

# Sources, Data, and Methods of WMEAT 2021

*This section describes the sources and characteristics of data used in this edition of WMEAT, the methods by which those data are used to produce numeric values, and the rationales for those methods. WMEAT figures, especially for armed forces personnel, military expenditures, and arms transfers, are neither so accurate nor so reliable as uniform presentation in statistical tables might seem to imply, due to incompleteness, ambiguity, or total absence of data for some countries either in those parameters or in parameters such as GDP price deflators or rates used in Table I to convert national-currency-denominated values to US dollars.*

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## Time period covered

This edition of *World Military Expenditures and Arms Transfers (WMEAT)* takes its title year from the year of its preparation rather than most recent year covered. *WMEAT 2021* presents annual data for the 11-year period 2009 – 2021.<sup>1</sup> [WMEAT 2019](#), covering 2007 – 2017 and prepared in 2019, was the most recent previous edition. Each annual edition of WMEAT is now published with a two-year lag between most recent year covered and year of publication. Since for most parameters covered, including such non-military parameters as GDP and total exports or imports, final data for any year generally remain unavailable until two years later, figures for the most recent year covered may be less accurate and more likely to be revised in the next edition of WMEAT than are figures for the ten earlier years covered.

## New features in this edition

*WMEAT 2021* retains the format, data sourcing, and methods of *WMEAT 2021*, except that U.N. Statistical Division data as reported by the World Bank's WDI database replace the US Census Bureau's International Database (IDB) as the source of WMEAT's population data because IDB data is no longer published in a conveniently accessible format. However, due to impediments posed by responses to the coronavirus 2019 pandemic:

- no 2020 edition of WMEAT was published; and
- in WMEAT 2021, figures for the last two years covered, in particular 2019, tend to be informed by less complete data and may be less accurate than figures for earlier years covered, to an extent greater than in previous editions of WMEAT.

Revision of data from external sources routinely changes WMEAT figures across editions of WMEAT. Updated source data for population, labor force, GDP in both current and constant currency terms, currency conversion rates, goods and services trade, and for some arms transfers, are downloaded into each recent edition of WMEAT. In addition, improved or previously unknown or unavailable source data or contextual data may warrant revision of WMEAT figures for armed forces personnel, military expenditure, or arms transfers from one edition to the next.

## Scope of coverage

The statistical tables in *WMEAT 2021* present 2007-2017 figures for 170 countries, including 168 of the 193 [members of the United Nations](#) as of mid-2019, as

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<sup>1</sup> Figures reported are either for the calendar year or for the fiscal year, the most days of which occur in the indicated calendar year.

well as Taiwan and Kosovo.<sup>2</sup> In 2019, these 170 countries accounted for more than 99.7% of the global population of 7.65 billion (as estimated by the U.N. Statistics Division per the World Bank's WDI database, data series "SP.POP.TOTL") and about 99.3% of the global GDP of \$87.734 trillion at market exchange rates (as estimated in the World Bank's WDI database, data series "NY.GDP.MKTP.CD").<sup>3</sup> U.N. members not covered are generally small and not militarily significant; relevant source data for them are often unavailable.<sup>4</sup> Sub-national groups and non-state entities are not covered with respect to any military parameter.

In Table I (military expenditures), the term "*world*" refers to the sum of the countries covered. In Tables II, III, and IV (arms transfers), the term "world" refers to all trade among identifiable specific countries covered by WMEAT or between such countries and "unspecified or multinational" entities; trade known to be to and/or from specific countries not covered by WMEAT is excluded. Excluded arms trade (mostly U.S. arms exports) is of relatively small magnitude – not more than 1.5% of the world total for any year covered and less than 1% of the world total for the 11-year period. As the arms transfer tables jointly indicate, arms transfers to "unspecified and multinational" entities have been chiefly U.S. exports; the growth in the value of such transfers in recent years is due chiefly to increasing U.S. commercial arms exports to destinations identified only as "various" by the U.S. licensing authority.<sup>5</sup>

## Country groupings

This edition of WMEAT groups countries into *geographic, political, and economic groups* for purposes of statistical analyses.

In every edition of WMEAT, countries have been assigned to *geographic groups*. Since *WMEAT 2005*, WMEAT has assigned European countries to either of two groups that are not strictly regional, namely the *European Union* and *Non-EU Europe*. In *WMEAT 2021*, this is done on the basis of [EU membership](#) as of the end of 2019. The

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<sup>2</sup> Hong Kong and Macau are treated as part of China. WMEAT global export and import values for China are obtained by adding the global exports or imports of China, Hong Kong, and Macau, without subtracting trade among these three entities.

<sup>3</sup> All WDI data used in preparing *WMEAT 2021* are from the [WDI database](#) posted online as of April 2021.

<sup>4</sup> The UN members as of mid-2019 that are not covered by WMEAT are: Andorra, Antigua and Barbuda, the Bahamas, Comoros, Dominica, Grenada, Kiribati, Liechtenstein, Maldives, Marshall Islands, Micronesia, Monaco, Nauru, Palau, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, San Marino, Sao Tome and Principe, Seychelles, Solomon Islands, Tonga, Tuvalu, and Vanuatu. Also omitted or not entered as distinct entities are: The Holy See; the West Bank and Gaza; the territory with unresolved sovereignty of Western Sahara; and [dependencies and areas of special sovereignty](#) including Bermuda, Hong Kong, Macau, Puerto Rico, and many small islands.

<sup>5</sup> Destinations of U.S. commercial arms exports licensed by the Directorate of Defense Trade Controls (DDTC) are reported by DDTC in its annual "[Section 655](#)" reports.

geographic group to which each country is assigned is indicated both on the Table of Contents page and at the top of each country page in Table I (the military expenditures table), as well in Table III (an arms transfers table). The geographic groupings of countries in *WMEAT 2021* are identical in composition to those in *WMEAT 2019*; the UK's withdrawal from the EU did not take effect until January 2020.

This edition continues the practice, innovated in *WMEAT 2012*, of assigning countries to *political groups* that are *quintiles of world population ranked by NGO-assessed country political scores*. The two sets of NGO country scores used for this purpose are: (1) the “[political rights](#)” (PR) scores assigned to countries by Freedom House (FH) in the course of producing its annual *Freedom in the World* report (although published separately from that report), which range in integers from -3 (worst) to 40 (best), a 44-point scale; and (2) the “[voice and accountability](#)” (V&A) scores assigned annually to countries by The World Bank Institute (WBI), the observed range of which is from about -2.30 (worst) to about +1.85 (best).<sup>6</sup> All such scores assigned to a country during the period covered are recorded on the country page of Table I (rows 96 and 97). FH:PR and WBI:V&A country rankings have regressed on each other with a slope of about one, a high correlation, and a low standard error; they may be interpreted as two measurements of roughly the same thing, perhaps most simply described as the extent to which a country's political structure is democratic.<sup>7</sup> To create an 11-year-mean political ranking for countries, WMEAT makes separate 11-year FH:PR and WBI:V&A country rankings based on average country scores during the 11 years covered, then averages the 11-year-mean FH:PR and WBI:V&A rankings, weighting each by the number of annual observations available.<sup>8</sup>

This edition also continues the practice, innovated in *WMEAT 2012*, of assigning countries to *economic groups* that are *quintiles of world population ranked by national gross domestic product (GDP) per capita*, sourced chiefly from the World Bank's [WDI database](#). Two sets of such quintiles are offered. One, indicated by headings in **green** typeface, is based on GDP converted to U.S. dollars at a real market exchange rate

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<sup>6</sup> Political scores assigned to countries by these NGOs have been used for purposes of determining country eligibility for Millennium Challenge assistance, consistent with section 607 of the Millennium Challenge Act of 2003 (MCA), title VI of Division D of [PL 108-199](#), the Consolidated Appropriations Act, 2004 [118 Stat. 215], enacted Jan. 23, 2004, as amended, codified as 22 USC 770, which requires use of “objective and quantifiable indicators of a country's commitment to ... just and democratic government.”

<sup>7</sup> FH's PR scores are only half the basis for its overall *Freedom in the World* country rankings; the other half is “civil liberties” scores. – Article IV, Section 10, of the IBRD's Articles of Agreement, a prohibition on political activity, has been so interpreted by World Bank General Counsel as to lead the Bank to avoid using the word “democracy,” and to prefer instead terms like “voice and accountability in governance.” See, for example, Ibrahim F.I. Shihata, “[Prohibition of Political Activities in the Bank's Work](#),” Legal Opinion by the Senior Vice President & General Counsel,” July 12, 1995.

<sup>8</sup> The way in which WMEAT combines FH:PR and WBI:V&A results is entirely ordinal, not cardinal. A country's FH:PR or WBI:V&A ranking is its score-ordered position in a roster of WMEAT-covered countries. Given that WMEAT now covers 170 countries, the range is 1 to 170 for both FH:PR and WBI:V&A. Alphabetical ordering of country names is used to break ties.

(MER), based on the mean of all 11 year-average market exchange rates, assigned to the mid-period (sixth) year.<sup>9</sup> The other, indicated by headings in **dark red** typeface, is based on GDP converted to U.S. dollars at purchasing power parity (PPP).<sup>10</sup> The quintile of world population to which a country is assigned may vary depending on which conversion method is used.

Among the advantages of using world population quintiles for political and economic groups is that all such groups contain the same number of people. This facilitates comparison among groups and obviates conversion of group values to per capita values. As with any country groupings, the group positioning of such demographic and economic behemoths as China, India, and the U.S. greatly influences the relative values of the groups in many parameters.

In the arms transfer tables of all editions of WMEAT, a country-group's exports and imports, both of arms and of all goods (and, since *WMEAT 2005*, of all services), includes trade between states within a geographic, economic, or political group; *i.e.*, trade values of groups of countries are “gross” rather than “net” of intra-group trade.

