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## Global Ivory Market Prices since the 1989 CITES Ban

**Article impact statement:** Four variables, including legality, region, type, and transaction index, affect ivory prices, which have been increasing since 1989.

**Running head:** Global ivory market prices since 1989

**Keywords:** Economics, Elephants, Trade, Smuggling, Poaching, Threatened species

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1 I. Introduction

2 The wildlife trade involves the sale or exchange of wild animals or plants and their  
3 derivatives, such as skins, tourist curios, or food products. It is estimated that this global trade is  
4 worth up to \$350 billion annually, with illegal transactions accounting for approximately \$20  
5 billion (TRAFFIC n.d.; Wyler & Sheikh 2008; Petrossian et al. 2016; UNODC 2016). Data on  
6 illegal trafficking seizures indicate that the wildlife trade is unevenly distributed across taxa;  
7 mammals account for 51% of all wildlife seizures, with ivory being a significant subcategory,  
8 making up 25% of mammalian seizures by number (TRAFFIC n.d.; Petrossian et al. 2016).

9 By 1976, the ivory trade had pushed elephants to the brink of extinction. Plunging African  
10 elephant (*Loxodonta africana*) populations drew international attention, at which point concerns  
11 about their long-term survival led to their listing by the Convention on the International Trade in  
12 Endangered Species (CITES). By 1989, the African elephant had made its way onto CITES  
13 Appendix I, which criminalized all international trade and left individual nations responsible for  
14 the regulation of domestic trade activity (Lemieux & Clarke 2009). In 1999 and 2008, however,  
15 several elephant range countries had elephants down listed to Appendix II due to increasing  
16 populations, and legally auctioned government-stockpiled ivory to designated Asian trading  
17 partners. These two events are known as the “one-off ivory sales” (USFWS 2013). Up until  
18 2016, China and the US, the two largest ivory markets, still had legal components to the trade. In  
19 2016, however, both countries agreed to shut down markets by the end of 2017. The following  
20 analysis assesses market data from 1989 to this 2017 shutdown, which will likely mark a new era  
21 for the ivory trade and African elephants.

22 Almost 600,000kg of illegal ivory has been seized since 1991 (CITES Secretariat 2016a,  
23 2016b). Primarily the product of elephant poaching, these seizures represent the death of

24 approximately 50,000 elephants per year, highlighting the grave effects of the trade on remaining  
25 African elephant populations, currently estimated at just over 350,000 (Chase et al. 2016).

26 As is the case for any commodity, the ivory trade (and therefore elephant poaching activity)  
27 is driven by demand (Milner-Gulland & Leader-Williams 1992; Knapp 2012; Holden &  
28 McDonald-Madden 2017; Holden 2018). Higher ivory market prices lead to higher poaching  
29 incentives, and therefore greater numbers of elephants being killed. Previous researchers have  
30 studied ivory price at multiple levels ranging from local markets to national scale, but the  
31 majority of studies suffer from data deficiency or employ a purely qualitative approach.

32 One of the first analyses examining trends in ivory market price was performed by  
33 Wittemyer et al (2014). The authors collated price information from markets in Samburu, Kenya  
34 and demonstrated that observed spikes in ivory price circa 2008 were correlated with increased  
35 elephant poaching and ivory seizure rates. This study, although limited to Samburu, was among  
36 the first to link ivory prices to elephant poaching and illegal seizures (Wittemyer et al. 2014).

37 Gao and Clark performed a similar analysis in 2014, focusing specifically on price trends in  
38 China. The researchers visited Chinese ivory markets to gather information on ivory price, type,  
39 and weight, amongst other variables. Through their analysis, Gao and Clark established that  
40 illegal ivory prices increased dramatically in the years leading up to 2013, and that illegal raw  
41 ivory was approximately ten times more expensive in China than in Africa (Gao & Clark 2014).

42 Gao and Clark's (2014) conclusions about increasing prices were supported by 't Sas-Rolfes  
43 et al. (2014), who observed significant ivory price increases from 2000-2014 in both Africa and  
44 East Asia. The researchers noted increases in elephant poaching and ivory seizures around 2008,  
45 which supported the findings of Wittemyer et al. (2014).

46 In 2015, Stiles, Rowan, and Moyle published a study drawing connections between the  
47 previously noted price increases and both the one-off ivory sale of 2008 as well as the Global  
48 Financial Crisis of 2007/2008. Their analysis also explored relationships between ivory prices  
49 and elephant poaching, ivory shipping costs, and macroeconomic indicators such as LIBOR and  
50 gold price (Stiles et al. 2015).

51 The only quantitative approach to analyzing ivory markets was published by Milner-Gulland  
52 in 1993. In this paper, Milner-Gulland developed an econometric model to describe consumer  
53 demand for ivory and rhino horn in Japan, which was found to be primarily income-driven. This  
54 analysis, however, is relatively out of date and limited solely to Japanese markets (Milner-  
55 Gulland 1993).

56 Each of these publications highlights the multidimensional nature of the ivory trade by  
57 integrating variables such as the estimated number of elephant poaching events, global ivory  
58 seizure volumes, the type, weight, and legality of ivory, and various macroeconomic indicators.  
59 To the best of our knowledge, however, there have been no attempts to integrate these variables  
60 with market price data in a systematic manner. There is also a lack of studies exploring market  
61 prices both temporally and geographically. The aim of this study, therefore, was to examine a  
62 large dataset of ivory market prices, together with information such as ivory product type (raw,  
63 polished, carved), weight, region, and legality. Alongside the Transaction Index (TI) (which  
64 estimates the number of transactions in a given year) and world gold price, this data will be used  
65 to (1) examine the temporal and geographic trends in market price since the 1989 CITES ban, (2)  
66 determine factors significantly linked to ivory price, and (3) propose a predictive equation for  
67 price based on these factors.

68 By exposing trends in market price since the 1989 CITES ban and identifying its  
69 determinants, it is hoped that better policy decisions can be made with regards to regulation,  
70 education, and conservation efforts. This could, for example, be more stringent trade regulation  
71 in regions where ivory price, and therefore likely demand, is highest. Ideally, this would lead to  
72 decreased poaching incentives and a more secure future for elephants.

73

## 74 2. Methodology

### 75 2.1 Data collection

76 Market data was obtained from two sources. The UK-based non-profit ‘Stop Ivory’  
77 facilitated the provision of pricing data collected between 1999 and 2004. This dataset contained  
78 320 individual transactions from ivory markets visited across Africa, Europe, as well as South,  
79 Southeast, and East Asia. Some historical samples in this dataset stretched back to 1874. This  
80 novel unpublished data was collected using the methods described in Martin and Stiles’s  
81 previous publications (Martin & Stiles 2000, 2002, 2003, 2005).

82 A second set of information was collected via literature search. The search for articles was  
83 executed using the databases Science Direct, Web of Science, and Google Scholar. Google web  
84 searches were also used to find news publications citing ivory prices. Search terms included  
85 ‘ivory price,’ ‘ivory market survey,’ ‘elephant ivory,’ ‘ivory trade,’ and their variations. Prices  
86 were recorded only from peer-reviewed publications, globally recognized news sources, or  
87 reputable elephant non-profit organizations to ensure price sample reliability. A complete record  
88 of collected samples and their information sources is provided in appendix A.

89 Ivory prices from both datasets were filtered to only include samples from 1989 onwards in  
90 order to focus on the global market after the 1989 (CITES) ban on the international ivory trade.

91 Once filtered, the first dataset contained 182 samples and the second 109 samples. This filtered  
92 data was used for all analyses.

93 Data from both sets included the following information: market price, product type (raw,  
94 polished, or carved), estimated weight of sample, country of transaction, legality of transaction  
95 (legal, illegal, or unknown), and the year of the transaction. Raw ivory was defined as tusks that  
96 had not been carved, polished, or worked, essentially coming straight from an elephant (n=201);  
97 polished ivory was defined as tusks that had been polished but not been worked or carved  
98 (n=33); and carved ivory was defined as tusks that had been carved and worked (n=48). Data  
99 was also classified by legality as legal (n=118), illegal (n=83), and unknown (n=90), based on  
100 the records of the original data collectors.

