ORGANIZED CRIME INDEX
BACKGROUND PAPER

GLOBAL INITIATIVE
AGAINST TRANSNATIONAL ORGANIZED CRIME

USING SEIZURE DATA TO MEASURE THE SCOPE AND SCALE OF ORGANIZED CRIME

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ABOUT THE SERIES

In the run-up to the launch of the second iteration of the Global Organized Crime Index in September 2023, we are publishing a series of 13 discussion papers. These cover each illicit market considered during the development of the Index. The papers, written by international experts, have been commissioned to help move forward the debate around definitions and measurements used in analyzing transnational organized crime markets, and thus support responses to organized crime.

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INTRODUCTION

The covert nature of transnational organized crime makes it inherently challenging to quantify its scope and scale: it is difficult to estimate the extent of illicit trade in commodities, how this trade varies geographically and how it changes over time. Certain elements of transnational organized crime activity, however, become visible when law enforcement agencies seize illicit commodities, and this is commonly the foundation for most analysis and conclusions that are drawn on global illicit flows.

This paper considers whether data about these seizures can actually quantify the scope and scale of transnational organized crime. It describes various mechanisms used to gather seizure statistics into a database and the main challenges in using seizure data to understand illicit flows. A framework to account for some of these difficulties is described and illustrated using a methodology developed for understanding the illegal ivory trade from seizure data. The uses and limitations of these types of indices are described. Finally, the paper discusses some characteristics of databases of seizure records for learning about the scope and scale of transnational organized crime.

COLLATING SEIZURE RECORDS

Many organizations collate records of seizures of illicit products. In some cases, these records are collected as part of a formal data collection process. For example, UN drug conventions require UN member states to report all drug seizures to the UN Office on Drugs and Crime (UNODC). This data forms the Individual Drugs Seizure data set.[1] The Convention for International Trade in Endangered Species of Wild Fauna and Flora (CITES) requires each party to the convention to produce an annual report on all wildlife seizures made within its borders.[2] For these types of data sets, government or law enforcement agencies provide the data.

In other cases, more informal processes are used to collect seizure records. In such cases, data might be derived from a combination of publicly available records, such as news media, official enforcement agency reports and court records. The data may be sourced from physical documents or by means of online trawls, searches and alerts of research papers, unofficial reports, grey literature, mailing lists and newsletters. For example, the Wildlife Trade Portal[3] uses many of these methods to build its database of wildlife seizures. Databases may also include information from contacts within law enforcement agencies.

Some databases may consist of records obtained from multiple sources using both formal and informal methods. For example, the World Customs Organization uses data submitted (voluntarily) by the customs administrations of its members.[4] It also has information found from searching official government media outlets and online reports from customs administrations and international organizations involved in combating illicit trade.

Whatever the process, the result is a database with a set of seizure records. The database may be publicly available or restricted to specific personnel or organizations. Depending on the scope of data collection, a database could include records of seizures made anywhere in the world of any illicit item, or be limited to seizures made by customs officials of one particular commodity entering or leaving a country.

In general, seizure records are of two kinds: illicit items seized in situ where commodities are obtained, made, processed, stored or sold; or items seized in transit – for example while they are being transported by air, sea or road (for example, in shipping containers, personal luggage or mail). For the purposes of this paper, goods obtained in a seizure – whether they are in situ or in transit – will be defined as a shipment.

Information collected about individual seizures may include the following:

- Characteristics of the shipment, such as:
  - a description of the goods and some measure of quantity (for example, number of items, volume or weight);
  - the route of the shipment (if relevant), potentially including both the country, or location it originated from and where it was destined;
  - the mode of transportation and how it was concealed; or
  - the individuals associated with the shipment.
- Characteristics of the seizure event, such as:
  - when and where the seizure was made (although the detail may range from year and country to the specific date, time and location – for example, a specific airport or building);
  - how the shipment was detected; or
  - the law enforcement organizations involved in making the seizure.
- Characteristics of the reporting mechanism, such as
  - where the seizure record came from, noting that the record may have been reported by multiple sources; or
  - the organization(s) or search mechanism that reported the seizure.

The quality and amount of data collected on seizures can vary widely within a given database because it depends on exactly what information is collected by the law enforcement agencies that made the seizures.

Once collated, many databases produce reports summarizing seizure records. These can provide a minimum estimate of volumes of illicit trafficking, useful information on the nature of seized items and insights into illicit markets. A good example is the set of summaries produced by the UNODC's World Drug Report on cannabis and opioids.[5] The report summarizes the total weight seized globally of different drugs and how the amounts seized change over time. The totals are also broken down by region and country. Maps show the trafficking routes of seized shipments and identify countries that are key source, transit or destination points for these shipments. This is undoubtedly useful information for agencies trying to combat transnational organized crime. However, as stated by the UNODC in its reports,[6] the trends and patterns seen in seizure data do not necessarily reflect the trends and patterns of illicit markets.

