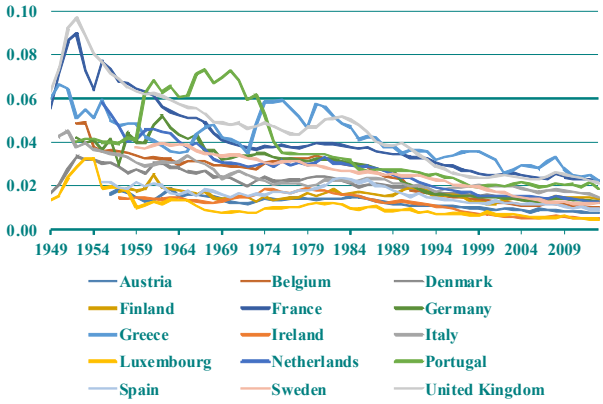


Figure 1: EU15 defense burdens (military expenditure as percent of GDP), 1949–2014. *Source*: SIPRI.

Military expenditure, as indicated, is taken from SIPRI's database, covering the 1988–2015 period (the "old" data) and a longer ("new" data) period going back to the early 1950s. Since data availability differs for the EU15, the period used in this article is 1960–2011, ensuring a balanced panel. The data for all other variables used are taken from the Penn World Table v8.1 (PWT) which covers 1950–2011. The dependent variable is the real growth rate of GDP per capita, computed as the first difference of real GDP per capita. Investment is captured as the ratio of investment to GDP, a proxy for physical capital (s). Population growth follows standard growth econometrics by augmenting it with exogenous elements, $g+d$, equal to five percent. Human capital is indexed in the Penn World Table and computed as the average years of schooling along with an assumed rate of return on primary, secondary, and tertiary education. Nonmilitary public spending as a share of GDP is calculated as the difference between the public spending share and the military spending share in GDP. Note that transfer payments are not included.) Finally, military expenditure, in the form of its share in GDP (the defense burden), is computed by and taken from SIPRI.[7]

Plotting the defense burden for each of the EU15 countries, Figure 1 shows a general downward trend and convergence of the majority of the EU15 defense burdens below two percent of GDP. In contrast to other publicly available data, SIPRI's extended dataset includes the cold war period, and the figure illustrates the evolution of the defense burden over the entire time span. The defense burden range (maximum minus minimum defense burden) has declined over time, even as distinct defense burden patterns can be identified among countries, as discussed in the next section.[8]

Heterogeneity

The EU15 countries features many differences in terms of their defense and economic policies. It therefore appears crucial to identify the main sources of heterogeneity so as to control for them properly in any statistical work. This section discusses reasons for the heterogeneity among the EU15 countries. Table 1 shows the defense burden for different subsamples (the average defense burden within each subsample is unweighted).[9]

The primary aim of military expenditure is to provide security and to deter enemy aggression. The cold war era was a period of high risk since the countries of the Warsaw pact, notably the then-Soviet Union, was viewed as a threat to Western Europe. To deter attack, EU15 countries devoted a larger share of GDP to the military during the cold war years (2.96 percent) than thereafter (1.76 percent).[10]

Defense policy drives in part on the existence of a defense industry. To maintain a measure of control over procurement, a country may develop in its own defense industry. Some countries produce the (nearly) complete scope of defense goods for air, naval, and land forces (France and the U.K.) and others manufacture major platforms such as aircraft, frigates, or tanks (Germany, Italy, Spain, and Sweden). Technologically advanced, these platforms require massive investment in R&D. Still other countries specialize in certain defense items such as small arms (Belgium). Major producers are known as the Letter of Intention (LoI) countries, a group composed of France, Germany, Italy, Spain, Sweden, and the UK. Their defense industries are viewed as strategic industries both for procurement autonomy and for economic reasons. In Table 1, the average defense burden for LoI members is 2.83 percent, as compared to 2.2 percent for non-LoI members.[11]

Among LoI members, France and the U.K. share common defense policy features. Permanent members of the UN Security Council, both take fairly interventionist postures vis-à-vis overseas operations and see nuclear deterrence as a policy pillar. Their strategic ambitions are considered as higher than those of the other EU15 countries. Unsurprisingly, then, in absolute terms France and the U.K. are the EU15 biggest military spenders.[12]

NATO membership also affects defense policy decisions. Among the EU15, only four countries are not members of the alliance (Austria, Finland, Ireland, and Sweden). To allow the defense burden to be shared fairly, NATO members have to fulfill a list of budgetary commitments. Specifically, each members' defense budget should be above 2 percent of GDP and defense equipment spending should equal at least 20 percent of the defense budget. In 2014, the latter criteria was met only by France, Greece, Portugal, and the U.K. The equipment criteria was met, in 2013, only by France and the U.K. Nonetheless, NATO members spend a significantly larger share of GDP on defense as compared to non-NATO members (2.74 versus 1.67 percent; see Table 1).[13]

Table 1: Heterogeneity defense policy, 1960–2011

	Number of observations	*Average defense burden*
Full sample	780	0.0245
Cold war period	450	0.0296
Post-cold war period	330	0.0176
LoI members	312	0.0283
Non-LoI members	468	0.0220
Nuclear powers	104	0.0388
Nonnuclear powers	676	0.0223
NATO members	575	0.0274
non-NATO members	208	0.0167

Note: LoI = Letter of Intent countries. See text for explanation.
Source: Computed from SIPRI data.

In light of these differences, assuming parameter homogeneity in the estimation of equation (1) would seem peculiar. In growth econometrics, homogeneity means that each country has the same production function. This assumption has been criticized as too restrictive. In recent years, the assumption of a common production function has been relaxed and authors of comparative studies conclude that homogeneity leads to estimation bias, so that "empirical exercises which fail to incorporate parameter heterogeneity are likely to produce misleading results." [14]

From an econometric perspective, standard Dynamic Fixed Effect (DFE) estimation implies homogeneity in slopes which is not suitable to estimate the model in equation (1). Two alternative estimators are considered. A Mean Group (MG) estimator estimates the model for each country and calculates averages so that no restrictions are imposed. An intermediate path is the Pooled Mean Group (PMG) estimator which allows the short-run coefficients and the error correction term to be heterogeneous but imposes homogeneity on the long-run coefficients. This article uses the PMG estimator method. Empirically, the hypothesis of long-run homogeneity for developed countries is confirmed in recent articles, and modern

growth econometrics uses this estimator as it better fits the data to the underlying model. Moreover, the PMG estimator fits an error correction model which appears to be suitable in macro panel data. Finally, endogeneity is a major concern in the growth literature but the ARDL approach is appropriate to overcome this issue.[15]

In a panel setting, and given the PMG approach, equation (1) becomes:

$$(2)\ ln(y_{it}) = -\theta_i\, ln(y_{i,\,t-1}) - \gamma_1\, ln(s_{it}) - \gamma_2\, ln(h_{it}) - \gamma_3\, ln(n_{it}) - \gamma_4\, ln(m_{it}) - \gamma_5\, ln(civil_{it}) + \beta_{1,i}\, ln(s_{it}) + \beta_{2,i}\, ln(h_{it}) + \beta_{3,i}\, ln(n_{it}) + \beta_{4,i}\, ln(m_{it}) + \beta_{5,i}\, ln(civil_{it}) + \epsilon_{it}\ ,$$

where the subscript i denotes countries, $\gamma_i = \theta_i / \alpha_i$. The other notations are unchanged. Estimating the long-run relationship consists of evaluating all the γ_i coefficients. In the following, I rely only on these coefficients. Unit root (Im, Pesaran and Shin) and cointegration (Pedroni) tests have been conducted (see Appendix). They conclude that, except for human capital, each variable is nonstationary and a long-run cointegrating vector exists among them.

Table 2: Long-run estimates

	1960–2011	*1988–2011*
Investment ratio (s)	0.1698*** (0.0214)	0.1728*** (0.0290)
Population growth (n)	–2.4133*** (0.7932)	–1.6955*** (0.5964)
Human capital (h)	0.2916 (0.4821)	0.7825 (0.5588)
Military expenditure (m)	–1.1088*** (0.2431)	–0.2463 (0.5964)
Nonmilitary exp. (civil)	–2.8680*** (0.6912)	–0.8434** (0.3593)
ECT	–0.0213*** (0.0043)	–0.0693*** (0.0124)
Number of observations	780	360

Note: Standard errors in brackets. *, ** and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. ECT stands for error correction term.

Results

The results are presented in Table 2. Note that the estimations use one lag to compute the error correction model thanks to the PMG estimator. Alternative estimators (Mean Group or Dynamic Fixed Effect) are not presented here because Hausman tests show the superiority of the PMG estimator. The dependent variable is the real growth rate of GDP per capita.

The exercise was run twice, once for the "old" SIPRI data (1988–2011) and once for the extended SIPRI data 1960–2011. An unbalanced panel was estimated as well with the longest time span for each country. Compared to the 1960–2011 results shown here, there are no significant changes.[16]

Almost all of the control variables come in with the expected sign. For both periods, investment is statistically significant and positive, with only a small coefficient change. Population growth exerts a negative influence, less adverse for the shorter than for the longer time period. The ECT is statistically significant and negative, as suggested by econometric theory.