101 Prices were calculated in USD against the weight of the ivory piece and then adjusted for  
102 inflation using the US Consumer Price Index (CPI). This resulted in the final unit of 2017-  
103 equivalent USD per kg. Inspection of the residuals from the statistical models for normality and  
104 homogeneity of variance (applied to inflation-adjusted prices) suggested that the natural  
105 logarithm of price should be used as the outcome variable to satisfy the modeling requirements.  
106 Therefore, all prices hereafter referred to are the natural log of 2017 USD/kg ('LnPrice').

107 Due to sample size constraints, samples were grouped by region, rather than by country.  
108 Regional groupings were maintained as originally assigned by Martin and Stiles (2000, 2002,  
109 2003, 2005) in their market surveys (Table 1).

110

111 [INSERT TABLE 1 ABOUT HERE]

112 Finally, the following global-level variables were collected for each year since 1989: ivory  
113 Transaction Index (TI) (Milliken et al. 2013; Underwood et al. 2013; CITES Secretariat 2016a)  
114 and the international price of gold (Macrotrends n.d.).

115 Ivory TI was applied to this analysis as an index of transaction activity for a given year.  
116 Applied to the trade in 2013 by Underwood, Burn, and Milliken, TI estimates the relative  
117 number of transactions of a target good in a given year (Halpern 1997; Underwood et al. 2013).  
118 Ivory TI also takes into account the number of ivory seizures made by 68 countries for each year  
119 from 1996 to 2015 as well as the relative weight of ivory seized.

120

## 121 *2.2 Statistical Analysis*

122 R v3.5.1 (R Core Team 2018) was utilized for statistical analyses. A univariate general linear  
123 model (GLM) was used to examine temporal and spatial trends and to determine factors  
124 significantly associated with the price of ivory. LnPrice was the dependent variable; fixed factors  
125 tested within the models included data source (field surveys versus literature search), legality,  
126 product type, and region. Covariates tested in the analysis were weight of sample, as well as TI  
127 and gold price of the year of transaction. All fixed factors and covariates were assessed for their  
128 statistical significance at an alpha of 0.05.

### 129 *2.2.1 Temporal and geographic analysis*

130 For temporal analysis, price data was initially plotted against time and fit using LOESS (75%  
131 points to fit, Kernel = Epanechnikov). The fit of the LOESS suggested splitting the data to fit  
132 two linear regression models (Fig. 1). The price data was consequently fit with two linear models  
133 to provide a stronger summary of the price trends over time – the location of the split is  
134 discussed below.



135 *2.2.2 Price determinants*

136 A series of GLMs were run to test different combinations of fixed factors and covariates. An  
137 initial series of GLMs tested for a significant overall difference between the data from the two  
138 sources. Because no difference was found, this factor was removed from all subsequent models  
139 and the combined dataset was used throughout the remaining modeling process. This modeling  
140 process involved running the GLM repeatedly to identify the strongest combination of predictors  
141 of ivory price, assessed collectively by adjusted R-squared values and significance levels. All  
142 factors in the final model that were statistically significant ( $p < 0.05$ ) were retained. It should be  
143 noted that, because of the exploratory nature of this type of study, p-values here should only be  
144 seen as a guideline to identify candidate variables that can be assessed as causal factors in future  
145 hypothesis-led studies. Amongst the factors tested but subsequently removed were: weight,  
146 amount of ivory crushed per year, China's gross national income, and the proportion of elephants  
147 illegally killed per year (PIKE).

148

149 **3. Results**

150 *3.1 Temporal and geographic analysis*

151 A LOESS fitted curve was applied to the overall ivory market price data (Fig. 1). The data  
152 suggested an initial slow decrease in LnPrice followed by a steep increase after approximately  
153 the year 2000. The precise point of inflection is hard to discern, as the LOESS fitted line will be  
154 overly influenced by the weight of data from 1999, for which price samples were heavily  
155 clustered from Africa. The year 2007 was selected as a break point due to historic, recorded  
156 market changes, discussed below. The LOESS fitted line does suggest a slightly earlier point of  
157 inflection; however, even if an earlier point of inflection were to be adopted, the slopes of the

158 two fitted lines would remain relatively unaffected. The mean annual price of ivory as LnPrice is  
159 graphed by region as well as globally (shown as world means) (Fig. 2).

160

161 [INSERT FIG. 1 ABOUT HERE]

162 [INSERT FIG. 2 ABOUT HERE]

163

### 164 *3.2 Price determinants*

165 There was no statistically significant difference between LnPrice from the two data sources,  
166 namely the field survey data and data collected via literature search, therefore, this term was  
167 dropped from the model, as was the variable ‘estimated weight of ivory,’ which proved  
168 insignificant to price estimation. The variables retained in the final model included region, type,  
169 legality, the region\*legality interaction, the region\*type interaction, TI and the world gold price  
170 (see Table 2 for predictive variables retained in the final model and their levels of statistical  
171 significance). Baseline values, or those tied to the intercept in the equation, are the ‘Africa’  
172 prices, ‘carved’ ivory type, and ‘illegal’ legality.

173

174 [INSERT TABLE 2 ABOUT HERE]

175

176 The analysis presented shows that the relationship between the price of ivory and region,  
177 legality and type is complex (Table 2). The significant interaction term between region and type  
178 indicates that the price differential between the different types of ivory is dependent upon region,  
179 and the significant interaction between region and legality indicates that the price differential  
180 between the legality categories is also dependent upon region. The model also shows that, on

181 average, for every unit increase in TI (transaction index, i.e. related to the number of transactions  
182 in a given year) there was an associated 0.0006 increase in LnPrice and for every unit increase in  
183 gold price an associated increase of 0.001 in TI.

184

185 [INSERT FIG. 3 ABOUT HERE]

186

187 Ivory price is depicted as it varies according to legality across regions (Fig. 3a). Overall,  
188 illegal ivory was the most expensive. Ivory of unknown legality had intermediate prices, while  
189 legal ivory had the lowest prices. Asian (i.e. East as well as South and Southeast Asia) and online  
190 illegal ivory had particularly high prices. Africa and Europe, on the other hand, had notably low  
191 legal ivory prices. Southeast Asia had almost equal legal and illegal ivory prices, a phenomenon  
192 which did not occur in any other region.

193 The model shows that prices tended to be higher for carved and polished ivory (Fig. 3b). For  
194 all types, higher prices were observed across Asia. East Asia had particularly high prices for  
195 carved and polished ivory; the significant interaction between region and product type such that  
196 the East Asian carved ivory was notably more expensive ( $p=0.007$ ). Prices for carved and  
197 polished ivory were lowest in Africa, with slightly higher prices observed across Europe and the  
198 USA.

199

## 200 4. Discussion

### 201 4.1 Summary of Findings

202 The price model developed explains approximately 72.5% of the variation in the ivory price  
203 (LnPrice) since the CITES ban. Determinants significant to ivory market price included: (1)

204 region; (2) type; (3) Transaction Index; and (4) legality. Interaction effects were present between  
205 region and legality, and between region and type. There was a strong positive linear relationship  
206 between Transaction Index (which estimates the number of ivory transactions each year and  
207 takes into account both the number and weight of ivory seizures made from 1996 through 2015)  
208 and year, with a general increase with successive years (see appendix B).

209 The total weight of ivory at a sale proved a non-significant factor on price per kilogram.  
210 Weight in the current dataset ranged from a minimum 0.17kg to a maximum of 80kg, with a  
211 mean of 5.4kg and a standard deviation of 7.1kg. A histogram of the reported sample weights is  
212 included within appendix C. Various publications, including those by CITES, classify weight of  
213 each ivory transaction into three categories of: <10kg, 10-100kg, and 100kg+ (Underwood et al.  
214 2013; CITES Secretariat 2016b), and deem weight an important factor in the analyses of ivory  
215 trade data, with larger pieces generally attracting higher prices per kilogram. It is likely due to  
216 the limited weight range and generally low weights in comparison to other reports, that weight  
217 was not significant in the present model.

