Small Arms Survey 2012: Moving Targets

Annexe 8.1: Methodology
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The methods for estimating the annual global value of imports of parts and accessories are presented in Chapter 8 of the *Small Arms Survey 2012,* 'Piece by Piece: Authorized Transfers of Parts and Accessories' (Grzybowski, Marsh, and Schroeder, 2012, pp. 247–50). This annexe contains additional details on some of the data and estimation techniques used in the chapter, including for the estimate of imports of weapon parts; it also discusses the revisions of the estimates of imports of firearms and light weapons originally conducted in 2009 and 2011, respectively.[2]

I. Estimating the overall annual value of imports of parts of small arms and light weapons

Transfers of parts of many categories of small arms, such as pistols and revolvers as well as sporting guns and shotguns, are well documented by UN Comtrade. Taken together, imports of these weapon parts have an average annual value of USD 459 million for the years 2005–09. Imports of parts of military firearms and light weapons, however, are neither widely reported nor clearly distinguished from imports of parts of larger conventional weapons in UN Comtrade categories. Therefore, an estimation technique was used to estimate the annual value of international transfers in these parts.

As with previous instalments of Small Arms Survey's four-year study on transfers of small arms and light weapons, estimation models were used to calculate the estimated value of undocumented transfers of parts for small arms and light weapons. The general idea of the interpolation method is to estimate the import values of non-reporting countries based on available information on imports from reporting countries. By assuming that the general relationship between imports and particular variables—referred to here as 'independent variables'—is roughly similar for reporters and non-reporters, this relationship between import values and the independent variables can be transferred from reporting countries to non-reporting countries so that their imports are estimated based on information about their independent variables.

The models used to generate the estimates make several assumptions about the effect of certain explanatory factors or independent variables on individual countries. While necessary, these assumptions cannot fully account for idiosyncrasies in national arms procurement and arms import practices. Given this methodological caveat, the figures generated through the estimation model should be viewed as estimates rather than definitive accountings of international transfers.

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[1] The methods described in this annexe have been developed by Small Arms Survey researchers over the multi-year project on authorized arms transfers and studies preceding this project. Two key contributors are Pablo Dreyfus and Patrick Herron, who served as co-authors in previous phases of this study.

[2] See Dreyfus et al. (2009) and Herron et al. (2011).

In assessing authorized transfers of light weapons and ammunition, the independent variables used in the estimation models were chosen based on the authors' perception of which characteristics of individual countries would be most closely associated with their arms imports. These characteristics include the size of the armed forces, military expenditure per soldier, involvement in armed conflict, and production capacity.[3]

Estimating the value of transfers of parts for small arms and light weapons involved several steps. First, a large data set was constructed in order to identify variables that correlate most closely with actual imports of parts in countries for which import data was available.[4] The data set for the estimation of transfers of parts comprises 201 countries,[5] although several countries were excluded because data for the independent variables was lacking. In the case of the estimation model for imports of weapon parts, 173 countries could be included in the calculations.[6] The number of countries for which documented imports of parts under HS code 930591 was available was 83; for the other 90 countries, data for independent variables was used to estimate imports of parts of military firearms and light weapons.

Had the regression analysis yielded statistically significant and important results, a more sophisticated method than interpolation could have been established by generating a precise formula that included all relevant factors in their exact proportional weight. However, while some factors were found to be statistically significant, their importance was only moderate.[7] This might be due to widespread idiosyncratic import practices, as the analysis of the documented trade itself also suggests.[8] It was thus decided to opt for an interpolation analysis based on the three most important factors that could be identified from the statistical analysis: 1) OECD membership, 2) GDP, and 3) the predominance of either private or state-owned production.

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[3] See Herron et al. (2010; 2011).

[4] The tested variables include: the extent of light weapons production—coded as ordinal variable by the authors according to information from Jane's (2004) and Leff (2007)—military expenditure (IISS, 2010), size of armed forces (IISS, 2010), military expenditure as a proportion of GDP, GDP, GDP per capita, total population (World Bank), firearms per capita, total firearms in the country (based on information provided by Small Arms Survey senior consultant Aaron Karp via private correspondence; all continuous variables), OECD membership, NATO membership, EU membership (all three membership variables coded as dichotomous or dummy variables), and the predominance of private or state-owned production (coded as a dichotomous or dummy variable by the authors based on information from company web sites and news sources).

[5] Not all of these are independent states; some are autonomous territories that report their customs data directly to UN Comtrade. This data set was also used for the revision of the estimate of small arms imports discussed section II of this annexe).

[6] The 28 countries that were excluded because of lacking data for one or more of the independent variables are the Comoros, Djibouti, Dominica, the Federated States of Micronesia, Gambia, Grenada, Guinea-Bissau, Kiribati, Liberia, the Marshall Islands, Myanmar, Nauru, the Netherlands Antilles, North Korea, Palau, São Tomé and Príncipe, Samoa, the Seychelles, the Solomon Islands, Somalia, St. Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Taiwan, Timor-Leste, Tonga, Tuvalu, and Vanuatu.

