Using law enforcement data to estimate illicit activity in an internationally traded illegal commodity

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ABSTRACT

Estimating illicit activity of an internationally traded illegal commodity is challenging because of the hidden nature of the trade. This makes it difficult to observe and to collect data. One source of data is that collected by law enforcement agencies, from seizures of illicit goods. But this data does not represent a random sample of illicit activities. Instead it represents those activities that have come to the attention of law enforcement agencies either due to intelligence or via routine activities. To be able to use law enforcement data to understand patterns in illicit activity, for example estimate trends through time or compare activity in different countries, it is therefore necessary to account for the mechanisms by which the data is obtained and reported.

In this paper I describe a strategy for dealing with the biases in seizures data using the example of the illegal ivory trade. Countries are mandated to report seizures of illicit ivory to the Elephant Trade Information System (ETIS) which holds over 20,000 records of illegal ivory seizures from 1989 onwards. Countries differ in their ability to make and report seizures and in the quality of the information they provide to ETIS. A suite of proxy variables was identified that could potentially explain differences in reporting and seizure rates between countries and over time. By fitting Bayesian hierarchical latent variable models to the data, the proxy variables that best explained the variability in the data were selected. The model was used to produce relative indicators of the number of transactions and the total weight of ivory over time for individual countries for different sizes and types (raw or worked ivory) of ivory shipments.

In addition to outlining the methodology I also discuss the more general implications of this strategy on data collection and analysis to learn about international trade in an illicit commodity.

Keywords: Illegal ivory seizures data, Bayesian hierarchical latent variable models, bias adjustment

PAPER

1. Introduction

Records of seizures of illicit products are sometimes used to learn about trade in illicit activities. For example, the UNODC's World Drugs Report (UNODC, 2015) reports on numbers and sizes of seizures and changes in numbers of seizures of different drugs by region and transportation methods. Similarly, the World Customs Organisation reports on seizures of many different items including drugs, endangered species, counterfeit goods, highly taxed goods such as tobacco, and weapons (WCO, 2015). A major difficulty with seizures data is understanding what these figures say about the relative importance of different countries in the trade and trends in the trade over time.

This paper describes ivory seizures data collected by the Elephant Trade Information System (ETIS), the biases in these data and strategies for accounting for these biases. An overviewof a methodology described in detail in Underwood et al (2013) to estimate trends in the illicit trade using seizures data is given. This paper then reflects on key features of the methodology and data that need consideration when applying to other commodities.

Ivory seizures data

Demand for ivory is mainly for high status decorative and artistic purposes. Elephants are the main source of ivory and are killed to remove the tusks. Raw ivory, tusks or pieces of tusks, are taken to processing plants where the ivory is carved into finished objects, now defined as worked ivory, and then reshipped and sold wholesale or retail to consumers. A single piece of worked ivory may have been involved in multiple transactions and passed through several countries in shipments of varying sizes. Typically, ivory is sourced from Africa and "consumed" in Asia.

In 1997, the Convention for International Trade in Endangered Species of Wild Fauna and Flora (CITES) set up the Elephant Trade Information System (ETIS) database to monitor status and trends in the illegal ivory trade. The data were to be used to report to CITES meetings to inform decision making on elephants

and trade in elephant products. These decisions may require specific countries to strengthen control of their ivory trade and commit to legislative and enforcement actions. As such analyses are needed to identify trends in the trade and key players in the trade and how these change over time.

ETIS includes data on seizures that have been made all along the trade chain. Seizures might be made (1) at various locations such as national parks with elephant populations, warehouses, or ports with ivory waiting to be consolidated into shipments, ivory processing plants or ivory markets or (2) when the ivory is in transit between countries either by air, sea or road in containers, luggage or the mail. Law enforcement organisations that make seizures include national park rangers, customs officers, and local police.

A country's CITES Management Authority (CMA), rather than the organisations that make the seizures, have the responsibility of reporting seizures to the CITES Secretariat or ETIS directly. CMAs are mandated to report ivory seizures within 90 days but in practice this does not happen. Some CMAs send information regularly, for example quarterly or annually, others send records when prompted by CITES notifications which are sent to all CITES Parties and others only in response to direct questions from ETIS, for example about specific seizures that have been noted in the press. Some countries do not report any seizures to ETIS even though it is suspected that seizures might be made in that country. ETIS also receives reports from World Customs Organisation and NGOs. 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 ivory seizure records is entered into ETIS.