218

#### 219 *4.2 Identified price determinants*

220 The identified price determinants, such as region, product type, legality, and the interactions  
221 between region and legality as well as region and type, may reflect the sociocultural demand for  
222 ivory in its various forms. Regional differences in particular should be representative of social  
223 and cultural demand. Regional demand for a type of ivory (raw, polished, carved) may be  
224 reflective of the more particular market demands, as well as potentially the existence of domestic  
225 ivory processing facilities. For example, high prices across Asia are likely reflective of a local  
226 demand, and distinctly higher prices of carved and polished ivory in East Asia (Fig. 3b) may be

227 indicative of particularly strong demand for these products. Legality may also reflect  
228 sociocultural attitudes towards ivory or regional enforcement activity. Almost equivalent prices  
229 for legal and illegal ivory observed in South Asia may be indicative of a disregard of ivory  
230 legality or low risk of law enforcement intervention.

231 As discussed, TI is indicative of global market size, with more global transactions  
232 corresponding to a larger global market and higher prices. The inclusion of TI in the model  
233 should account for fluctuations in the global market, therefore more accurately depict  
234 sociocultural demand both globally and regionally.

235 Lastly, world gold price is indicative of global investment into and demand for luxury goods.  
236 Gold market prices fluctuate due to interest rates, geopolitical relations, currency markets,  
237 inflation and deflation, investment demand, and equity markets (Gold Price 2018). The  
238 integration of world gold price into the model reflects these factors and the status of the global  
239 economy, which would affect the price of ivory, another luxury good.

#### 240 *4.3 Other price determinants*

241 Other variables likely explain the price discrepancies between regions, type, and legality  
242 observed and must account for at least some of the 28.1% of variation unaccounted for by the  
243 model. These may include corruption-related expenses, shipping costs, speculative investing,  
244 production costs, ivory quality, and significant events including signings of international  
245 agreements and ivory destructions by authorities.

##### 246 *4.3.1 Corruption*

247 Legal prices were lower than those for illegal ivory across almost all regions (Fig. 3a); the  
248 exception is South and Southeast Asia. The prominence of corruption and bribes in South and  
249 Southeast Asian regions may account for the difference in price according to legality observed.

250 As the prices of ivory classified as ‘unknown’ legality were similar to those of illegal ivory in  
251 East Asia, it is probable that much of this ivory was also illegal. Bennett (2015) reported that up  
252 to \$30,000 a day might be disbursed in bribes to officials on the Vietnam-China border. These  
253 officials often facilitate the integration of illegal ivory into legal markets and contribute to  
254 already poor law enforcement (Martin & Stiles 2003; Moyle & Conrad 2014; Bennett 2015;  
255 Vigne & Martin 2016). Due to the clandestine nature of these activities there is data deficiency  
256 preventing the inclusion of corruption into the model.

#### 257 *4.3.2 Shipping costs*

258 Shipping expenses impact both operational costs and market prices. Moyle (2014)  
259 demonstrated that shipping costs were correlated with smuggling levels, as indicated by ivory  
260 seizures. Specifically, lowered transport costs were correlated with increased ivory seizures  
261 indicating larger volumes being transported. If shipping costs influence the volume of ivory  
262 smuggled, they are likely to affect market prices indirectly. Because shipping costs have been  
263 demonstrated to follow similar patterns to global ivory seizures and global business cycles  
264 through the oil price, they were not integrated into the present model and instead were accounted  
265 for using TI and gold price.

#### 266 *4.3.3 Speculative investing*

267 It has been reported that the estimated amount of ivory leaving Africa is not fully accounted  
268 for in seizures and market sales (Moyle & Conrad 2014; Stiles 2015). This suggests a leak into  
269 an alternative market – likely speculative stockpiling. Stiles et al. (2015) as well as Moyle and  
270 Conrad (2014) show that the 37 legal factories in China only had a collective throughput of 28-  
271 30 tusks per month from mid 2009 to early 2014. During this same period, up to 200 mega tons  
272 of ivory could have been entering China per year; at an average of 10kg per tusk this would

273 equate to 20,000 tusks per year. This large discrepancy is most likely accounted for by  
274 speculative stockpiling. This behavior may increase demand for primarily raw ivory, which  
275 would in turn affect market prices (Stiles et al. 2015). As with many black market commodities,  
276 there is data deficiency when it comes to inventory; the volumes kept for investment each year  
277 were unclear and therefore not incorporated into our price model.

278 Bulte, Mason, and Horan (2003) have further discussed the profitability of speculative  
279 stockpiling when it comes to endangered species. Linking the value of this practice to the  
280 dynamics of supply and demand, the authors argue that the profitability of such behaviors may  
281 be tied to an *active effort* to decrease long-term supply – in the case of elephants, poaching. The  
282 large scale killing of certain species (such as elephants) directly increases the value of wild  
283 stocks, and therefore fuels a cycles of behavior the authors have coined “banking (or betting) on  
284 extinction” (Bulte et al. 2003; Mason et al. 2012).

#### 285 4.3.4 *Production costs*

286 Both polished and carved ivory require work by a craftsman. Martin and Stiles (2003) cite  
287 the salary of an experienced craftsman in Tokyo in 2001 to reach \$38,400 per year, while an  
288 average-earning craftsman in working part time in Hong Kong earned an average \$18,000 per  
289 year in 2002. These labor costs must be accounted for in the market price of any worked ivory,  
290 explaining price discrepancies between raw and worked pieces. However, little other data exists  
291 as to ivory craftsman salaries, making it impossible to include in the price analysis. The dummy  
292 variable in our model accounts for this difference to some degree (i.e. linearly).

#### 293 4.3.5 *Quality*

294 Quality of ivory, which generally refers to color and presence of visible cracks, has not been  
295 systematically quantified. However, various price citations note differences between low and

296 high quality ivory. In Thailand, for example, high quality ivory was reported to attract as much  
297 as double the standard price, or \$182 rather than \$91 per kilogram (Martin & Stiles 2002).  
298 Differences based on quality were also noted in Cambodia, where prices ranged from \$100 to  
299 \$340 per kilogram around 1994. In 2001, Vietnamese prices fluctuated by approximately \$170  
300 per kilogram due solely to quality. Thus, quality could contribute to variations in price for  
301 similar types of ivory.

#### 302 *4.3.6 Significant events*

303 Various events since the 1989 ban could have impacted market price. These include two one-  
304 off ivory sales, the adoption of the Cotonou Declaration, as well as various major ivory seizures  
305 and destructions. In 1999, CITES approved the first one-off ivory sale of Botswanan, Namibian,  
306 and Zimbabwean stockpiles to a designated trading partner in Japan (USFWS 2013). The second  
307 one-off sale occurred in 2008 of Botswanan, Namibian, Zimbabwean, and South African  
308 stockpiles to China and Japan. These sales added approximately \$5 million and \$15.5 million  
309 worth of ivory into the market, respectively, which likely affected global supply and demand  
310 dynamics (USFWS 2013; Hsiang & Sekar 2016).

311 The second one-off sale was followed by the adoption of the Cotonou Declaration by 22  
312 African elephant range states in 2015. The declaration called for a closure of all domestic ivory  
313 markets in an effort to end the trade and conserve elephants (WCS 2016). African market prices  
314 are much below the world average and those of other regions (Fig. 2), however, as this  
315 declaration was adopted in 2015, the discrepancy is likely due to other factors, such as minimal  
316 of shipping costs within Africa as opposed to abroad, and lower labor costs.

317 This second one-off sale corresponded with the 2007 inflection point applied to display the  
318 trends in ivory market prices. The use of 2008, the year of the sale, as the inflection point made



319 little difference to the fit of the lines. The data inflection point also corresponded with the Global  
320 Financial Crisis of 2007-2008 (Wittemyer et al. 2014; 't Sas-Rolfes et al. 2014; Stiles et al.  
321 2015).

322 Since 1989, over 20 countries have crushed and burned more than 260 tons of ivory, the  
323 majority having been destroyed in the last 5 years (Biggs 2016; Braczkowski et al. 2018). Not  
324 only a symbol of ivory devaluation (Nuwer 2013; Coghlan 2015), these destructions remove  
325 ivory from potential re-entry into the market, and therefore may affect supply and demand. It is  
326 difficult to estimate how much ivory is being crushed or burned from global stockpiles due to the  
327 secrecy surrounding government inventory. Based on ETIS global seizure data submitted by  
328 participating governments and reports of global ivory destruction retrieved via literature and  
329 Google searches for news articles, we estimate that approximately 40% of all ivory seized  
330 between 1991 and 2016 has been destroyed. A graph of these destructions by country is available  
331 in appendix D.

