

Small Arms Survey 2010: Annexe 1.3

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June 2010

Methodology

This annexe provides supplementary information on the methodology used in Chapter 1, ‘Emerging from Obscurity’, to calculate the average value estimate of USD 4.3 billion for annual authorized international transfers of ammunition for small arms and light weapons between 2006 and 2009. The estimate, and the process by which it was derived, is part of a multi-year effort to reassess the Small Arms Survey’s current estimate of USD 4 billion for the annual authorized international trade in small arms and light weapons, and their parts, accessories, and ammunition.

Estimating annual light weapons ammunition transfers

Basic methodology

Because of the almost complete absence of data on transfers of light weapons ammunition in the public domain,¹ the study makes use of the slightly more plentiful data on public procurement² of ammunition. Publicly available records were used to build a fairly complete picture of government procurement of light weapons ammunition for a sample of countries. By analysing the identity and location of the contractor supplying the ammunition, the authors categorized purchases as either imports or domestic procurement for each of these countries. They then identified a number of factors (‘independent variables’) believed to predict levels of light weapons ammunition procurement by states. These variables were used in conjunction with the data on imports by the sample countries to generate an estimated level of light weapons ammunition procurement for every country outside the sample. The USD 2.5 billion estimate of average annual authorized transfers of light weapons ammunition is the sum of the data on imports for the sample countries and the import estimates for every other country in the world.

Sample

The authors were able to compile what they believe to be fairly complete data on government procurement (including imports) of light weapons ammunition for ten countries: Australia, France, Ireland, Italy, Latvia, Slovakia, South Africa, the UK, the United States, and an additional African state.³ This data was gathered from electronic databases, procurement bulletins, requests under freedom of information laws, and

¹ See Small Arms Survey (2010, pp. 10–13).

² For the purposes of this study, the civilian market for light weapons ammunition is assumed to be negligible.

³ Data relating to this state was provided on condition of anonymity. Import data for Sweden was also used in the calculation of the documented trade; however, Sweden was not used as a sample country because total procurement was not known (see ‘Final calculations’, p. 5).

responses from government and industry contacts to queries submitted by the Small Arms Survey.

Model

The model used to extrapolate from the data on the sample states to the estimated annual dollar value of light weapons ammunition imports for every other state uses four variables:

1. the size of a state's armed forces.
2. the state's military expenditure per soldier.⁴
3. the extent to which the state is involved in armed conflict.
4. the state's capacity for domestic production of light weapons ammunition.

Statistical method

The method used in the extrapolation model relies on two key assumptions:

1. The military expenditure (Mil X) per soldier and the size of a given country's armed forces affect the quantity and value of light weapons ammunition that the country procures in a non-linear fashion. That is, these two variables cannot be used to scale up or down light weapons ammunition procurement from the sample states to generate estimates for all countries.
2. However, within specific ranges of Mil X per soldier and armed force size, countries will spend, on average, a similar amount on light weapons ammunition per year, per soldier.⁵ Therefore, countries can be grouped into categories; it is possible to extrapolate from data on a sample country to an estimated dollar value for procurement of light weapons ammunition for each of the other countries within each of these categories.

Based on these assumptions, the statistical method used in the study consisted of four key steps:

1. grouping countries according to Mil X per soldier and armed force size.
2. estimating typical procurement per soldier per group.
3. extrapolating according to armed force size.
4. modifying the resulting estimate to account for conflict status and domestic production.

Below are descriptions of each step.

Step 1. Grouping countries according to Mil X per soldier and armed force size

The first step consisted of placing all countries in the world into groups according to the size of their armed forces and their military spending per soldier.⁶ Each country was placed into one of three ranges (high, medium, or low) for each variable,

⁴ The term 'soldier' here refers to any member of national armed forces, rather than only members of the land component of those forces.

⁵ This general rule applies provided that it also reflects the extent to which a country is involved in conflict.

⁶ The sources for data on these variables were SIPRI (2009), IISS (2009), and CIA (n.d.).

resulting in nine groups of countries (see Table 1). While it would have been preferable to have a larger number of groups, the relatively small number of sample countries precluded a more refined method.