DIFFICULTIES INHERENT IN USING SEIZURE RECORDS TO UNDERSTAND ILLICIT MARKETS

The presence of seizure records in a database tells us that illicit activity, enforcement activity and reporting have all occurred. For example, many shipments of an illicit commodity might pass through a country, but if there is no law enforcement activity, then there will be no recorded seizures. Similarly, if law enforcement agencies do make seizures but there is no mechanism or capacity for reporting or capturing them in a database, the result is also no seizure records. Therefore, a lack of recorded seizures does not imply an absence of illicit activity. Changes in the number of reported seizures over time or differences in the number of seizures reported by two countries may therefore reflect differences in reporting or enforcement rather than actual differences in the size of illicit markets. For example, Figure 1 shows a hypothetical time series of reported seizures in one country. Could the spike in reported seizures in 2018 be due to an increase in illicit trafficking in 2018? Or were more seizures made in 2018 because of increased enforcement effort? Is the observed decline in reported seizures in 2019 driven by the high seizure rate in 2018 as traffickers sought different transportation routes, which went undetected by law enforcement agencies? Or is it because of changes in reporting – for example, did staff receive training on the reporting system in 2018, so they were more seizures reported. Perhaps halfway through 2019 the trained staff left and were not replaced, so no more seizures were reported. The low numbers reported in 2022 might be because staff had not yet recorded the most recent seizures. It is most likely that a combination of differences in law enforcement, reporting and trade dynamics are happening over time.

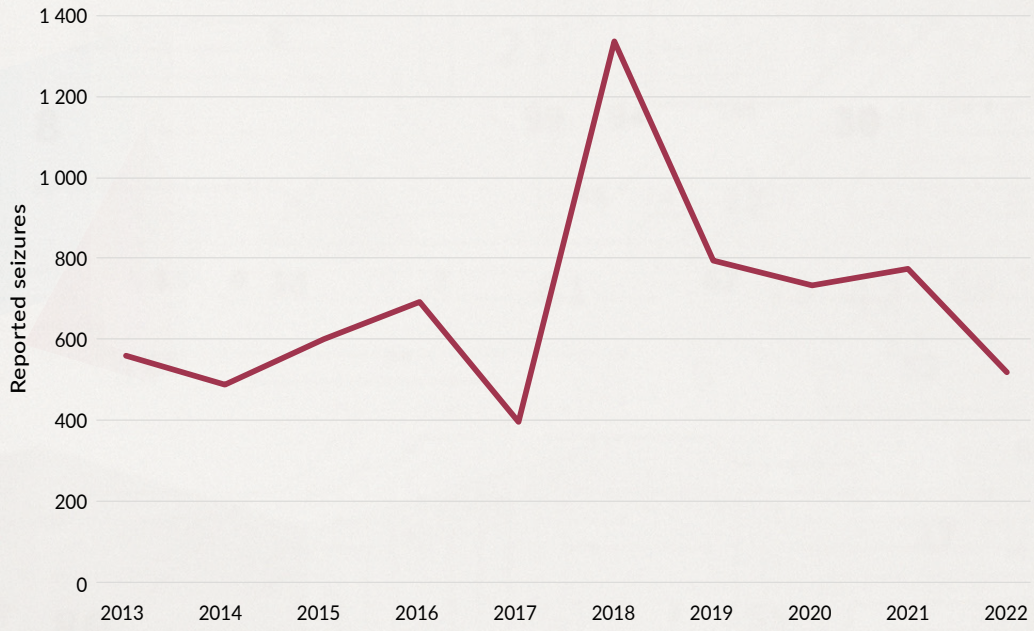

FIGURE 1 Hypothetical example of the total number of reported seizures over a 10-year period.

As a second example, consider three countries where there were 250 shipments in Country A, 500 in Country B and 1 000 in Country C (see figures 2 and 3).[7] Country A and Country B were equally good at making seizures, and seized 20% of the shipments that passed through their country. This proportion is known as the seizure rate. Country C was better at making seizures and had a seizure rate of 50%. Country C has better capabilities for making seizures: for example, x-ray machines, more staff and better training, and there are fewer opportunities for corrupt officials to allow shipments to pass through without being seized.

FIGURE 2 Total number of shipments disaggregated by number of reported seizures (orange), number of seizures (blue) and number of shipments (red) for three countries. Although the number of reported seizures is the same in each case, the total number of shipments varies greatly between countries.