332 't Sas-Rolfes (1997) argued that destroying ivory stockpiles reduces the potential legal  
333 supply relative to demand, thereby increasing the perceived market value of ivory. This could  
334 inflate market prices and make trade more lucrative. Ivory destruction was not included in the  
335 model due to the inclusion of TI, which accounts for ETIS seizure data, and therefore  
336 government holdings. Our supplementary destruction dataset includes records on the total  
337 amount of ivory destroyed within a calendar year for nine separate years, the first being 1998. A  
338 follow-up two-tailed test for bivariate correlation between the total amount of ivory crushed or  
339 burned globally and the price of ivory (LnPrice) was not significant ( $r=0.430$ ,  $p=0.288$ ).

340 However, given the small sample size and the magnitude of the correlation, we cannot rule out

341 the possibility that a significant positive relationship would become apparent with a larger  
342 sample size.

#### 343 *4.3.7 Other determinants*

344 There are two other potential variables that could not be tested due to data restrictions or  
345 redundancy that might account for price discrepancies and/or the unaccounted remaining 28.1%  
346 of variation. The first is changes in the trade chain over time, for instance by increased  
347 militarization (Duffy et al. 2019) or integration into terrorist or narcotics networks (Wylér &  
348 Sheikh 2008; ADMCF 2018); the second is natural fluctuations in elephant population ecology  
349 which could alter the perceived value of ivory or potentially increase the challenge of poaching  
350 (Courchamp et al. 2006; Holden & McDonald-Madden 2017). Of the two, the latter issue can  
351 potentially be addressed by means of bioeconomic modelling using the present data, as discussed  
352 in the concluding section.

353

#### 354 *4.4 Analytical Limitations*

355 One of the most cited limitations of studying the ivory trade is data deficiency. The illegal  
356 ivory trade and related poaching activity are by nature cryptic. Many researchers have found it  
357 difficult to gather data on issues related to the ivory trade and hence study global ivory prices of  
358 ivory over time (’t Sas-Rolfes et al. 2014; Wittemyer et al. 2014; Stiles et al. 2015). In the  
359 present study, this limitation was partially overcome by incorporating both novel market surveys  
360 data from Martin and Stiles, as well as originally collected data into a meta-analysis.

361 Another potential issue is systematic biases, whereby both ETIS (Elephant Trade Information  
362 System) and PIKE (Proportion of Illegally Killed Elephants) datasets are underestimated in some  
363 areas as warned by, and therefore may influence TI (Underwood et al. 2013). These biases arise

364 primarily due to the varied but limited abilities of countries to make ivory seizures as well as  
365 report those seizures to the ETIS database (Underwood et al. 2013; CITES Secretariat 2016b).  
366 There are, however, no better estimates of ivory seizures, elephant poaching, or transactions that  
367 are currently available.

368

369

## 370 5. Conclusion

371 Ivory price data included in this analysis start in 1989, the time of the CITES ban and reach  
372 2017. Globally, our analysis indicates that prices have been increasing since this ban.  
373 Researchers disagree, however, on the effect of the ban on elephant poaching. Some argue that it  
374 has reduced or reversed the decline in elephant populations by making international trade illegal  
375 and by increasing criminal risks for those partaking (Khanna & Harford 1996; Lemieux & Clarke  
376 2009). Others argue that it has stimulated speculative stockpiling, potentially increasing the price  
377 of ivory and encouraging poaching activities to continue ('t Sas-Rolfes 1997). We hope our  
378 exploratory analysis can provide some insights into this debate.

379 The present analysis has provided a global overview of ivory prices since the CITES trade  
380 ban, giving both geographic and temporal perspectives. The model depicted overall increasing  
381 price trends commencing at some point after 2000, with highest market values in Asia.

382 It is hoped that by elucidating these trends and the variables relevant to price determination,  
383 better decisions can be made with regards to global ivory policies. An understanding of regional  
384 price trends and associated demand, alongside a comprehension of which factors influence  
385 market price, can inform conservationists, law enforcement, and policy makers on where to focus  
386 efforts on ivory trade campaigns, wildlife conservation, and education. For example, focusing

387 limited resources on efforts to more heavily regulate trade in East Asia, where ivory price and  
388 therefore demand likely is highest, could lead to decreased poaching incentives and a more  
389 secure future for elephants.

390 Finally, quantitative results from the present study have the potential to contribute to the  
391 bioeconomic modeling literature (Bulte & Van Kooten 1999; Bulte & Swanson 2003; van  
392 Kooten, 2008; Holden & McDonald-Madden 2017) that examines optimal intervention  
393 mechanisms related to elephant population management. For example, existing models could be  
394 calibrated, tested and modified with the regional and temporal price trends identified in Section 3  
395 to improve their accuracy and hence derive more effective policy design. This may add evidence  
396 to support decisions concerning the CITES ivory ban, national trade regulations, as well as to  
397 global stockpile management. A similar framework could also be applied to other endangered  
398 species experiencing poaching and illegal trade in their products, such as rhinos and tigers, so as  
399 to achieve more orchestrated conservation efforts for global wildlife.

400

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403

#### 404 Supporting Information

405 Literature review samples (Appendix A), a graph of transaction index versus year (Appendix B),  
406 histogram of ivory sample weights (Appendix C), and a graph of ivory destruction by country  
407 from 1989-2016 (Appendix D) are available online. The authors are solely responsible for the  
408 content and functionality of these materials. Queries (other than absence of the material) should  
409 be directed to the corresponding author.

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542

543 Table 1. Regional grouping with included countries

Region	N	Definition
Africa <sup>1</sup>	104	Gabon, Cameroon, Central African Republic, Chad, Cote D'Ivoire, Democratic Republic of the Congo, Ethiopia, Nigeria, Senegal, Kenya, Egypt, Tanzania, Zimbabwe
Europe <sup>1</sup>	17	Germany, France, and the United Kingdom
East Asia <sup>1</sup>	47	China, Hong Kong, Japan
South/S. East Asia <sup>1</sup>	17	Thailand, Cambodia, India, Laos, Nepal, Singapore, Myanmar (Burma), Vietnam, Sri Lanka
United States	11	
Online	13	Samples from global online marketplaces
World	5	Citations of general 'world' price in a given year

544 <sup>1</sup>Regional groupings as assigned by Martin and Stiles (2000, 2002, 2003, 2005)

545 Table 2. The final predictive model of LnPrice showing the significant fixed factors and  
 546 covariates and their significant interactions together with the parameter estimates, significance  
 547 and a 95% confidence interval of the estimate.

Term	Estimate	Std. Error	Statistic	P-value
Intercept	3.6277	0.3732	9.7196	0.0000
Year As Transaction Index	0.0059	0.0016	3.5940	0.0004
Year As Gold	0.0006	0.0003	2.1660	0.0313
Continent E Asia	4.3084	0.8966	4.8054	0.0000
Continent Europe	1.5355	0.8399	1.8282	0.0688
Continent Online	-0.1124	0.4890	-0.2299	0.8183
Continent S Asia	1.7385	0.8421	2.0645	0.0401
Continent USA	0.2568	0.5163	0.4974	0.6194
Continent World	1.6990	0.4827	3.5199	0.0005
Type Polished	-0.0478	0.2121	-0.2252	0.8220
Type Raw	-0.8909	0.2346	-3.7971	0.0002
Legality Legal	-0.2185	0.3089	-0.7072	0.4801
Legality Unknown	0.8313	0.3045	2.7296	0.0068
Continent E Asia: Type Polished	-0.4767	0.9872	-0.4829	0.6296
Continent Europe: Type Polished	-0.6327	1.1115	-0.5692	0.5698
Continent Online: Type Polished	1.9607	0.6955	2.8189	0.0052
Continent S Asia: Type Polished	0.7469	0.8727	0.8559	0.3930
Continent E Asia: Type Raw	-2.1450	0.8503	-2.5227	0.0123