Table 1 **Country groupings according to thresholds**

Country group		Thresholds	
		Military expenditure (USD) per active service person	Armed force size (personnel)
1	High–large	> 100,000	> 1,000,000
2	High–medium	> 100,000	27,000–1,000,000
3	High–small	> 100,000	< 27,000
4	Medium–large	20,000–100,000	> 1,000,000
5	Medium–medium	20,000–100,000	27,000–1,000,000
6	Medium–small	20,000–100,000	< 27,000
7	Low–large	< 20,000	> 1,000,000
8	Low–medium	< 20,000	27,000–1,000,000
9	Low–small	< 20,000	< 27,000

Step 2. Estimating typical procurement per soldier per group

Procurement data from the ten-country sample was then used to calculate annual procurement estimates for each of the nine country groups. For example, data on light weapons ammunition procurement by Ireland and Latvia was used to calculate an average annual value of spending on light weapons ammunition per soldier for the other countries in the high–small country group.

For each of the ten countries in the sample, the procurement data was used in the following way:

- The mean value of procurement per year for each sample country was calculated.
- For countries involved in armed conflict, the resulting mean procurement figure was adjusted downward to yield a ‘normal’ procurement figure, that is, an estimate of that country’s light weapons ammunition procurement were it not involved in armed conflict.⁷
- The average value of procurement per 1,000 service personnel for each country was then calculated.
- Where there were multiple sample countries in a single group, an average of all those countries was calculated. This generated an average typical value of procurement per 1,000 service personnel for each of the nine country groups.

The authors were unable to obtain procurement data for any of the countries in three of the nine country groups. These groups were: medium–large; low–large; and low–medium (see Table 1). The effect of this data gap on the study was mitigated in two ways. First, the medium–large group contained just three members: China, India, and the Russian Federation. Research into the procurement practices of these three

⁷ Adjustments were made according to the same conflict modifiers used for non-sample countries. See Step 4, below.

countries reveals that they import little, if any, light weapons ammunition because they have a policy of only purchasing such ammunition from domestic sources. The authors deem that North Korea—which is the only country in the low–large category—probably follows the same policy.⁸ A value of zero for light weapons imports was thus assigned to the medium–large and low–large country groups. For the remaining country group (low–medium), an average annual procurement was estimated based on data from other categories.

Step 3. Extrapolating according to armed force size

Provisional estimates of the value of light weapons ammunition procurement for every country in the world⁹ were generated by extrapolating from the ‘typical’ values in each of the nine country categories calculated in Step 2. This extrapolation was made by scaling the typical value (light weapons ammunition spending per 1,000 service personnel) upwards according to armed force size.¹⁰ For example, the typical light weapons ammunition spending per 1,000 service personnel for group 2 countries (high–medium) was USD 291,465. Consequently, the provisional annual average dollar value for light weapons procurement for Germany, a group 2 country with an armed force size of 244,000, is USD 71,117,460.

Step 4. Modifying procurement according to conflict status and domestic production

Provisional procurement estimates were then modified to take into account the effect of engagement in armed conflict. States involved in armed conflict, either within their own borders or abroad, were assumed to consume more ammunition. A list of countries experiencing armed conflict in their territories was developed using the PRIO–Uppsala conflict dataset.¹¹ These conflicts were ranked as either minor (more than 25 battle deaths) or major (more than 1,000 battle deaths). Second, a list of foreign troop deployments to conflict zones was compiled from *The Military Balance 2008* (IISS, 2008).¹²

These lists were used to identify every country involved in armed conflict during the time period covered in the study (2006–09). Each country in conflict was then assigned a modifier that was used to revise upwards initial estimates of light weapons ammunition procurement.¹³ Modifiers were generated based on:

⁸ This assessment was made based on the complete absence of reports of significant exports of light weapons ammunition to North Korea.