There is a standard pro-forma for seizure records but not all of this information is provided for each seizure. Data for all records used in the main analyses include the country that made the seizure, the year in which the seizure was made, whether the seizure was of raw or worked ivory and an estimate of the quantity – either weight or number of pieces. The information on quantity is of mixed quality. Only about half the seizures record the weight and these can range from a few grammes to several tonnes (the maximum recorded being 6.4 tonnes). In many cases the weights, in particular of large seizures, are only approximately recorded – for example four tonnes. For seizures that only reported the number of pieces of ivory the ivory class was predicted based on statistical models fitted to seizures data where both the number of pieces and weight of the seizure were recorded. Conversion of raw ivory into worked pieces leads to some wastage of ivory. To account for this the weight of worked pieces of ivory is converted to an equivalent raw weight, the Raw Ivory Equivalent (RIE). Additional information that is requested includes other countries in the trade chain, that is the other countries through which the shipment has passed, originates from or is on route to, the methods of concealment and detection and the nationality of suspects. Most of this additional information is reported in less than a quarter of the reported seizures.

The ETIS database currently holds over 20,000 records from over 90 CITES Parties (countries or territories that have signed up to CITES). Approximately half of the CITES Parties have not reported any seizures themselves. The aim of the trends analyses is to describe the main trends and countries involved in the trade. As such it is necessary to consider both countries that have made seizures themselves and countries that have been implicated in seizures. To make the analysis tractable countries that play a minor role should not be included. Thus a threshold for inclusion in analysis is defined based on the total number of seizures and estimated weights of seizures that a country has made or has been implicated in over the time period of the analysis. For example, for early analyses this threshold was at least 30 seizures or seizures with a combined weight of 300 kg.

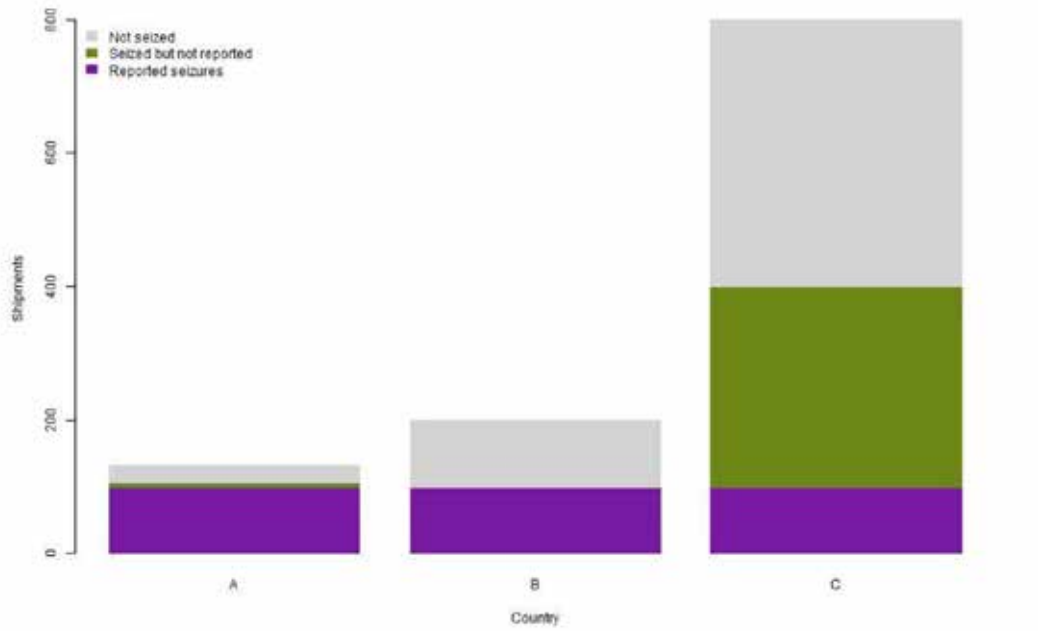
Over the period 1996 – 2011,68 countries met the threshold described above with a total of nearly 12,000 seizures. The USA and China both reported around 2,000 seizures, although the USA's were relatively evenly spread over the whole time period, but over 1,500 of China's reported seizures were from 2009 and onwards. Over the same time period Germany, France, Kenya and Switzerland each reported around 500 seizures in total and at least twenty countries reported between one and ten seizures. Other countries such as Angola, Laos and Togo did not report any seizures but met the threshold for inclusion because of the seizures they had been implicated in.