[7] The strongest results were obtained in a model with the three independent variables OECD membership, predominance of private or state-owned production, and GDP.

[8] The analysis also shows why OECD membership and GDP are indeed associated with particular trade patterns (see Grzybowski, Marsh, and Schroeder, 2012, pp. 251–61).

As described in the chapter, country groups were based on the two variables: OECD membership and whether arms production is primarily private or state-owned. The group of 173 countries mentioned above were divided into four groups based on these variables (see Table 8.1).[9] These groups were then divided into sub-groups by GDP so as not to include countries with vastly different GDP values in the same group. In each sub-group, the average value of parts imported by all reporting countries was calculated as well as the average GDP value of all countries, including non-reporters. Dividing the average GDP value by the average import value yielded a 'country factor'. The GDP value of every non-reporting country was then divided by the 'country factor' to produce an estimated import value for this country. Once corrected and adjusted based on mirror data,[10] global import values of documented and undocumented transfers could be generated.

Table 8.1 **Principal country groups in the interpolation model**		
	Predominantly state-owned production	**No predominantly state-owned production**
OECD member	**Group 1:** OECD members with predominantly state-owned production (such as Poland)	**Group 2:** OECD members without predominantly state-owned production (such as Germany)
Non-OECD states	**Group 3:** Non-OECD states with predominantly state-owned production (such as the Russian Federation)	**Group 4:** Non-OECD states without predominantly state-owned production (such as Singapore)

Another necessary adjustment concerned the exclusion of the estimated value of parts that were not intended for small arms or light weapons, but for larger conventional weapons. As explained in the chapter,[11] in UN Comtrade, data on transfers of parts of small arms and light weapons is aggregated with data on transfers of parts for other weapons and reported under a single commodity category (HS code 930591). However, the data on the weapons themselves are categorized in different HS codes so that transfers of small arms and light weapons can be largely, if not entirely, distinguished from transfers of other conventional weapons. Based on the assumption that the proportions between the categories of small arms and light weapons, on the one hand, and particular conventional weapons whose parts are included in the category under HS code 930591, on the other hand, correspond to those between the parts of the respective weapon types under HS code 930591, the proportion of conventional weapons was subtracted from the overall estimate of parts imports so as

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[9] See Grzybowski, Marsh, and Schroeder (2012, pp. 248–49).

[10] In this interpolation model, import data was supplemented by mirror data (see Khakee, 2004). This led to a marginal adjustment of estimates and in particular regarding the distinction between documented and undocumented transfers. In the case of countries that had reported their imports between 2005 and 2009, this meant that agglomerated data based on the reliability index was used for the import values. In the case of countries that had not reported any imports but for which export mirror data was available, this data was at first not used so that the import value could be estimated through interpolating. The estimated import value was then compared to the mirror data; where the interpolated results exceeded the mirror data, the mirror data was added to the documented trade whereas the remaining difference between the interpolated result and the mirror data was treated as undocumented import value.

[11] See Grzybowski, Marsh, and Schroeder (2012, p. 249).

to exclude imports of parts for weapons other than small arms and light weapons (see Table 8.2).[12]

Table 8.2 Share of imports, by weapon category and type, 2009		
Weapon category (HS code)	**Weapon type**	**Percentage of imports**[14]
Military firearms (930190)	Small arms	41%
Grenade launchers, rocket launchers, etc. (930120)	Light weapons	33%
Self-propelled artillery (930111)	Larger conventional weapons	11%
Mortars, non-self-propelled artillery (930119)	Larger conventional weapons but mixed with some light weapons	14%

Source: UN Comtrade (n.d.)

The resulting figure of USD 969 million is the estimated average annual value of imports in parts of military firearms and of light weapons. Together with the aggregate value of USD 459 million dollars for imports of parts of pistols, revolvers, sporting rifles, and sporting shotguns, the overall value of the trade in parts of small arms and light weapons is estimated at USD 1.428 billion.[13]

II. Revising the estimate of small arms (firearms) imports

In 2009, the Small Arms Survey published the findings of a rigorous analysis of existing data on the authorized trade in small arms.[14] The estimate was based on a method that differs from the estimation technique developed for the study of ammunition in 2010 and was used in subsequent instalments of the four-year study.[15] To more thoroughly account for undocumented transfers, the previous estimate for transfers of small arms was replaced with an estimate derived via an interpolation model. This section briefly explains how the model was constructed and applied.

Data on international transfers of pistols and revolvers (HS code 930200) and sporting rifles and shotguns (HS codes 930320 and 930330) is widely reported to the UN Statistics Division and is made available through UN Comtrade in fairly disaggregated commodity categories. Far fewer states report on transfers of military firearms (HS code 930190); therefore, undocumented imports of military firearms

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[12] The only 'mixed' weapon category that includes both light weapons and larger artillery is HS code 930119. As there was no conceivable way of establishing how large a proportion of this category should be treated as belonging to small arms and light weapons, the entire proportion of this category was excluded from the estimate of transfers of parts.
[13] Differences in the sum of the individual figures are due to rounding.
[14] For the purposes of this study, the term 'small arms' refers to all firearms, including heavy machine guns and sniper rifles, which are often categorized as light weapons.
[15] See Dreyfus et al. (2009).

have to be estimated.[16] To account for gaps in reporting on military firearms, an estimation model similar to the models described above was developed.