⁹ For a small number of states, data on armed force size and military expenditure was not available. Based on the small size of these states, the authors judged them to be insignificant to the total annual global value of light weapons ammunition imports. On this basis they were omitted from the model and are not included in the USD 4.3 billion total estimate.

¹⁰ Data on armed force size was taken from IISS (2009).

¹¹ See UCDP/PRIO (n.d.).

¹² See IISS (2009).

¹³ Estimates for countries with very low levels of foreign deployment (below two per cent of total armed force size) were not modified on the assumption that such small deployments would not have a significant effect on levels of light weapons ammunition procurement.

- an analysis of the difference in the value of light weapons ammunition procurement by Australia and the United States before and during their involvement in the conflicts in Iraq and Afghanistan.
- interviews with ammunition procurement experts.
- author assessments of the probable impact of conflict on ammunition usage.

The effect of domestic production of light weapons ammunition on procurement levels was then factored in (as a ‘production modifier’). This was a two-step process. First, production modifiers for the nine country categories were generated from analysis of the extent to which states in the ten-country data sample procured ammunition domestically. Second, this modifier was applied to a percentage of the provisional procurement estimate for each country. The percentage of the provisional total to which the modifier was applied was determined according to the capacity of a state to produce light weapons ammunition domestically; that is, the modifier was only applied to the proportion of a state’s procurement that it *could have* produced domestically.¹⁴

The application of the conflict and production modifiers generated an estimated average annual value of light weapons ammunition imports for the period 2006–09 for every country in the world.

For example, data on the sample countries suggested that states in country group 3 (high–small) procured 50 per cent of their light weapons ammunition domestically when they had domestic production capacity. Hence, the Czech Republic—a group 3 country with the capacity to produce light weapons ammunition—was assigned a production modifier of 50 per cent. However, because the Czech Republic was judged to have the capacity to produce only 40 per cent of the types of light weapons ammunition assessed in this study, the 50 per cent production modifier was applied to only 40 per cent of the country’s estimated annual procurement dollar value. The calculation for the Czech Republic was:

Estimated annual procurement = USD 25,693,214
 Potential domestic production = 40% of 25,693,214 = USD 10,277,286
 Estimated domestic production = 50% of 10,277,286 = USD 5,138,643
 Estimated imports = 25,693,214 – 5,138,643 = USD 20,554,571

Final calculations

The data generated through the process explained above was then used to derive separate dollar-value estimates for documented and undocumented transfers of light weapons ammunition. The estimated value of documented transfers (USD 302 million) is the sum of the annual average import values of light weapons ammunition for the ten sample countries plus Sweden. Sweden was not included as a sample country in the statistical calculations because data was available only on *imports* rather than total procurement.

¹⁴ Domestic production capacity was based on production data in Jane’s (2007) and Small Arms Survey (2008).

The undocumented value of USD 2.194 billion for international transfers is the sum of the estimated values for every country in the world other than the 11 countries that make up the documented value.

The sum of these two values yields a total estimated value of authorized transfers of light weapons ammunition of USD 2.5 billion. This represents a typical annual value for the period 2006–09.

Estimating undocumented small arms ammunition transfers

The estimated value of undocumented transfers of small arms ammunition was calculated in a fashion similar to that for light weapons ammunition described above. However, extensive reporting to the UN Commodity Trade Statistics Database (UN Comtrade) by states on the trade in small-calibre cartridges meant that this transfer data was used rather than procurement data. Agglomerated figures based upon both import and export data¹⁵ were used.

Country groups

Country groups were based on three variables:

- The number of small arms in a country. This was estimated using the sum of estimated civilian firearm holdings¹⁶ and the number of active personnel in the armed forces.¹⁷ The results were disaggregated into high, medium, and low.
- Gross national income (GNI),¹⁸ which was disaggregated into high, medium, and low.
- Domestic production of small-calibre cartridges. This was a simple ‘yes’ or ‘no’ classification based on information in Jane’s (2003), Omega Foundation (2001), and other sources (such as comments from peer reviewers).