Contrary to theoretical expectation, human capital appears statistically insignificant for both periods. One explanation may lie in the construction of the human capital variable (which is not consistent with many recent works) which includes a rate of return of schooling. But a model estimated without human capital is consistent with the results in Table 2.[17]

Turning to the fiscal policy variables, major changes are observed between the two time periods. First of all, public spending as a whole (military and nonmilitary) generates a negative effect on per capita growth, a finding which in is line with recent growth econometrics literature. This means that the negative influence of taxation dominates any positive influence of public spending (externality) on the private sector. However, splitting public expenditure between military and nonmilitary results in a different outcome. For the 1960–2011 period, both military and nonmilitary expenditure exert a detrimental effect on growth (and the coefficient for nonmilitary expenditure more so than that for military expenditure). But the 1988–2011 period, though, no statistically significant effect is observed for military expenditure whereas its nonmilitary counterpart still is growth damaging. The coefficients for the shorter time period are quite a bit smaller (less harmful) than for the longer period.[18]

Why would nonmilitary (civilian) public expenditure appear to be more harmful for per capita growth than military expenditure for the 1960–2011 period? One explanation may lie in the *level* of military expenditure which is very much smaller lower than the level of nonmilitary expenditure and, smaller yet, for mostly post-cold war world of 1988–2011. A second explanation may lie in the composition of military expenditure: For the major countries, the military concentrates a high proportion of public investment, due to procurement, whereas nonmilitary expenditure consists mainly of civil service wages. The negative influence of day-to-day civilian public sector wage expenditure is cancelled out by the positive

effect of military equipment expenditures.

In sum, compared to prior research, use of SIPRI's extended military expenditure data and estimating a dynamic model (with ECM) offer a new perspective on the military expenditure–economic growth relationship for the EU15 area.

Conclusion

The research reported in this article evaluates the long-term economic growth consequences of public expenditure by disentangling military from nonmilitary expenditure for the EU15 countries. It relies on an augmented Solow growth model and PMG estimators which allows one to take heterogeneity among countries into account. Moreover, the extended dataset permits one to investigate the dynamics of the relation with an error correction approach. The results indicate that the effects of military and nonmilitary expenditure are not equal. For the shorter time period—1988–2011—military expenditure does not exhibit a statistically significant adverse impact on growth whereas nonmilitary spending does. For the longer period—1960–2011—both military and nonmilitary expenditure impede economic growth but nonmilitary spending more so than military spending.

One issue is to learn whether changes in the *composition* of public expenditure are growth promoting. The results provided in this article do not offer a clear answer to this question: For the shorter time period, the estimated coefficient of military spending is negative but not statistically significant but for the longer period, it is both significant and negative. According to the results coming off the extended dataset, one cannot expect a positive influence on long-term growth from a reallocation of public spending from the military to the nonmilitary sector.

The research reported here can be enriched in at least three ways. First, significant economic consequences can flow from the way public expenditure is financed (with deficits or via direct or indirect taxes). If included in the analysis, different findings may result. Second, military expenditure is a response to perceived or actual threats, so that security needs may need to be included in the analysis, e.g., with an interaction term between military expenditure and threats. Third, composition issues (e.g., splitting military expenditure between equipment and day-to-day spending) are probably quite relevant for a more complete understanding of the relationship between public sector spending and economic growth.[19]

Notes

1. No consensus: See, e.g., Hebous (2011). Debt limit: Reinhart and Rogoff (2010) reinvestigate the debt–growth relationship and argue that if public debt is above 90 percent of GDP, it impedes economic growth. Although criticized, their paper has been widely discussed given its policy implication.

2. On Russia: In a recent interview, NATO Secretary General Jens Stoltenberg acknowledges that "we have to deal with a more aggressive behavior from Russia at the east." *Le Monde* (6 June 2016). Defense strategy: For instance, Schmidt (2013) argues that Europe's Common Security and Defence Policy (CSDP) is ineffective. Sherpherd (2016) argues that due to their increasing interconnections, the distinction between internal and external security threats is no longer relevant.

3. Not entirely conclusive: For a recent survey, see Dunne and Tian (2013). Numerous channels: See Dunne, Smith, and Willenbockel (2005) for a general discussion. Negative effect in EU15 countries: E.g., Kollias, Mylonidis, and Paleologou (2007), Mylonidis (2008), and Dunne and Nikolaidou (2012) for a growth model in a panel setting. Chang, Lee, and Chu (2015) use a Granger-causality test rather than a growth model. Heterogeneous EU15: Dunne and Nikolaidou (2012).

4. Framework: Barro (1991) published the pioneering work and shows that there exists an optimal value of public spending when the positive externality of public services equals the negative impact of taxation. The literature concludes: Bergh and Henrekson (2011). Homogeneity: As noted by Brock and Durlauf (2001, pp. 8–9), "the assumption of parameter homogeneity seems particularly inappropriate when one is studying complex heterogeneous objects such as countries." Some authors: See, e.g, Arnold, *et al*. (2011a) and Gemmel, Kneller, and Sanz(2016) for an evaluation of fiscal policy.

5. Standard source: See Smith (2009).

6. Standard growth model: See Mankiw, Romer, and Weil (1992) for the pioneering work.

7. Note that human capital data is available from the OECD for shorter time spans and has often been used in research papers in the form of averages years of schooling. Use of the PWT data in this article is original.

8. Convergence: For discussion, see Arvanitidis, Kollias, and Anastopoulos (2014). Two percent: NATO set a threshold, stating the its members each should spend at least two percent of GDP on military expenditure. Of the EU15 countries, 11 are NATO members.

9. Obviously, major differences arise between EU15 countries with respect to their economic policies (e.g., euro membership, fiscal policies, social preferences for public expenditure). In this article, I focus on defense policy differences.

10. The *t*-statistic for the mean difference is 14.29.

11. The *t*-statistics is a statistically significant 10.05. One referee rightly argues that among LoI members, nuclear powers have a prominent place. The average defense burden for the four non-nuclear LoI members is 2.32 percent which is close to the non-LoI average but still statistically significantly different from them (the relevant *t*-statistic equals 3.95).

12. Policy pillar: The French White Paper on Defense and Security insists on the need of nuclear deterrence. In the U.K., the recent Strategic Defence and Security Review points out that the Trident nuclear force has to be replaced to fulfill its

commitments to Britain's defense strategy. For both countries, the only option considered is Continuous-At-Sea Deterrence, which requires at least four submarines. Strategic ambitions: Smith (2009).

13. Regarding the 2 percent criterion, note that SIPRI's definition varies from NATO's. Using NATO data, only Greece and the U.K. respect the criterion.

14. Assumption has been criticized: For a survey, see Eberhardt and Teal (2011). Quote: Durlauf, Kourtellos, and Minkin (2001, p. 935).

15. PMG estimator: This method was developed by Pesaran, Shin, and Smith (1999). Recent articles: See, e.g., Arnold et al. (2011b) among others. Better fits the data: Gemmell, Kneller, and Sanz (2016). Macro panel data: Eberhardt and Presbitero (2015).

16. Unbalanced panel: Not shown but available upon request.

17. Rate of return: See Temple (2001) for discussion.

18. Results for the combined public expenditure variable are available upon request.

19. Second: See Aizenman and Glick (2006). Third: Among recent contributions, see, e.g., d'Agostino, Dunne, and Pieroni (2011) and Malizard (2015).

References

Aizenman, J. and R. Glick. 2006. "Military Expenditure, Threats and Economic Growth." *Journal of International Trade and Economic Development*. Vol. 15, No. 2, pp. 129–155. http://dx.doi.org/10.1080/09638190600689095

Arnold, J., B. Brys, C. Heady, Å. Johansson, C. Schwellnus, and L. Vartia. 2011a. "Tax Policy for Economic Recovery and Growth." *The Economic Journal*. Vol. 121, pp. 59–80. http://dx.doi.org/10.1111/j.1468-0297.2010.02415.x

Arnold J., A. Bassanini, and S. Scarpetta. 2011b. "Solow or Lucas? Testing Speed of Convergence on a Panel of OECD Countries." *Research in Economics*. Vol. 65, No. 2, pp. 110–123. http://dx.doi.org/10.1016/j.rie.2010.11.005

Arvanitidis, P., C. Kollias, and C. Anastopoulos. 2014. "Is there an International Convergence in Defence Burdens? Some Initial Findings." *Peace Economics, Peace Science and Public Policy*. Vol. 20, No. 4, pp. 611–620. http://dx.doi.org/10.1515/peps-2014-0030

Barro, R.J. 1991. "Government Spending in a Simple Model of Endogenous Growth." *Journal of Political Economy*. Vol. 98, No. 5, pp. 103–125. http://dx.doi.org/10.1086/261726

Bergh, A. and M. Henrekson. 2011. "Government Size and Growth: A Survey and Interpretation of the Evidence." *Journal of Economic Surveys*. Vol. 25, No. 5, pp. 872–897. http://dx.doi.org/10.1111/j.1467-6419.2011.00697.x

Brock, W. and S. Durlauf 2001. "Growth Economics and Reality." *World Bank Economic Review*. Vol. 15, No. 2, pp. 229–272. http://dx.doi.org/10.1093/wber/15.2.229