Biases in seizures data

The difficulty with seizures data is that simplesummaries of the total number, or weight, of seizures do not provide an accurate description of the trends and patterns in the illicit trade. Seizures do not represent a random sample of illicit transaction. Instead they represent the dysfunctional part of the trade and are themselves an intervention in the trafficking process. The mechanisms by which data are obtained, in particular the differences in how seizures are made and reported both between countries and over time, needs to be accounted for.

In particular, we cannot assume that changes in the number of seizures over time or differences in the number of seizures reported by two countries represent actual differences in the trade. For example, consider three countries which all report 100 seizures in one year as shown in Figure 1. For now, let's ignore the size of these shipments.

Figure 1 - Total number of shipments disaggregated by number of reported seizures, unreported seizures and unseized shipments under different scenarios. Although the number of reported seizures is the same in each case the total number of shipments, varies greatly between the three countries.

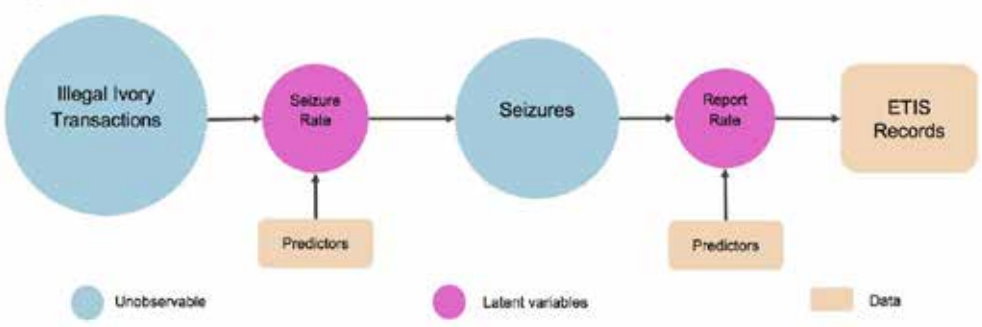


If all countries were equally good at making seizures (we call the proportion that are seized the seizure rate), and reporting these seizures (we call the proportion of seizures that are reported the reporting rate), then we could assume that the illegal trade in each of the three countries is the same. But Country A seized 80% of the shipments that passes through their country and reported 95% of these to ETIS. Countries B and C only seized half of the ivory shipments that passed through their countries. Of these Country B reported all of these seizures and Country C reported one quarter of the seizures. Although A, B and C all report the same number of seizures they represent 76%, 50% and 12.5% of the transactions within each country. The total number of shipments, or transactions, are then 132, 200 and 800 respectively for the three countries. That is, the observed number of seizures is a product of the number of transactions, seizure and reporting rate for each country.

Accounting for biases in seizure and reporting rates

In practice, it is not possible to know the actual seizures and reporting rates for any country, or how the rates vary over time.An alternative approach is to obtain estimates of relative seizure and reporting rates, by identifying the reasons why these rates might vary over time or differ between countries and finding predictor variables that describe aspects of the reasons. Using these relative rates and knowledge of the number of reported seizures it is then possible to estimate the relative number of transactions, as shown in Figure 2.In the Figure 1 example relative rates would indicate that Country C has four times as much trade as Country B and Country B has 50% more activity than Country A. The estimates of the relative number of transactions can be used to describe trends in the trade over time and the relative importance or roles of different countries in the trade.

Figure 2 - Conceptual model of seizures data. From Underwood et al. (2013)



It can be challenging to find data on variables that potentially describe the reasons why countries differ in their ability to make and report seizures.In particular,to find variables on comparable scales across multiple countries. For example, countries may differ in their ability to make seizures because of the effort expended on law enforcement, such as the resources to make seizures, and the effectiveness of this effort. Direct measures of law enforcement, for example the number of staff and the availability of

equipment, are not readily available for all countries that report or are implicated in ivory seizures.