- For example: an export from France to Belgium is counted both as an EU export and as an EU import. An export from the U.S. to Germany is counted both as an export and as an import of the group of countries that make up the richest quintile of world population, based on national GDP per capita. An export from the U.S. to Germany is counted both as an export and as an import of the group of countries that make up the most democratically governed quintile of world population.
- For most groups, goods and services trade net of intra-group trade cannot readily be evaluated, because no adequate worldwide data for trade in all goods and services, disaggregated by country of destination and well as country of origin, are readily available; *WMEAT* presents regional arms trade data in “gross” form comparable with that of regional total trade data.
- The proportion by which a group’s “gross” trade exceeds its trade net of intra-group trade tends to increase with the number of states in the group; *e.g.*, it is likely to be greater for the EU than for North America. It also tends to be greater for richer groups than for poorer groups, *i.e.*, it is likely to be greater for Europe than for Africa. However, a group’s trade balance (surplus or deficit), either for the arms trade or for trade in all goods and services, is the same whether calculated “gross” or net of intra-regional trade.

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<sup>9</sup> That is, it is based on GDP converted to U.S. dollars using currency conversion **Method 3**, described [below](#) in the subsection titled, “Methods of converting military expenditures and GDP to U.S. dollars.”

<sup>10</sup> That is, it is based on GDP converted to U.S. dollars using currency conversion **Method 4**, described [below](#) in the subsection titled, “Methods of converting military expenditures and GDP to U.S. dollars.”

## Parameters covered: definitions and data sources

Table I reports figures in two military parameters – *armed forces* and *military expenditures*. It also reports *population* and *labor force* as comparators to the number of armed forces personnel and *gross domestic product (GDP)* as a comparator to military expenditures. The figures are expressed in three ways:

- as numbers of people for the *demographic* parameters of *armed forces*, *population*, and *labor force*.
- as monetary values for the *economic* parameters, *military expenditures*, and *GDP*, which WMEAT seeks to source in local currency terms, although it must convert national-currency-denominated values to U.S. dollars in order to aggregate them across countries with diverse local currencies; and
- in percentage or multiple terms for ratios of the military and comparator figures.

Tables II, III, and IV report figures in one military parameter, *arms transfers* delivered, including arms exports, arms imports, and arms trade balance. Table II also reports *total trade in goods and services*, including total goods and services exports and imports and the balance of total trade in goods and services, as a comparator to arms transfers. Both arms transfers and total trade in goods and services are reported not only by WMEAT but also by WMEAT's data sources in U.S. dollar terms. In addition:

- Table II reports ratios between arms transfers and total trade in percentage terms;
- Sub-table II.f reports the ratio of the value of a country's arms exports to the values of its arms imports in numerical terms; and
- Sub-table IV.c reports arms transfers as percentages of the world arms trade.

### *Armed forces*

Armed forces figures, given in Table I, enumerate active-duty military personnel. Reserve forces are included only insofar as activated. Non-state armed groups – *e.g.*, Hezbollah in Lebanon, the Taliban in Afghanistan, Boko Haram in Nigeria, and ISIL in Syria and Iraq – generally are excluded.

Figures for total armed forces personnel for all [NATO member countries](#) including the *United States* are as reported on the [Information on defence expenditures](#) page of the NATO website.<sup>11</sup> Although *Iceland* has paramilitary forces, WMEAT

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<sup>11</sup> In 2004, NATO members agreed to change NATO's definitions of defense personnel and expenditures to exclude paramilitary forces that cannot realistically be deployed for military missions and expenditures for such forces. Consequently, NATO and WMEAT figures for the military personnel and expenditures of some NATO member states to exclude expenditures for forces, *e.g.*, France's *gendarmerie*, that are included in some other published figures for those countries' military personnel and spending.

reports it as having no armed forces or military expenditures because NATO reports it as having none.<sup>12</sup>

On each country page of Table I (rows 17-22), the total armed forces personnel of each country covered is disaggregated by service, into army, navy, air force, other regular forces (including but not limited to joint forces and uniformed support forces), and paramilitary or irregular forces. Service figures may not sum to total armed forces personnel figures due to rounding, especially for single years, for which rounding is greater than for 11-year period averages.

No disaggregation of armed forces personnel is offered for geographic, economic, or political groups of countries, because country breakdowns of armed forces personnel by service vary too greatly to permit meaningful cross-country aggregation. Across countries, available data sources are not consistent, nor is this edition of WMEAT consistent, with respect to: whether air defense personnel are included in land forces, the air force, or other regular forces; whether marines are included in land forces, naval forces, or other regular forces; and whether uniformed medical, logistical, and administrative personnel are assigned to distinct services or considered joint forces.

WMEAT's estimates of the total number of armed forces personnel for non-NATO countries, and of armed forces personnel by service for all countries, are informed by on public sources including: national publications and websites; the IISS's [Military Balance](#); the [Defence Data Portal](#) of the European Defence Agency (EDA) for non-NATO EDA member states; the country armed forces profiles on [defenceWeb](#) for African countries; media reports; and, for years before 2015, *Jane's World Armies*, *Jane's World Navies*, *Jane's World Air Forces* and the "Armed Forces," "Army," "Navy," "Air Force" and "Security and Foreign Forces" sections of *Jane's Sentinel Security Assessments*, although Jane's information is no longer accessible to WMEAT due to U.S. Government economy measures. For years before 2015, WMEAT's estimates of the total number of armed forces personnel for non-NATO countries, and of armed forces personnel by service for all countries, are also informed by no-longer available data resources of U.S. Government agencies.

WMEAT seeks, insofar as available data permit, to report the number of active-duty armed forces members on payroll, not the (often higher) number authorized by law or the number physically present or effective (often lower due to corruption or chronic disease).

Whether paramilitary forces are included is guided by NATO accounting principles, insofar as available data permit; in principle, it depends on the extent to which such forces are capable of performing the function of the regular armed forces. In NATO contexts this generally depends on whether a paramilitary force is capable of performing

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<sup>12</sup> By contrast, WMEAT counts as armed forces the paramilitary forces of non-NATO countries, such as Costa Rica, Haiti, and Panama, that have had no other armed forces during all or some of the period covered; WMEAT also counts outlays for these forces as military expenditures.

an external defense mission. However, in non-NATO contexts, this may depend largely on the extent to which the mission of the regular armed forces is external. Insofar as the mission of the regular armed forces is not external defense (*e.g.*, is internal security or narcotics trade suppression), paramilitary forces may appropriately be included in the armed forces, and expenditures on them may appropriately be included in military expenditures.<sup>13</sup> Data to implement these criteria accurately and consistently are lacking for many countries. Nevertheless, this approach tends to increase the armed forces personnel of less democratic states relative to those of more democratic states.

In this edition of WMEAT, known inclusion of paramilitary forces in WMEAT's armed forces personnel figures is noted in country notes (around row 185) on the country page in Table I. Absence of any note implies that only regular military forces are believed to be included.

Figures for armed forces routinely include, insofar as available data permit, any praetorian guard force – diversely called the presidential, royal, “republican,” or “national” guard or “state security” forces – distinct from the regular armed forces. Since the purpose of keeping such praetorian forces organizationally distinct from the regular armed forces is generally to forestall *coups d'état* by the latter, such guard forces generally tend to be at least as capable militarily as army units of similar size.

### Population

The population figures in all editions of WMEAT are for total population at mid-year. In this edition of WMEAT, population figures for nearly all countries are sourced from the U.N. Statistical Division via the World Bank's [WDI database](#) [data series “SP.POP.TOTL”].<sup>14</sup> For the few countries for which the World Bank offers no population data, WMEAT obtains such data from national government statistical publications.

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<sup>13</sup> In applying to non-NATO countries NATO criteria for including paramilitary internal-security forces and related expenditures in armed forces and military expenditures, WMEAT is guided in large part by whether the organization, recruitment, equipment, training, and deployment of the regular armed forces indicate that their mission is internal rather than external. Countries with high NGO-assigned democracy scores generally (absent counter-narcotics use of the military) have externally-oriented militaries. However, some countries with low NGO-assigned democracy scores have militaries with chiefly external missions, in addition to paramilitary internal security forces; *China* and *North Korea* are examples.

<sup>14</sup> However, this edition of WMEAT uses population and labor force figures for *Cyprus* that exclude the area of the so-called “Turkish Republic of Northern Cyprus.” It also estimates the population of *Burma* as substantially less than reported by the IDB, and its labor force as being substantially less than reported by the World Bank, for reasons stated in American Embassy Rangoon's 1997 [Foreign Economic Trends: Burma](#) report, page 99 (note 51). That 1997 prediction appears to have been substantially validated by the results of Burma's 2014 census; see Thomas Spoorenberg, “Provisional results of the 2014 census of Myanmar: the surprise that wasn't,” *Asian Population Studies* 11/1 (2015): 4–6.



### *Labor force*

This edition of WMEAT continues the practice, innovated in *WMEAT 2012*, of presenting labor force data in Table I, both on each country page and the world pages. It does so for several reasons:

- For many purposes, including assessing the labor-intensivity of the armed forces relative to the labor-intensivity of the economy as a whole,<sup>15</sup> labor force size is a better demographic comparator to armed forces personnel than is population.
- Labor force as a share of population varies greatly across countries.
- Labor force as a share of population is changing in novel ways in many countries, due either to entry of women into the workforce or to historically unprecedented fertility rate declines and resulting changes in population age structures.

For nearly all countries, the labor force data are taken from the World Bank's [WDI database](#) [data series "SL.TLF.TOTL.IN"]. For the few countries for which the World Bank offers no labor force data, WMEAT either obtains such data from national government statistical publications.

### *Military expenditures*

Insofar as possible, WMEAT reports military expenditures on the basis of outlays or disbursements, in contrast to proposed or approved budgetary allocations or "obligational authority," although source data of the latter types are used when disbursements-basis expenditure data are unavailable.

Insofar as possible given data quality constraints, WMEAT reporting of military expenditures attempts to follow the NATO definition. In this definition, (a) civilian-type expenditures of the defense ministry are excluded and military-type expenditures of other ministries are included; (b) grant military assistance is included in the expenditures of the donor country; and (c) purchases of military equipment on credit are included at the time the debt is incurred, not at the time of payment.<sup>16</sup> Nevertheless, for many non-NATO countries, available data are insufficient to operationalize the NATO definition accurately or even consistently. For [NATO member countries](#), the national-currency military

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<sup>15</sup> This assessment not only is interesting in itself, but also is part of this edition of WMEAT's effort to estimate, albeit notionally, a defense-sector-specific PPP rate, used in currency conversion [Method 5](#), described [below](#) in the subsection titled, "Methods of converting military expenditures and GDP to U.S. dollars."