Chang, T., C.-C. Lee, and H.-P. Chu. 2015. "Revisiting the Defense–Growth Nexus in European Countries." *Defence and Peace Economics*. Vol. 26, No. 3, pp. 341–356. http://dx.doi.org/10.1080/10242694.2013.832556

d'Agostino, G., J.P. Dunne, and L. Pieroni. 2011. "Optimal Military Spending in the U.S.: A Time Series Analysis." *Economic Modelling*. Vol. 28, No. 3, pp. 1068–1077. http://dx.doi.org/10.1016/j.econmod.2010.11.021

Dunne, J.P., R.P. Smith, and D. Willenbockel. 2005. "Models of Military Expenditure and Growth: a Critical Review." *Defence and Peace Economics*. Vol. 16, No. 6, pp. 449–460. http://dx.doi.org/10.1080/10242690500167791

Dunne, J.P. and E. Nikolaidou. 2012. "Defence Spending and Economic Growth in the EU15." *Defence and Peace Economics*. Vol. 23, No. 6, pp. 537–548. http://dx.doi.org/10.1080/10242694.2012.663575

Dunne, J.P. and N. Tian. 2013. "Military Expenditure and Economic Growth: A Survey." *Economics of Peace and Security Journal*. Vol. 8, No. 1, pp. 5–11. http://dx.doi.org/10.15355/epsj.8.1.5

Durlauf, S., A. Kourtellos, and A. Minkin. 2001. "The Local Solow Growth Model." *European Economic Review*. Vol. 45, Nos. 4–6, pp. 928–940. http://dx.doi.org/10.1016/S0014-2921(01)00120-9

Eberhardt, M. and F. Teal. 2011. "Econometrics for Grumblers: A New Look at the Literature on Cross-Country Growth Empirics." *Journal of Economic Surveys*. Vol. 25, No. 1, pp. 109–155. http://dx.doi.org/10.1111/j.1467-6419.2010.00624.x

Eberhardt, M. and A. Presbitero. 2015. "Public Debt and Growth: Heterogeneity and Non-Linearity." *Journal of International Economics*. Vol. 97, No. 1, pp. 45–58. http://dx.doi.org/10.1016/j.jinteco.2015.04.005

Gemmell, N., R. Kneller, and I. Sanz. 2016. "Does the Composition of Government Expenditure Matter for Long-Run GDP Levels?" *Oxford Bulletin of Economics and Statistics*. Vol. 78, No. 4, and pp. 522–547.

Hebous, S. 2011. "The Effects of Discretionary Fiscal Policy on Macroeconomic Aggregates: A Reappraisal." *Journal of Economics Surveys*. Vol. 25, No. 4, pp. 687–707. http://dx.doi.org/10.1111/j.1467-6419.2010.00659.x

Kollias, C., N. Mylonidis, and S.-M. Paleologou. 2007. "A Panel Data Analysis of the Nexus between Defence Spending and Growth in the European Union." *Defence and Peace Economics*. Vol. 18, No. 1, pp. 75–85. http://dx.doi.org/10.1080/10242690600722636

Malizard, J. 2015. "Does Military Expenditure Crowd Out Private Investment? A Disaggregated Perspective for the Case of France." *Economic Modelling*. Vol. 46, No. April, pp. 44–52. http://dx.doi.org/10.1016/j.econmod.2014.10.049

Mankiw, N.G., D. Romer, and D.N. Weil. 1992. "A Contribution to the Empirics of Economic Growth." *Quarterly Journal of Economics*. Vol. 107, No. 2, pp.

407–437.
http://dx.doi.org/10.2307/2118477
Mylonidis, N. 2008. "Revisiting the Nexus between Military Spending and Growth in the European Union." *Defence and Peace Economics*. Vol. 19, No. 4, pp. 265–272.
http://dx.doi.org/10.1080/10242690802164801
Pesaran, H.M., Y. Shin, and R.P. Smith. 1999. "Pooled Mean Group Estimation of Dynamic Heterogeneous Panels." *Journal of the American Statistical Association*. Vol. 94, pp. 621–634.
http://dx.doi.org/10.1080/01621459.1999.10474156
Ramey, V.A. 2011. "Identifying Government Spending Shocks: It's All In The Timing." *Quarterly Journal of Economics*. Vol. 126, No. 1, pp. 1–50.
http://dx.doi.org/10.1093/qje/qjq008
Reinhart, C. and K. Rogoff. 2010. "Growth in a Time of Debt." *American Economic Review*. Vol. 100, No. 2, pp. 573–578.
http://dx.doi.org/10.1257/aer.100.2.573
Schmidt, O. 2013. "A Tragic Lack of Ambition: Why EU Security Policy is No Strategy." *Contemporary Security Policy*. Vol. 34, No. 2, pp. 413–416.
http://dx.doi.org/10.1080/13523260.2013.808076
Sherpherd, A.J.K. 2015. "The European Security Continuum and the EU as an International Security Provider." *Global Society*. Vol. 29, No. 2, pp. 156–174.
http://dx.doi.org/10.1080/13600826.2015.1018146
Smith, R.P. 2009. *Military Economics: The Interaction of Power and Money*. London: Palgrave MacMillian.
http://dx.doi.org/10.1057/9780230244672
Temple, J. 2001. "Growth Effects of Education and Social Capital in the OECD Countries." *OECD Economic Studies*. Vol. 2001, No. 2, pp. 57–101.

Appendix: Unit root and cointegration tests

For each variable and each period of analysis, Table A1 shows the results of the Im, Pesaran, and Shin unit root test (with intercept and lags determined by Akaike information criteria). The last line indicates the value of the Pedroni (rho) cointegration test (one intercept is included as an exogenous term).

Table A1: Unit root and cointegration tests

	1960–2011	*1988–2011*
$ln(y_{i,t})$	IPS stat=-0.3758 Prob=0.3535	IPS stat=2.5857 Prob=0.9951
$ln(s_{i,t})$	IPS=-1.2073 Prob=0.1137	IPS stat=-1.9149 Prob=0.1278
$ln(h_{i,t})$	IPS=-1.8601 Prob=0.0314	IPS=-4.5631 Prob=0.0000
$ln(m_{i,t})$	IPS=4.1981 Prob=1	IPS stat=-0.6716 Prob=0.2509
$ln(civil_{i,t})$	IPS stat=-1.0040 Prob=0.1577	IPS stat=-0.5566 Prob=0.2889
Pedroni test	Rho=2.2039 prob=0.9580	Rho=1.9485 Prob=0.9743

A dynamic panel analysis using SIPRI's extended military expenditure data: The case of Middle Power nations

Mohamed Douch and **Binyam Solomon**

Mohamed Douch, the corresponding author, is Associate Professor, Management and Economics Department, Royal Military College of Canada, Kingston, Ontario, Canada. He may be reached at mdouch@mdouch.net. Binyam Solomon is Senior Defence Scientist, Defence Research and Development, Department of National Defence, and Adjunct Professor, Carleton University, both in Ottawa, Canada. He may be reached at binyam.solomon@forces.gc.ca.

Abstract

This study employs SIPRI's extended military expenditure dataset to estimate a dynamic panel analysis of Middle Powers' defense posture. The dynamic approach, particularly the Auto Regressive Distributed Lag (ARDL) approach, permits simultaneous, but separate, assessment of short- and long-run effects of a particular variable on military expenditure. We verify the robustness of earlier findings on Middle Power nations' defense posture. In particular, their military expenditure tends to an income elasticity of greater than one indicating that military power is, at least in part, a status good. In addition, Middle Powers react to threat variables that proxy global instability, such as nuclear power proliferation, and they use foreign aid as a complementary policy tool. Competing demands for funds lead to significant tradeoffs between military and nonmilitary government spending.

The Stockholm International Peace Research Institute (SIPRI) is expected to release the final, public version of its extended military expenditure dataset in late 2016. This dataset is expected to cover over 170 countries for the period 1961 to 2014 and, in a number of cases, extends back to 1950. (The current version covers 1988 to 2015). This article uses the *alpha* version of the new dataset to reestimate the demand for military expenditure of Middle Power nations and to validate the dataset by comparison with official national and NATO statistics.[1]

To preview the findings, the use of the new SIPRI dataset essentially replicates previous results even as it enabled us to include two additional Middle Power nations in the study (Ireland and Spain, identified as a Middle Powers in an earlier study but omitted there due to data limitations).[2] The new dataset also permits us to apply a dynamic panel estimation technique, further validating the robustness of our earlier findings.

The key findings in this article include the following:

1. Middle Power nations' military expenditure tends to exhibit an income elasticity of greater than one, indicating that military power is, at least in part, a status good.
2. Middle Power nations react to threat variables that proxy global instability, such as nuclear power proliferation.
3. Middle Power nations use foreign aid as a complementary policy tool, along with military expenditure.
4. Middle Power nations face significant tradeoffs between military and nonmilitary government spending.

The data validation exercise we conducted using NATO's official statistics and Canadian national data show some notable deviations particularly in the later years of the dataset. These deviations are due to NATO's changes in definition and to NATO's failure to link its time series for consistency (that is, data is not updated backward to keep consistent definitions throughout the time series). We therefore suggest that for empirical analyses and cross-country comparisons, the SIPRI dataset be used, as consistency is maintained over the whole of its time series.