Continent Europe: Type Raw	-0.2244	0.8658	-0.2592	0.7957
Continent Online: Type Raw	2.0591	0.6386	3.2244	0.0014
Continent S Asia: Type Raw	0.0615	0.8251	0.0745	0.9407
Continent USA: Type Raw	0.5250	0.5729	0.9163	0.3605
Continent E Asia: Legality Legal	-1.0727	0.4367	-2.4567	0.0148
Continent Europe: Legality Legal	-1.5564	0.6265	-2.4842	0.0137
Continent S Asia: Legality Legal	0.5047	0.3918	1.2882	0.1990
Continent World: Legality Legal	0.5353	0.7497	0.7140	0.4759
Continent E Asia: Legality Unknown	-1.0407	0.4227	-2.4624	0.0145
Continent S Asia: Legality Unknown	-0.5872	0.4221	-1.3912	0.1655

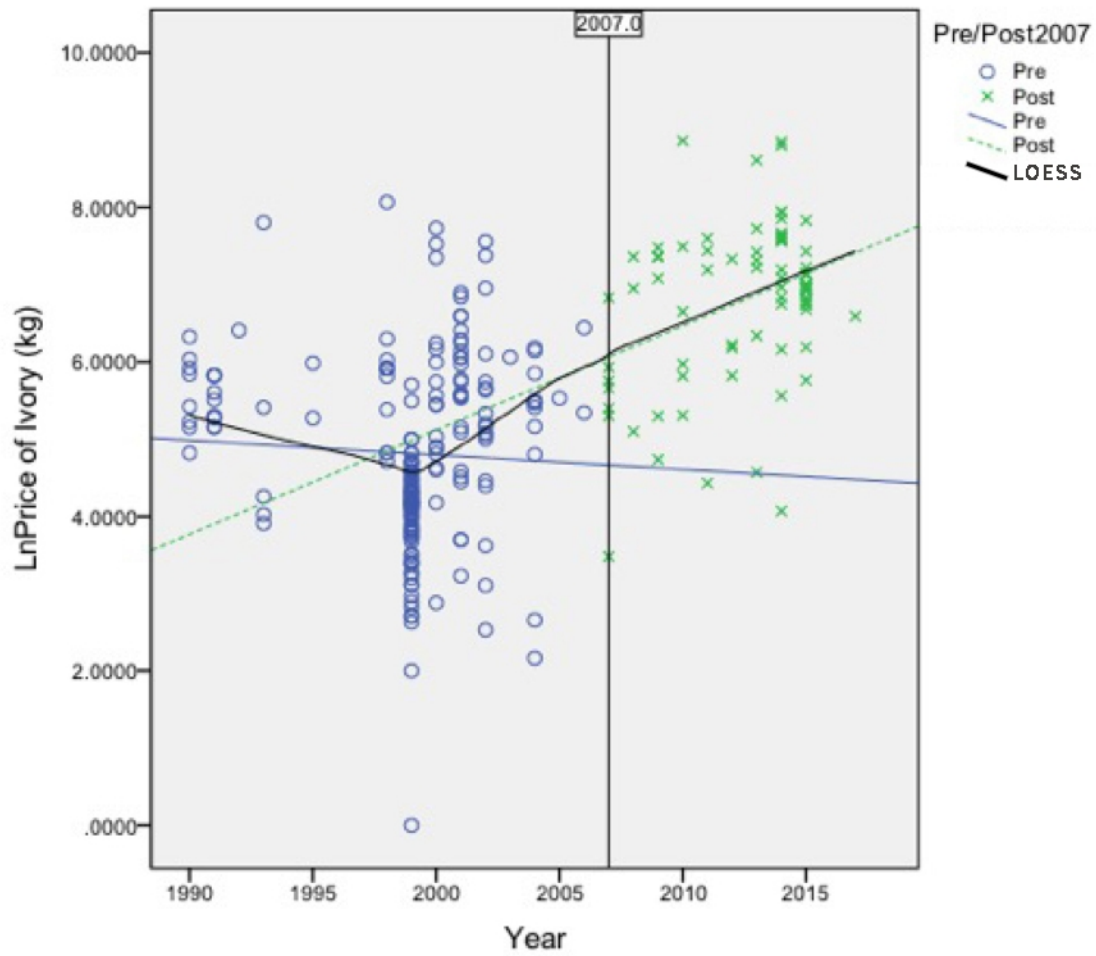


Figure 1. Global ivory market price data 1989-2017 with best-fit line options (linear split at 2007 and LOESS)

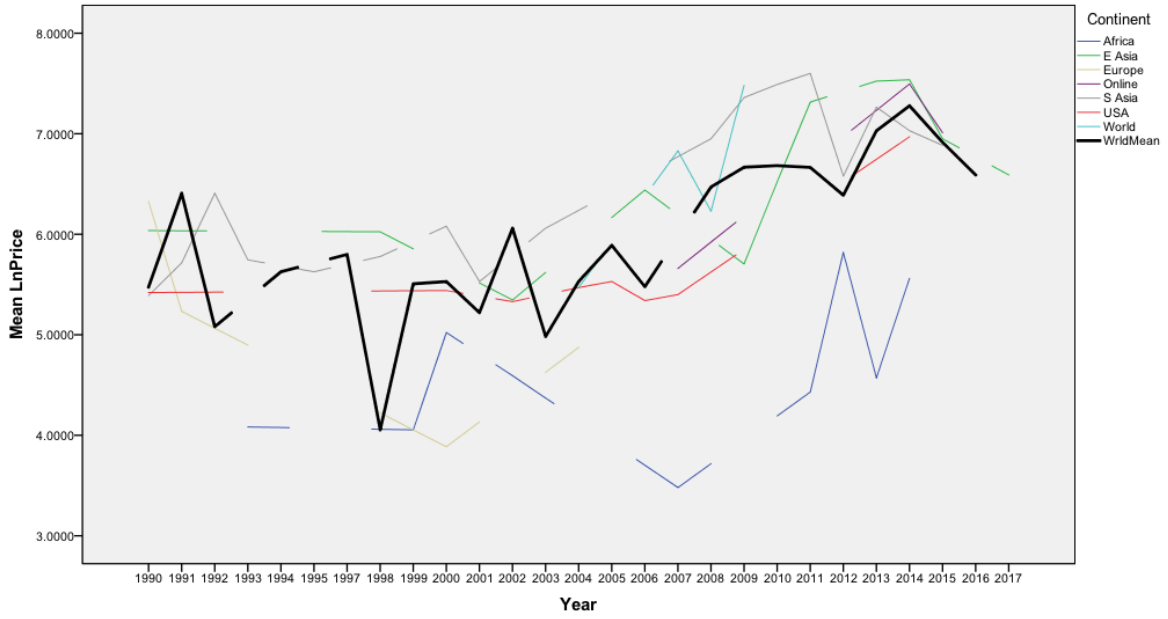
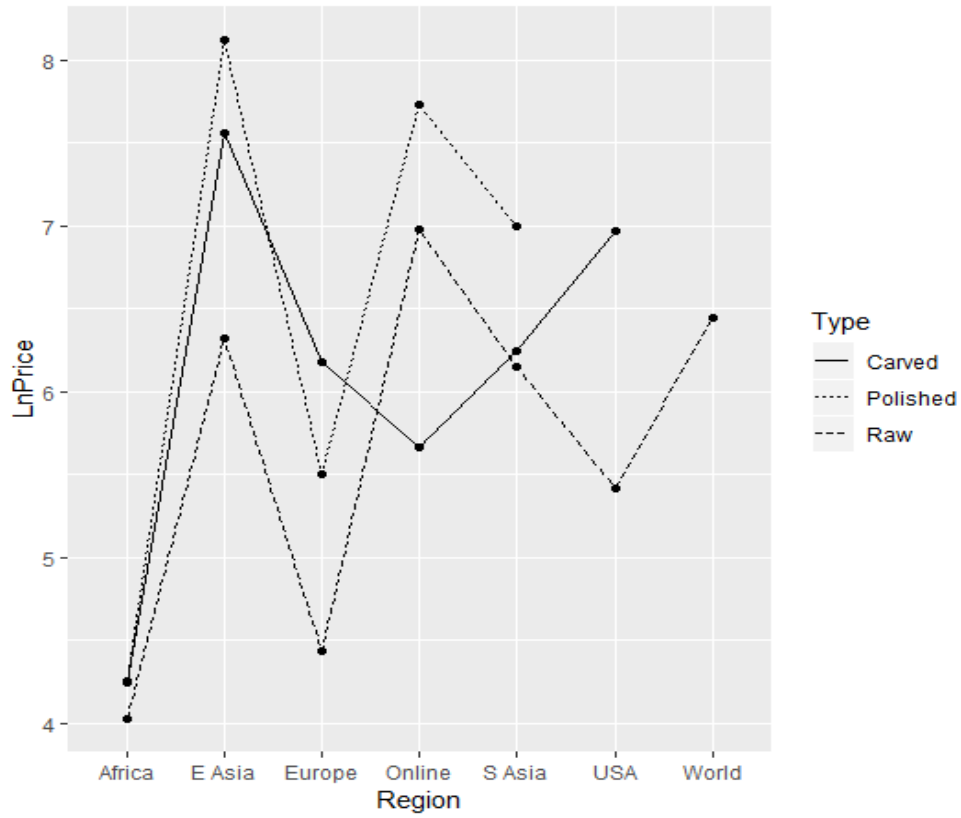
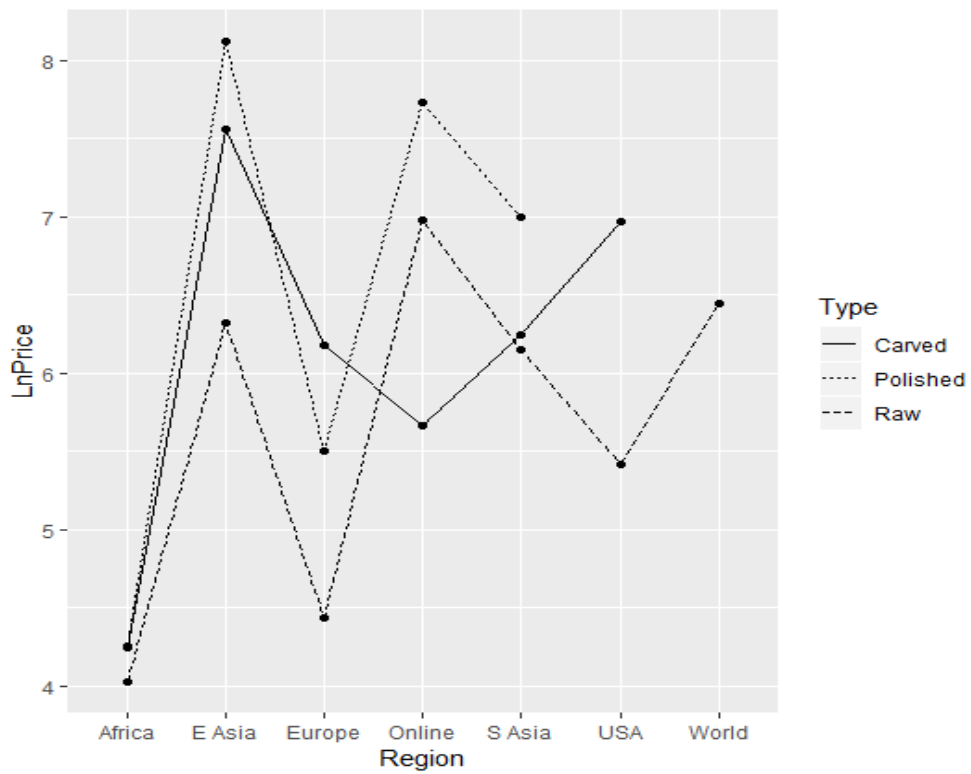


