IAEA-CN-184/313

Understanding nuclear trade: data sources and tools

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Abstract. Over the last decade a growing concern developed around the trade of equipment especially designed for nuclear use and nuclear-related dual-use items that may be diverted to non-peaceful uses. Global trade data presented in this paper can enhance understanding of nuclear related trade from different perspectives, including IAEA safeguards and export controls. Global trade data stem from declarations made by importers and exporters to customs authorities. Customs data are collected nationally and published by decision of individual States. Bringing these data together gives a global view on trade, on all commodities, in quantitative form over several years. Global trade data are retrieved by Harmonised System (HS) codes, the taxonomy of goods by the World Customs Organization. Hence the use of these data requires mapping items of interest to safeguards to HS codes. To this goal, correspondence tables have been developed by trade analysts and experts of the HS. To make these tables easy-to-use, we have designed and developed a software tool named The Big Table (TBT) which supports: (a) searching a collection of reference documents relevant to nuclear trade analysis (legal documents and technical handbooks); (b) selecting items of interest to specific verifications; (c) mapping these items to HS codes by means of correspondence tables. TBT is currently in use at IAEA's Trade and Technology Analysis Unit. Other perspective uses of global trade data pertain to the area of export controls. These include the estimation of trade flows of controlled items to inform the design of export control policies, as well as verifications on trade compliance with export controls regulations.
In this paper we present firstly a collection of data sources on global trade. The paper then tackles in some detail the use of trade data to support safeguards with a focus on the TBT tool for nuclear trade analysis. Other perspectives uses of global trade data are then briefly outlined.

1. Introduction

In the last decade a growing concern has developed about the trade of nuclear equipment and dual-use items that may be diverted to non-peaceful uses. Trade data collections presented in this paper may enhance understanding of nuclear trade from different perspectives.

One perspective is IAEA safeguards. Since 2007 the Joint Research Centre (JRC) has been supporting the IAEA in identifying and evaluating data on global trade. The analysis of trade related information by the IAEA is proving useful for [1][2]:

- The State evaluation process and for drawing broader safeguards conclusions;
- Verifying import and export declarations made by States under Additional Protocols (APs) [3];
- Identifying indicators of activities to be declared under APs [3] or other nuclear fuel cycle activities.

Other perspective uses of global trade data include the estimation of flows of export-controlled items to inform trade policies, as well as verifications on trade compliance with export controls regulations and restrictive measures.

In this paper we firstly present a collection of data sources on global trade. The paper will then tackle in some detail the first perspective, i.e. the use of trade data for IAEA safeguards, focusing on a software tool developed by JRC is support to nuclear trade analysis. Other possible uses of global trade data will then be briefly outlined in the concluding Section.

2. Data services on world trade

Data services on the world trade described in this paper are *open source*. The data can be accessed by any individual either for free or after the payment of a subscription fee. Differently from other sources on trade (such as news and specialized trade press), the information provided by trade data services has a *regulatory origin* as it stems from declarations made by traders to *customs*. Customs data are collected at national level and, by decision of individual States, released under specific formats, which broadly fall in two categories: transactional and statistical data.

Transactional data are largely equivalent to declarations made by importers/exporters to customs.

Declared data fields subject to disclosure may include:

- A code classifying the commodity traded, e.g. according to the *Harmonized System* (HS) product nomenclature [4] (see Section 3);
- Free text description of the commodity;
- Quantity, expressed in weight or number of items;
- Value;
- Date of shipment;
- Country/port of import/export;
- Party names.

The scope of transactional services can be national or multi-national. Figure 1 shows a map of countries for which collections of transactional data exist and have been catalogued in a survey carried out by JRC [5]. Services on transactions are offered mostly by private companies against a subscription fee. Data services can be delivered online or off-line. Online services are the most common, and rarely offer archive data (e.g. data before 2004). For archive data, CD-ROM services are offered instead.