In terms of reporting, Country A reported 100% of its seizures to the database, whereas Country B reported 50% and Country C reported only 10%. The proportion of seizures reported to the database is known as the reporting rate. Country A might be keen to be seen tackling the issue of illicit trafficking, so it ensures that all seizures are reported and recorded. Country B is not willing to report some seizures because they are of a sensitive nature, and Country C is actively suppressing seizure reports because it does not want to be viewed as a country that has a problem with trafficking.

COUNTRY	NUMBER OF SHIPMENTS	SEIZURE RATE	NUMBER SEIZED	REPORTING RATE	NUMBER REPORTED
A	250	20%	50	100%	50
B	500	20%	100	50%	50
C	1 000	50%	500	10%	50

FIGURE 3 Number of shipments, seizures and reported seizures, and seizure and reporting rates for three countries.
NOTE: The data corresponds to that shown in Figure 2.

The outcome is that each country has reported 50 seizures to their databases, even though the amount of trafficking in each country differs substantially. Without any context to explain potential differences in the ability to make and report seizures, the data would suggest that there are equal levels of trafficking in these three countries. The data tells us only that there have been at least 100 shipments in each country but gives no idea of the actual extent of illicit markets.

The same issues also apply when mapping trafficking routes using seizure data. For example, suppose equal numbers of shipments move from Country X to both Country Y and Country Z. All three countries have equally high reporting rates. But Country X and Y have low seizure rates because their law enforcement is poor, so they seize very few shipments that move from Country X to Country Y. Country Z has better enforcement and a high seizure rate, and seizes most of the shipments that move from Country X to Country Z. The outcome is that the trafficking route between Country X and Country Z will appear much more significant than the trafficking route between Country X and Y, even though the actual flows are equivalent.

In summary, because increases or decreases in seizure records can conflate increases or decreases in illicit trafficking, enforcement activity or reporting activity, it is not possible to make a direct link between summaries of seizure data and summaries of illicit trafficking. Information on seizure and reporting rates is required to make more sense of the data.

A FRAMEWORK FOR USING SEIZURE DATA TO DESCRIBE ILLICIT ACTIVITY

Figure 4 represents the relationship between shipments of an illicit commodity and seizures, using the seizure rate; and between seizures and reported seizures, using the reporting rate. If the seizure and reporting rates were known, it would be possible to work backwards from the number of reported seizures (the only information held by the database) to calculate the number of seizures and the total number of shipments. In practice, however, the actual seizures and reporting rates for any country, or how the rates vary over time, are not known.

Creating relative indicators of illicit activity

An alternative approach is to calculate relative indicators of illicit activity. If the seizure and reporting rates were the same for all counties, and remained constant over time, then changes in numbers of reported seizures would mirror changes in shipments or transactions. Although some literature quotes provisional seizure rates (for example, 10% is sometimes quoted for ivory),[8] it is not clear what evidence these rates are based on. It is, however, unrealistic to assume that all countries have the same reporting and seizure rates, and that they do not vary over time.

Instead of assuming fixed and constant rates, we estimate relative seizure and reporting rates. Using these relative rates and knowledge of the number of reported seizures, it is then possible to estimate the relative number of shipments. Using the example above where countries A, B and C have equal numbers of seizure records, Country B has the same, unknown seizure rate as Country A, but a reporting rate that is half that of Country A's. Thus, Country B has twice as many shipments

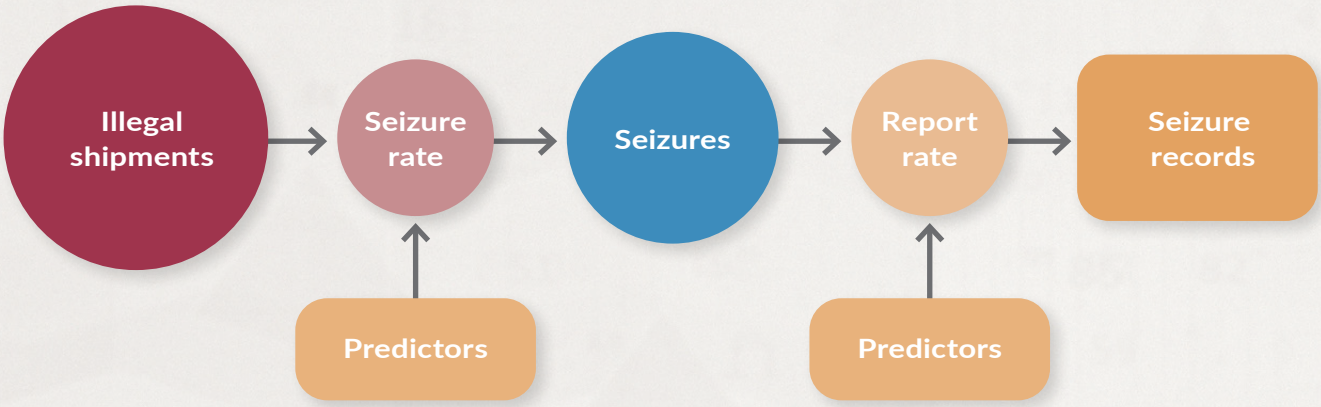

FIGURE 4 Conceptual model of seizure data.