<sup>16</sup> To operationalize the NATO definition of military expenditures meaningfully would require detailed knowledge of the financing terms of arms transfers. The value of an arms transfer should be credited to the military expenditures of the exporting country rather than the importing country insofar as it is grant financed. However, arms transfers are often financed both preferentially and opaquely, and the "grant element" percentage of a preferential loan depends on characteristics, like grace periods and contract interest rates relative to default-risk-adjusted market interest rates, that frequently are not readily observable in the arms trade.

expenditure figures reported by WMEAT are sourced from the [Information on defence expenditures](#) page of the NATO website.<sup>17</sup>

WMEAT's estimates of the military expenditures of non-NATO countries are informed by a variety of sources including: national government publications and websites; standardized annual "Vienna Document" reporting to the [Forum for Security Cooperation](#) (FSC) of the Organization for Security and Co-operation in Europe (OSCE) by OSCE member states (obligatory but not publicly available); other international-organization reports; and data resources of U.S. government agencies. For years since 2010, WMEAT has ceased to consult the [military expenditures database](#) of the U.N. Office of Disarmament Affairs due to inaccuracies in that database's posting of data provided by member states.

Other published sources used to evaluate military spending include the [Government Finance Statistics](#) issued by the International Monetary Fund (IMF/GFS); the [SIPRI Military Expenditure Database](#), issued annually by the Stockholm International Peace Research Institute; [The Military Balance](#), issued annually by the International Institute for Strategic Studies (IISS, in London); the EDA's [Defence Data Portal](#) for non-NATO EDA member states; the country armed forces profiles on [defenceWeb](#) for sub-Saharan African countries; media reports; and, for years before 2015, *Jane's Defence Budgets* and the "Defence Budget" sections of Jane's *Sentinel Security Assessments*, although WMEAT no longer has access to Jane's information due to U.S. Government economy measures.

In Table I, *the military expenditure values are of uneven accuracy and completeness*. For some countries, only an aggregate defense budget figure is available, what it includes and excludes sometimes being unclear. Sometimes, the only version of the defense budget figure is proposal- or authorizations-basis rather than disbursements basis. For some countries, available data are known or believed to omit military pensions, capital expenditures, or arms purchases, the magnitude of which may or may not be known or estimable. No rigorous and consistent way of rectifying these data defects is apparent. For example, even if it is known certainly that a country's reported military expenditures omit all arms imports, it is seldom possible to obtain an estimate of military expenditures that is consistent with the NATO definition simply by adding the value of the country's arms imports (as shown in Table II). As previously noted,<sup>18</sup> the proportion of the value of arms imports that should be added depends on the "grant element" proportion of the arms transfer financing, which often is not readily observable.

Government practices that obscure the magnitude of such expenditures include double-bookkeeping, use of extra-budgetary accounts, highly aggregated budget categories, opacity of military assistance or of arms transfer financing, repression or manipulation of foreign exchange markets, and use of inoperative exchange rates for national accounting. In some cases these practices appear intended to obscure the magnitude of military spending; in other cases, they merely have that effect. Although all

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<sup>17</sup> See notes 11 and 12, above.

<sup>18</sup> See note 16, above.

governments have incentives to conceal some military spending from potential foes, the more repressive of them may also have strong incentives to conceal much military spending from their own citizens, external creditors, and consumers of their exports. Casual observation suggests a broad and strong correlation across countries and over time between democratic accountability in governance and transparency of military expenditure. WMEAT's military expenditures estimates generally are more reliable for more developed countries with democratic governments.

For countries that may have major clandestine weapons development programs, evaluation of military expenditures is particularly difficult and liable to underestimation.

Evaluating the military expenditures of some countries, such as *North Korea*, is made difficult by the exceptional scarcity and ambiguity of released information. In such cases, WMEAT estimates are labeled with an [indicator of extraordinary uncertainty](#). In some such cases, country notes on the country page (following row 185) describe data problems and means used to cope with them.

WMEAT's estimates of military expenditures generally exclude those of non-state armed groups.

Whether expenditures for paramilitary forces are included is guided by NATO accounting principles; it depends on the extent to which such forces resemble regular military forces in their mission. Insofar as the organization, equipment, training, and deployment of the regular military forces indicate that their mission is not external defense (*e.g.*, is internal security or narcotics trade suppression), expenditures for paramilitary forces may appropriately be included in military expenditures, and expenditures on them may appropriately be included in military expenditures. Data to implement these criteria accurately and consistently are lacking for many countries.<sup>19</sup> Nevertheless, this approach tends to increase the military expenditures of less democratic states relative to those of more democratic states.

In this edition of WMEAT, known inclusion of spending on paramilitary forces in WMEAT military expenditure figures is noted in country notes of the country page (following row 185). Absence of any note implies that spending on paramilitary forces is not believed to be included.

Figures for military expenditures routinely include, insofar as available data permit, spending on praetorian guard forces that are distinct from the regular armed forces and serve chiefly to protect a ruler from them.

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<sup>19</sup> WMEAT attempts to include spending on paramilitary forces in its military expenditure figures if and only if such forces are included in its armed forces personnel figures. However, expenditure on internal security forces can be no less opaque than expenditure on regular armed forces. For some countries, the availability only of an aggregate "defense and security" budget authority figure forces a choice between either including all security forces in armed forces personnel or crudely estimating expenditures on forces selected for inclusion.

Disbursements of funds earned by participation in international peacekeeping activities are, insofar as possible, treated as military assistance, that is, included in the military expenditures of countries funding those activities.

### *Gross Domestic Product (GDP)*

GDP measures the final value of market-traded goods and services produced within the territory of a country, regardless of the nationality of the firms or individuals engaged in their production. WMEAT sources GDP data for most countries from the World Bank's [WDI database](#), which provides GDP figures in both current and constant local currency terms [WDI data series "NY.GDP.MKTP.CN" and "NY.GDP.MKTP.KN"].

For countries that are not members of the World Bank or have not reported GDP data to the World Bank, GDP values are obtained from sources including the [National Accounts Main Aggregates Database](#) of the U.N. Statistics Division and the [EIU Data Tool](#) service of the *Economist Intelligence Unit (EIU)*.

In this edition of WMEAT, GDP figures in current and constant local currency terms are presented on the country pages (rows 31 and 32) of Table I. Figures in black generally are sourced from the WDI database; figures in green or blue color-coding to indicate greater uncertainty are mostly sourced from the National Accounts Main Aggregates Database or the EIU Data Tool.

### *Arms transfers*

Arms transfers (arms imports and exports) represent the international transfer (under terms of grant, credit, barter, or cash) of military equipment and related services, including weapons of war, parts thereof, ammunition, support equipment, and other commodities designed for military use, as well as related services. Among the items included are tactical guided missiles and rockets, military aircraft, naval vessels, armored and non-armored military vehicles, communications and electronic equipment, artillery, infantry weapons, small arms, ammunition, other ordnance, parachutes, and uniforms. In principle, dual use equipment, which can have application in both military and civilian sectors, is included when its primary mission is identified as military. The building of defense production facilities and licensing fees paid as royalties for the production of military equipment, as well as equipment delivery, maintenance, operating, and training services, are included when they are contained in military transfer agreements. Military services such as training, supply, operations, equipment maintenance or repair, technical assistance, and construction are included where data are available.<sup>20</sup> Excluded are foodstuffs, medical equipment, petroleum products, and other supplies.

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<sup>20</sup> Services appear to constitute a growing and double-digit albeit uncertain percentage of the total value of global arms transfers. The services component of arms transfers seems particularly large in conjunction with transfers of technically sophisticated and complex equipment, especially to less developed countries.

The arms imports and exports statistics contained in Tables II, III, and IV are estimates of the value of goods and services actually delivered during the reference year(s), in contrast both to payments and to the value of programs, agreements, contracts, or orders concluded during the reference year(s). Deliveries data represent arms transfers only to governments or to entities (typically enterprises) authorized by their countries' governments to receive them.

International arms transfers disaggregated by weapons system rather than by monetary value as reported by a number of countries since 1991 are posted on the *United Nations Register of Conventional Arms* (UNROCA) database at <http://www.unroca.org>.

*U.S. arms exports* in WMEAT accounts include private (commercial) enterprise-to-government or enterprise-to-enterprise arms exports under the Direct Commercial Sales (DCS) program administered by the [Directorate of Defense Trade Controls](#) (DDTC) in the Bureau of Political-Military Affairs of the U.S. Department of State, pursuant to section 38 of the Arms Export Control Act, as amended (codified as [22 USC 2778](#)) as well as government-to-government transfers under programs administered by the Department of Defense (DOD) including: Foreign Military Sales (FMS) including Foreign Military Construction Sales (FMCS), drawdowns of non-excess DoD equipment stocks (Drawdowns); transfers of Excess Defense Articles (EDA); the Military Assistance Program (MAP), and International Military Education and Training (IMET), all administered by DoD's [Defense Security Cooperation Agency](#) (DSCA); and ship transfers, administered by the U.S. Navy through its [Program Executive Office, Ships](#) (PEOS) and the Ship Transfer Program Office of its [Naval Sea Systems Command](#) (NAVSEA), and "other programs."<sup>21</sup>

For years since 1996, principal sources for the value of U.S. arms exports, by year and country of destination, include three distinct annual publications, all published pursuant to Section 655 of the Foreign Assistance Act, as amended (in 1996), codified at [22 USC 2415](#):

– DDTC's "Section 655 Report," now published on the [news and events](#) page of DDTC's website. These reports have provided values for commercial arms exports licensed by DDTC, but not for DCS deliveries under exemptions from license requirements. For commercial exports of arms services, these reports have provided the value only of exports licensed, not the value of deliveries under those licenses. For commercial exports of arms articles (goods), these reports for fiscal years since 2008 have also provided values for shipments (deliveries) under DDTC license.