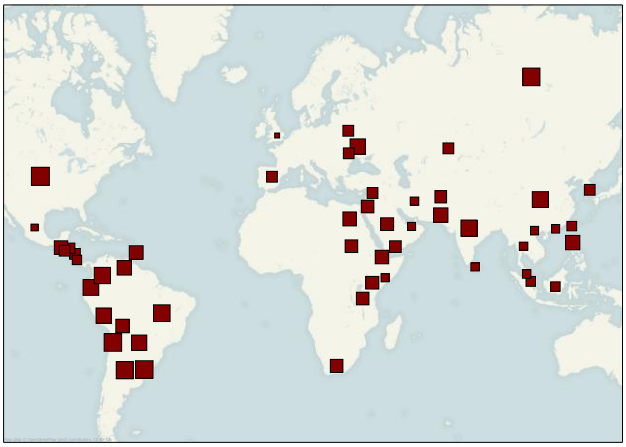

Figure 1. *Countries for which transactional data are available are marked on the map by a square. The size of the square is proportional to the number of years of data available, ranging 1 to 14, starting in 1995. Trade transactions cover imports and exports, except for Spain, UK and US for which only import data are available.*

Statistical data on trade are derived by aggregating transactions data by country, trade flow (import or export), period of time (months, years) and product categories as specified by a nomenclature, the most common being the HS [4] .

A typical data record includes:

- Reporting country (the exporting or the importing country);
- Partner country in trade;
- Trade flow (import or export);
- Category of commodities (HS);
- Time period (months or years);
- Cumulative value of the trade for the above fields;
- Cumulative quantity of trade for the above fields.

The scope of statistical data services is in most cases multi-national. As an example, COMTRADE [6], by the United Nations Organisation, offers the largest geographical coverage, including 150 reporting countries with annual series of data. Archives date back to 1995 or earlier. COMEXT [7], by the Statistical Office of the European Union (EU), is a second example: focused on European reporting countries, COMEXT provides monthly records on EU trade since 1995.

Statistical trade data are offered by international organizations, governmental organizations and national statistical offices, often for free or for limited fees. Private companies also provide access to these data as pay services. The cost of the service is justified by valuable combinations of data sets and advanced interfaces to search and retrieve the data.

Likewise services on transactions, the data collection supporting statistical services takes place at national level, together with the aggregation of the data. After aggregation, national data are released in broader data services contributing to building a global perspective on trade (e.g., as for COMEXT and COMTRADE). Statistical data are published respecting data confidentiality requirements whose definition are country-specific. In the EU and in a number of other countries, the data used for the production of statistics are considered confidential when they allow statistical units to be identified (e.g., the value of a single shipment) either directly or indirectly [8].

3. Mapping items of interest to safeguards with HS codes

Data available from trade data services are retrieved by HS [4] categories. Designed by the World Customs Organization, HS has become the reference taxonomy for commodities adopted by customs, trade associations and statistical offices worldwide. HS is based on about 5,000 commodity groups organized in 22 Sections and a hierarchy made up of Chapters, Headings Subheadings. Each level in the hierarchy is identified by a *code* and an *explanatory note*. Codes are 2-digit for Chapters, 4-digit for Headings and 6-digit for Subheadings. For example, the sequence: 90 → 9026 → 9026.20 leads to a six-digit code for pressure measuring instruments, described in HS by the explanatory note given in Table 1.

Code	***Explanatory note***
90	*OPTICAL, PHOTOGRAPHIC, CINEMATOGRAPHIC, MEASURING, CHECKING, PRECISION, MEDICAL OR SURGICAL INSTRUMENTS AND APPARATUS; PARTS AND ACCESSORIES THEREOF*
9026	*Instruments and apparatus for measuring or checking the flow, level, pressure or other variables of liquids or gases, e.g. flow meters, level gauges, manometers, heat meters (excl. instruments and apparatus of heading 9014, 9015, 9028 or 9032)*
9026.20	*Instruments and apparatus for measuring or checking pressure of liquids or gases (excl. regulators).*
9026.20.20.00	*Electronic instruments and apparatus for measuring or checking pressure of liquids or gases (excl. regulators)*
9026.20.40.00	*Spiral or metal diaphragm type pressure gauges*
9026.20.80.00	*Instruments and apparatus for measuring or checking pressure of liquids or gases, non-electronic (excl. spiral or metal diaphragm type pressure gauges, and regulators)*

Table 1. *Codes and explanatory notes for Chapter (2-digit), Heading (4-digit) and Subheading (6-digit) leading to a HS category for pressure measuring instruments. Further subdivisions (beyond HS) lead to more specific categories that are country-specific. For example, the 10-digit codes reported in the Table refer to the HS subdivision adopted by EU Member States, also called TARIC ([11]).*