NOTE: Rectangles represent data and circles represent unobservable quantities or rates.
SOURCE: Adapted from Fiona M Underwood, Robert W Burn and Tom Milliken, Dissecting the illegal ivory trade: An analysis of ivory seizures data, *PLoS ONE*, 8, 10 (2013).

as Country A.[9] Country C has a seizure rate that is 2.5 times more than Country A and a reporting rate that is a tenth of Country A's. Hence, Country C has four times more illicit shipments than Country A.[10] From this, a relative index of the number of shipments can be produced by arbitrarily setting the value of Country A's index to, say, 100. Then Country B's relative index is 200 and Country C's 400. Although this does not give an estimate of the extent of the illicit flows, it does accurately reflect the fact that Country C (with 1 000 shipments) has four times more shipments than Country A (250 shipments) and twice as many as Country B (500 shipments). The estimates of the relative number of shipments can be used to describe trends in flows over time and the relative importance or roles of different countries in the trade.

Estimating relative seizure and reporting rates

The challenge is to estimate the relative seizure and reporting rates. The starting point is to explain why these rates might vary over time or differ between countries. The next step is to seek predictors that describe aspects of these explanations. It can be difficult to find these predictors, especially ones measured on comparable scales across multiple countries for a period of years. For example, countries may differ in their ability to make seizures because of the effort expended on law enforcement, such as the resources needed to make seizures, and the effectiveness of this effort. Experience from the illegal ivory trade shows that direct measures of law enforcement, for example the number of staff and availability of equipment, are not readily available in all countries.

Instead, we seek proxy variables. These proxies are not perfect descriptors of a country's ability to make or report a seizure but potentially capture some aspect of its ability. For example, the effectiveness of a country's ability to make, and report, seizures may depend on the socio-economic environment within which law enforcement agencies operate. In countries with poor governance and little relevant legislation one might expect fewer seizures than in countries with good governance and relevant legislation, even if the levels of illicit flows are similar. Variables such as the World Governance Indicators,[11] the UN Development Programme's Human Development Index[12] and International Monetary Fund GDP per capita data[13] can provide background measures of a country's capacity to make and report seizures of any commodity. For illicit wildlife trade, the CITES National Legislation Project can provide a measure of the strength of wildlife trade legislation[14] – the assumption being

that countries with solid wildlife legislation are more likely to seize ivory than countries with poor wildlife legislation. Whether a country has fulfilled its annual reporting obligation to CITES may be taken to indicate how likely that country is to report its seizures to a database.[15]

More specific variables that relate directly to the commodity being trafficked may be internally derived from the seizure records if no other information is available. Variables capturing reasons for differences in the reporting rate will need to record both the ability of data providers to submit, or push, records to the database and actions taken to acquire, or pull, information into the database.

Once a number of proxy variables have been identified, these are tested in a statistical model to estimate relative seizure and reporting rates and relative indicators of illicit activity.

Estimating relative rates and indicators for the illegal ivory trade

We illustrate here how to develop and use proxy variables with the example of the illegal ivory trade.[16] CITES mandated TRAFFIC International to set up the Elephant Trade Information System (ETIS) in 1997 to monitor the status of and trends in the illegal ivory trade.[17] ETIS maintains records of seizures made all along the trade chain from various locations where ivory is in situ or in transit.[18] Law enforcement personnel who make ivory seizures include park rangers, customs officers and local police.

Proxy variables

As a proxy for law enforcement effort, information on trafficking routes was used to derive a law enforcement ratio. This variable is the number of seizures that a country made divided by all known shipments that the country was implicated in. A country is implicated in a seizure either if it made the seizure or if it had an opportunity to make the seizure. The seizures that a country could have made but missed were found from the information on the trade route of shipments seized by other countries. For example, a shipment seized in Malaysia may have come from Tanzania and have been destined for China. This seizure therefore implicates Tanzania and Malaysia, but not China. A low score, close to zero, suggests that a country has poor law enforcement effort, because shipments are getting through and being seized further along the trade chain by other countries. A high score, close to one, suggests better law enforcement effort because few shipments are getting through and being seized later along the trade chain.

