COMMENTARY

Impact of the ivory trade ban on poaching incentives: a numerical example

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Abstract

How does the CITES trade ban on international trade in elephant ivory affect the incentives to poach African elephants? In this commentary, the major effects of a trade ban on poaching incentives are captured in a simple static model of world ivory supply and demand. It is shown that a trade ban has ambiguous effects on poaching incentives. Although the ban reduces international ivory demand, official production as well as confiscations are withheld from consumer markets, increasing black market prices paid to poachers. It is found that a trade ban is likely to reduce poaching if it leads to a reduction in demand, if it facilitates interception of smuggled goods, if there is little official production piling up and if it does not negatively affect law enforcement efforts. A numerical example based on the presented model indicates that the ivory trade ban is likely to reduce poaching. © 2001 Elsevier Science B.V. All rights reserved.

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1. Elephant economics

Poaching for ivory is a major short-run threat to the African elephant (*Loxodonta africana*), with changes in land use a threat in the longer run. In response to a drastic decline in African elephant stocks, perceived to be caused to a large extent by rampant poaching, the Convention on International Trade in Endangered Species (CITES) banned all international trade in ivory in 1989. Since then, economists and others have discussed whether banning trade will be able to stop illegal elephant hunting and ivory trade (Barbier et al., 1990; Khanna and Harford, 1996). The major policy issue is whether managed trade in elephant products such as ivory, hides and meat (of modest quantities originating from official production) should be allowed from Southern African range states with large and relatively well-managed elephant populations, or whether the ban should be complete. The main argument for a
complete ban is that even managed trade risks creating loopholes for laundering illegal ivory.

Bowing partly to pressure from opponents of the ban, a limited export quota was granted in 1997 allowing Botswana, Zimbabwe and Namibia to sell stockpiled ivory to Japan. 49.5 metric tonnes of ivory was consequently sold to Japanese buyers at a one-off auction in 1999, fetching a price of US$ 100 per kilo. In addition, Zimbabwe sold elephant hides worth US$ 1.9 million. The proceeds from these sales go to special conservation funds or to community-based management schemes. Discussions on managed trade remain vigorous, with South Africa, Botswana, Zimbabwe and Namibia proposing annual export quotas that would allow them to export limited amounts of ivory and hides, while Kenya and India, among others, are opposed to legal trade of any form (Milliken, 2000).

Two excellent surveys of elephant economics have recently appeared in Ecological Economics. Bulte and van Kooten (1999b) review the arguments for and against managed ivory trade, and conclude in favour of the ban. The main reason is that if enforcement of wildlife laws was sufficient, the CITES trade ban would be unnecessary in the first place. Given that anti-poaching and anti-smuggling enforcement has long been the key problem for elephant conservation, complete enforcement of the managed trade option appears unrealistic. Managed trade would then create loopholes and might increase poaching. Burton (1999) surveys models of poaching effort, concluding that the incentives to poach are so strong that even low levels of ivory prices may be insufficient to deter poachers from substantially reducing elephant populations. However, whether this finding is good or bad news for the proponents of managed trade depends crucially on the effect of the trade ban on illegal market ivory prices. That is, how does the trade ban affect poachers’ incentives. This key issue has not received much attention in any of the existing studies and surveys. Hence the motivation for this paper.

There is a lack of updated and precise information on the status of African elephant populations and on the amount of poaching after the CITES ban went into effect (Bulte and van Kooten, 1999a). Special elephant monitoring systems are currently being developed, but no results are ready yet. Ivory markets have remained active during the ban period in a number of African countries as well as in many Southeast Asian countries supplied by substantive illegal trade. There is no evidence that can link changes in poaching to developments under CITES (Milliken, 2000). A lot will depend on the impact of the ivory trade ban on the price received by poachers, of which there seems to be no empirical knowledge. In the absence of good data, a simple numerical example based on a static model of ivory supply and demand can be used to help understand better the trade ban – price link. This link is essential when assessing the likely impact of CITES interventions on poaching levels and on population numbers.