– The Department of State's annual *Congressional Budget Justification for Foreign Operations* (CBJFO, now accessible for 2001-2009 [here](#)) provided for years prior to 2007, typically in "Supporting Information" included in or appended to Part III, the value of article shipments under DDTC's DCS program. No such data for 2007 are known to have been published.

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<sup>21</sup> U.S. arms exports under "Other Programs," as described by pages of that title in the *DSCA Facts Book*, began in 2009, and have to date been chiefly to Afghanistan or Iraq.

– The *DSCA Historical Sales Book* (a.k.a. the *DSCA Historical Factsbook* or the *DSCA Facts Book*) published by DoD/DSCA, of which the most recent edition has been accessible on the [publications](#) page of DSCA’s website. The *DSCA Facts Book* has provided deliveries data for exports under FMS and FMCS, MAP drawdowns, IMET, and “other programs.” DSCA has stated in the notes to *Facts Books* that DoD considers IMET fully delivered when it is funded.

This edition of WMEAT estimates deliveries of Drawdowns using figures given in the “MAP Deliveries/Expenditures including MASF, emergency drawdowns, and other grant assistance” section of the *DSCA Facts Book*. Values for EDA deliveries are sourced from DSCA’s [EDA Database](#) using “current prices.”

Data for the value of U.S. ship transfer agreements and deliveries, not known to be published, are obtained from NAVSEA’s Ship Transfer Program Office.

The shipping terms on which the non-services components of U.S. arms exports are valued (*e.g.*, f.a.s., f.o.b. or c.i.f.) are not known to be consistent across the above-listed programs.

WMEAT’s values for U.S. arms exports substantially exceed those found in some other published sources<sup>22</sup> because WMEAT’s values do not exclude commercial arms exports under the DCS program, which appear to account for a preponderant and growing share of U.S. arms exports.<sup>23</sup>

For fiscal years 2005, 2006, and apparently 2008, the values for U.S. commercial export deliveries (shipments) of arms articles under the DCS program published by the above-referenced sources were based on exporter reporting to Customs and Border Protection (CBP) via the Automated Export System (AES).<sup>24</sup> This reporting was mandated by law in 1999 and implemented in FY 2004.<sup>25</sup> It was hoped that AES-based

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<sup>22</sup> *E.g.*, the Congressional Research Service’s report, [Conventional Arms Transfers to Developing Nations, 2008-2018](#) (CRS R44716, CATDN report), released 19 December 2016, which states, on page 17: “United States commercially licensed arms deliveries data are not included in this report. ... By excluding U.S. commercial licensed arms deliveries data, the U.S. arms delivery totals will be understated.”

<sup>23</sup> General Accountability Office report [GAO-10-952](#), “Defense Exports: Reporting on Exported Articles and Services Needs to Be Improved,” published September 2010, estimated that deliveries of DCS article exports under DDTC license constituted about 60% of all U.S. arms article (goods) export deliveries during 2005-2009. No published estimate of the DCS share of U.S. arms services export deliveries is known.

<sup>24</sup> The [CBJFO for FY 2007](#), page 627 (part III, Supporting Information: Commercial Exports Licensed or Approved Under the Arms Export Control Act), states: “The first column, entitled “Actual Deliveries (preliminary)” shows the preliminary dollar value totals by destination of exports during fiscal year 2005. These export totals ... are compiled from data found in the Automated Export System (AES).” Similarly, the [CBJFO for FY 2008](#), page 732 [same part, same section], states: “The first column, entitled “Actual Deliveries (preliminary)” shows the preliminary dollar value totals by destination of exports during fiscal year 2006. These export totals ... are compiled from data found in the Automated Export System (AES).”

<sup>25</sup> Section 1252, “Mandatory Use of the Automated Export System for Filing Certain Shippers’ Declarations” [113 Stat. 1501] of [PL 106-113](#), The Consolidated Appropriations Act for FY 2000, enacted

reporting might improve the quality of data on DCS articles export deliveries.<sup>26</sup> The AES-based values of DCS articles export deliveries for FYs 2005, 2006, and 2008 were roughly an order of magnitude greater than the annual values of DCS article export deliveries published by DDTC, which have also been roughly an order of magnitude smaller than the annual values of article export license authorizations published by DDTC. However, 2005, 2006, and 2008 are the only years for which AES-based data on the value of DCS articles deliveries have been published, although the statutory requirement that exporters of items on the U.S. Munitions List report such exports through AES appears to remain in effect (per note 25, above).

The AES-based value of DCS article export deliveries for 2005, 2006, and 2008 exceeded the value of DDTC license authorizations of DCS article exports in those years, in part because the AES reporting included exports under exemption from license requirement. On the other hand, DDTC's commercial arms export licensing data reportedly include uncertain values of both (a) sales to U.S. forces overseas and (b) re-

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29 November 1999, codified at [13 USC 301](#)(h), and Section 1404(a)-(c) [116 Stat. 1454] of [PL 107-228](#) (div. B, title XIV), Foreign Relations Authorization Act, FY 2003, enacted 30 September 2002; [68 FR 42533](#), "Automated Export System Mandatory Filing for Items on the Commerce Control List (CCL) and the United States Munitions List (USML) That Currently Require a Shipper's Export Declaration (SED)," a final rule by the Census Bureau published in the Federal Register on 17 July 2003; and [22 CFR 123.22](#), "Filing, retention, and return of export licenses and filing of export information."

<sup>26</sup> Annual CRS CATDN reports dating back at least to 6 August 2002 (RL31529), have included language substantially similar to that in CRS R44716, cited in note 22, above, at p. 17: "Data maintained on U.S. commercial sales ... deliveries are incomplete ... Once an exporter receives from the State Department [DDTC] a commercial license authorization ... there is no current requirement that the exporter provide to the State Department ... details regarding any sales contract that results from the license authorization." – The [CBJFO for FY 2006](#), page 585 (part III, Supporting Information: Commercial Exports Licensed or Approved Under the Arms Export Control Act), states: "The first column, entitled "Actual Deliveries (preliminary)" shows the preliminary dollar value totals by destination of exports during fiscal year 2004. These export totals ... are compiled from expired or completed licenses returned to the Department by exporters or the Department of Homeland Security/Customs Border Patrol (CBP) and export shipment data recently made available to the State Department via the Automated Export System (AES). The totals are very preliminary because (a) the vast majority of State Department munitions export licenses are approved for four calendar years, thereby allowing shipments to span five fiscal years, and are not returned to the State Department until usage of the licenses usage is completed or the licenses expire; and (b) the fiscal year 2004 AES information is still being compiled and under review for accuracy. Thus, information on "Actual Deliveries (preliminary)" in this chart is incomplete. In the future, information collected through AES and reporting of technical data exports directly to the State Department will allow a more accurate portrayal of "up-to-date" export transactions. For further information, see also the classified annex to this document." Similarly, the [CBJFO for FY 2005](#), page 552 [same part, same section] states: "The first column, entitled "Actual Deliveries preliminary," shows the preliminary dollar value totals by destination of exports during fiscal year 2003. These export totals are compiled from expired or completed licenses returned to the Department by the U.S. Customs Service, pending the availability of a more comprehensive method. The totals are preliminary because the vast majority of State Department munitions export licenses are approved for four calendar years, thereby allowing shipments to span five fiscal years, and are not returned by the U.S. Customs Service until the license is completed or expired. With full implementation of the Automated Export System (AES) and mandatory reporting by industry of actual shipment data, information that more realistically reflects "up-to-date" export transactions is expected to be available. ... For further information, see also the classified annex to this document."

exports of articles temporarily returned to the U.S. for repairs or other servicing.<sup>27</sup> From this, it may be inferred that the DCS export delivery values based on AES reporting also include uncertain values of both sales to U.S. forces overseas and re-exports of articles temporarily returned to the U.S. for repair or other servicing.

In this edition of WMEAT, as in all editions since *WMEAT 2005*, values for U.S. arms exports are aggregates of figures for fiscal years as reported by the Department of State or of Defense as described above, except that WMEAT's (unpublished) estimates of values of U.S. arms export deliveries under the DCS program, added into WMEAT's published estimates of values of all U.S. arms export deliveries, are obtained as follows:

- For 2005, 2006, and 2008, WMEAT's (unpublished) estimates of values of U.S. arms export deliveries under the DCS program are the article (goods) export shipments values published in the CBJFO or in DDTC's section 655 report, plus service export delivery values estimated as the authorized license values pro-rated over the term of the licenses on the assumption of higher deliveries during earlier years of a license. This method of estimating DCS service export delivery values yields delivery values lower, relative to export license authorization values, than are the delivery values reported for DCS articles based on AES-based reporting for 2005, 2006, and 2008.
- For other years, WMEAT's (unpublished) estimates of values of U.S. arms export deliveries under the DCS program are the authorized articles (goods) and services license values pro-rated over the terms of the licenses on the assumption of higher deliveries during earlier years of a license. This method of estimating total DCS export delivery values yields articles and services delivery values lower, relative to license authorization values, than are the delivery values reported for DCS articles based on AES-based reporting for 2005, 2006, and 2008.

WMEAT's method of estimating the value of deliveries of U.S. commercial arms merchandise exports for years other than 2005, 2006, and 2008, if applied to those years, would yield values substantially lower than the value of DCS articles (goods) deliveries reported by AES those years.

WMEAT's estimates of values of U.S. arms export deliveries exclude deliveries of "600 series" exports licensed since October 2013 by the Bureau of Industry and Security (BIS) of the Department of Commerce. These "600 series" exports include

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<sup>27</sup> See General Accountability Office report [GAO-10-918](#), "Persian Gulf: U.S. Agencies Need to Improve Licensing Data and to Document Reviews of Arms Transfers," published September 2010; General Accountability Office report [GAO-10-952](#), "Defense Exports: Reporting on Exported Articles and Services Needs to Be Improved," published September 2010. The magnitude of double-counting due to including re-exports of repaired articles is not known to have been investigated. [GAO-10-918](#) found that at least \$6 billion of \$21 billion in DDTC license authorizations for arms exports to six Persian Gulf states during 2005-2009 – about 30% – were sales to U.S. forces operating in Gulf states. However, DDTC's published values for article and service exports authorized for those six countries during fiscal years 2005 through 2009 appear to sum to only \$16.7 billion.



items on the U.S. Munitions List, regulated before October 2013 by DDTC pursuant to section 38 of the Arms Export Control Act, as amended. Since 1996, BIS also has regulated exports of items on the Commerce Control List pursuant to the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies. On the “[USML to CCL Regulatory Changes](#)” statistical report page of its website, BIS has reported a total of “\$37.1 billion in U.S. exports under BIS jurisdiction for 600-series items” from October 2013 through December 2020, which, being sourced from the Automated Export System in May 2021, appears to be a total of delivery values, and implies an average annual value of about \$5.2 billion of “600 series” export deliveries; BIS seems not to have published on that page any annual values of “600 series” exports, either in total or disaggregated by country of destination.