A further variable, the trade chain index was also developed. This is a function of the proportion of times a country featured as the destination for a seizure compared to the proportion of times it featured elsewhere on the trade chain. The variable describes the position of the country along the trade chain. This is needed because two countries with similar seizure rates but at opposite ends of the trade chain will have different law enforcement ratios. There are many opportunities for shipments missed by a source country where elephants are poached to be seized later in the trade chain – giving a low law enforcement ratio. In comparison, if goods only enter a country and never leave, because this is their final destination, there is no opportunity for these shipments to be captured later by other countries because they are at the end of the trade chain and so the law enforcement ratio is one.

Proxies for reporting rates focused on how seizure records entered the database. CITES parties are mandated to report all seizures of elephant products within 90 days to ETIS via their CITES management authority. In practice, some countries report regularly, say quarterly; others send reports when notified; and others only in response to direct questions from ETIS about specific seizures. ETIS also receives reports from NGOs and the World

Customs Organization, and has internet alerts for media reports. In the past, ETIS staff, in collaboration with government officials, have carried out focused data collection exercises to ensure that a country's backlog of physically held ivory seizure records are entered into ETIS.

To capture these different approaches, the mechanism by which each seizure entered the database was recorded. This was summarized as a data collection score, calculated as the proportion of records in any year that were either actively sought by ETIS or obtained from automated and regular reporting systems. A high score might suggest a high reporting rate. A low score, when most records are obtained using more ad hoc methods, often not from the CITES management authority, might suggest a low reporting rate.

The same basic concept has been applied to analyses of other wildlife trade data. Tittensor et al used data of wildlife seizures from European countries (extracted from the EU Trade in Wildlife Information Exchange – EU-TWIX) an information data exchange about wildlife trade within Europe) and the US (extracted from the Law Enforcement Management Information System for US seizures).[19] They modelled volumes of multiple species within one model but allowed trends for each species to be different. As a proxy for enforcement effort, they used the total number of seizures across all illegal wildlife trade goods. For the US, they also considered the total number of containers inspected. To capture variability in reporting rate, they used a covariate that described the proportion of countries in each year that provided a complete record of seizures to EU-TWIX, weighted by the mean relative proportion of seizures ascribed to that country. For the US, they assumed that reporting rate remained constant over time.

An analysis of wildlife seizure data collected by government officials over eight years in Ethiopia used information on law enforcement resources and activities in the country.[20] This was from the Ethiopian Wildlife Conservation Authority and included the number of personnel, the number of days spent on controlling illegal wildlife product activities at Bole International Airport and the number of organized operations conducted by the Ethiopian Wildlife Conservation Authority and Federal or Regional policy. They also calculated the proportion of all seizures for which legal prosecutions were successfully made.

Statistical modelling

For ETIS, a statistical model was fitted to the number of seizures. The model was complex[21] and captured the framework described in Figure 4. The model found that a small number of the proposed proxy variables were necessary to describe the variability in the relative seizure and reporting rates between countries and over time. For the seizures rate, these were the law enforcement ratio and trade chain index and, in early analyses, the World Governance Indicators Rule of Law. For the reporting rate, the important variables were the data collection score and the CITES reporting score. Examination of the relative reporting and seizure rates showed considerable variation between countries and over time.

The statistical model jointly estimated the relative seizure and reporting rates, and the relative number of shipments for each of six ivory classes[22] in each country in each year. Six ivory classes were used because trade dynamics – for example, the countries involved and the trends over time – were expected to be different for raw and worked ivory, and for small and large shipments.[23] The estimates of the relative number of shipments were named the Transactions Index. Further statistical models were fitted to convert the Transactions Index into a relative weights index. An interpretation of these indices is that they represent the relative number and weights of seizures that one would expect to be reported in the database if the seizure and reporting rates were the same for all countries and years.

WHAT DO WE LEARN ABOUT TRANSNATIONAL ORGANIZED CRIME FROM SEIZURE DATA?

The original motivation for this paper was to consider how data collected about seizures of a commodity can be used to learn about transnational organized crime. Simple summaries of seizure records cannot be assumed to reflect trends and patterns in illicit markets because they do not account for seizure and reporting rates that differ between countries and over time. This paper has described an approach that accounts for these differences, so that seizure records are transformed into useful indices. Here we outline the uses and limitations of these indices.

The indices quantify the relative size of illicit markets in different countries and how this changes over time. By modelling multiple commodities together – for example, raw and worked ivory products – it is possible to compare and assess their relative importance and examine the contribution of countries to different elements of the trade. The indices can be combined over commodities and/or countries to provide regional and global indices of temporal trends in illicit markets. The relative indices for each country and commodity, and the seizure and reporting rates are useful summaries in themselves and can be processed to give additional insights. For example, when reporting to CITES, a cluster analysis identified countries with similar profiles in the illegal ivory trade.[24]

In addition to describing aspects of illicit markets, the indices can be used in analyses that seek to explain why some countries play a larger role than others in the trade, why there are increases or decreases in flows over time, or to assess the impact of specific policy interventions to combat illicit activity. To understand whether an intervention has had an impact, it is important to consider all possible drivers of an illicit market and how they interlink. Illicit markets are complex, with many drivers operating on different spatial and temporal scales. The effect of any one intervention must be considered along with all other drivers, otherwise its effect might be over- or underestimated.