2. A simple model of ivory trade before and after CITES trade ban

In this section a simple static model is presented to illustrate some of the major effects of a trade ban on poaching incentives. The focus is the interaction between trade ban, illegal price and supply of ivory to world markets. There is no attempt to assess the welfare consequences of the ban, which were dealt with by Anderson (1992).

In the model, poaching is assumed to depend positively on ivory price (Milner-Gulland and Leader-Williams, 1992). The influence of law enforcement (patrolling, conviction) on poaching is ignored — the likelihood of detection and conviction is assumed unchanged by the ban (Burton 1999 deals with this issue). However, the amount of smuggled ivory that can be intercepted in customs is likely to vary with the imposition of a trade ban. Thus, a trade ban facilitates customs control in exporting, importing and transit countries by closing the loopholes through which poached ivory might acquire legal status. Denoting the additional share of smuggled ivory that can be intercepted due to the ban with \(t\), the expected price to the smuggler-cum-poacher is \(p\) before the ban and \(p[1 - t]\) after. (In other words, \(p\) is the expected price net of the pre-ban average...
interception levels.) Under these assumptions, Africa-wide poaching offtake can be written
\[ Q_0^I = Q^I(p), \quad \text{(pre-ban)} \]
\[ Q_1^I = Q^I(p[1 - t]), \quad \text{(post-ban)} \]
\[ \frac{\partial Q^I}{\partial p} > 0, \quad 0 \leq t < 1, \quad (1) \]
where \( Q^I \) is illegal supply in kilograms of ivory and subscripts 0 and 1 are used to distinguish pre-ban and post-ban values, respectively.

Prior to the ban, total ivory supply reaching overseas markets was the sum of legal production \( Q^L \) and illegal production \( Q^I \), as the range states were able to market all stocks and confiscations. After the ban, supply of ivory is no longer equal to production. Under the CITES trade ban no ivory can be legally marketed — not even stockpiles originating from confiscations and culling programs (except for the above-mentioned quota granted in 1997 to Botswana, Zimbabwe and Namibia). Supply therefore reduces to that part of the illegal production that evades customs, \([1 - t]Q^I\), with the remaining ivory piling up in government stocks. Thus, total ivory supply \( S \) reaching overseas consumer markets can be written
\[ S_0 = Q^I + Q^L \quad \text{(pre-ban)} \]
\[ S_1 = [1 - t]Q^I \quad \text{(post-ban)} \]
Total elephant offtake is
\[ Q = Q^I(\cdot) + Q^L, \quad (2) \]
both before and after the ban, assuming that legal ivory production \( Q^L \) stemming from problem animal control and culling programs is unaffected by the ban. This assumption implies that legal ivory production is either piled up indefinitely or destroyed (local ivory markets catering to national demand are abstracted from in the analysis of this paper).

The demand side is represented by a global demand function for unworked ivory, which is assumed to depend negatively on price as well as on the imposition of the ban
\[ D_0 = D(p), \]
\[ D_1 = [1 - m]D(p), \]
\[ \frac{\partial D}{\partial p} < 0, \quad 0 \leq m < 1, \quad (4) \]
where \( m \) is the proportionate demand reduction stemming from a trade ban. This captures the ‘moral impact’ of a ban — historically, a large part of the international ivory market disappeared in response to the ban and the concern of many consumers over the rapid decline in elephant populations. It is here assumed that \( m \) is a fixed proportion of demand, but this is not critical. The alternative — to model the demand reduction as a constant, which is independent of the price level — is also plausible, and yields similar results.

Market equilibrium implies that supply equals demand, or
\[ D_0(p) = Q^I(p) + Q^L \quad \text{(pre-ban)} \]
\[ [1 - m]D_0(p) = [1 - t]Q^I(p[1 - t]), \quad \text{(post-ban)}. \]
\[ (5) \]
Eq. (5) does not say whether poaching incentives will increase or decrease due to the ban. For that, the parameters of the model have to be quantified — the numerical example in Section 3 below is an attempt at this. The model is static and ignores the influence of the elephant population level on poaching incentives. It is therefore best seen as a short-run model that is valid for a single point in time. The model may nevertheless serve as a useful illustration of the major effects on poaching caused by the CITES ban, and it provides the framework for the numerical example below.