In sum, it seems that WMEAT’s (unpublished) estimates of the value of U.S. commercial arms export deliveries for recent decades, other than for the years 2005, 2006 and 2008, tend to overstate due to inclusion of unknown values of shipments to U.S. forces overseas, of re-exports of repaired or otherwise serviced goods, and of licensed but undelivered goods and services exports under the DCS program, but tend to understate due to exclusion of unknown values of DCS shipments exempted from DDTC licensing and (since October 2013) of deliveries of “600 series” exports.<sup>28</sup>

**U.S. arms imports** in WMEAT accounts include (a) imports of military-type goods, data for which are published by the Economic Indicators Division (supported by the International Trade Management Division) of the Census Bureau of the Department of Commerce (Census EID), and (b) for years before 2015, Department of Defense direct expenditures abroad for major equipment, data for which were obtained from the Balance of Payments Division of the Commerce Department’s Bureau of Economic Analysis, but the relative magnitude of which was negligible.

The goods in (a) are those in Census EID’s “Import End Use Categories 50000 and 50010,” and include: complete military aircraft and parts; engines and turbines for military aircraft; military trucks, armored vehicles, *etc.*; military (naval) ships and boats; tanks, artillery, missiles, guns, and ammunition; military apparel and footwear; and other military goods, equipment and parts.” Data for such U.S. military imports for the ten most recent years, disaggregated by country of origin, have been published on the “[U.S. Imports by 5-digit End Use Code](#)” page of the website of the Census Bureau. These import End Use Category data are in terms of customs value for general imports.

WMEAT’s values for ***arms transfers between countries other than the United States*** are estimates by U.S. Government sources, expressed in current U.S. dollar terms.

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<sup>28</sup> Sam Perlo-Freeman, “[How Big is the International Arms Trade?](#)” *World Peace Foundation* of the Fletcher School of Tufts University, 19 July 2018 (22 pages), suggests that WMEAT may overestimate the value of U.S. arms exports by overestimating the value of U.S. commercial arms exports. That seems plausible, although the magnitude of any such overestimation is uncertain and may be less than Dr. Perlo-Freeman suggests, and no well-founded means of producing a better estimate of the value of U.S. arms export deliveries is readily apparent.

The merchandise components of these data are understood generally to be valued in f.a.s. (freight alongside) terms.

WMEAT's estimates of U.S. arms exports, of U.S. arms imports, and of arms transfers between countries other than the U.S. differ in their sourcing. WMEAT's estimates of U.S. arms imports exclude services for want of data, hence may be substantially understated relative to its estimates of U.S. arms exports arms transfers between countries other than the U.S. Otherwise, the extent to which these differently sourced parameters are comparable in effective scope of coverage cannot readily be assessed.

Close comparisons between the estimated values shown for arms transfers and for military expenditures are not warranted. Much of the international arms trade involves not only offset or discounted prices, but also full-grant financing, highly preferential debt financing, barter arrangements, third party payments, or partial debt forgiveness. Acquisition of armaments thus need not impose, either in the delivery year or in later years, the burden on an economy that is implied by the estimated U.S. dollar value of the shipment. Consequently, caution is warranted in comparing the value of arms imports to other values for other parameters, such as GDP or military expenditure.

#### *Total imports and exports*

In this edition of WMEAT, as in editions since *WMEAT 2005*, the values for total imports and exports, found in Table II, include not only merchandise but all goods and non-factor services, in order to render "total imports" more comparable with "arms transfers," which appear increasingly to consist of services as well as goods.

In Table II of this edition of WMEAT, values for exports and imports of all goods and services are sourced from the IMF via the World Bank's [WDI database](#) [WDI data series "BX.GSR.GNFS.CD" and "BM.GSR.GNFS.CD"] for countries and years for which such WDI data are available, otherwise from the [National Accounts Main Aggregates Database](#) (NAMAD) of the UN Statistics Division. The IMF's total goods and services trade data is calculated on a balance-of-payments basis, in U.S. dollars, and appear to include exports in f.o.b. terms and imports in c.i.f. terms. NAMAD total goods and service trade data are calculated on a national accounts basis in local currency terms, and appear to include merchandise import and export values in f.o.b. (freight on board) terms. NAMAD national-accounts-basis goods and services trade data are more complete than IMF BoP-basis goods and services data. However, national-accounts-basis trade data are more readily subject to distortion, including by exchange rates, since national accounts generally are reckoned in local currency terms.

Total goods and services trade values for *Taiwan* are from balance of payments data on the [website](#) of its Directorate-General of Budget, Accounting and Statistics.

## Rounding and significant digits

In Table I, armed forces personnel are expressed in thousands of persons, population and labor force in millions of persons, and military expenditures and GDP in millions of U.S. dollars. Figures are rounded at least to these units, and are further rounded if necessary to show only three significant digits. On the country pages, single-year single-country figures for armed forces personnel, military expenditure, GDP, military expenditure per capita and per armed forces member, and GDP per capita, are further rounded: values between 20 and 100 to the nearest multiple of five, values between 100 and 1000 to the nearest multiple of 10. Ratios and percentages vary in their rounding, depending in part on their typical magnitude, and in part on whether they are given for single countries (sometimes more rounded) or for groups of countries (sometimes less rounded), but all are rounded to show only three significant digits.

It is hoped that this rounding may remind users of the imprecision of most figures, ratios and percentages in Table I, especially for single countries, although it may tend to overstate that imprecision for some parameters and fields (*e.g.*, U.S. armed forces personnel) while understating it for others (*e.g.*, the military expenditures of North Korea). Of course, systematic rounding to no more than three significant digits makes the magnitude of rounding increase with the magnitude of values rounded.

In Table I, rounding and number of significant digits shown does not vary across countries, groups of countries, or years, or across editions of WMEAT, to reflect varying confidence in values shown. Such variation is not feasible given limits on resources available for WMEAT production, and resulting error seems likely to be small relative to error from other sources.

In Table I, rounding of all values, percentages, and ratios is done only after all calculation. To vary the number of significant digits to reflect varying confidence in the precision of country-specific and year-specific values before calculation of eleven-year means, country-group totals, and diverse percentages and ratios, is not feasible given limits on resources available for WMEAT production. Furthermore, the resulting error seems likely to be small relative to error from other sources.

In the arms transfer tables (Tables II, III, and IV), all trade values for both total trade and arms trade and for both specific countries and groups of countries are rounded to the nearest tenth of a billion (100 million) U.S. dollars. Ratios of arms exports to arms imports are rounded to thousandths. Percentages are rounded to tenths of a percent, except that in Table IV.c, suppliers' market shares are rounded to percents for markets smaller than the global market. This rounding of arms trade values, like other aspects of the structure of the arms trade tables, is a condition of WMEAT's use of some of its arms trade input data; total trade data are rounded identically. No further rounding to limit the number of significant digits is attempted, partly because WMEAT is unable to assess the relative precision of arms trade values across countries or years. As in Table I, rounding of all values, percentages and ratios is done only after all calculation.

## Indicators of extraordinary uncertainty in Table I

On the country pages of Table I, annual figures are color-coded to indicate levels of uncertainty. Rough estimates that seem uncommonly uncertain are shown in **green** typeface. Very rough estimates that seem still more uncertain, being based on scant information and apparently subject to a wide range of error, are shown in **blue** typeface. The symbol “**n/a**,” appearing in **red** typeface instead of a value or estimate, indicates an estimate so egregiously uncertain that it seems not to warrant publication.

However, whether a highly uncertain estimate warrants publication, that is, whether it is shown in **blue** typeface or as a red “**n/a**,” depends not only on perceived uncertainty (an information-quality consideration), but also upon international military importance (an information-demand consideration). For example, the quality of military expenditure data for *North Korea* is so poor that if its military were not widely perceived as threatening other countries, estimates of its GDP and military expenditures might be assigned an “**n/a**” (as military expenditures for *Bhutan* are) rather than shown in blue.

An estimate is made of every variable covered for every country covered in every year covered, even if an “**n/a**” is published instead of that estimate; such estimates for all countries covered by the report are included in the aggregates for geographic, political, and economic groups of countries even if not published separately.

In this edition of WMEAT, 11-year mean figures are published for all parameters for all countries covered, partly because this edition’s country ranking on the basis of 11-year mean figures would bracket them so narrowly that there is little point in masking them. 11-year mean figures are not color-coded. However, the quality of 11-year-mean figures depends on the quality of the annual figures of which they are averages. Users of 11-year country mean figures in the “Country Rankings” page of Table I are advised to check the color-coding in the country pages to assess the quality of the figures.

## Deflators used to generate constant currency values

This edition of WMEAT, like all previous editions except *WMEAT 2005*, uses the U.S. GDP deflator to deflate all figures expressed in constant dollar terms.<sup>29</sup>

This edition continues the practice, begun in *WMEAT 2012*, of sourcing constant and current dollar values for U.S. GDP provided by the World Bank’s [WDI database](#), which derive from U.S. GDP statistics published by the [U.S. Bureau of Economic](#)

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<sup>29</sup> However, diverse U.S. defense-sector-specific price indices and deflators are available in the National Defense Budget Estimates (aka “the Green Book”) published annually by the [Office of the Comptroller](#) of the U.S. Department of Defense.