Figure 2. Regional and global trends of ivory price 1990-2017 based on the mean LnPrice for each year





a. Ivory Region\*Legality Means Plot



### b. Ivory Region\*Type Means Plot

Figure 3. Means plots showing the interaction effects of region\*legality and region\*type on global ivory market price 1989-2017. In Fig. 3a LnPrice is depicted as it varies according to legality across regions, whilst in Fig. 3b the LnPrice is shown as it varies according to type across region (whilst all other predictive variables are held constant). The covariate TI in the model is evaluated at 146.29, and the covariate Gold Price at 661.55.

## Appendix A: Literature Review Samples

Country	Region	Type	Year	Weight Range	Weight (kg)	Price	Averaged Price	Inflation Index AVG	Inflation Adjusted to 2017	LnPrice	Legality	Citation
China	E Asia	Raw	2010			750	750	218.056	772.25	6.65	Illegal	(AFP, 2014)
China	E Asia	Raw	2014			2100	2100	236.736	1991.68	7.60	Illegal	(AFP, 2014)
China	E Asia	Raw	2013			5700	5700	232.957	5493.69	8.61	Legal	(Gao and Clark, 2014)
Online	Online	Raw	2014			2150	2150	236.736	2039.10	7.62	Illegal	(Gao and Clark, 2014)
Tanzania	Africa	Raw	2014	>5kg	5	275	275	236.736	260.82	5.56	Illegal	(Gao and Clark, 2014)
Second stockpile sale		Raw	2008			157	157	215.303	163.72	5.10	Legal	(Enviromental Investigation Agency International, 2012)
Second stockpile sale		Raw	2008			1500	1500	215.303	1564.25	7.36	Legal	(Enviromental Investigation Agency International, 2012)
China	E Asia	Polished	2010			6839	6839	218.056	7041.89	8.86	Friendship Store	(Enviromental Investigation Agency International, 2012)
China	E Asia	Raw	1989	5-10kg	7	197-350	273.5	124	495.22	6.21	Unkonwn	(Stiles, 2004)
China	E Asia	Raw	2002	5-10kg	7	120-170	145	179.9	180.97	5.20	Unkonwn	(Stiles, 2004)
Hong Kong	E Asia	Raw	1988	5-10kg	7	180	180	118.3	341.63	5.83	Unkonwn	(Stiles, 2004)
Hong Kong	E Asia	Raw	2002	5-10kg	7	200-300	250	179.9	312.01	5.74	Unkonwn	(Stiles, 2004)
Japan	E Asia	Raw	1989	5-10kg	7	288	288	124	521.48	6.26	Unkonwn	(Stiles, 2004)
Japan	E Asia	Raw	2002	5-10kg	7	140-320	230	179.9	287.05	5.66	Unkonwn	(Stiles, 2004)
Cote D'Ivoire	Africa	Raw	1999	5-10kg	7	40-80	60	166.6	80.86	4.39	Unkonwn	(Stiles, 2004)
Cameroon	Africa	Raw	1989	5-10kg	7	65-81	73	124	132.18	4.88	Unkonwn	(Stiles, 2004)
Cameroon	Africa	Raw	1999	5-10kg	7	27-50	38.5	166.6	51.89	3.95	Unkonwn	(Stiles, 2004)
DRC	Africa	Raw	1989	5-10kg	7	40-50	45	124	81.48	4.40	Unkonwn	(Stiles, 2004)
DRC	Africa	Raw	1999	5-10kg	7	30-50	40	166.6	53.91	3.99	Unkonwn	(Stiles, 2004)
Gabon	Africa	Raw	1989	5-10kg	7	45-65	55	124	99.59	4.60	Unkonwn	(Stiles, 2004)
Gabon	Africa	Raw	1999	5-10kg	7	30-42	36	166.6	48.52	3.88	Unkonwn	(Stiles, 2004)
Nigeria	Africa	Raw	1989	5-10kg	7	14-29	21.5	124	38.93	3.66	Unkonwn	(Stiles, 2004)
Nigeria	Africa	Raw	1999	5-10kg	7	46-50	48	166.6	64.69	4.17	Unkonwn	(Stiles, 2004)
Myanmar	S Asia	Raw	2001	5-10kg	7	91-182	136.5	177.1	173.05	5.15	Unkonwn	(Stiles, 2004)