Care is needed if the relative indicators are to be compared to, combined with, or simply expected to be proxies for metrics that describe other aspects of transnational organized crime, particularly when they relate to activities at the beginning or end of the trade chain. For the wildlife trade, this could be the impact on wild populations, such as poaching pressure[25] or changes in the size of populations.[26] For the drug trade, it may be estimates of the quantity of drugs being produced or the number of people using drugs. Trade chains can vary in length and complexity depending on the commodity; in the case of live animals, trade chains are necessarily short. Some commodities, such as ivory, have long and complex trade chains: the time taken for raw materials to be processed and reach the consumer can take several years.[27]

The relative annual indices are derived from the seizures made each year. Depending on the commodity, there may therefore be more or less correspondence between the relative indices and these other metrics. For example, one might not expect trends in the relative indices derived from ivory seizures to necessarily match trends in elephant poaching or changes in elephant populations because the seizures contain ivory from elephants killed over several years. In comparison, trends in live animals might match changes in population numbers more directly.

Mapping and quantifying the links across the whole trade chain will give a fuller understanding of the scope and scale of illicit activity. The approach described above is a first step in how seizures data can be used to learn about illicit flows. Further statistical work is needed to be able to describe trade routes, while accounting for variable seizure and reporting rates, to model the (varying) speed at which items move along the trade chain and to integrate data from other sources, particularly those describing production and consumption. [28]

One caveat about using seizures data is worth keeping in mind. Seizures do not represent a random sample of illicit transactions, shipments and activity. Instead, they represent the dysfunctional, or failed, part of the trade. Thus, if undetected criminal activity is entirely different from activity that results in a seizure, then these activities will not be captured by the indices derived from seizures data. However, with limited information on illicit activities, it is important to squeeze as much as possible out of any available data sets. When treated appropriately, as described here, seizures data can provide some insights into illicit markets. Linking seizures data to other data sets by mapping the entire trade chain may provide further opportunities to describe and quantify parts of the trade not captured by seizures.

CHARACTERISTICS OF SEIZURE DATA SETS FOR LEARNING ABOUT TRANSNATIONAL ORGANIZED CRIME

The approach described above was initially developed for modelling data from ETIS. There are a number of characteristics of the ETIS database that make such an approach possible and that therefore would be useful if applying a similar approach to model illicit flows in other commodities. ETIS contains a large number of seizures, necessary for estimating trends in several ivory classes and reporting and seizure rates for each country over time. It contains seizures made along the entire trade chain by many different law enforcement agencies. Seizure reporting includes a formal reporting process that is available to all CITES parties. The last two points are expanded on below.

Data covers the whole trade chain and all types of shipments

Not only does ETIS contain plenty of seizure records[29] but these records also cover all parts of the trade chain, from national parks, where elephants are killed, through to where ivory is sold in markets. The seizures could potentially come from all countries involved either as source, transit or consumer countries.

Global statements about the illicit ivory trade require national-level seizure data. Conversely, it is not possible to make statements about trade at the level of individual countries, or regions (such as Africa), without the global analysis, specifically, without data from other countries or regions. For example, the law enforcement ratio in ETIS, one of the variables that adjusts for biases in seizure

rate, requires information about all seizures that a country is implicated in. That is, we learn about law enforcement in one country from its successes in law enforcement (the seizures that the country makes) and from some of its failures (those shipments that passed through the country and were then seized elsewhere). In other words, we learn about illicit flows in one country or region (for example, Africa) by looking at seizures in other regions (for example, Asia) when African countries act as a source, transit or destination for the commodity. It is therefore not easy to see how to describe the scope of illicit activity within one region or country without considering data on illicit activities from outside that region or country.

Not all seizures might at first appearance fit the definition of transnational organized crime. Although seizures of large shipments clearly indicate the presence of organized crime, it can be less clear for seizures of small shipments, even though large shipments come from combining many small shipments. For example, local people might capture wild animals and sell them in the city. They may not be part of an organized crime network but may sell commodities to someone who is. Some data sets and analyses focus only on recording and describing seizures of large shipments. But criminals can change their modus operandi. For example, if law enforcement agencies seize a greater proportion of large shipments, criminals may switch to using smaller shipments. An indicator based only on large seizures would decline, but this does not correspond to a decline in organized crime: rather, it is a decline in using that style of shipment.[30] Thus, the seizures database and analyses should capture shipments of all sizes to make it more possible to measure and detect changes in illicit flows related to transnational organized crime.