Since trade data are reported by HS, a condition to access data relevant to safeguards is to relate items of interest with HS codes. Generally two approaches are possible. The *first* is to browse the HS guided by its hierarchical structure or through a textual search on keywords to identify relevant HS codes. This approach requires specific expertise and technical knowledge of the commodities for which the HS code is sought. The *second* approach is to consult *correspondence tables* compiled by experts associating HS codes (or country-specific subdivisions of the HS) to items subject to export controls. One such table is the European 'Correlation Table' (CR) [9], a mapping between Annex I to the Council Regulation 428/2009[1] [10] for the control of exports of dual-use items and a 10-digit subdivision of the HS. The CR is part of TARIC[2] [11], a database by the European Commission on the Community legislation on trade tariffs, quotas, import/export prohibitions, and restrictions. Community legislation is retrieved in TARIC by a 10-digit subdivision of HS adopted by EU Member States. A subset of the CR concerning only items listed in the Nuclear Suppliers Group (NSG) Guidelines Part 1 [12] and Part 2 [13] is presented in [14].

As an example, according to the CR, 'pressure transducers' listed in [10] as item 2B230 (Figure 2) are related to one HS 6-digit code (9026.20), and, more specifically, to three 10-digit codes whose explanatory notes are reported in Table 1. Pressure transducers meeting specifications in 2B230 are export-controlled in that they can be used to measure the pressure of uranium hexafluoride in facilities used for the separation of uranium isotopes by the gas centrifuge process. Non-nuclear applications of 2B230 include the control of chemical processes and semiconductor manufacturing operations.

2B230	"Pressure transducers" capable of measuring absolute pressures at any point in the range 0 to 13 kPa and having both of the following characteristics: a. Pressure sensing elements made of or protected by aluminium, aluminium alloy, nickel or nickel alloy with more than 60 % nickel by weight; and b. Having either of the following characteristics: 1. A full scale of less than 13 kPa and an 'accuracy' of better than ± 1 % of full-scale; or 2. A full scale of 13 kPa or greater and an 'accuracy' of better than ± 130 Pa. *Technical Note:* *For the purposes of 2B230, 'accuracy' includes non-linearity, hysteresis and repeatability at ambient temperature.*

Figure 2. *Definition of 'pressure transducers' as in the European Council Regulation 428/2009 [10].*

In general, the mapping between export-controlled items and HS codes is *many-to-many*: an item listed for export controls may be related to several HS codes, and viceversa. Furthermore, comparing the detailed definition of pressures transducers in Figure 2 with the explanatory note of the 6-digit HS code in Table 1 shows the degree of approximation introduced by the use of HS. HS does not discriminate between export-controlled pressure transducers from ordinary pressure measuring devices. Despite that, this HS code is the most likely used by exporters and importers for customs declarations on pressure transducers listed under export controls legislation. Under this hypothesis, their export will appear in trade data services under this category together with other pressure measuring instruments. Cases can be expected where actual trade on controlled pressure transducers reported under this HS code can be recognized by trade-related criteria, such as the *trade unit value*. The trade unit value is the ratio between the value and quantity of trade. Applied to transactional data, it indicates the price at which a commodity was traded. For statistical data, it indicates the average price for a HS category in a minimum time period of one month. The variance of the price is not published. For low quantity trade, the unit value approximates the price at which a commodity was traded. Export-controlled pressure transducers have a market price around 1000 USD, a price range that separates them from ordinary, cheaper pressure measuring

[1] Annex I of EU Council Regulation on dual-use 'implements internationally agreed dual-use controls including the Wassenaar Arrangement, the Missile Technology Control Regime (MTCR), the Nuclear Suppliers' Group (NSG), the Australia Group and the Chemical Weapons Convention (CWC)'.
[2] Integrated tariff of the European Communities.

devices and the very sophisticated and expensive ones. Applied to analyze transactional data or low-quantity statistical data, the unit value criterion highlights trade data points that *may* indicate import or export of controlled transducers, as illustrated in Figure 3.