Vietnam	S Asia	Raw	2001	5-10kg	7	142-350	246	177.1	311.88	5.74	Unknnonwn	(Stiles, 2004)
Singapore	S Asia	Raw	2001	5-10kg	7	350-500	425	177.1	538.81	6.29	Unknnonwn	(Stiles, 2004)
Egypt	Africa	Raw	1999	5-10kg	7	62-98	80	166.6	107.82	4.68	Unknnonwn	(Stiles, 2004)
Zimbabwe	Africa	Raw	1999	5-10kg	7	12-17	14.5	166.6	19.54	2.97	Unknnonwn	(Stiles, 2004)
Cote D'Ivoire	Africa	Raw	1999	5-10kg	7	58-80	69	166.6	92.99	4.53	Unknnonwn	(Stiles, 2004)
Ethiopia	Africa	Raw	1999	5-10kg	7	37-53	45	166.6	60.65	4.11	Unknnonwn	(Stiles, 2004)
Cameroon	Africa	Raw	1999	5-10kg	7	30-50	40	166.6	53.91	3.99	Unknnonwn	(Stiles, 2004)
Nigeria	Africa	Raw	1999	5-10kg	7	50	50	166.6	67.38	4.21	Unknnonwn	(Stiles, 2004)
Cote D'Ivoire	Africa	Raw	1999	5-10kg	7	40-80	60	166.6	80.86	4.39	Unknnonwn	(Stiles, 2004)
Cote D'Ivoire	Africa	Raw	2002	5-10kg	7	115-123	119	179.9	148.52	5.00	Unknnonwn	(Stiles, 2004)
Senegal	Africa	Raw	1999	5-10kg	7	100-120	110	166.6	148.25	5.00	Unknnonwn	(Stiles, 2004)
Senegal	Africa	Raw	2002	5-10kg	7	115-164	139.5	179.9	174.10	5.16	Unknnonwn	(Stiles, 2004)
Nigeria	Africa	Raw	1999	5-10kg	7	46-50	48	166.6	64.69	4.17	Unknnonwn	(Stiles, 2004)
Nigeria	Africa	Raw	2002	5-10kg	7	24-36	30	179.9	37.44	3.62	Unknnonwn	(Stiles, 2004)
Kenya	Africa	Raw	1969			2.5	2.5	2.50	224.53	5.41	Unknnonwn	(Messer, 2000)(Lemieux and Clarke, 2009)
Kenya	Africa	Raw	1978			34	34	34.00	224.53	5.41	Unknnonwn	(Messer 2000) (Lemieux and Clarke, 2009)
Kenya	Africa	Raw	1989			90	90	124	162.96	5.09	Unknnonwn	(Messer 2000) ((Lemieux and Clarke, 2009)
World	World	Raw	2004			200	200	188.9	237.72	5.47	Unknnonwn	(Stiles et al., 2011)
World	World	Raw	2007			850	850	207.3	920.63	6.83	Unknnonwn	(Stiles et al., 2011)
World	World	Raw	2009			1700	1700	214.537	1779.15	7.48	Unknnonwn	(Stiles et al., 2011)
Vietnam	S Asia	Raw	2009			1500	1500	214.537	1569.83	7.36	Unknnonwn	(Stiles et al., 2011)
Vietnam	S Asia	Raw	2009			1500	1500	214.537	1569.83	7.36	Unknnonwn	(Stiles et al., 2011)
Vietnam	S Asia	Raw	2009			1500	1500	214.537	1569.83	7.36	Unknnonwn	(Stiles et al., 2011)
China	E Asia	Raw	2011			1700	1700	224.939	1696.87	7.44	Unknnonwn	(Stiles et al., 2011)
China	E Asia	Raw	2014			2100	2100	236.736	1991.68	7.60	Unknnonwn	(Martin et al., 2017)
China	E Asia	Raw	2015			1100	1100	237.017	1042.02	6.95	Unknnonwn	(Martin et al., 2017)
China	E Asia	Raw	2017			730	730	224.525	730.00	6.59	Unknnonwn	(Martin et al., 2017)
Kenya	Africa	Raw	2007			30	30	207.3	32.49	3.48	Illegal	(Wittemyer, 2015)
Kenya	Africa	Raw	2011			150-180	84	224.939	83.85	4.43	Illegal	(Wittemyer, 2015)

Kenya	Africa	Raw	2013			100	100	232.957	96.38	4.57	Illegal	(Wittemyer, 2015)
Hong Kong	E Asia	Raw	1979			68.82	68.82	72.6	212.83	5.36	Unknnonwn	(Parker and Martin, 1983)
Hong Kong	E Asia	Raw	1980			62.77	62.77	82.4	171.04	5.14	Unknnonwn	(Parker and Martin, 1983)
Hong Kong	E Asia	Raw	1981			46.3	46.3	90.9	114.36	4.74	Unknnonwn	(Parker and Martin, 1983)
Hong Kong	E Asia	Raw	1982			38.23	38.23	96.5	88.95	4.49	Unknnonwn	(Parker and Martin, 1983)
Japan	E Asia	Raw	1979			84.7	84.7	72.6	261.95	5.57	Unknnonwn	(Parker and Martin, 1983)
Japan	E Asia	Raw	1980			75.64	75.64	82.4	206.11	5.33	Unknnonwn	(Parker and Martin, 1983)
Japan	E Asia	Raw	1981			79.13	79.13	90.9	195.45	5.28	Unknnonwn	(Parker and Martin, 1983)
Japan	E Asia	Raw	1982			74.06	74.06	96.5	172.31	5.15	Unknnonwn	(Parker and Martin, 1983)
China	E Asia	Raw	2006			564	564	201.6	628.14	6.44	Unknnonwn	(Gabriel et al., 2011)
China	E Asia	Raw	2009			1133	1133	214.537	1185.75	7.08	Unknnonwn	(Gabriel et al., 2011)
China	E Asia	Raw	2011			1322	1322	224.939	1319.57	7.19	Unknnonwn	(Gabriel et al., 2011)
China	E Asia	Raw	1939			14,941 YEN					Unknnonwn	(Fischer, 2004)
China	E Asia	Raw	1989			37,216 YEN		124			Unknnonwn	(Fischer, 2004)
China	E Asia	Raw	1999			10904 YEN		166.6			Unknnonwn	(Fischer, 2004)
Nepal	S Asia	Raw	1998			81	81	163	111.57	4.71	Unknnonwn	(Martin, 1998)
Nepal	S Asia	Raw	1998			242	242	163	333.34	5.81	Unknnonwn	(Martin, 1998)
Vietnam	S Asia	Raw	2015			1100	1100	237.017	1042.02	6.95	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	1990			100	100	130.7	171.79	5.15	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	1991			150	150	136.2	247.27	5.51	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	1989	2-3kg	2.5	150	150	124	271.60	5.60	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	1990	2-3kg	2.5	200	200	130.7	343.57	5.84	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2003			350	350	184	427.09	6.06	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2008			500- 1500	1000	215.303	1042.83	6.95	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			845- 1032	938.5	237.017	889.04	6.79	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			889- 1244	1066.5	237.017	1010.29	6.92	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2010			1743	1743	218.056	1794.71	7.49	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2014			1262	1262	236.736	1196.91	7.09	Unknnonwn	(Vigne and Martin, 2016)