Formal and informal reporting mechanisms

In the ETIS analyses, it is the data collection score, describing how seizures enter the database, that is the most important variable in adjusting for the biases in the seizures data. This variable aims to capture some of the reasons why countries differ in their ability to report seizures to ETIS. For ETIS, it is possible to identify the different mechanisms by which records enter the database partly because countries are mandated to report ivory seizures to ETIS, even if they do not always do so.

It is more challenging to identify proxies to represent differences in how seizure records are found when there is no formal mandate for reporting seizures. A particular difficulty arises when the source of seizure records is media reports. This difficulty remains even when internet trawls can capture all relevant online media reports in multiple languages, because the challenge is around understanding which seizures are reported in the media and which are not. A media outlet may have periods when it takes an interest in illicit trade in a commodity and periods when it does not. Seizure reportage therefore reflects media and public interest in the topic rather than increases or decreases in seizures. If trade in an illicit product and seizures remain at a relatively constant, sustained level, it may be less likely that these are reported over time, as they are no longer newsworthy. When there is less interest in a commodity, the media may only report exceptional cases – for example, because the contents, size or method of concealment is unusual. More generally, one might not expect the media to report smaller seizures, so this part of the trade is not represented, even if it is a significant part of the trade. Overall, one might expect media reports to represent only a small proportion of all seizures, and a very biased sample at that. It is not clear how to define a proxy variable to capture this, in particular when comparing countries that have very different media.

CONCLUSION

Data on seizures of illicit commodities is a window onto transnational organized crime. Seizure records are collected by various organizations using formal and informal methods. Simple summaries of the data provide useful information about the nature of the seizures. However, care needs to be taken when using them to better understand the scope and scale of illicit flows, because summaries conflate information on trade, enforcement and reporting.

Statistical models that describe the relationship between seizure records and illicit trade provide a framework for adjusting for the bias in seizure records. The approach requires the use of proxy variables to describe differences in a country's ability to make and report seizures. Development of the proxy variables and the statistical modelling can be complex, but results in simple relative indices of illicit trade activity. These indices can be used to describe trends in illicit flows over time and the relative importance of different countries in the trade. There is potential for the methods to be adapted and new methods developed to describe trafficking routes, model time lags and integrate with other data sources.

For such an approach to work, the data set of reported seizures needs to be large, covering the whole range of countries involved in the trade of the relevant commodity. The collation of seizure records should not rely only on informal methods, such as searching media reports. Care is needed in using relative indices for commodities with a long lifespan, particularly if they are to be linked with other data sets describing, for example, the production of the illicit commodity (for example, number of wild animals killed). An understanding of the whole trade chain is therefore useful when deciding what to collect, measure and model.

NOTES

1 See UNODC, Individual Drug Seizures (IDS) data collection, https://www.unodc.org/unodc/en/data-and-analysis/statistics/drugs/seizures_cases.html.

2 See CITES, Annual illegal trade report, https://cites.org/eng/resources/reports/Annual_Illegal_trade_report.

3 See Wildlife Trade Portal, Traffic International, 2022, https://www.wildlifetradeportal.org/.

4 World Customs Organization, 2021 Illicit trade report, https://www.wcoomd.org/en/media/newsroom/2022/june/the-wco-issues-its-2021-illicit-trade-report.aspx.

5 UNODC, World Drug Report, Sales No. E.21.XI.8, 2021.

6 Also noted by other organizations that collect and use seizures data to learn about illicit trade.

7 For simplicity, we report on number of shipments (assuming they are all similar sizes) rather than looking at weights.

8 S Wasser et al, Genetic assignment of large seizures of elephant ivory reveals Africa's main poaching hotspots, *Science*, 349, 6243 (2015), 84–87.

9 The reciprocal of the product of the relative seizure (1) and reporting rate (0.5): 1/(1 x 0.5) = 2.

10 The reciprocal of the product of the relative seizure (2.5) and reporting rate (0.1): 1/(2.5 x 0.1) = 4.

11 The World Bank, World Governance Indicators, http://www.govindicators.org.

12 UN Development Programme, Human Development Index, https://hdr.undp.org/data-center/human-development-index#/indicies/HDI.