Instead, proxy variables are sought. These proxies are not perfect descriptors of a country's ability to make or report a seizure but potentially capture some aspect of their abilities. For example, the effectiveness of a country's ability to make 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 to be made. World Governance Indicators, UNDP's Human Development Index, and the IMF's per capita GDP were used as background measures of effectiveness and a score from the CITES National Legislation Project used as a measure of the strength of wildlife trade legislation.

For law enforcement effort, data on the number of staff and the availability of equipment is not available for all countries. Instead an internally generated variable – lagged law enforcement ratio – was used as a proxy. This variable is the number of seizures that a country has made divided by the number of seizures that have passed through that country – i.e.both those the country has made and those made by other countries but passed through the country of interest before seizure. A low score, close to zero suggests that a country has low law enforcement effort whereas a high score, close to one suggests much more effort.

Differences in the reporting rate may depend on both the ability of a country to submit records to ETIS and actions made by ETIS to acquire information. The mechanism by which each seizure entered the database was captured to create the data collection score. This was summarised to represent the proportion of records in any year that were either actively sought by ETIS or obtained via automated and regular reporting systems. A high score might suggest that most seizures are reported.A low score, obtained when most records are obtained in ad-hoc methods, possibly from sources other than the CMA such as the media or other organisations,might suggest thatmany seizures are not being reported by that country. A second measure, the CITES reporting score, was derived as the proportion of years that a country fulfilled their reporting obligations to CITES (including ETIS) divided by the number of years that the country had been a CITES Party. A high score, close to one, might indicate that a country takes their reporting requirements to CITES seriously and so could suggest that the seizures reported to ETIS represent most of the seizures that have been made by that country. The socio-economic variables used as proxies for the seizure rate were also considered as possible proxies for reporting rate.

Statistical modelling

The number of transactions that a country is involved in is modelled using the general framework described above with a Bayesian hierarchical latent variable model. We do not expect trading patterns to be the same for raw and worked ivory or for shipments of very different sizes. For example, we might expect different countries to be involved in shipments of raw and worked ivory and trends over time to differ between small and large shipments. Because of the uncertainty with the weights data we categorize the seizures into six ivory classes representing three weight categories, small (less than 10kg), medium (10kg to less than 100kg) and large (at least 100kg) and the two ivory types.

We want to be able to compare the relative number of transactions between the different ivory classes so we jointly model all six ivory classes together. Let y_{ijt} represent the number of seizures made by country i of ivory class j in year t. Then the number of seizures is modelled as a negative binomial distribution with mean μ_{ijt}.

$$y_{ijt} \sim NegBinom(\mu_{ijt})$$

The mean of this distribution is the product of three latent variables. The key variable of interest, λ_{ijt}, the number of ivory class $j$transactions for country i in year t, the relative seizure rate, θ_{it}, and reporting rate, ϕ_{it}.

$$\mu_{ijt} = \lambda_{ijt}\,\theta_{it}\,\phi_{it}$$

The seizure and reporting rates are common across ivory classes for each country because of identifiability issues and because not all countries report seizures in each ivory class. The seizure and reporting rates are functions of relevant covariates. Because of identifiability issues the relative seizure and reporting rates have no intercepts and by standardising variables the average country has a reporting and seizure rate of 0.5.

$$logit(\theta_{it}) = \sum_{l} b_l x_{lit}\; logit(\phi_{it}) = \sum_{m} c_m z_{mit}$$

The number of transactions for each country in each ivory class is modelled as a smooth function over time. The intercept and linear trend were allowed to vary between countries but remained correlated across ivory classes within each country. Higher order terms are shared across all countries in each ivory class to reduce the number of model parameters and because of the lack of data in many cases.

$$log(\lambda_{ijt}) = a_{0ij} + a_{1ij}\, f_1(t) + \sum_{k} a_{kj}\; f_k(t)$$

$$\underline{a}_{0i} \sim MVN(\underline{\alpha}_{0i}, \Sigma_0)\underline{a}_{1i} \sim MVN(\underline{\alpha}_{1i}, \Sigma_1)$$

Model selection was carried out using the Deviance Information Criterion and inspection of credible intervals. The order of fitting was to first identify which covariates best described the seizure and reporting rate, when $log(\lambda_{ijt}) = a_{0ij}$. Given these variables the number of polynomial terms for the trend was identified.