[Analysis](#) (BEA). U.S. GDP deflator values are generated from these constant- and current-dollar GDP data.<sup>30</sup>

Similarly, as stated [above](#) in the subsection on GDP, WMEAT's current and constant local currency values for the GDPs of other countries, which this edition of WMEAT publishes on the country pages of Table I, are mostly sourced from the WDI database, derive from national government reporting, and jointly generate national GDP deflators that WMEAT applies to its figures for local currency figures for military expenditure in order to convert them from current to constant local currency units.

### **Methods of converting military expenditures and GDP to U.S. dollars**

Cross-country comparison of Table I's economic parameters – military spending and its comparator parameter, GDP – requires expression in a common currency of values originally expressed in diverse local currencies. Consequently, Table I reports values for military expenditures and GDP in U.S. dollar terms for all countries, based on source data expressed in local currency terms. (By contrast, preparation of Tables II, III, and IV, the arms transfer tables, involves no currency conversion; WMEAT receives its input data for arms transfers and total trade in current U.S. dollar terms.)

In Table I, each country page presents national-currency-denominated values in terms of only one local currency for each country, even if the country has changed or redenominated its currency or used multiple currencies simultaneously during the period covered. That local currency is identified on each country page in the currency notes (following line 180). If a country has changed, redenominated, or pegged its currency or used a multi-country currency during the period, then the currency notes also indicate that.

This edition of WMEAT continues the practice, innovated in *WMEAT 2012*, of generating U.S. dollar figures for military expenditure and GDP using multiple distinct methods of currency conversion – five of them for countries and geographic groups, three of them for political and economic groups, and for rankings. In Table I, each country page (rows 165-177) shows the annual values for each of the national-currency-to-U.S.-dollar conversion rates generated by these five methods. Each currency conversion method used has advantages and disadvantages that make different methods better for different analytic purposes.

The results yielded by these methods may differ substantially, both over time and across countries, with respect either to the dollar value of military spending or to the ratio of military spending to GDP. The “Overview” page of Table I shows, for both countries and groups of countries, the range of military spending, both in dollar terms and as a share of GDP, yielded by these different conversion methods.

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<sup>30</sup> The values used for the U.S. GDP deflator are given at the bottom the constant-dollar sections of Tables II.a, II.b, and II.c, and at the bottom of Tables II.d and IV.a.

The problem of choosing a conversion method adds to the already large uncertainties posed by data quality problems for many countries. It is hoped that presentation of U.S. dollar values for military spending and GDP obtained by multiple currency conversion methods may both illustrate the magnitude of this uncertainty and help analysts to cope with it.

The remainder of this subsection will describe each of the five currency conversion methods used in this edition of WMEAT to convert foreign-currency-denominated data for military spending and GDP to U.S. dollars, the sources and limitations of data for each, and the advantages and disadvantages of each.

***Method 1:** Conversion of both military expenditure and GDP at a real market exchange rate based on the most recent year covered.*

This is the method of currency conversion used for all countries by *WMEAT 2005*, and for most countries by earlier editions of WMEAT. In this edition of WMEAT, it is used to generate the first of the five sets of dollar-denominated economic parameter values on the country pages (rows 40 – 49 and 113 – 121) and on the first of the two “Geographic Groups” pages of Table I. The headings for dollar values and percentages generated by this method are shown in the left-hand column in **black** typeface.

This method is designed to facilitate “trend” or “time-series” analysis within a single country over a number of years, such as the 11-year period covered by a WMEAT edition.<sup>31</sup> It avoids distortion of such trends by market exchange rate fluctuation due to factors other than “real” changes in relative aggregate price levels between the U.S. and another country. Insofar as aggregate price changes in the defense sectors of both countries approximate aggregate price changes in their economies as a whole, it does so without distorting trends in the share of GDP to which military spending is equivalent, commonly called “the military burden.”

This method eliminates “non-real” exchange rate fluctuations by using an observed or estimated market exchange rate (MER) for only one year, the base year, which in WMEAT has been the most recent year covered (2019 for *WMEAT 2021*). Market exchange rates for the other ten of the 11 years covered are not used to generate dollar values of military spending or GDP for those years. Instead, the base-year exchange rate is projected onto the other years, discounted by the relative rate of aggregate price inflation for the U.S. and the foreign country, as measured by the ratio of their respective GDP deflators. Because it seeks to eliminate the effects of exchange rate fluctuations that are not due to changes in the relative prices of “real” goods and services,

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<sup>31</sup> Since its inception in the 1960s, WMEAT has focused on trends in both military expenditures and arms transfers. Since 1994, section 404 of PL 87-297, the Arms Control and Disarmament Act as amended, codified as [22 USC 2593b](#), has required that WMEAT highlight trends in arms transfers.

international economic literature calls the non-base-year conversion rates generated by this process “real exchange rates.”<sup>32</sup>

For example, if aggregate price inflation between the base year and a previous year were 5% for the U.S. and 10% for country X, then this method would in effect convert values for the year prior to the base year from country X’s currency into “current dollars” at a rate that values dollars  $100((1.10/1.05) - 1)\%$  less relative to country X’s currency than did the observed exchange rate in the base year.

Apart from the foreign-currency-denominated data values to be converted, this method requires (a) an observed or estimated year-average MER for one year, the base year, and (b) GDP deflators for both the U.S. and the foreign country for all years covered. For most countries, including the U.S., time series both of year-average MER’s and of GDP in national-currency terms at current and constant prices, from which GDP deflators are readily derived, are provided by the World Bank’s [WDI database](#), and are used by WMEAT.

In this edition of WMEAT, these year-average MERs are mostly the “DEC alternative conversion factor” [WDI data series “PA.NUS.ATLS”] from the World Bank’s WDI database. The “DEC” rate is usually the official exchange rate published in the IMF’s [International Financial Statistics](#), but may differ from it greatly if a country has more than one exchange rate (*e.g.*, Syria) or slightly if market exchange rate fluctuations briefly deviate substantially from relative changes in GDP deflators. Such MERs are used for all countries for which they are available unless another rate is both legal and generally used, regardless of the extent to which government may repress or manipulate foreign exchange markets.<sup>33</sup> They are frequently not market-clearing or “equilibrium” exchange rates and may also differ greatly from black market rates.

For some countries covered by WMEAT, either “market” exchange rate data or GDP deflator data or both are not available from either the World Bank or the IMF, either because they are not members of those institutions (*e.g.*, North Korea) or because, although members, they have not reported economic data for the period covered to those institutions. Exchange rate data for such countries are drawn from other sources, including the [EIU Data Tool](#) service of the *Economist Intelligence Unit* and the [National Accounts Main Aggregates Database](#) of the UN Statistics Division. For countries with an

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<sup>32</sup> See Luis A.V. Catão, “Why Real Exchange Rates?” *Finance and Development: A Quarterly Magazine of the IMF* 44/3 (September 2007), online [here](#). *Caveat*: In a single-currency context, “real dollars” is widely used as a synonym for “constant dollars,” meaning “inflation-discounted” as opposed to “nominal” or “current” dollars. However, in a multiple-currency context, converting a time series of other-currency-denominated values to dollars at “real exchange rates” does not yield what is commonly meant by “real” or “constant” dollars.

<sup>33</sup> A summary annual overview of national exchange rate regimes has been provided by the IMF’s [Annual Report on Exchange Arrangements and Exchange Restrictions](#) (AREAR); results of all AREAR reports since 1950 have since 2015 been accessible online by subscription in the IMF’s AREAR Database, now published in [AREAR Online](#).

“unofficial” but legal and generally used but not officially reported exchange rate (e.g., Burma before 2011), that rate is used by WMEAT.

**Method 2:** *Conversion of both military expenditure and GDP a current year-average market exchange rates*

This is the method that one might naïvely expect to be used: for each year, local currency data values for that year are multiplied by an observed or estimated year-average market exchange rate for the same year. In this edition of WMEAT, this method is used to generate the second of the five sets of dollar-denominated economic parameter values on the country pages (rows 51 – 60 and 123 – 131) and on the first “Geographic Groups” page of Table I. To generate these values, each annual national-currency-denominated value is simply converted at the “DEC alternative conversion factor” [WDI data series “PA.NUS.ATLS”] for that year from the World Bank’s WDI database, or at a year-average MER for that year provided by the [EIU Data Tool](#) service of the *Economist Intelligence Unit* or the [National Accounts Main Aggregates Database](#) of the UN Statistics Division. The headings for dollar values and percentages generated by this method are shown in the left-hand column in **brown** typeface.

This currency conversion method has the advantages of being easy to understand and of facilitating the construction of long-term time series of values given by successive editions of WMEAT.

The military expenditure and GDP values generated by **Method 2** also are arguably better than those generated by **Method 1**, **Method 3**, or **Method 4** for comparison to WMEAT’s values for arms transfers or total goods and services trade, which are based on data that WMEAT receives already denominated in U.S. dollars.

In addition, **Method 2** is likely to be superior to **Method 1** for cross-country comparisons, although inferior to **Method 1** for single-country trend analysis. A real exchange rate scheme for 11 years based on an observed exchange rates for only a single base year (**Method 1**) projects into all 11 years any foreign exchange market anomalies in that one year. For example, if the Japanese yen is unusually dear but the Euro is unusually cheap in the base year, **Method 1** will make Japan’s military spending and GDP anomalously large relative to Germany’s military spending and GDP for all 11 years. Since a large “error” of this sort is less likely to be observed in all 11 years than in a single year, **Method 2** tends to be less prone to error in cross-country comparison than **Method 1**. However, **Method 2** tends to be inferior for single-country trend analysis because it does not exclude the effects of year-to-year exchange rate fluctuations caused by factors other than relative aggregate price changes.



**Method 3:** Conversion of both military expenditure and GDP at a real market exchange rate based on the mean of all 11 year-average market exchange rates, assigned to the mid-period (sixth) year.

In this edition of WMEAT, this method is used to generate the third of the five sets of dollar-denominated economic parameter values in dollar terms on the country pages (rows 62 – 72 and 133 – 142) and on the first “Geographic Groups” page of Table I. It is also used to generate the first of three sets of economic parameter values on the second “Geographic Groups” page and on the “Political Groups,” “Economic Groups,” “Group Rankings,” and “Country Rankings” pages of Table I. The headings for parameter values generated by this method are shown in the left-hand column in **green** typeface.