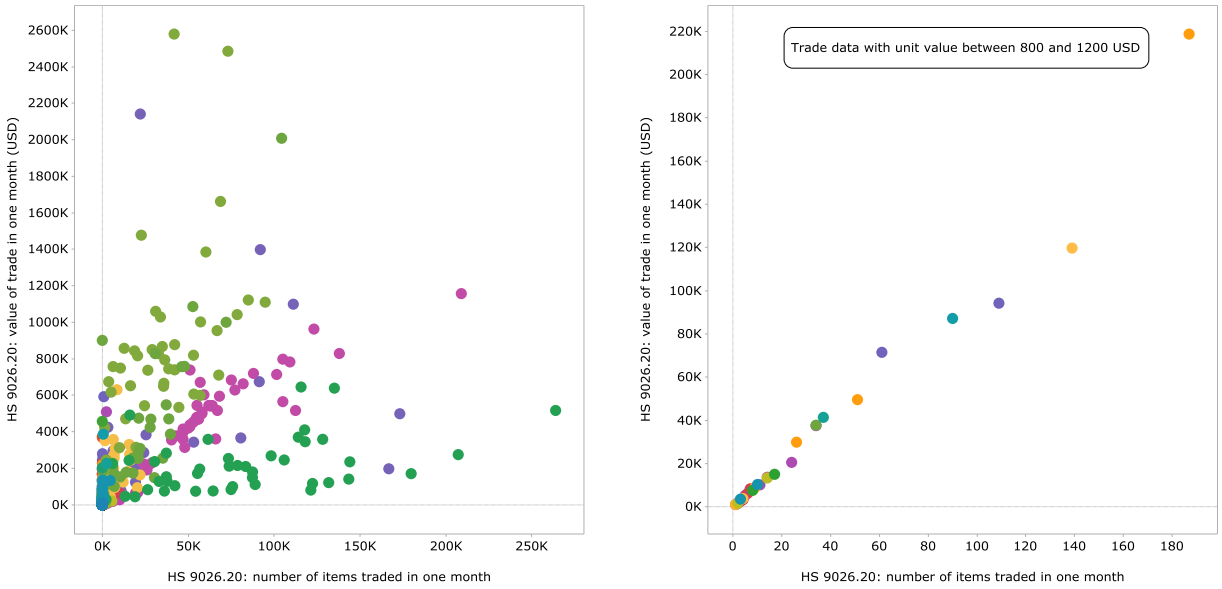

Figure 3. *Trade analysis applied to statistical data of world exports to Country X of items declared as HS 9026.20. Each plot shows monthly exports (dots) reported as number of items traded (horizontal axes) and value of trade expressed in USD (vertical axes). Dots' colors indicate different exporting countries (anonymised). Left plot: Complete monthly trade over 2 years. This plot shows the large variability in quantity and value of trade under HS 9026.20. Right plot: Monthly trade filtered by unit value between 800 and 1200 USD. These data points correspond to pressure measuring devices matching the market price of export-controlled pressure transducers. As such, these data points may trigger actions aimed at clarifying the precise nature of the trade.*

4. The Big Table: a tool in support to nuclear trade analysis

Before addressing the Harmonized System, the identification of items relevant for nuclear trade analysis requires the consultation of a collection of reference documents where export-controlled items are listed and described. The collection of reference documents includes *regulatory documents* and *technical handbooks* on 'listed' items.

Regulatory documents of relevance are: the Additional Protocol Annex II [1], the NSG Guidelines Part 1 [12] and Part 2 [13], the Goods Review List Annex 3 (GRL) [15], and the European Council Regulation 428/2009 Annex I [10]. Supporting handbooks have been developed in connection to regulatory documents, namely: the IAEA handbooks on items listed in Annex II of the AP [16] and in the GRL list [17]. Finally, the Harmonized System [4] needs to be consulted as explained in the previous Section.

This collection of documents describes items from different perspectives, and with different levels of information. Regulatory documents 'define' controlled items. Handbooks provide information on the items' manufacturing process, appearance and uses. The HS provides indications on customs categories that more likely are used by exporters of listed items. It is then relevant for an analyst to search, read and use documents that are cross-referenced to get a complete picture on a given item. In order to facilitate usage of the documents in a coherent and efficient way, we have developed an *information tool on export-controlled items* called The Big Table (TBT). TBT is to identify, present and manage correspondences between items described in the collection of reference documents. It also helps to identify HS codes relevant to a particular item.