The remainder of this article is structured as follows. The next section briefly discusses what we mean by the Middle Powers. The sections thereafter presents the data and the reestimation of Middle Powers' demand for military expenditure with emphasis placed on the key differences in estimation approaches, dynamics, and key findings. The final section concludes and suggests new research directions.

Middle Powers and their military expenditure

From an economics perspective, the determinants of military expenditure can be derived from standard social welfare optimization models and alliance theory. Generally speaking, these models show that the key drivers of demand for military expenditure are income constraints, threats, military alliances (degree of publicness of military expenditure), and specific demand shift variables. But questions remain. For example,

how is threat perceived when a nation does not have a known adversary? Or, do nations use military expenditure as a status good? Are there competing or complementary policy tools that can be used instead of or alongside military expenditure?[3]

In an earlier study, published in 2014, we address such issues for nine nations identified as Middle Powers. That study did show policy complementarity between military expenditure and foreign aid and identified nuclear proliferation indicators as proxies for global instability and as likely threat variables for Middle Power nations. While the study identified a high income elasticity of military expenditure (i.e., higher national income is statistically associated with higher military expenditure), an elasticity of greater than one could only be established for selected Middle Power nations.[4]

One of the drawbacks of the 2014 study pertained to data limitations. Even though the time series used in the study covered over 50 years of data, it extended to only nine Middle Powers. From a technical, econometric perspective, the use of fixed effects panel estimation is inappropriate when the number of cases (9) is smaller than the time series (50+). Moreover, while two additional nations were identified as Middle Powers (Ireland and Spain), the lack of consistent time series excluded their inclusion in the 2014 study. In this article, in contrast, Ireland and Spain are included on account of the extended SIPRI dataset. In addition, we use the Auto Regressive Distributed Lag (ARDL) approach to better assess the dynamics of the model.[5]

Data

As noted, data on the military expenditure for the period 1961 to 2014 (in constant 2011 U.S. dollars) are available in the new SIPRI dataset. The 11 nations included in the analysis here are Australia, Belgium, Canada, Denmark, Finland, Ireland, Italy, the Netherlands, Norway, Spain, and Sweden. Spain is deemed to be a Middle Power after 1980, i.e., for the post-Franco period. Military expenditure for the United States is included in the study as well, as a proxy for the dominant NATO ally.

GDP figures for the 11 nations and deflators to convert foreign aid data from the OECD are obtained from the World Bank's online data facility. To reflect tradeoffs faced by nations between socioeconomic and security needs, government expenditure was obtained from the World Bank as well (removing military expenditure and foreign aid from the aggregate). The main threat variables—the size of the strategic arsenal—was provided by Jim Finan (Royal Military College, Canada). Specifically, these refer to the number of nuclear-tipped intercontinental missiles, the nuclear total arsenal, and the potential yield of nuclear explosions. In addition, we use conflict casualties data from the Peace Research Institute, Olso's (PRIO) armed conflict dataset. In the present study we also include Doomsday Clock data from the Bulletin of the Atomic Scientists to amplify our 2014 argument that, in the absence of country-specific or regional adversaries, Middle Powers react to global instability proxies.[6]

Method

As indicated, this study uses a panel data set which includes data for 11 Middle Power countries. By employing advanced dynamic panel techniques, such as Autoregressive Distributive Lag (ARDL) estimation, one can capture the dynamic nature of the data and present empirical evidence about the relationship between and among military expenditure, threat perception, and so on as outlined beforehand. Static models, such as fixed and random effects models, were not considered due to their inability to capture the data dynamics which is crucial in determining any short- and long-term relationships that may be present in the data. Further, the ARDL approach allows one to simultaneously, but separately, assess both the short- and long-run effect of a particular variable on military expenditure.[7]

The GMM system estimators developed by Arellano and Bond and Arellano and Bover are competing techniques suitable for panel data analysis but known to suffer from certain shortcomings. For example, GMM is unable to capture long-run data dynamics. These estimators were, therefore, not used in this study. The ARDL approach is based on Pesaran and on Pesaran, Shin, and Smith where dynamics are incorporated into an error correction model by using lags of the dependent and independent variables. This allows for rich dynamics in the sense that the dependent variable adapts to changes in the explanatory variables.[8]

The ARDL (p, q_1, ..., q_k) technique, where p is the lag of the dependent variable and q_j is the lag of the independent variables (j = 1, 2, ..., k) can be stated as follows:

$$(1)\quad Milex_{it} = \sum_{j=}^{p} \lambda_{ij} Milex_{i,t-j} + \sum_{j=0}^{q} \beta_{ij} X_{i,t-j} + \mu_i + \varepsilon_{it} ,$$

where $i = 1, 2, ..., 11$ is an index for the eleven countries; $t = 1, 2, ..., T$ is an index for time; X_{it} is a $k \times 1$ vector of explanatory variables (income, threat variable, U.S. military expenditure, and other government spending); β_{it} are the $k \times 1$ coefficient vectors; λ_{it} are scalars; and μ_i is the country-specific effect. The time period T must be large enough such that the model can be fitted for each country separately. Constant term, time trends, and other fixed regressors may be included. Following the discussion in Pesaran, Shin, and Smith, and if the variables in (1) are, for example, I(1) and cointegrated, then the error term is an I(0) process for all i.[9] This feature implies an error

Table 1: Long-run coefficients, 1961–2014

Variable	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
GDP	2.03***	1.49***	1.37***	1.55***	1.2***
Threat (–1)	0.21***	0.06*	0.38	–0.02	0.9***
MainAlly (–1)	–0.1	–0.23**	–0.69**	–0.3	–0.14*
OtherGovExp	–1.14***	–1.16***	–1.21***	–0.92***	–0.36**
ODA	0.21***	0.52***	0.82***	0.22***	0.03

Notes: ***, **, * reflect statistical significance at the 1%, 5%, and 10% levels. Threat variables used in Models 1 to 5 are, respectively, total nuclear arsenal, nuclear intercontinental missiles, Doomsday Clock, conflict casualties, and nuclear explosion. MainAlly is U.S. military expenditure; OtherGovExp is other government expenditures; ODA is foreign aid.

Table 2: Short-run coefficients, 1961–2014

Variable	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
ConEq1	–0.09***	–0.07**	–0.03	–0.05**	–0.11***
ΔGDP	0.35***	0.4***	0.46***	0.39***	0.39***
ΔThreat(–1)	0.14***	0.02	–0.02	0.01	0.001
ΔMainAlly (–1)	0.11**	0.11**	0.11**	0.11**	0.12**
ΔOtherGovExp	0.44***	0.44***	0.43***	0.47***	0.41***
ΔODA	–0.02*	-0.03*	–0.02	–0.02	–0.02
β0	–0.68***	0.08	0.18	0.07*	–0.13***

Notes: See Table 1. In addition, β0 is the intercept term; ConEq1 is the co-integration equation.

correction model in which the short-run dynamics of the variables in the system are influenced by the deviation from equilibrium. Thus it is common to reparametrize equation (1) into the following error correction equation:

$$\Delta Milex_{it} = \phi_i (Milex_{i,t-1} - \theta_i' X_{i,t}) + \sum_{j=}^{p-1} \lambda_{ij}^* \Delta Milex_{i,t-j} + \sum_{j=0}^{q-1} \beta_{ij}^* \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (2)$$

where Δ is the first difference operator; and

$$\phi_i = -(1 - \sum_{j=1}^{p} \lambda_{ij}) \; ; \; \theta_i = \sum_{j=0}^{p} \beta_{ij} / (1 - \sum\nolimits_k \lambda_{ik}) \; ;$$

$$\lambda_{ij}^* = -\sum_{m=j+1}^{p} \lambda_{im} \text{ , j=1, 2, ..., p–1; } \beta_{ij}^* = -\sum_{m=j+1}^{q} \beta_{im} \text{ , j=1, 2, ..., q–1.}$$

Of interest are the error-correcting speed of adjustment term, that is, the parameter ϕ_i , and the vector θ_i , which contains the long-run relationships between the variables. The error-correcting term is expected to be negative in a statistically significant way under the prior assumption that the variables return to a long-term equilibrium.

In the recent literature on dynamic panel regressions, three techniques are used, dynamic fixed effects, mean group (MG), and pooled mean group (PMG) estimations. The choice among the three is determined by employing the joint Hausman test. In our case, PMG is preferred to both MG and DFE. Results shown in the next section thus omit both DFE and MG. (They are available upon request.)

Results

Table 1 presents the estimated long-run coefficients for the panel of Middle Power nations using the PMG estimator. The estimated model includes Ireland and Spain and the time period covered (1961–2014) includes more of the post-cold war period than our previous study (1952–2007).

As shown in Table 1, regardless of the threat variables used (indicated in Models 1 to 5) the GDP or income elasticity of Middle Powers' military expenditure exceeds 1. This is consistent with the theoretical prediction that Middle Powers use military expenditure as a positional good. Significant tradeoffs in government expenditure due to competing demands is another characteristics of Middle Power nations. This is shown by the large and statistically significant negative effects of other government expenditure. Similarly, we find statistically significant results for the policy complementarity of foreign aid.