This method was innovated by WMEAT 2012 in the hope of capturing both the time-series (trend) analysis advantages of **Method 1** and the cross-country analysis advantages of **Method 2**. To our knowledge, it has not been used elsewhere.

Like **Method 1**, **Method 3** converts foreign-currency-denominated values to dollars at “real exchange rates” based on an exchange rate assigned to a single year, and using the ratio of U.S. and foreign GDP deflators to project that rate into the other ten years. **Method 3** thereby eliminates the effects of exchange rate fluctuations not caused by changes in the relative aggregate prices of goods and services in the U.S. and the foreign country, just as **Method 1** does. However, in **Method 3**, the exchange rate assigned to the base (mid-period, *i.e.*, sixth) year is not a single year’s average market exchange rate; it is the inflation-difference-discounted average market exchange rate for the whole 11-year period. The arithmetic mean of the 11 year-average market exchange rates deflated by the U.S. GDP deflator is assigned the mid-period year, then is reflatored or deflated from that base year to other years using the ratio of the U.S. GDP deflator to the foreign GDP deflator.

**Method 3** is as good as **Method 1** for trend (time series) analysis: for any given parameter, for any country or group of countries, the percentage change in value between any two years covered (*e.g.*, from the first year covered to the last year covered) is identical before rounding for both methods. Consequently (for reasons already stated in comparing **Method 1** to **Method 2**), **Method 3** seems likely to be better than **Method 2** for trend analysis.

Unlike **Method 1**, **Method 2** and **Method 3** cannot yield results distorted by a single base year’s deviation from the period-average MER. Hence, **Method 3**, like **Method 2**, is superior to **Method 1** for cross-country analysis – insofar as the evolution of inflation-difference-discounted exchange rates during the period is not distorted by arithmetic averaging.

For the period covered by this edition of WMEAT, **Method 3** seems empirically, for purposes of cross-country analysis, to be better than **Method 1** both for most

countries and for groups of countries. Relative to **Method 1**, **Method 3** appears to yield a distribution of period-mean values closer on average to those yielded by **Method 2**.<sup>34</sup>

Consequently, **Method 3** appears better, as a single method to be used for both trend analysis and cross-country analysis purposes, than either **Method 1** or **Method 2**. Accordingly, in Table I:

- **Method 3** is the only “market exchange rate” conversion method used both on the second “Geographic Groups” page, on the “Political Groups” and “Economic Groups” pages, and on the “Group Rankings” and “Country Rankings” pages, as a comparator to PPP conversion methods (**Method 4** and **Method 5**);<sup>35</sup> and
- **Method 3** is the “market exchange rate” used, along with the PPP conversion rate for the whole economy, to estimate notionally a PPP conversion rate for the defense sector in **Method 5**.

**Method 4:** *Conversion of both military expenditure and GDP at the purchasing power parity rate for the whole economy (at PPP-for-GDP)*

In this edition of WMEAT, this method is used to generate the fourth of the five sets of dollar-denominated economic parameter values on the country pages (rows 74 – 83 and 144 – 152) and on the first “Geographic Groups” page of Table I. It is also used to generate the second of three sets of economic parameter values on the second “Geographic Groups” page and on the “Political Groups,” “Economic Groups,” “Group Rankings,” and “Country Rankings” pages of Table I. The headings for parameter values generated by this method are shown in the left-hand column in **dark red** typeface.

<sup>34</sup> In WMEAT 2021, the 11-year-mean value for GDP yielded by **Method 3** was closer to that yielded by **Method 2** than is that yielded by **Method 1** for the world, for every continent, and each of all 15 regions. Moreover, across the 170 countries covered:

- the period-mean values yielded by **Method 3** are closer to those yielded by **Method 2** than are those yielded by **Method 1** for 137 of 170 countries;
- the absolute value of the average percentage deviation from the period-mean value yielded by **Method 2** is less for **Method 3** (1.9%) than for **Method 1** (9.4%); and
- the standard error from the period-mean value yielded by **Method 2** as a proportion of that value is less for **Method 3** (9.6%) than for **Method 1** (10.6%); but
- the greatest country percentage deviation from the period-mean value yielded by **Method 2** is roughly the same for **Method 3** and for **Method 1** (47.2%).

<sup>35</sup> Use of **Method 3** to generate country and country-group rankings based on 11-year-mean MER values may seem questionable, inasmuch as 11-year-mean MER values generated by **Method 3** seem likely to be inferior, for cross-country comparison of static values, to those generated by **Method 2**. However: (a) The “Country Rankings” page of WMEAT’s Table I, already more than 7,500 rows in length including rankings based on only one MER conversion method, would become even more unwieldy if it included rankings based on more than one such method; (b) the rankings both of countries and of groups compare not only static values but also trends across countries, for which combination of purposes **Method 3** seems the best MER conversion method; and (c) to use different conversion methods to generate MER-based group rankings and MER-based and country rankings could be confusing, and **Method 3** seems best for generating group rankings at an MER.

The U.S. dollar purchasing power parity (PPP) value of a foreign good or service, or set of foreign goods and services, is what that good, service, or set of goods and services costs in the United States. The PPP value of a foreign country's economy is notionally what all the goods and services produced in that country would be worth if valued at U.S. prices. The U.S. dollar PPP conversion rate for the whole economy of that country, usually referred to simply as the PPP rate for that country, is the MER multiplied by the ratio of that country's GDP at the market exchange rate to its GDP evaluated at U.S. purchasing power parity.

This edition of WMEAT sources U.S. dollar PPP values for GDP and U.S. dollar PPP conversion rates for most foreign countries from the World Bank's [WDI database](#). [data series "PA.NUS.PPP"].

For other countries, including countries that are not members of the World Bank, U.S. dollar values for GDP or PPP conversion rates for GDP are sourced from diverse sources including national statistical agency websites or the [EIU Data Tool](#) service of the *Economist Intelligence Unit (EIU)*.

In theory, the extent to which the U.S. dollar PPP value of a foreign country's GDP differs from its U.S. dollar MER value depends on chiefly on (a) the extent to which its economy consists of "non-tradables," that is, products and inputs that are not readily tradable internationally, and (b) the extent to which the prices of non-tradables in that country differ from the prices of non-tradables in the U.S. Of these non-tradables, by far the greatest in terms of aggregate value, in most countries, is labor. The proportion by which the U.S. dollar PPP value of a foreign country's GDP exceeds its U.S. dollar value at the MER tends to increase with the extent to which its labor tends to be less productive and to earn less than labor in the U.S. – that is, insofar as its people are poorer than people in the United States. Conversely, the PPP values of the economies of the few countries that are richer than the U.S. at the MER tend to be less than their MER values.

For a country substantially poorer than the U.S., converting its military spending to U.S. dollars at a market exchange rate tends to understate the value of the output of a country's military spending, *i.e.*, of what it gets for its military spending, relative to that of the U.S. and other comparably rich countries, insofar as the foreign country's defense sector employs internationally non-tradable resources that are priced below U.S. prices – in particular, insofar as its military and its defense industries employ labor at wages lower than U.S. wages. Converting its military spending to U.S. dollars at the PPP rate may correct this understatement. As SIPRI has observed on the "[Frequently asked questions](#)," page of the "[SIPRI Military Expenditure Database](#)" section of its website:

Using GDP-based PPP rates instead of MERs for currency conversion results in much higher output and expenditure figures for many developing and transition countries since they have relatively low prices for non-traded goods and services – thus giving the currency higher purchasing power. ... For those such developing and transition countries for whom

data was available for 2014, the median increase in military expenditure figures from using PPP rates instead of MERs was by a factor of 2.13. Three-quarters of these countries would see their relative figures increase by at least 79 per cent.

However, to convert a foreign country's military expenditures at the U.S. dollar PPP rate for its GDP yields an accurate indicator of the output of military expenditures only if:

- (a) the country's defense sector employs non-tradables to the same extent as its economy as a whole, and
- (b) the prices of non-tradables in the defense sector differ from their U.S. prices to the same extent as in its economy as a whole, or if
- (c) lower (higher) non-tradables intensity in the defense sector is fortuitously offset by higher (lower) non-tradables prices in the defense sector.

For most countries, including most countries poorer than the U.S., the defense sector seems less labor-intensive, and hence less non-tradables intensive, than the economy as a whole. An indicator of this is that, for most countries, the ratio of military spending per armed forces member to GDP per labor force member (given on row 34 of each country page in this edition of WMEAT) substantially exceeds one. Insofar as capital may tend to be more tradable internationally than labor, and insofar as the capital-intensity of militaries may tend to be correlated positively with the capital-intensity of defense sectors across countries, this suggests that most countries, including most lower- and middle-income countries, may have defense sectors more tradables-intensive than their economies as a whole.

For such a country, to convert military spending to U.S. dollars at the PPP rate for the whole economy, *i.e.*, at the PPP rate for GDP, may overstate the value of the output of the country's military spending relative not only to the military spending of the U.S. and other rich countries, but also to that country's GDP.

For any single country and for any single year, a country's "military burden," that is, the share of its GDP to which its military expenditure is equivalent, is unaffected by the choice of method used to convert military spending and GDP to dollars, provided that both are converted at the same rate – as they are by **Method 1**, **Method 2**, **Method 3**, and **Method 4**. Either for a group of countries or for a single country's multi-year period average, the military burden may vary, but generally varies only slightly, across such methods.<sup>36</sup> Consequently, if **Method 4** may tend to overstate the military burden of lower- and middle-income countries, then so, to roughly the same extent and for the same reason, may any other method that converts both military expenditure and GDP to dollars at the same rate, including **Method 1**, **Method 2**, and **Method 3**. None of these methods allows for the likelihood that the defense sectors of lower- and middle-income countries

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<sup>36</sup> Consequently, the "military burden" ratios that result from conversion methods 1, 2, 3, and 4 are the same for single years, and roughly the same for the 11-year-mean, as the "military burden" percentage generated from national-currency-denominated figures and shown on the country pages of Table 1 in row 35.

generally may be much less non-tradables intensive than their economies as a whole, as seems suggested by the observation that their militaries generally appear far less labor-intensive than their economies as a whole. The domestic purchasing power and the domestic opportunity cost of resources employed in their defense sectors generally may be less, relative to that of resources employed in their economies as a whole, than is indicated by the military burden ratio generated by any currency conversion method that converts both military expenditure and GDP to dollars at the same rate.