The three key explanatory factors used in this model were military spending per soldier, the size of the armed forces, and GDP.[17] All countries were divided into the following three groups based on their annual military expenditures per soldier:

(1) more than USD 100,000;
(2) USD 20,000–100,000; and
(3) less than USD 20,000.

These groups were further subdivided into three sub-groups, based on the size of the armed forces:

(1) more than 1,000,000 soldiers;
(2) 27,000–1,000,000 soldiers; and
(3) fewer than 27,000 soldiers.

All countries included in the estimation process[18] were thus divided into nine groups.[19] Within each of these groups, the average import value of military firearms of all reporting countries was calculated as well as the average GDP, including for non-reporters. By dividing the average GDP by the average import value a 'country factor' was calculated. The GDP value of every non-reporting country was then divided by the 'country factor', resulting in an estimated import value for this country.[20] This procedure yielded estimated annual import values of military firearms for all non-reporting countries. The sum of these values was then added to the value of all documented imports of military firearms. The annual undocumented trade is estimated to be worth USD 102 million, while the annual documented trade amounts to USD 152 million.

As explained in the chapter, the documented trade in pistols and revolvers, shotguns and sporting shotguns, and military firearms is worth an estimated USD 1.560 billion. This figure is based on an annual average import value between 2005 and 2009 as reported under HS codes 930190, 930200, 930320, and 930330. Together with the

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[16] For a general review of the differences between countries reporting to UN Comtrade, among various other databases, see Lazarevic (2010).

[17] The figures for the size of the armed forces are from 2010 while the data for military expenditure—which was used to calculate the expenditures per soldier—is from 2008; see IISS (2010, pp. 462–68). GDP values were generated based on World Bank (n.d.) in October 2011; like the import values downloaded from UN Comtrade, they represent an annual average of the years 2005–09.

[18] Countries for which no data regarding one or more of the independent variables was available were excluded from the estimation procedure. These are Andorra, Antigua and Barbuda, Bhutan, the Comoros, Costa Rica, Dominica, the Federated States of Micronesia, Grenada, Haiti, Kiribati, Kosovo, Liechtenstein, Macau, the Marshall Islands, Mauritius, Monaco, Nauru, Palau, Panama, Samoa, San Marino, São Tomé and Príncipe, the Seychelles, the Solomon Islands, Somalia, St. Kitts and Nevis, St. Lucia, Timor-Leste, Tonga, Tuvalu, and Vanuatu.

[19] The same procedure of grouping countries based on the variables military spending per soldier and size of the armed forces was also used in the previous studies on transfers of light weapons ammunition and light weapons; see Herron et al. (2010; 2011).

[20] This calculation method differs from the one used in previous studies (Herron et al., 2010; 2011) but is similar to the one used in this year's estimation of the authorized transfers of parts (see above).

estimated value of the undocumented trade in military firearms, the calculations yield a total value of USD 1.662 billion of the annual trade in small arms.

III. Revising the estimated annual value of authorized transfers of portable guided missiles

As summarized in the *Small Arms Survey 2011*, the annual value of authorized transfers of light weapons, including portable missile systems, was derived through the use of an estimation model (Herron et al., 2011). Methodology Annexe 1.3 for the *Small Arms Survey 2011* provides a detailed description of this model. For transfers in which only the quantity of imported units was known, the Survey calculated an estimated value for the transfer by multiplying the number of units by an estimated generic unit value for the model of the transferred missile system. Unit value estimates were compiled from several sources, including government documentation and data gathered by Forecast International, Jane's Information Group, and the Small Arms Survey.

Based on input received during a workshop held in October 2011 to review the findings from the four-year study, the Survey revised some of the unit value estimates used in the estimation model for light weapons. These revisions resulted in an increase in the estimated annual value of authorized transfers of man-portable air defence systems, or MANPADS, from USD 102 million to USD 123 million. Comparable changes to unit value estimates for anti-tank guided weapons resulted in a downward revision of the annual value of authorized transfers from USD 755 million to USD 431 million. When combined with the previous estimate for other light weapons (which did not change), these figures yield an annual estimated value of USD 811 million for authorized transfers of light weapons (Herron et al., 2011, Table 1.4; see Table 8.3).

Table 8.3 The average annual value of transfers of small arms and light weapons, their ammunition, parts, and accessories (USD million)			
	Annual average value of documented transfers	Annual average value of undocumented transfers	Overall average annual value
Small arms	1,560	102	1,662
Light weapons	256	555	811
Parts of small arms and light weapons	1,282	146	1,428
Accessories of small arms and light weapons (weapon sights)[19]	350	n/a	350
Ammunition	1,903	2,363	4,266
All small arms and light weapons, their parts, accessories, and ammunition	5,351	3,166	8,517

Note: All figures are rounded to the nearest USD million. Differences between the column totals and the sum of the individual figures in the columns are due to rounding.

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