While our 2014 study found all threat variables to be statistically significant, in this study only three are found to be statistically significant, two the at 1 percent level and one at 10 percent level. The new threat variable included in this study, Doomsday Clock, and the conflict casualties variable are not statistically significant. In future studies, the size of the total nuclear arsenal and the nuclear explosion yields may be the preferred global instability proxies.[10]

U.S. military expenditure as a proxy of the dominant ally

Table 3: Long-run effects, cold war and post-cold war years

Variable	Cold war (1961–1990)	Post-cold war (1991–2014)
GDP	0.6*	1.51***
Threat (–1)	–0.59***	0.01
MainAlly (–1)	0.24*	–0.3***
OtherGovExp	0.33	–0.61
ODA	0.1***	–0.05

Note: The threat proxy used here is the size of the total nuclear arsenal.

shows a statistically significant and negative relation to Middle Powers' military expenditure. This possibly points to free-riding by Middle Powers, but the results are not robust across the various threat proxies.

In regard to the short-run dynamics, the estimated coefficients shown in Table 2 suggest a more theoretically consistent relation to U.S. military spending. Specifically, U.S. military spending affects Middle Powers' military expenditure in a statistically significant and positive way. Also notable is that other government spending inertia tends to dominate the short-run dynamics for Middle Powers.

The new SIPRI dataset also permits us to separately test the military expenditure behavior of Middle Power nations during the cold war and post-cold war periods. Thus, Table 3 shows an income elasticity of greater than one irrespective of the time period. However, the magnitude is larger during the post-cold war years. The threat variable is statistically significant only for the cold war years, the (potential) free-riding variable switches signs, and the other two variables are not statistically significant. These are rather diverse findings that may warrant further investigation.

Conclusion

The forthcoming expansion of SIPRI's military expenditure data back to the early 1960s is welcome news to researchers. Longer time series, starting, for most countries, as from 1961 will allow for more dynamic and robust estimation of models using the military expenditure data. Our own recent (2014) work on the military expenditure behavior of Middle Power nations has benefitted from this backward extension of SIPRI's time series. Specifically, it allowed the inclusion of data for two additional nations previously identified as Middle Powers. Our main findings in the study mostly concur with those of our earlier study. Middle Powers' military expenditure tends to show income elasticity of greater than one, they react to threat variables that proxy global instability, such as military-nuclear power proliferation, they appear to use foreign aid as a complementary policy tool, and tradeoffs between military and nonmilitary government spending are observed in the data.

Although not detailed here, it should be pointed out that the new SIPRI dataset permits researchers to reassess official NATO and country-specific military expenditure-related data. SIPRI's use of a (fairly) consistent definition over the range of its time series allows researchers to conduct cross-country estimation and analyses. In contrast, NATO's official statistics do not update previous data to match changes in definitions while country data tend to be specific to national legislative or expenditures management requirements, and this limits their use in robust cross-country comparisons.

We believe that future studies should continue to use nuclear arsenal-related proxies as a threat measure, especially for nations with no known country-specific adversary. An extension to our models ought to look at the possibility of nonlinear dynamics of military expenditure pattern as nations transit from less to more inclusive economies and polities.

Notes

We are grateful to Professor James Finan for providing updated data on threat variables and for his continuous help throughout the project. The authors also thank this journal's editor as well as an anonymous referee for constructive comments and suggestions.

1. SIPRI released the *alpha* version to selected researchers in late 2015.

2. The earlier study is Douch and Solomon (2014).

3. Social welfare optimization models: See, e.g., Smith (1989; 1985). Alliance theory: See, e.g., Murdoch and Sandler (1982).

4. The classification and selection of Middle Powers is discussed in Douch and Solomon (2014) and it is not repeated here.

5. Technical aspect of fixed effects panel: Breitung and Pesaran (2008). Thus, Douch and Solomon (2014) employed seemingly unrelated regression equations (SURE) instead of a fixed effect panel estimation.

6. PRIO: http://www.pcr.uu.se/research/ucdp/datasets/ucdp_prio_armed_conflict_dataset/. Doomsday Clock: See http://thebulletin.org/overview. [Both accessed 14 February 2016].

7. Simultaneously, but separately: Bentzen and Engsted (2001).

8. GMM: Arellano and Bond (1991); Arellano and Bover (1995). GMM shortcomings: Samargandi, Fidrmuc, and Ghosh (2015). Unable to capture long-run dynamics: Eberhardt

(2012). ARDL approach: Pesaran (1997); Pesaran, Shin, and Smith (2001).

9. Pesaran, Shin, and Smith (2001). The ARDL approach may be applied to time series variables irrespective of whether they are I(0), I(1), or mutually cointegrated (Pesaran and Shin 1999). This makes testing for unit roots unnecessary.

10. Unlike the other threat variables used in the study, the Doomsday Clock variable works in reverse so that a negative relationship is expected: The fewer the minutes left to "midnight," the graver the threat.

References

Arellano, M. and S. Bond. 1991. "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *Review of Economic Studies*. Vol. 58, No. 2, pp. 277-297. http://dx.doi.org/10.2307/2297968

Arellano, M. and O. Bover. 1995. "Another Look at the Instrumental Variable Estimation of Error-Components Models." *Journal of Econometrics*. Vol. 68, No. 1, pp. 29-51. http://dx.doi.org/10.1016/0304-4076(94)01642-D

Bentzen, I. and T. Engsted. 2001. "A Revival of the Autoregressive Distributed Lag Model in Estimating Energy Demand Relationship." *Energy*. Vol. 26, No. 1, pp. 45-55. http://dx.doi.org/10.1016/S0360-5442(00)00052-9

Breitung, J. and H. Pesaran. 2008. "Unit Roots and Cointegration in Panels," pp. 279-322 in L. Matyas and P. Sevestre, eds. *The Econometrics of Panel Data: Fundamentals and Recent Developments in Theory and Practice*. 3rd ed. Dortrecht: Kluwer. http://dx.doi.org/10.1007/978-3-540-75892-1_9

Eberhardt, M. 2012. "Estimating Panel Time-Series Models with Heterogeneous Slopes." *Stata Journal*. Vol. 12, No. 1, pp. 61-71.

Douch, M. and B. Solomon. 2014. "Middle Powers and the Demand for Military Expenditures." *Defence and Peace Economics*. Vol. 25, No. 6, pp. 605-618. http://dx.doi.org/10.1080/10242694.2013.861652

Murdoch, J.C. and T. Sandler. 1982. "A Theoretical and Empirical Analysis of NATO." *Journal of Conflict Resolution*. Vol. 26, No. 2, pp. 237-263. http://dx.doi.org/10.1177/0022002782026002003

Pesaran, H. 1997. "The Role of Econometric Theory in Modeling the Long Run." *Economic Journal*. Vol. 107, No. 440, pp. 178–191. http://dx.doi.org/10.1111/1468-0297.00151

Pesaran, H. and Y. Shin. 1999. "An Autoregressive Distributed Lag Modeling Approach to Cointegration in Econometrics and Economic Theory in the 20th Century," pp. 371-413 in S. Strom, ed. *The Ragnar Frisch Centennial Symposium*. New York: Cambridge University Press.

Pesaran, H., Y. Shin, and R. Smith. 2001. "Bounds Testing Approaches to the Analysis of Level Relationships." *Journal of Applied Econometrics*. Vol. 16, No. 3, pp. 289-326. http://dx.doi.org/10.1002/jae.616

Samargandi, N., J. Fidrmuc, and S. Ghosh. 2015. "Is the Relationship between Financial Development and Economic Growth Monotonic? Evidence from a Sample of Middle-Income Countries." *World Development*. Vol. 68, No. 1, pp. 66-81. http://dx.doi.org/10.1016/j.worlddev.2014.11.010

Smith, R. 1989. "Models of Military Expenditure." *Journal of Applied Econometrics*. Vol. 4, No. 4, pp. 345-359. http://dx.doi.org/10.1002/jae.3950040404

Smith, R. 1995. "The Demand for Military Expenditure," pp. 69-87 in K. Hartley and T. Sandler, eds. *Handbook of Defense Economics*. Vol. 1. Amsterdam: North Holland.

Military expenditure and economic growth, 1960–2014

J. Paul Dunne and **Nan Tian**

J. Paul Dunne is at the School of Economics and the Southern Africa Labour and Development Research Unit (SALDRU), both at the University of Cape Town, Cape Town, South Africa. The corresponding author, he may be reached at John.Dunne@uct.ac.za. Nan Tian is at SALDRU, University of Cape Town, and may be reached at nan.tian.eco@gmail.com.

Abstract

This article compares results of our 2015 study of the effect of military expenditure on economic growth, 1988–2010, with results using an additional 28 years of data provided in the newly revised and extended SIPRI dataset, 1960–2014. When the additional data points are added, we find no substantive differences and confirm the statistically significant negative effect of military expenditure on growth reported in our prior research. Using the same estimation process, there is no evidence of a structural break in the time series. Considering nonlinearity and heterogeneity, the estimates using the new data for ninety-seven countries are remarkably consistent with the earlier results and, overall, are very similar in sign and statistical significance, and many of the coefficients are larger (more adverse) than before. The new data provide valuable extra information and support for the original findings.