TBT user interface of is shown in Figure 4. Trade analysts can search items in the document collection either by text or by *correspondence tables*. In general terms, correspondence tables relate items listed in different documents of the collection. Some tables identify *equivalent* items appearing in different reference documents. For example, pressure transducers referenced in Council Regulation 428/2009 as item 2B230 are listed in the NSG Guidelines Part 2 as item 3.A.7: this correspondence is immediately made available by TBT. Other correspondences associate items with HS codes: this in view of trade data retrieval and analysis.

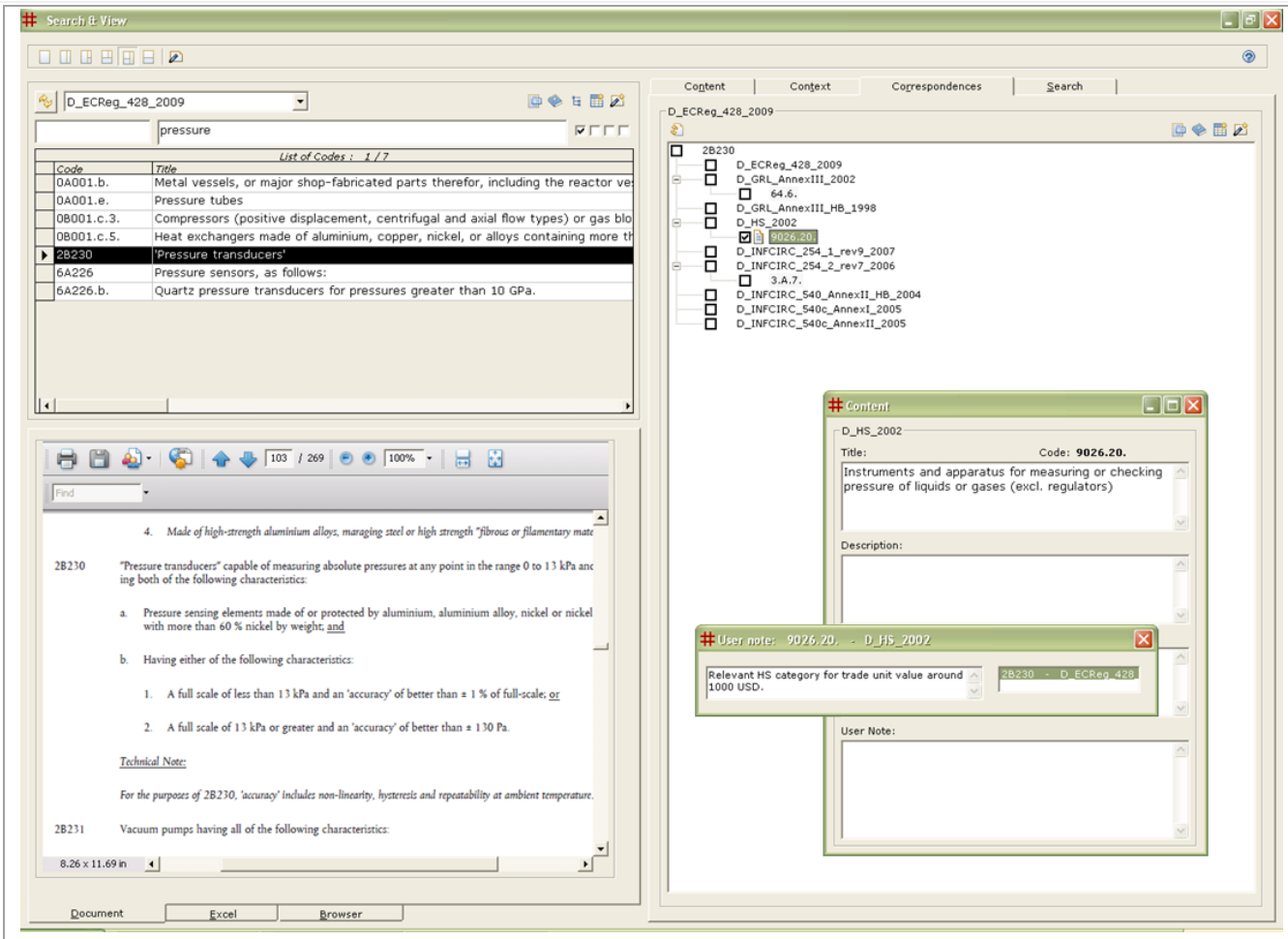

Figure 4. *Interface of 'The Big Table tool for nuclear trade analysis. A document in the collection can be searched by text (top-left panel). Selecting an item of interest retrieves: (i) its definition in the original document (bottom-left panel); (ii) corresponding items in other documents of the collection (top-right panel). Among these Harmonized System codes can be selected in view of querying trade data services. A correspondence to a given HS code can receive analysts' annotations (top-most window on the right).*

Correspondence tables are either *'native'* or *'derived'*. Native correspondences are made by experts by comparing pairs of documents. For example, the 'Correlation Table' between Council Regulation 428/2009 Annex I and HS is native. Derived correspondences are obtained by *composing existing correspondences* (whether native or derived). Given three documents D_1, D_2, D_3 and two correspondences $D_1 \rightarrow D_2$, and $D_2 \rightarrow D_3$, a third correspondence is derived between D_1 and D_3 by: $D_1 \rightarrow D_3 = D_1 \rightarrow D_2 \rightarrow D_3$. This is useful in different ways. *First*, and in view of trade analysis, it is of interest to make relevant HS codes available to items *whatever* the reference document they appear in. For example, the HS codes associated by the Correlation Table to pressure transducers in the Council Regulation 428/2009 can be 'inherited' by pressure transducers listed in the NSG Guidelines Part 2. *Second*, the composition operator facilitates the incorporation of revisions of regulatory documents that are already part of the collection. It suffices to define in TBT the correspondence between the new and old version of the document. This is rapidly done using comparison tables that always accompany the revisions of regulatory documents.

Figure 5, left, shows as solid lines native correspondences between pairs of documents. The European CR is indicated, relating Council Regulation 428/2009 to the HS. A dashed line shows a derived correspondence connecting the NSG Guidelines Part 2 to the HS. This is obtained by composing two native correspondences, the one connecting NSG Part 2 to Council Regulation 428/2009, and the CR. We have derived and embedded in TBT all meaningful correspondences between documents in the collection for these to be immediately available to analysts. For instance Figure 5, right, shows all correspondences in TBT connecting items listed in Annex II of the AP to related items in all documents of the collection.