In addition to modelling the number of transactions a relative weights index is calculated. First the rounded values of the λ_{ijt} s are interpreted as the number of illegal ivory transactions in each ivory class for each country and year. By fitting statistical distributions to the weights of shipments for raw and worked ivory separately we simulated weights of each of the λ_{ijt} s.

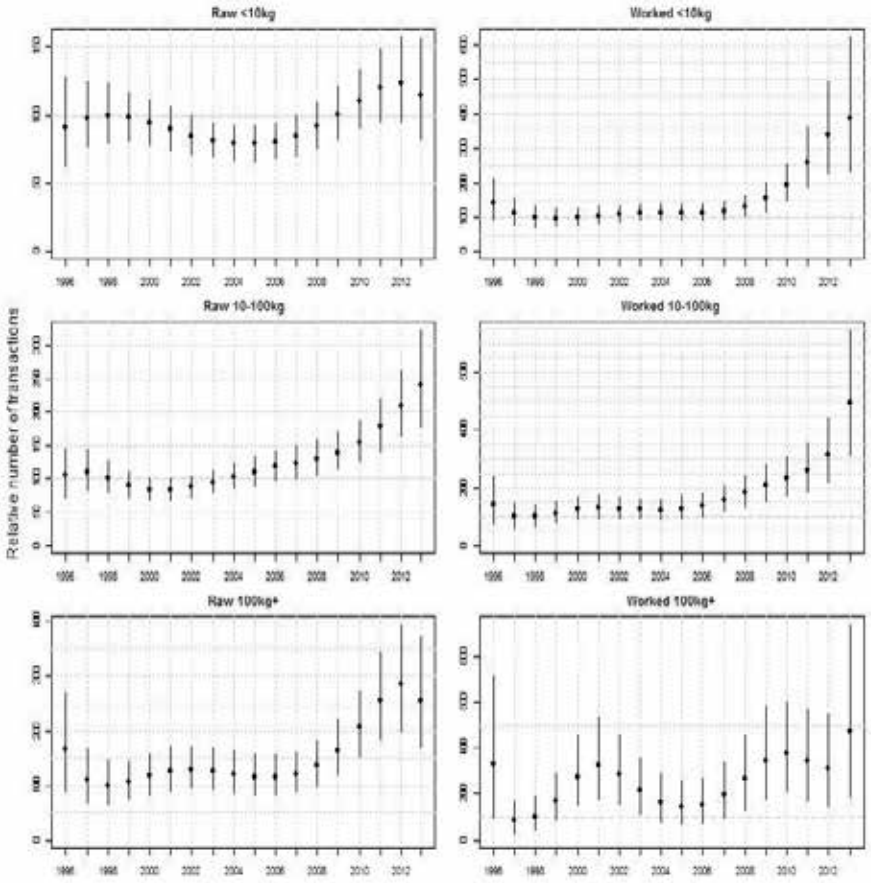
Further details of the modelling, and the creation of proxy variables, are provided in Underwood et al (2013) and Burn and Underwood (2013) and results in Milliken et al (2o13).

Modelling outputs

The λ_{ijt} sare the relative number of illegal ivory transactions for each country in each year in each ivory class. These indices represent the number of seizures that we

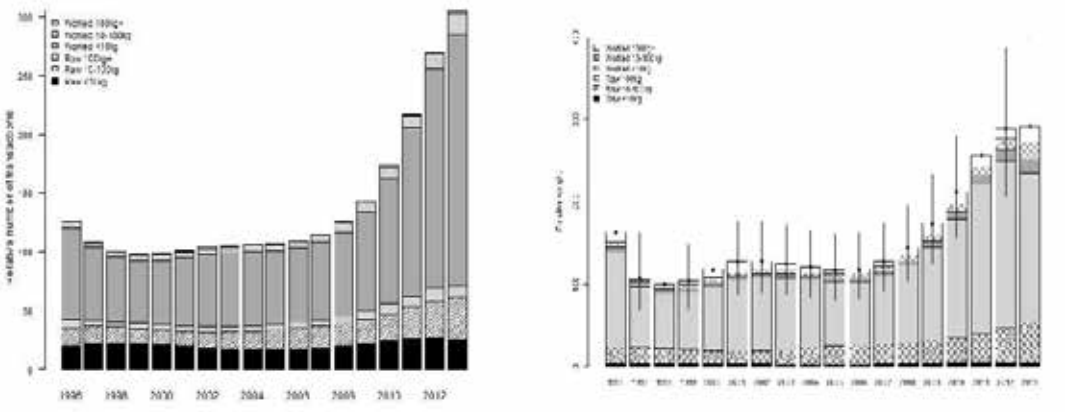
might expect from each country in each year if they were all equally good at making and reporting seizures.