Military expenditure data provided by the Stockholm International Peace Research Institute (SPIRI) have been an important source for empirical research on the effect, if any, of military spending on economic growth for many years. Some of SIPRI's data were available for as far back as 1950, but *consistent* data across countries was only available from 1988. This limited the coverage of most cross-country studies engaging in the debate. The newly revised, extended, and consistent series now provide researchers with a valuable resource with which to validate previous analyses. The data also allows them to take advantage of new panel data techniques that have become available and which are more reliable with longer time series of data.[1]

The application of new data and new techniques is particularly valuable in this debate. Early studies had found it difficult to identify the impact of military spending on growth. Later studies seemed to be consistently identifying a statistically significant negative effect when post-cold war data points began to become an important part of the sample. Certainly, the end of the cold war saw substantial changes in the geopolitical environment and large worldwide reductions in military expenditure. This reduction, coupled with strong economic performance, provided valuable information in the data and some support for the existence of a peace dividend, recognizing the opportunity cost of military expenditure. Diverting resources to other development purposes, such as education, healthcare, infrastructure, or job creation, has been found to improve economic performance.[2]

This article takes the models in our previous study, estimated on data for 1988–2010, and examines whether the newly available data points have any statistically significant impact on the results. It also considers the robustness of the results to nonlinearity and group heterogeneity across the samples and investigates potential structural breaks in the full dataset of 97 countries for the period 1960–2014. The next section includes a brief review of the literature. The section thereafter provides a discussion of the dataset. This is followed by the presentation of the estimation results. The last section concludes.[3]

Effects of military expenditure on economic growth

Empirical studies on military expenditure and economic growth are comprehensively reviewed in our two recent survey pieces. Earlier surveys, by J. Paul Dunne and Ron Smith, respectively, had suggested little empirical regularity. That said, they did conclude that there exists no evidence of any statistically significant positive effect of military spending on growth. Instead, most studies reported negative coefficients, but often with a statistically insignificant value. There was certainly no theoretical consensus to guide the empirical analysis. Simple Keynesian aggregate demand arguments suggested that the expansion of government spending in a less than full-employment environment would increase investment, income, employment, and hence lead to higher rates of economic growth. There were also suggestions that military spending may lead to higher economic growth through positive spillover effects. Adding an aggregate production function to a Keynesian model made the theoretical predictions less clear. Allowing for the existence of vested interests and the presence of a military industrial complex suggested a negative impact on

growth due to adverse externality effects on the rest of the economy. Only underconsumptionist or effective demand Keynesian theorists saw a clear economy-enhancing role for military spending. In contrast, a neoclassical perspective would see military expenditure, financed by taxes or borrowing, as crowding out private investment and reducing growth. Although there may be security benefits to the economy as a result of military spending, resource diversion away from more productive government activities such as education or health, leads to large opportunity costs. This lack of consensus in the theoretical approaches meant the debate became largely an empirical one.[4]

In our 2013 survey, we found that of 168 studies published since Benoit's seminal work appeared in 1973, military spending had negative effects on economic growth in 44 and 31 percent of cross-country and case studies respectively. Only 20 percent of studies found positive results, while about 40 percent reported unclear results. An earlier suggestion, by Dunne and Uye, that increasing the proportion of post-cold war data might provide more consistent results indeed seemed to have supporting evidence. A comparison of time periods indicated that 53 percent of authors who used predominantly post-cold war data found military spending to have a negative effect on growth, while only 38 percent found such a result when using data before the end of the cold war. In a meta analysis using data covering 1960–1990, Alptekin and Levine found the combined effect of military expenditure on growth to be positive, with no evidence of a negative defense–growth relation for the least developed countries, nor in general. While their choice of studies was not comprehensive this—combined with findings dominated by post-cold war data—does illustrate the possibility that the available data did not consist of time series long enough to identify any particular impact of military spending on growth.[5]

Model, data, and empirical methods

Following Dunne, Smith, and Willenbockel, the military expenditure–economic growth relation is modeled in this article using an augmented Solow growth model with Harrod-neutral technical progress. The full derivation and description of the model can be found in our 2015 study. (The specific growth equation to be estimated is shown in the next section.)[6]

Military expenditure data comes from SIPRI's database. GDP per capita, the change in the capital stock (a proxy for investment) and population data come from the World Bank's *World Development Indicators* (WDI). Conflict-related data are taken from the UCDP/PRIO armed conflict database. The final balanced panel consists of data for 97 countries for

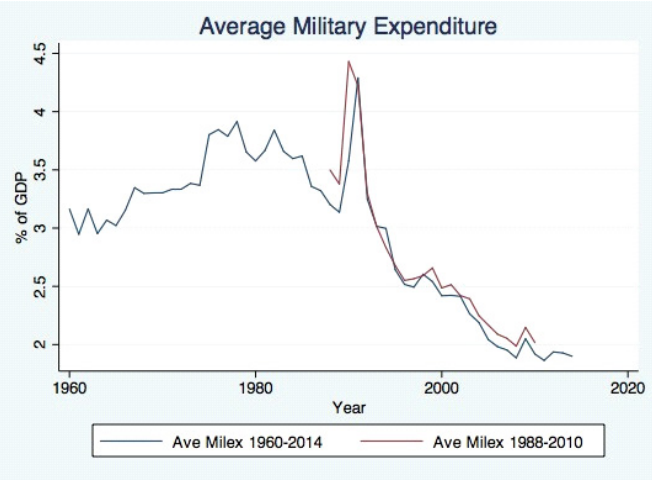


Figure 1: Average military expenditure, 1988–2010 and 1960-2014. *Source*: SIPRI "old" and "new" dataset.

1960–2014. Due to missing data, the number of countries included in the study was narrowed down from an initial group of 170. For example, there are no data for Angola before 1988, Liberia before 2004, or for North Korea (for the entire 55 year period). Indeed, a number of countries did not even exist for some of the relevant time period. Countries such as Botswana, Mozambique, Namibia, and the majority of the current eastern European block could not be included for this reason. Thus, even though SIPRI's new dataset contains an additional 28 years of data, such considerations restricted us to 97 countries, nine less than in our 2015 study. Figure 1 displays the difference in average military expenditure between our 2015 paper and this article.

Table 1 (next page) gives summary statistics for the main empirical variables in our 2015 dataset and compares them to the current study. As mentioned, the main differences are the addition of 28 years of data and the exclusion of 9 countries. Our sample includes 25 developed and 72 developing countries. Regarding major continental regions, we include 33 African countries, 15 from Asia and Oceania, 19 European, and 21 North and South American ones as well as 9 from the Middle East. In the full sample, 44 percent of all countries experienced some form of violent conflict, 67 percent received official development assistance (ODA), and 38 percent are deemed to be natural resource dependent.

Since the new data provides more information for countries during the cold war period, the comparison shows, on average, slightly higher military expenditure as well as lower GDP and population size. The capital stock as a percentage of GDP remained roughly the same. For purposes of comparison, the same indicator variables are used for sample stratification. They include income groups, developed and developing

Table 1: Variables and comparative descriptive statistics

		1960–2014		*Dunne and Tian (2015)*	
Variable	*Description*	*Mean*	*St.Dev.*	*Mean*	*St.Dev.*
m	Military spending % of GDP	2.96	3.59	2.7	3.71
y	GDP per capita	9,355	13,025	11,964	12,658
k	Capital stock % of GDP	21.22	6.84	21.28	6.57
pop	Population in 000's	33,987	95,321	50,408	156,627
Δy	Growth in per capita GDP	1.88	5.62	1.96	4.78
Δm	Growth in military spending	–0.58	7.68	–2.2	20.58
Δk	Growth in capital stock	0.04	16.17	0.13	14.84
Conflict	% of conflict experience	44.3	49.7	36.1	48.3
Aid	% of ODA recipients	67	47	63.2	48.2
Nat	% of resource dependent	38.2	48.6	35.8	47.9

Table 2: Growth effects of military expenditure over varying time periods

	(1)	*(2)*	*(3)*
Sample	*1960–2014*	*1960–1987*	*1988–2014*
Variables	*Δly*	*Δly*	*Δly*
Δlk	0.085** (0.005)	0.110** (0.008)	0.062** (0.006)
Δlm	–0.032** (0.004)	–0.043** (0.006)	–0.020** (0.006)
lngdpop	–0.024** (0.005)	–0.095** (0.020)	–0.043** (0.005)
ly1	–0.033** (0.003)	–0.054** (0.009)	–0.076** (0.007)
lk1	0.030** (0.003)	0.035** (0.006)	0.030** (0.004)
lm1	–0.017** (0.002)	–0.023** (0.004)	–0.012** (0.003)
Constant	–0.289** (0.134)	0.657 (0.484)	–2.117** (0.298)
Trend	Yes	Yes	Yes
LR coefficient	–0.515	–0.426	– 0.158
Observations	3,962	1,608	2,354
R-squared	0.132	0.176	0.151

Note: Dependent variable: Δly; standard errors in parentheses; significance levels: ** p<0.01, * p<0.05, † p<0.1; all standard errors reported are the normal standard errors.

countries, conflict experience, natural resource dependence, ODA receipts, and political institutions. Disaggregation into subsamples takes concerns regarding group heterogeneity and nonlinearity into account.