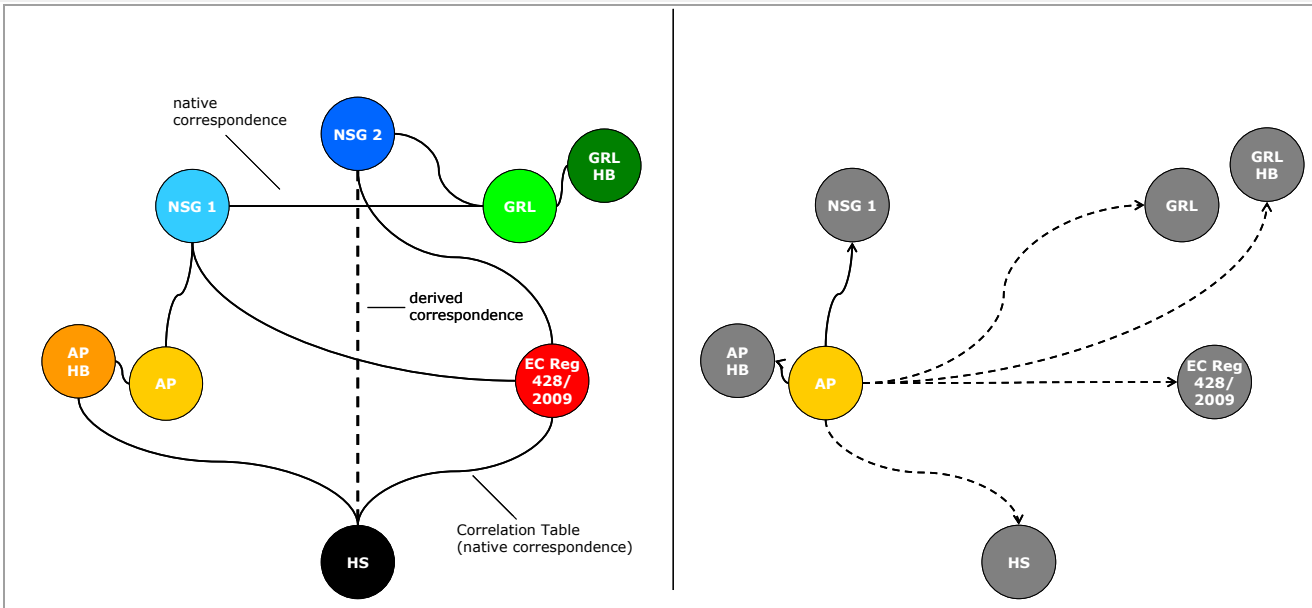

Figure 5. *Schematic view of correspondence tables (represented as lines) between reference documents in TBT (represented as circles). Left: native correspondences shown as solid lines. An example of derived correspondence is shown as a dashed line. Right: all native and derived correspondences connecting the Additional Protocol (Annex II) to other reference documents.*

Finally correspondences can receive analysts' annotations. For correspondences towards the HS, the annotations record experts' appreciation on the value of a link to HS for nuclear trade analysis. For example, the link between pressure transducers and the corresponding HS code can be annotated to be relevant for pressure measuring instruments traded at a unit price of about 1000 USD.

TBT is currently in use at IAEA's Trade and Technology Analysis Unit.

5. Uses of global trade data

A collection of open source data on world trade was presented. The data exist *independently* of safeguards as they originate from declarations made by exporters and importers to customs authorities. Notable features of this collection are:

- Global geographical coverage, allowing for trade analysis beyond national perspectives.
- Complete data series over several years, making visible trends and trade patterns between countries.
- Large product coverage, enabling analysis on any type of commodity traded.
- Numerical trade descriptors (values and quantities), allowing for quantitative data analysis.

These features make trade data supportive to IAEA safeguards [2] despite inherent limitations linked to the use of Harmonized System codes. Within these limitations, positive cases exist where HS codes are sufficiently accurate to give indications on trade of interest; also, the data can be made less ambiguous by quantitative analysis on trade-related criteria such as price indicators.

Besides uses in safeguards, other uses of global trade data yet to be explored pertain to the area of export controls. In all countries, the licensing of export-controlled items is responsibility of national authorities. It is based on detailed information provided by exporters in license applications. It makes use of deep technical expertise by licensing officers and a history of national trade on export-controlled items. However there is a global perspective to export controls that goes beyond data and knowledge available at single country level.

For example, it might prove useful to frame licensing requests for selected items into a global trade profile of given destination countries. The trade profile may include the same commodities being licensed or related ones. When considered *together*, information about global trade in these commodities may have a significance different from when considering national trade only.

As a second example, on the enforcement side of export controls, national customs authorities may need to consider global trade data to detect cases of deflection of trade. These are cases where nationally controlled items

licensed for export to a given destination country may be re-exported to a third country, possibly circumventing national trade restrictions towards the end-destination country.
Finally, at policy level, the effective implementation of export controls must facilitate low-risk trade while impeding trade connected to significant proliferation risks. At EU level, one instrument intended to facilitate low-risk trade is the Community General Export Authorization (CGEA). This is a European-wide generalization of the concept of national general export authorizations implemented in some EU Member States. CGEAs are configured as lists of controlled items and low-risk destinations for which export licences are automatically granted. The decision about how to configure CGEAs is taken as EU level. Global trade data can help shape CGEAs on areas where a facilitation of trade may be needed due to existing high-volume trade flows towards low-risk destination countries.
In all these cases, information derived from global trade data can play a role as presently no official data about the world trade on export-controlled items exist in formats that countries are ready to share. However global trade data can only give indications on trade covered by export controls regulations due to approximations introduced by the use of Harmonized System descriptors.

Acknowledgments. The work here presented has been carried out within the European Commission (EC) Support Programme to IAEA by the EC Joint Research Centre, Action on Information Analysis for Nuclear Security, funded under the 7th Euratom Framework Programme. The authors wish to thank R. Chatelus and M. Tarvainen of IAEA's Trade and Technology Analysis Unit for their guidance on this work.

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