13 International Monetary Fund, IMF data, https://data.imf.org/?sk=388dfa60-1d26-4ade-b505-a05a558d9a42.

14 CITES, National Legislation Project, https://cites.org/eng/legislation/National_Legislation_Project.

15 CITES, Annual report, https://cites.org/eng/imp/reporting_requirements/annual_report.

16 The modelling approach described here was initially developed to model the ETIS data and describe the illegal ivory trade. But the methodology could be applied elsewhere. Detailed description of the methodology and its application can be found in Fiona M Underwood, Robert W Burn and Tom Milliken, Dissecting the illegal ivory trade: An analysis of ivory seizures data, *PLoS ONE*, 8, 10 (2013); T Milliken et al, The Elephant Trade Information System (ETIS) and the illicit trade in ivory: A report to the 18th meeting of the Conference of the Parties to CITES CoP18, 2018, https://cites.org/sites/default/files/eng/cop/18/doc/E-CoP18-069-03-R1.pdf; and for methodological and coding details, see fmunderwood/ETIS_CITES Reporting_R Code, on Zenodo, https://doi.org/10.5281/zenodo.3334771, 2019.

17 See CITES, Elephant Trade Information System (ETIS), https://cites.org/eng/prog/etis.

18 For ivory, the trade chain involves multiple stages. Elephants are the main source of ivory and are killed to remove the tusks. Raw ivory, tusks or pieces of tusks, is taken to processing plants where it is carved into finished objects, now defined as worked ivory, and then reshipped and distributed to be sold to consumers.

19 Derek P Tittensor et al, Evaluating the relationships between the legal and illegal international wildlife trades, *Conservation Letters*, 13, 5 (2020).

20 M Tessema et al, Trends, challenges and opportunities of illegal wildlife trafficking and trade activities within and through Ethiopia, *Ethiopian Journal of Science*, 44, 1 (2021), 47–61.

21 Bayesian hierarchical latent variable models were fitted to the data, assuming a multivariate negative binomial distribution for the response variables.

22 The six ivory classes were for raw and worked ivory divided into three size categories. The sizes were small (less than 10 kilograms), medium (at least 10 kilograms and less than 100 kilograms) and large (at least 100 kilograms). In more recent analyses, the medium and large worked ivory classes have been combined because the number of large worked ivory shipments is small.

23 A single piece of worked ivory may have been involved in multiple transactions and been trafficked through several countries in shipments of varying sizes. Trade dynamics

are therefore not expected to be the same for raw and processed ivory, or for large and small shipments.

24 T Milliken et al, The Elephant Information System (ETIS) and the illicit trade in ivory: A report to the 18th meeting of the Conference of the Parties to CITES CoP18, Doc. 69.3 (Rev.1), Annex 1, 2018, https://cites.org/sites/default/files/eng/cop/18/doc/E-CoP18-069-03-R1.pdf; S Baruch-Mordo et al, The Elephant Trade Information System (ETIS) and the illicit trade in ivory, CoP19, Doc 66.6, Annex 1, 2019.

25 CITES Secretariat, Monitoring the illegal killing of elephants (MIKE) report: PIKE trend analysis – methodology and results, see https://cites.org/sites/default/files/MIKE/E_CITES_Secretariat_MIKE_report_Final_CITESwebsite_Nov2020.pdf.

26 CR Thouless et al, African elephant status report 2016: An update from the African Elephant Database, Occasional Paper Series of the IUCN Species Survival Commission, No. 60 IUCN.

27 For example, one analysis of data from 14 large ivory seizures (at least 500 kilograms per seizure) found that the ivory came from elephants that had been killed many months before the seizure. A seizure made in Togo contained ivory with an average age of 22 months – that is, some elephants had been killed nearly two years before the shipment was seized. See Thure E Cerling et al, Radiocarbon dating of seized ivory confirms rapid decline in African elephant populations and provides insight into illegal trade, *PNAS*, 113, 47 (2016), 13330–13335. Using similar technology to date coca seizures, products were made from coca estimated to have been harvested up to three years earlier. See James R Ehleringer et al, 14C analyses quantify time lag between coca leaf harvest and street-level seizure of cocaine, *Forensic Science International*, 214, 1–3, 7–12 (2011). Furthermore, there is evidence that items held in government stockpiles are returned to illicit markets. See D Stiles, African elephant ivory, GI-TOC, August 2021, https://globalinitiative.net/analysis/african-elephant-ivory. In the case of ivory, this represents elephants that were killed decades earlier. See Thure E Cerling et al, 14-Carbon demonstrates that some illegal ivory is being taken from government stockpiles, *PNAS*, 119, 44 (2022).

28 To aid this work, seizure records need to capture as much information as possible on the countries involved in individual shipments, including, for biological commodities, the location and date when the resource was taken from the wild. Developments in methodologies for dating and locating biological commodities mean this is becoming more common.

29 Over 11 000 in the first analysis, describing trends from 1996 to 2011.

30 T Milliken et al, The Elephant Information System (ETIS) and the illicit trade in ivory: A report to the 18th meeting of the Conference of the Parties to CITES CoP18, 2018, Doc. 69.3 (Rev.1) Annex 1, https://cites.org/sites/default/files/eng/cop/18/doc/E-CoP18-069-03-R1.pdf.

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