Classification of countries as developed or developing, and into income groups, is taken from the World Bank's WDI database. Developed countries are coded with a numerical value of one; all remaining countries received a value of zero. To balance the sample sizes of the different income groups, the categories of low and low-middle income countries were combined into a single low-income category. High-middle income countries were defined as middle-income countries. The category of high-income countries remains unchanged. The armed conflict indicator differentiates between civil and interstate wars. Natural resource abundance, measured by mineral exports as a share of total exports, uses data from Haglund and the UNCTADstat database. A combined measure of fuel and nonfuel minerals indicates whether a country is natural resource dependent. A country is considered mineral dependent if its mineral exports constitutes over 25 percent of total exports. ODA data is taken from the WB's WDI.[7]

The full sample of countries was initially divided into net ODA recipients and all others. Net receipts of aid are measured as a share of gross national income (GNI), and countries that received on average less than 0.1 percent of aid as a share of GNI are considered nonaid recipients. Finally, measures of political institutions use the polity variable extracted from the Polity IV database, ranging from –10 (high autocracy) to +10 (high democracy). To create an indicator variable consistent with the others, a country with a polity value of less than –3 is categorized as an autocratic state. Values between –3 and +3 (inclusive) are intermediate cases, and values of greater than +3 are seen as democratic states.[8]

Empirical results

The military expenditure and economic growth relation is estimated with a first-order dynamic model which can be written in the form:

$$\Delta lny_{it} = \gamma lny_{i,t-1} + \sum_{j=1}^{3} \beta_j \Delta lnx_{j,i,t} + \sum_{k=1}^{2} \alpha_k lnx_{k,i,t-1} + \eta_t + \mu_i + \nu_{it}, \text{ for } i = 1, 2, ..., N; t = 1, 2, ..., T,$$

where y is GDP per capita, x_1 is gross fixed capital formation as a share of GDP (to proxy investment), x_2 is military spending as a share of GDP, x_3 is the population growth rate (plus 0.05, or $n+g+\delta$). The reparameterized general first-order dynamic model is then estimated and results are shown in Table 2. All variables are in logs (l). The notation Δ represents the change in a variable, and a "1" following a variable name refers to a one-period lag. The dependent variable in all regressions is Δly, the change in the log of per capita GDP.

Table 3: Growth effects of military expenditure—development stratifications

	1960–2014			*1988–2010*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Sample	*All*	*Dev*	*Non-Dev*	*All*	*Dev*	*Non-Dev*
Variables	*Δly*	*Δly*	*Δly*	*Δly*	*Δly*	*Δly*
Δlk	0.085**	0.175**	0.077**	0.070**	0.213**	0.059**
	(0.005)	(0.011)	(0.057)	(0.006)	(0.014)	(0.007)
Δlm	–0.032**	–0.101**	–0.027**	–0.027**	–0.018**	–0.027**
	(0.004)	(0.089)	(0.005)	(0.005)	(0.006)	(0.006)
lngdpop	0.024**	–0.057**	0.039**	–0.056**	–0.093**	–0.046**
	(0.005)	(0.008)	(0.006)	(0.009)	(0.013)	(0.011)
ly1	–0.033**	–0.021**	–0.034**	–0.089**	–0.044**	–0.091**
	(0.003)	(0.004)	(0.004)	(0.008)	(0.012)	(0.009)
lk1	0.030**	0.029**	0.028**	0.030**	0.023**	0.026**
	(0.003)	(0.005)	(0.003)	(0.005)	(0.009)	(0.006)
lm1	–0.017**	–0.012**	–0.018**	–0.017**	(0.009)	–0.018**
	(0.002)	(0.003)	(0.002)	(0.004)	(0.006)	(0.004)
Cons	–0.289**	0.034**	–0.539**	–3.406**	(0.044)	–4.459**
	(0.134)	(0.226)	(0.165)	(0.398)	(0.587)	(0.497)
Trend	Yes	Yes	Yes	Yes	Yes	Yes
LR coefficient	–0.515	–0.571	–0.529	–0.191	–0.097	–0.198
Observations	3,962	1,166	2,796	2,148	607	1,557
R-squared	0.132	0.352	0.126	0.14	0.375	0.143

Note: Dependent variable: *Δly*; standard errors in parentheses; significance levels: ** p<0.01, * p<0.05, † p<0.1; all standard errors reported are the normal standard errors.

Table 2 shows results for the full sample for the complete period, 1960–2014 in column 1. As in our 2015 study, the new estimations show a well-defined empirical model, with all the traditional growth variables statistically significant and of the expected signs. The change in log capital (*Δlk*) is positive and statistically significant, the log of the population growth rate (+ 0.05) is negative and statistically significant, and the long-run coefficient of military spending is negative, statistically significant, and almost three times larger than that found in our 2015 study.

Our 2015 study was also concerned with possible group heterogeneity and thus divided the sample into developed and developing countries. The results are similar, but while military spending in the long-run was insignificant for the developing country group (Table 3, column 5), this was not the case for the extended time period (column 2). In our new study reported here, military expenditure exerts statistically significant negative effects on per capita GDP growth for both the long and the short-run, and with generally larger coefficients.

Another issue addressed in our previous paper concerned the possibility of heterogeneity across income levels, maybe in the form of a nonlinear relation. Table 4 (next page) shows the estimation results when the countries were stratified into different income groups, low, middle, and high. Once again, the empirical growth model is generally well-specified for the extended sample, with coefficients of the expected sign. For all three income groups, the effect of military expenditure on growth is negative and statistically significant, both in the short and long-run. The main differences between the new and old data periods (i.e., 1960–2014 as compared to 1988–2010) are the size of the coefficients and the significant effect found for middle-income countries. For low-income countries, military expenditure had a larger negative coefficient in the earlier study, but for medium and high-income countries, the new estimates suggest the opposite. As for Table 3, the long-run coefficients for the 1960 to 2014 dataset shows military expenditure to have a substantially larger negative effect on growth than when the data is limited to 1988 to 2010.

Previous studies have found differences in the military spending–growth relation for countries in conflict and those that are not and this led us to stratify by conflict experience in our 2015 study. As with that study, the results in Table 5 do not support this. Irrespective of whether a country has experienced conflict, military expenditure exerts a statistically significant negative effect on economic growth in both the short and long-run and there is no difference when only countries that

Table 4: Growth effects of military expenditure—income stratifications

	1960–2014			*1988–2010*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Sample	*Low*	*Middle*	*High*	*Low*	*Middle*	*High*
Variables	*Δly*	*Δly*	*Δly*	*Δly*	*Δly*	*Δly*
Δlk	0.050**	0.139**	0.144**	0.003	0.163**	0.112**
	(0.007)	(0.010)	(0.010)	(0.010)	(0.011)	(0.013)
Δlm	–0.011*	–0.047**	–0.092**	–0.034**	–0.019**	–0.025**
	(0.005)	(0.007)	(0.009)	(0.009)	(0.008)	(0.007)
lngdpop	0.079**	–0.136**	0.062**	–0.026**	(0.021)	–0.083**
	(0.007)	(0.020)	(0.008)	(0.015)	(0.022)	(0.010)
ly1	–0.030**	–0.037**	–0.018**	–0.093**	–0.092**	–0.082**
	(0.006)	(0.007)	(0.004)	(0.013)	(0.013)	(0.013)
lk1	0.027**	0.034**	0.010*	0.014†	0.043**	0.021*
	(0.004)	(0.007)	(0.005)	(0.008)	(0.009)	(0.010)
lm1	–0.016**	–0.018**	–0.023**	–0.027**	(0.005)	–0.020**
	(0.003)	(0.003)	(0.004)	(0.006)	(0.006)	(0.007)
Cons	–0.968**	0.718**	1.122**	–4.455**	–5.476**	(0.609)
	(0.209)	(0.296)	(0.261)	(0.673)	(0.790)	(0.635)
Trend	Yes	Yes	Yes	Yes	Yes	Yes
LR coefficient	–0.533	–0.486	–0.529	–0.29	–0.054	–0.244
Observations	1,485	1,081	1,396	831	638	695
R-squared	0.178	0.219	0.279	0.128	0.345	0.257

Note: Dependent variable: *Δly*; standard errors in parentheses; significance levels: ** p<0.01, * p<0.05, † p<0.1; all standard errors reported are the normal standard errors.

have experienced civil conflict are selected (columns 3 and 6). While our 2015 study found military spending to be marginally more harmful for countries in conflict as compared to those not in conflict, with the extended data, military spending in nonconflict countries has a higher adverse effect. Warranting further investigation, this is an intriguing result which points to the potential role that security plays in the military expenditure–economic growth relation.[9]

Finally, Table 6 shows the results across countries with differences in natural resource abundance, ODA receipts, and political institutions. Since the coefficients of the general Solow control variables remained consistent throughout these stratifications, only the coefficients of interest—military spending in the short and long-run—are reported. For natural resource dependence, the UNCTADstat data were used to divide the full sample into 37 resource dependent countries and 60 that are not. As in our 2015 study, military expenditure has negative, statistically significant short and long-run effects on growth. Once more, the coefficients are more negative when the extended data series is used. The results also suggest that military expenditure has negative, statistically significant short and long-run effects on per capita GDP growth, irrespective of whether a country receives foreign development aid or not. Finally, in regard to political institutions, use of the new SIPRI data suggests that economic growth is hampered in countries with all types of political institutions, albeit with the largest impact occurring for intermediate or transitional states.