The disaggregation of these three variables into three ranges (for the first two variables) and a categorical yes/no distinction (for the third variable) generated 15 country groups. The division of countries¹⁹ into these 15 groups is reflected in Table 2 at the end of this annexe.²⁰

Averages

Once the groups had been populated, the average values of imports per group were calculated.²¹ Any countries that had not reported any imports to UN Comtrade were

¹⁵ See ‘Estimating transfers in small arms ammunition’ in Small Arms Survey (2010, p. 18).

¹⁶ Provided by Small Arms Survey senior consultant Aaron Karp via private correspondence.

¹⁷ Data taken from IISS (2009).

¹⁸ GNI per capita figures for 2005 compiled by Small Arms Survey senior consultant Aaron Karp from several sources and received via private correspondence.

¹⁹ Countries were not included in the study if the sources used to estimate the total number of guns present did not contain any information. In practice, the countries not included in the estimate had small populations and armed forces, and so their exclusion had a minimal effect upon the global estimate.

²⁰ In theory there are 18 possible groups according to this model. However, no countries fell into the ranges of three of them (groups 1–1–0; 1–2–0; and 2–1–0), leaving 15 groups. See Table 2.

²¹ This was calculated from the average annual small arms ammunition imports, as reported to UN Comtrade, for each country within a specific group.

assigned estimated import values according to the average for the group to which they belonged.

Conflict

Countries in which there was major armed conflict (more than 1,000 battle deaths according to the UCDP/PRIO dataset) and that did not report import data were assigned a value of USD 30,000,000. This value was based on data provided by exporters to Afghanistan. During 2007 there were only four major armed conflicts—in Afghanistan, Iraq, Somalia, and Sri Lanka—none of which reported import data to UN Comtrade. Yet extensive reporting by other countries of *exports* of small arms ammunition to Afghanistan indicates that these exports were worth USD 19,157,925. This figure was increased to 30,000,000 as the export data was not comprehensive. Iraq, Somalia,²² and Sri Lanka were therefore assigned the value of USD 30,000,000 rather than the corresponding group estimate.

Values were not modified for countries experiencing minor territorial armed conflict or to countries with foreign military deployments. The reason for this was because, in general, civilian and law enforcement demand for small-calibre cartridges is equivalent to, or much greater than, military demand. So, unlike light weapons ammunition, a country's total demand for small-calibre cartridges is unlikely to be significantly affected by minor armed conflict or foreign deployment.

Final calculation

Finally, the individual figures of each country were summed, providing an estimate of global imports. The value of the documented trade (USD 1.601 billion)²³ was subtracted, leaving the estimated value of the undocumented trade of USD 169 million.

Table 2 **Country groups used to estimate the undocumented trade in small arms ammunition**

Firearms estimate*	GNI	Domestic production	Country
1	1	1	United States of America
1	1	1	Germany
1	1	1	France
1	1	1	Canada
1	1	1	Italy
1	1	1	Saudi Arabia
1	2	1	Mexico
1	2	1	Brazil
1	2	1	Russian Federation
1	2	1	Thailand
1	2	1	Turkey
1	2	1	South Africa
1	3	0	Yemen
1	3	0	Iraq

²² Somalia was included despite being under embargo as Security Council Resolution 1744 (2007) allowed the export of arms to Somalia for the use of the Somali Transitional Federal Institutions and the African Union Mission in Somalia (AMISOM). See UNSC (2007).

²³ This figure was derived from UN Comtrade data. For details, see Small Arms Survey (2010, ch. 1).