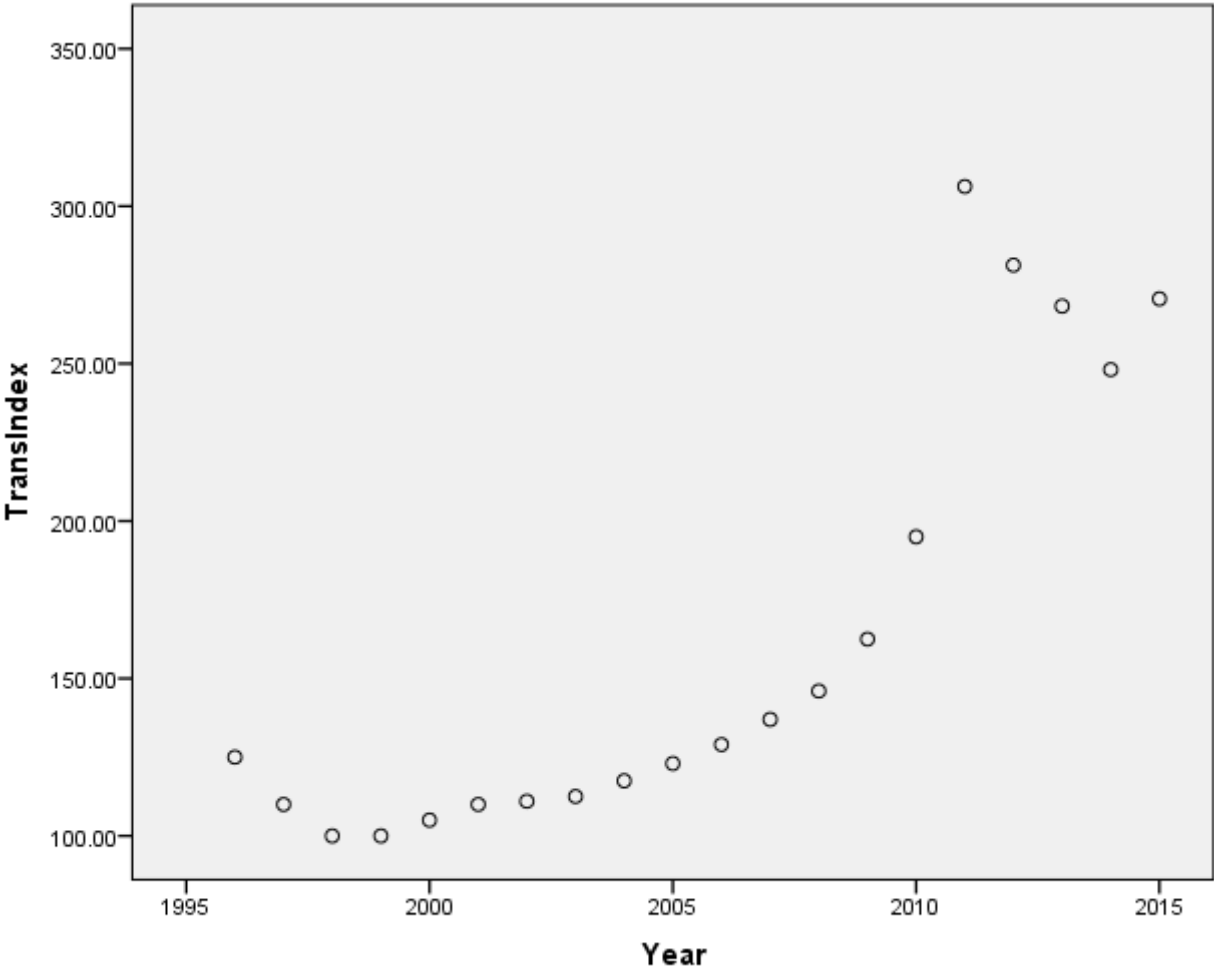
Vietnam	S Asia	Raw	2015	3-4kg	3.5	1067	1067	237.017	1010.76	6.92	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			1289-1333	1311	237.017	1241.90	7.12	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			1111	1111	237.017	1052.44	6.96	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015		4	1333	1333	237.017	1262.74	7.14	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2011	Tips		1998	1998	224.939	1994.32	7.60	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			889	889	237.017	842.15	6.74	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2014			1122	1122	236.736	1064.13	6.97	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			800-889	844.5	237.017	799.99	6.68	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			1156	1156	237.017	1095.07	7.00	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			1333-1556	1444.5	237.017	1368.37	7.22	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2013			1421-1669	1545	232.957	1489.08	7.31	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			1156	1156	237.017	1095.07	7.00	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2012			1440-1681	1560.5	229.594	1526.05	7.33	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			1156	1156	237.017	1095.07	7.00	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2013			1421	1421	232.957	1369.57	7.22	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			1111	1111	237.017	1052.44	6.96	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015	Low quality		311-356	333.5	237.017	315.92	5.76	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015	High quality		1333	1333	237.017	1262.74	7.14	Unknnonwn	(Vigne and Martin, 2016)
Vietnam	S Asia	Raw	2015			889	889	237.017	842.15	6.74	Unknnonwn	(Vigne and Martin, 2016)
China	E Asia	Raw	2013			590	590	232.957	568.64	6.34	Unknnonwn	(Montazeri, 2013)
USA	USA	Raw	1979	3-4kg	3.5	63	63	72.6	194.84	5.27	Unknnonwn	(Stiles and Martin, 2008)
USA	USA	Raw	1989	3-4kg	3.5	100	100	124	181.07	5.20	Unknnonwn	(Stiles and Martin, 2008)
USA	USA	Raw	1990	3-4kg	3.5	132	132	130.7	226.76	5.42	Unknnonwn	(Stiles and Martin, 2008)
USA	USA	Raw	2000	3-4kg	3.5	176	176	172.2	229.48	5.44	Unknnonwn	(Stiles and Martin, 2008)
USA	USA	Raw	2002	3-4kg	3.5	165	165	179.9	205.93	5.33	Unknnonwn	(Stiles and Martin, 2008)
USA	USA	Raw	2004	3-4kg	3.5	200	200	188.9	237.72	5.47	Unknnonwn	(Stiles and Martin, 2008)
USA	USA	Raw	2005	3-4kg	3.5	220	220	195.3	252.92	5.53	Unknnonwn	(Stiles and Martin, 2008)
USA	USA	Raw	2006	3-4kg	3.5	187	187	201.6	208.26	5.34	Unknnonwn	(Stiles and Martin, 2008)

USA	USA	Raw	2007	3-4kg	3.5	204	204	207.3	220.95	5.40	Unknonwn	(Stiles and Martin, 2008)
USA	USA	Carved	2014			595-645	62	236.736	58.80	4.07	Unknonwn	(Stiles, 2015)
USA	USA	Carved	2014			4150-10560	7355	236.736	6975.62	8.85	Unknonwn	(Stiles, 2015)
USA	USA	Carved	2014			500	500	236.736	474.21	6.16	Unknonwn	(Stiles, 2015)
USA	USA	Carved	2014			6000-8000	7000	236.736	6638.94	8.80	Unknonwn	(Stiles, 2015)
				1-5kgSemi-worked raw			346					(Stiles, 2015)
USA (online)	Online	Carved	2007	5-10kgSemi-worked raw	3	346		207.3	374.75	5.93	Unknonwn	
				10-20kgSemi-worked raw			185					(Stiles, 2015)
USA (online)	Online	Carved	2007	>20kgSemi-worked raw	7	185		207.3	200.37	5.30	Unknonwn	
							264					(Stiles, 2015)
USA (online)	Online	Carved	2007		15	264		207.3	285.94	5.66	Unknonwn	
USA (online)	Online	Carved	2007			287-293	290	207.3	314.10	5.75	Unknonwn	(Stiles, 2015)
Egypt	Africa	Raw	2000	5-11kg	8	78.49	78.49	172.2	102.34	4.63	Unknonwn	(Martin, 2000)
Egypt	Africa	Raw	2000	>12kg	12	117.23	117.23	172.2	152.85	5.03	Unknonwn	(Martin, 2000)
Egypt	Africa	Raw	2000	1-4kg	2.5	93.96	93.96	172.2	122.51	4.81	Unknonwn	(Martin, 2000)
Egypt	Africa	Raw	2000	5-10kg	7	102.58	102.58	172.2	133.75	4.90	Unknonwn	(Martin, 2000)
Egypt	Africa	Raw	2000	>20kg	20	237.47	237.47	172.2	309.63	5.74	Unknonwn	(Martin, 2000)
Sri Lanka	S Asia	Raw	1989			228-285	256.5	124	464.44	6.14	Unknonwn	(Santiapillai et al., 1999)
Sri Lanka	S Asia	Raw	1990			72	72	130.7	123.69	4.82	Unknonwn	(Santiapillai et al., 1999)
				14.2kg (avg of 99 tusks)			974					(Stiles, 2015)
China (online)	Online	Raw	201		14.2	974		237.017	922.67	6.83	Illegal	
China (online)	Online	Raw	2014	<5kg	5	2100	2100	236.736	1991.68	7.60	Illegal	(Stiles, 2015)
China (online)	Online	Raw	2015			921	921	237.017	872.46	6.77	Illegal	(Stiles, 2015)
China (online)	Online	Raw	2015			460-575	517.5	237.017	490.23	6.19	Illegal	(Stiles, 2015)
China (online)	Online	Raw	2015		14.2	974	974	237.017	922.67	6.83	Illegal	(Stiles, 2015)

China (online)	Online	Polished	2014			2930	2930	236.736	2778.87	7.93	Illegal	(Stiles, 2015)
China (online)	Online	Polished	2015	<10kg	5	2650	2650	237.017	2510.33	7.83	Illegal	(Stiles, 2015)
China (online)	Online	Polished	2015	>10kg	15	1628-1943	1785.5	237.017	1691.40	7.43	Illegal	(Stiles, 2015)



Appendix B: Transaction Index vs. Year



Appendix C: Histogram of ivory sample weights