Figure 3 - Transactions Index for each ivory class. From SC66 (2015). Some but not all ivory classes show an increase in trade over time.



For reporting purposes, the relative number of transactions is summarised across countries to show (1) trends in the number of transactions in each ivory class (Figure 3) (2) the relative contribution of each ivory class to the total number of transactions (Figure 4a) and (3) a global Transactions Index. There are different trends in these six ivory classes and the global Transactions Index is dominated by the small worked ivory class whereas most of the weight of ivory in circulation is dominated by the large raw ivory class (Figure 4b).

Figure 4 - Relative contribution of each ivory class to (a) Transactions Index (b) Weights Index. From SC66 (2015). Note how the small worked ivory class contributes most to the Transactions Index and the large raw ivory class most to the Weights Index.



We also obtain estimates of the relative seizure and reporting rates for each country over time. The important variables for seizure rate were the lagged LE ratio and, except in the most recent analysis, rule of law. For reporting rate,the main variable was the data collection score and the CITES reporting score. Examination of the relative rates show considerable variation between countries and over time. The relative importance of different countries and different years using the Transactions index can be considerably different to an interpretation based only on the unadjusted seizures data. This can encourage countries to report their seizures because reportingmore seizures does not necessarily make them more likely to be implicated as major players in the illicit trafficking of ivory.

Requirements for modelling trends in seizures data

The strategy has been developed to describerelative trends in the illegal ivory trade. Here I reflect on some of the data characteristics needed to transfer the approach to other commodities.

The analysis needs a large number of seizures to be able to model trends over time, especially if trade dynamics are thought to vary across different commodities or shipment size. Modelling the trend in each category as a combination of a random intercept and slope for each country and polynomials shared across countries for higher order terms overcomes the problems of very small numbers that are reported by some countries in anycategory. Not all countries can report only small numbers of seizures for this approach to work

The key challenge is dealing with the biases in the seizures data. In the ETIS analyses it is the data collection score which describes how seizures enter the database, that contributes most to bias adjustment. For ETIS, it was possible to identify the different mechanisms by which records enter the database partly because countries are mandated to report ivory seizures to ETIS. If there is no mandate for reporting it can be difficult to identify proxies to represent the reporting process. For example, there are a number of databases where individuals or organisations have tried to capture information about seizures of particular species without any mandate, procedure or requirement for countries to report their seizures. In these cases, seizures data have been obtained by scouring the internet for official and unofficial reports of seizures and by building up networks of people within law enforcement agencies to supply information. The challenge then is to identify proxy variables for the reporting rate that capture the different ways in which searches and networks are used.

To make global statements about the illicit ivory trade, national level seizures data is required. Conversely, it is not possible to make statements about trade at the level of individual countries without the global analysis. This is because the law enforcement ratio, one of the variables that adjusts for biases in seizure rate, uses information about seizures that implicate a country. This would not work without a significant number of seizures recordinginformation about the trade route.

The lack of good quality weights information for all seizures meant that categorizing seizures into only three broad weight categories was an obvious choice. If the weights data had been more accurate and complete, a strategy that directly modelled weights and numbers of seizures together might have been considered. This is a more challenging exercise than has been described here.

Conclusion

Biases in seizures data mean that changes in the number of seizures are not necessarily a good indication of changes in the illegal trade. By identifying the reasons why countries differ in their ability to make and report seizures and seeking out, or creating, predictor variables it is possible to extract useful information out of the data, to be able to make comparisons over time and between countries.

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