1	3	1	India
1	3	1	China
1	3	1	Pakistan
2	1	1	Taiwan
2	1	1	Spain
2	1	1	United Kingdom
2	1	1	Switzerland
2	1	1	Australia
2	1	1	Sweden
2	1	1	Greece
2	1	1	Austria
2	1	1	Finland
2	1	1	Belgium
2	1	1	Czech Republic
2	1	1	Norway
2	1	1	South Korea
2	1	1	United Arab Emirates
2	2	0	Algeria
2	2	0	Lebanon
2	2	1	Colombia
2	2	1	Argentina
2	2	1	Iran
2	2	1	Venezuela
2	2	1	Serbia
2	2	1	Chile
2	2	1	Guatemala
2	2	1	Uruguay
2	3	0	Angola
2	3	0	Vietnam
2	3	0	Uzbekistan
2	3	0	Afghanistan
2	3	0	Mozambique
2	3	1	North Korea
2	3	1	Nigeria
2	3	1	Sudan
2	3	1	Philippines
2	3	1	Ukraine
2	3	1	Myanmar
2	3	1	Egypt
2	3	1	Morocco
2	3	1	Indonesia
2	3	1	Syria
2	3	1	Paraguay
3	1	0	Kuwait
3	1	0	Qatar
3	1	0	Ireland
3	1	0	Cyprus
3	1	0	Slovenia
3	1	0	Bahrain
3	1	0	Equatorial Guinea
3	1	0	Luxembourg

3	1	0	Malta
3	1	0	Trinidad and Tobago
3	1	0	Barbados
3	1	0	Bahamas
3	1	0	Brunei
3	1	1	Denmark
3	1	1	Portugal
3	1	1	Japan
3	1	1	New Zealand
3	1	1	Israel
3	1	1	Hungary
3	1	1	Netherlands
3	1	1	Singapore
3	2	0	Libya
3	2	0	Croatia
3	2	0	Peru
3	2	0	Belarus
3	2	0	Jordan
3	2	0	Panama
3	2	0	Oman
3	2	0	Cuba
3	2	0	Former Yugoslav Republic of Macedonia
3	2	0	Dominican Republic
3	2	0	El Salvador
3	2	0	Latvia
3	2	0	Albania
3	2	0	Namibia
3	2	0	Kazakhstan
3	2	0	Jamaica
3	2	0	Gabon
3	2	0	Montenegro
3	2	0	Lithuania
3	2	0	Estonia
3	2	0	Botswana
3	2	0	Papua New Guinea
3	2	0	Suriname
3	2	0	Tunisia
3	2	0	Belize
3	2	0	Fiji
3	2	1	Bosnia
3	2	1	Poland
3	2	1	Bulgaria
3	2	1	Malaysia
3	2	1	Slovakia
3	2	1	Ecuador
3	2	1	Armenia
3	2	1	Romania
3	3	0	Democratic Republic of the Congo
3	3	0	Bangladesh
3	3	0	Somali Republic
3	3	0	Tanzania

3	3	0	Tajikistan
3	3	0	Honduras
3	3	0	Ethiopia
3	3	0	Sri Lanka
3	3	0	Côte d'Ivoire
3	3	0	Nicaragua
3	3	0	Azerbaijan
3	3	0	Georgia
3	3	0	Moldova
3	3	0	Zambia
3	3	0	Senegal
3	3	0	Eritrea
3	3	0	Burundi
3	3	0	Turkmenistan
3	3	0	Madagascar
3	3	0	Mali
3	3	0	Chad
3	3	0	Benin
3	3	0	Gambia
3	3	0	Guinea
3	3	0	Guyana
3	3	0	Republic of the Congo
3	3	0	Laos
3	3	0	Niger
3	3	0	Malawi
3	3	0	Ghana
3	3	0	Rwanda
3	3	0	Central African Republic
3	3	0	Togo
3	3	0	Mauritania
3	3	0	Mongolia
3	3	0	Liberia
3	3	0	Lesotho
3	3	0	Sierra Leone
3	3	0	Djibouti
3	3	0	Guinea Bissau
3	3	0	Cape Verde
3	3	1	Kenya
3	3	1	Cambodia
3	3	1	Uganda
3	3	1	Zimbabwe
3	3	1	Cameroon
3	3	1	Bolivia
3	3	1	Nepal
3	3	1	Burkina Faso
3	3	1	Kyrgyzstan

Note: * civilian and military

Sources:

firearms estimate: correspondence with Aaron Karp; IISS (2009);

GNI: correspondence with Aaron Karp;

domestic production: Jane's (2003); Omega Foundation (2001); expert comments

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