All in all, with more than 20 stratification runs, the empirical result is clear. Irrespective of country subgroups or sample periods, military expenditure consistently exerts an adverse effect on economic growth and adding the new data points to our study only strengthens this conclusion.

Conclusion

Due to the important influence such spending has on security and the potential for violent conflict, the economic impact of military spending on economic growth is a question of great concern to developed and developing countries alike. The launch of the revised and extended SIPRI data provides a valuable means of checking the robustness of prior research findings. This article reestimated the empirical models of our 2015 study, which used data for 1988-2010, with the extended data for 1960–2014. Given the running down of the cold war confrontation in the mid-1980s, this could be considered as adding in cold war-period data points. Our results suggest no evidence of a structural break in the time series and generally

Table 5: Growth effects of military expenditure—conflict stratifications

	1960–2014			*1988–2010*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Sample	*Conflict*	*Nonconflict*	*Civil conflict*	*Conflict*	*Nonconflict*	*Civil conflict*
Variables	*Δly*	*Δly*	*Δly*	*Δly*	*Δly*	*Δly*
Δlk	0.086**	0.083**	0.082**	0.045**	0.087**	0.046**
	(0.008)	(0.006)	(0.008)	(0.010)	(0.008)	(0.010)
Δlm	–0.023*	–0.040**	–0.022**	–0.028**	–0.025**	–0.027**
	(0.006)	(0.005)	(0.006)	(0.007)	(0.007)	(0.008)
lngdpop	0.060**	–0.047**	0.066**	–0.036**	–0.075**	–0.029**
	(0.007)	(0.008)	(0.008)	(0.013)	(0.012)	(0.014)
ly1	–0.040**	–0.029**	–0.038**	–0.118**	–0.067**	–0.107**
	(0.006)	(0.003)	(0.006)	(0.013)	(0.009)	(0.014)
lk1	0.039**	0.023**	0.037**	0.030**	0.029**	0.029*
	(0.005)	(0.003)	(0.005)	(0.008)	(0.006)	(0.009)
lm1	–0.015**	–0.022**	–0.017**	–0.021**	–0.018**	–0.019**
	(0.003)	(0.002)	(0.003)	(0.005)	(0.005)	(0.005)
Cons	–0.766**	0.348**	–0.824**	–5.897**	–1.450**	–5.998**
	(0.216)	(0.189)	(0.231)	(0.606)	(0.550)	(0.678)
Trend	Yes	Yes	Yes	Yes	Yes	Yes
LR coefficient	–0.385	–0.759	–0.447	–0.178	–0.269	–0.178
Observations	1,632	2,330	1,472	775	1,389	695
R-squared	0.159	0.156	0.166	0.193	0.138	0.257

Note: Dependent variable: *Δly*; standard errors in parentheses; significance levels: ** p<0.01, * p<0.05, † p<0.1; all standard errors reported are the normal standard errors.

Table 6: Growth effects of military expenditure—other stratifications

	1960–2014			*1988–2010*		
Sample	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Variables	*Δlm*	*lm1*	*LR coeff.*	*Δlm*	*lm1*	*LR coeff.*
Nat. resource	-0.026**	-0.022*	-0.361	-0.021**	-0.011*	-0.083
No nat. resource	-0.041**	-0.015**	-0.600	-0.028**	-0.021**	-0.328
ODA	-0.024**	-0.017**	-0.548	-0.028**	-0.018**	-0.170
No ODA	-0.092**	-0.024**	-1.412	-0.023**	-0.016*	-0.246
Autocratic	-0.026*	-0.022**	-0.333	-0.027†	-0.008	-0.114
Intermediate	-0.038**	-0.024**	-0.414	-0.052**	-0.041**	-0.318
Democratic	-0.031**	-0.014**	-0.666	-0.012*	-0.008*	-0.113

Note: Dependent variable: *Δly*; standard errors in parentheses; significance levels: ** p<0.01, * p<0.05, † p<0.1.

give consistent findings across the two samples, with military spending exerting clear, strong, and uniformly negative short and long-run effects on growth, and especially so over the longer time period. Consistent across sample stratifications, this provides further evidence of the robustness of the results already found for the more limited time series: In general, military spending has a negative effect on economic growth.

Notes

1. Consistent data: See Perlo-Freeman and Skons (2016). Limited coverage: Dunne and Tian, (2013).

2. Early studies: See, e.g., Ram (1995); Dunne (1996); Smith (2000). Later studies: See, e.g., Dunne and Tian (2013); Alexander (2013); Compton and Paterson (2015). Changes in geopolitical environment: SIPRI (2014). Diverting resources have been found: Gleditsch, *et al*. (1996).

3. Our previous study: Dunne and Tian (2015).

4. Our recent survey pieces: Dunne and Tian (2013; 2015). Earlier surveys: Dunne (1996); Smith (2000). Vested interests: Dunne (1996). Opportunity costs: Dunne, Smith, and Willenbockel (2005).

5. Seminal work: Benoit (1973). Earlier suggestion: Dunne and Uye (2010). Meta analysis: Alptekin and Levine (2012).

6. Dunne, Smith, and Willenbockel (2015); Dunne and Tian (2015).

7. Natural resource-abundance data: Haglund (2011); UNCTADstat database: http://unctadstat.unctad.org/EN/.

8. See Dunne and Tian (2015) for a full description of the various indicator variables.

9. Previous studies: Smaldone (2006).

References

Alexander, W.R.J. 2013. "Military Spending and Economic Growth in South Asia: Comment and Reconsideration." *Defence and Peace Economics*. Vol. 24, No. 2, pp. 173–178. http://dx.doi.org/10.1080/10242694.2012.679832

Alptekin, A. and P. Levine. 2012. "Military Expenditure and Economic Growth: A Meta-Analysis." *European Journal of Political Economy*. Vol. 28, No. 4, pp. 636–650. http://dx.doi.org/10.1016/j.ejpoleco.2012.07.002

Benoit, E. 1973. *Defense and Growth in Developing Countries*. Boston: Lexington Books.

Compton, R.A. and B. Paterson. 2015. "Military Spending and Growth: The Role of Institutions." *Defence and Peace Economics*. Vol. 27, No. 2, pp. 301–322.

Dunne, J.P. 1996. "Economic Effects of Military Expenditure in Developing Countries: A Survey," pp. 439–464 in N.P. Gleditsch, A. Cappelen, O. Bjerkholt, R.P. Smith, and J.P. Dunne, eds. *The Peace Dividend*. Amsterdam: North Holland. http://dx.doi.org/10.1108/S0573-8555(1996)0000235025

Dunne, J.P., R.P. Smith, D. Willenbockel. 2005. "Models of Military Expenditure and Growth: A Critical Review." *Defence and Peace Economics*. Vol. 16, No. 6, pp. 449–461. http://dx.doi.org/10.1080/10242690500167791

Dunne, J.P. and M. Uye. 2010. "Military Spending and Development," pp. 293–305 in A. Tan, ed. *The Global Arms Trade: A Handbook*. London: Europa/Routledge.

Dunne, J.P. and N. Tian. 2013. "Military Expenditure and Economic Growth: A Survey." *Economics of Peace and Security Journal*. Vol. 8, No. 1, pp. 5–11. http://dx.doi.org/10.15355/epsj.8.1.5

Dunne, J.P. and N. Tian. 2015. "Military Expenditure, Economic Growth and Heterogeneity." *Defence and Peace Economics*. Vol. 26, No. 1, pp. 15–31. http://dx.doi.org/10.15355/epsj.8.1.5

Gleditsch, N.P., A. Cappelen, O. Bjerkholt, R.P. Smith, and J.P. Dunne. 1996. *The Peace Dividend*. Amsterdam: North Holland. http://dx.doi.org/10.1108/S0573-8555(1996)235

Perlo-Freeman, S. and E. Sköns. 2016. "Snakes and Ladders: The Development and Multiple Reconstructions of the Stockholm International Peace Research Institute's Military Expenditure Data." *Economics of Peace and Security Journal*. Vol. 11, No. 2, pp. 5–13. http://dx.doi.org/10.15355/epsj.11.2.5

Ram, R. 1995. "Defense Expenditure and Economic Growth," pp. 251–273 in K. Hartley and T. Sandler, eds. *Handbook of Defense Economics*. Vol. 1 Amsterdam: Elsevier. http://dx.doi.org/10.1016/S1574-0013(05)80012-2

Smaldone, J.P. 2006 "African Military Spending: Defense versus Development?" *African Security Review*. Vol. 15, No. 4, pp. 18–32. http://dx.doi.org/10.1080/10246029.2006.9627618

Smith, R.P. 2000. "Defense Expenditure and Economic Growth," pp. 15–24 in N.P. Gleditsch, G. Lindgre, N. Mouhleb, S. Smit, and I. de Soysa, eds. *Making Peace Pay: A Bibliography on Disarmament and Conversion*. Claremont, CA: Regina Books.

[SIPRI] Stockholm International Peace Research Institute. 2014. *SIPRI Yearbook 2014: Armaments, Disarmament and International Security*. Oxford, UK: Oxford University Press.

THE ECONOMICS OF PEACE AND SECURITY JOURNAL

A journal of Economists for Peace and Security

VOL. 11, NO. 2 (2016)

SYMPOSIUM: SIPRI'S EXTENDED MILITARY EXPENDITURE DATA