***Method 5: Conversion of military expenditure at a notionally estimated defense-sector-specific PPP rate, and of GDP at the PPP rate for the whole economy***

For such reasons, the best indicator of the product of a country's military spending, relative not only to the products of the military expenditures of other countries but also to its own GDP, would be obtained by converting defense expenditures to dollars at a defense-sector-specific PPP rate, distinct from the PPP rate for the whole economy at which GDP should be converted to dollars to obtain the best indicator of a country's output relative to the outputs of other countries.

This has been widely recognized since before December 13, 1982, when the UN General Assembly (UNGA) asked the Secretary General to enlist qualified experts from member states to construct price indexes and purchasing power parities for military expenditures of voluntarily participating states. In response, a UN Group of Experts on the Reduction of Military Budgets submitted to the Secretary General, on 13 August 1985, an 81-page report, "[Construction of military price indexes and purchasing power parities for comparison of military expenditures](#)" (UN Document A/40/421), describing the data needed rigorously to construct defense-sector-specific PPP rates. On 1 November 1985, the chairman of the group, Hans Christian Cars of Sweden, reported to a [meeting](#) of the UNGA First Committee ("Verbatim Record of the 22<sup>nd</sup> Meeting," A/C.1/40/PV.22) that Australia, Austria, Finland, Italy, Norway, Sweden, the United Kingdom, and the United States had participated in the effort to construct defense-sector-specific PPP rates for their countries using the methodology prescribed by the UN Group of Experts. He reported the following results of the group's exercise:

Information on items which fall within the procurement category, that is, weapons, weapons systems, and other military equipment ... turned out to be much less available. The limited amount of data on military hardware presented a major problem for the group. ... Another major problem that the group faced was the comparison of conscripted and enlisted soldiers ... Military purchasing power parities have been constructed for all participating states ... However, to achieve those results, the Group had to use a limited number of surrogate indexes and parities ...

More than thirty-five years after the UN General Assembly's 1982 request, no rigorous estimate of a defense-sector-specific PPP rate is known to have been produced

for even one country for even one year. The data required to construct one rigorously appear not to be available, even for countries with relatively transparent military expenditures.

However, to convert military expenditures to dollars at notionally estimated country defense-sector PPP rates, constructed using data readily available for nearly all countries, might, despite lack of rigor, be better than converting both military expenditures and GDP to dollars *exclusively* at the same rate. **Method 5** attempts to do this, based on assumptions that are, admittedly, heroically strenuous. This method is offered, not as a stand-alone “best method,” but as a method that may “add value” when used *in conjunction with other methods* of converting military expenditure and GDP to dollars. The idea is to do what can be done with the data available, in the hope of offering some notion of how much:

- converting both military expenditure and GDP to dollars at an MER understates the value of the military expenditures of lower- and middle-income countries relative to those of upper-income countries including the United States;
- converting both military expenditures and GDP to dollars at PPP-for-GDP overstates the military expenditures of lower- and middle-income countries relative to those of upper-income countries including the United States; and
- converting both military expenditures and GDP to dollars at the same rate, regardless of the rate used, overstates the military burdens of lower- and middle-income countries relative to those of upper-income countries including the U.S.

Insofar as degree of political democracy may be correlated with GDP per capita,<sup>37</sup> “less democratic” may be substituted for “lower- and middle-income” and “more democratic” might be substituted for “upper-income” in the previous sentence.

The intuition underlying **Method 5** is the following. Assuming that the prices of non-tradables are the same across all sectors of a country’s economy, then:

- For a country with a defense sector that is far less non-tradables-intensive than its economy generally, the dollar value of military spending at defense-sector-specific PPP will be closer to the dollar value of military spending at the MER than to the dollar value of military spending at PPP-for-GDP.
- For a country with a defense sector that is only slightly less non-tradables-intensive than its economy generally, the dollar value of military spending at defense-sector-specific PPP will be closer to the dollar value of military spending at PPP-for-GDP than to the dollar value of military spending at the MER.

To operationalize this intuition with data that are readily available for nearly all countries:

- WMEAT uses the capital-intensivity of the military (as measured by military spending per armed forces member, ignoring civilian defense employees and contractors for want of data about them in many countries) as a surrogate for the tradables-intensivity of the defense sector; and

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<sup>37</sup> See the “Political Groups” page of Table I, rows 331 – 363.

- WMEAT uses the capital-intensity of the whole economy (as measured by GDP per labor force member) as a surrogate for the tradables-intensity of the whole economy.

The assumptions of this approach seem justifiable given the data constraints. Although labor tends to be the largest non-tradable in most economies, capital is not perfectly tradable internationally, labor is not utterly non-tradable, either as factor or as embodied in goods, and labor is not the only non-tradable in an economy. Furthermore, although the capital-intensity of the defense sector including defense industries seems likely to be correlated with the capital-intensity of the military, a correlation is not an identity. Nevertheless, setting these problems aside, this intuition can be restated in terms that can be operationalized with available data as follows:

- For a country with a defense sector that is far less labor-intensive (far more capital-intensive) than its economy generally, the dollar value of military spending at defense-sector-specific PPP will be closer to the dollar value of military spending at the MER than to the dollar value of military spending at PPP-for-GDP.
- For a country with a defense sector that is only slightly less labor-intensive (only slightly more capital-intensive) than its economy generally, the dollar value of military spending at defense-sector-specific PPP will be closer to the dollar value of military spending at PPP-for-GDP than to the dollar value of military spending at the MER.

In algebraic terms, **Method 5** involves estimating a country's defense-sector-specific PPP as follows:

$$S_s = \text{MIN} (S_p, (S_m + (K_e / K_d)(S_p - S_m)) \text{ IFF } S_p > S_m$$

(case typical of countries poorer than the U.S.)

OR

$$\text{MAX} (S_p, (S_m - (K_e / K_d)(S_m - S_p)) \text{ IFF } S_p \leq S_m$$

(case typical of countries richer than the U.S.)

where:

$S_s$  is the dollar value of military spending at a PPP rate for the defense sector. This is what is to be estimated.

$S_p$  is the dollar value of military expenditure at the PPP rate for the whole economy (PPP for GDP).

$S_m$  is the dollar value of military expenditure at the real MER generated by **Method 3**.<sup>38</sup>

<sup>38</sup> Any method of converting military expenditure to dollars at a market exchange rate could plausibly be used, e.g., either **Method 1**, **Method 2**, or **Method 3**. **Method 3** is used because it seems better than either

$K_d$  is an indicator of the capital-intensity of the defense sector, specifically military spending per armed forces member in local currency terms. This serves as a proxy for the tradables-intensity of the defense sector.

$K_e$  is an indicator of the capital-intensity of the whole economy, specifically GDP per labor force member in local currency terms. This serves as a proxy for the tradables-intensity of the whole economy.

Basically, this approach uses the ratio of military spending per armed forces member to GDP per labor force member to assign the defense-sector dollar PPP value of military spending to a point on the interval between the dollar value of military spending at the MER and the dollar value of military spending at the PPP rate for the whole economy.

This approach to estimating  $S_s$ , sets limits to keep the result within the range between  $S_m$  and  $S_p$ , specifically by setting the capital-intensity of the whole economy as a lower limit to the capital-intensity of the defense sector. The intuitive justification for these limits is that a military seems unlikely to be less capital-intensive than its country's economy as a whole, except in countries for which a patron state handles external defense and democratic legitimacy obviates the use of force for internal security. These limits are binding for about 20 countries for which military spending per armed forces member appears to be less than GDP per member of the labor force, on an 11-year-mean basis (per rows 3295 – 3464 of the “Country Rankings” page of Table I). However, this may indicate underestimation of military expenditure in local currency terms for many of these countries.

The specific functional form of this approach to estimating the defense-sector-specific dollar PPP value of military spending allows this to equal (but not to be further from the MER than) the value of military spending at PPP-for-GDP, but allows it only to approach the MER value of military spending. That in the ratio of GDP per labor force member to military spending per armed forces member, all four factors must be greater than zero, implies that it has an endogenous lower bound of zero, although it has no endogenous upper bound; it must be exogenously limited on one but not both extremes to yield a finite range of values.

Despite this asymmetry, the above-specified form of **Method 5** is the best approach to estimating the value of military spending at a defense-sector-specific GDP that the preparers of WMEAT have been able to think of. However, it is not necessarily the best approach that can be devised using data readily available for nearly all

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Method 1 or Method 2 as a single rate to be used both for trend analysis and for cross-country analysis, and the defense-sector-specific PPP value for military expenditure to be estimated is intended for use both for trend analysis and for cross-country analysis.



countries.<sup>39</sup> Readers' suggestions for improving **Method 5** in ways that require only data readily available for nearly all countries are sincerely solicited, and may be sent to WMEATEditor@state.gov.

In this edition of WMEAT, **Method 5** is used to generate the fifth of the five sets of dollar-denominated economic parameter values on the country pages (rows 85 – 93 and 154 – 161) and on the first “Geographic Groups” page of Table I. It is also used to generate the third of three sets of military expenditure and “military burden” values on the second “Geographic Groups” page and on the “Political Groups,” “Economic Groups,” “Group Rankings,” and “Country Rankings” pages of Table I. The headings for parameter values generated by this method are shown in the left-hand column in **purple** typeface.

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<sup>39</sup> An alternate although conceptually similar approach has recently been developed and applied to China by Peter E. Robertson & Adrian Sin, “Measuring hard power: China’s economic growth and military capacity,” Discussion paper, University of Western Australia, Sept. 2013; also published online in *Defense and Peace Economics* (Taylor and Francis, accessible only by subscription), April 2015. It yields a substantially higher U.S. dollar estimate of China’s military expenditure than that yield by WMEAT’s **Method 5**.