The model is illustrated in Fig. 1. Pre-ban market supply \( S_0 = Q^I_0 + Q^L \) is the sum of illegal and official production. Where it intersects the pre-ban demand curve \( D_0 \) gives the pre-ban price level \( p_0 \). Total pre-ban supply is 0–\( d \), of which 0–\( a \) is poaching (read off the poaching curve \( Q^I_0 \)) and \( a – d \) is legal supply.

The impact of the ban is (i) to increase confiscations, which changes the shape of the poaching function by making it steeper; (ii) Official ivory production, as well as that part of smuggled ivory that is intercepted in customs, does not reach consumer markets. As a consequence, overseas
consumer markets are supplied only with that part of poached ivory that avoids interception in customs, i.e. \( S_1 = [1 - t]Q_1 \). After the ban the market supply curve, \( S_1 \), therefore lies to the left of the poaching function with the difference consisting of interceptions; (iii) The demand curve is shifted downwards by the moral effect \( m \). The market price after the ban is found where the lower post-ban demand curve \( D_1 \) intersects with market supply, \( S_1 \), yielding \( p_1 \). The level of killing corresponding to \( p_1 \) is read off the poaching function, at \( b \). This level of post-ban poaching consists of illegally marketed ivory (0–\( c \)) and confiscations (\( c – b \)).

The net impact of the trade ban on poaching depends on whether \( b \) is higher or lower than \( a \). Theoretically, this is ambiguous as it depends on the relative magnitude of the different effects. The figure illustrates the case where poaching levels are higher after a trade ban. Obviously, the diagram could equally have been drawn to show the opposite case.

Summing up, the main effects of a trade ban on legal and illegal markets are as follows. One, the moral impact of a trade ban (and associated attention surrounding the plight of the African elephant) is to reduce demand, depressing prices and poaching. Second, official production cannot be shipped to overseas ivory markets. This drives up illegal prices and induces poaching. Third, a trade ban facilitates additional customs interceptions of smuggled ivory, which has an ambiguous effect on price and on poaching incentives. Interceptions increase smugglers’ risk premia and reduce the price offered to poachers. However, under a trade ban, confiscated ivory is withheld from the market, and for a given level of demand confiscations and stockpiling increase consumer ivory prices. A fourth aspect, which is outside the presented model, is that a trade ban may negatively affect funding for conservation and law enforcement (Khanna and Harford, 1996; Bulte and van Kooten, 1996, 1999a). This analysis — based on the realization that enforcement of bans is incomplete — highlights the need for CITES to consider more carefully the interactions between trade bans and incentives for continued illegal trade.

### 3. A numerical example

In order to assess the likely net effect of a trade ban on poaching incentives, a numerical example is derived. The numerical example is based on the model above and implemented using plausible parameter estimates to the extent possible. Cobb–Douglas functions are chosen for ivory demand.

![Fig. 1. Offtake and market price before and after a trade ban.](image-url)
and poaching supply. This way, Eq. (5) may be written in compact form as
\[ D_0 = kp^{-\gamma} = S_0 = lp^\delta + Q^L, \quad k, l, \gamma, \delta \geq 0 \]
\[ D_t = kp^{-\gamma} - mD_0 = S_t = [1 - t]lp(1 - t)\delta \]
\[ 0 \leq t, m < 1. \] (6)
where \( \gamma \) and \( \delta \) are the price elasticities of demand and poaching supply, \( k \) and \( l \) are constants, and \( m \) is the share of pre-ban demand that falls away due to the moral effect.

The model is calibrated using parameters estimated for global ivory trade in the 1979–88 period, where relatively good data exist. From 1989, when ivory trade went underground, there is no data available. Choice of parameter values is described in the following. First, an equation for global ivory demand was estimated econometrically, using data for implicit raw ivory prices and net imports by major consumer countries for 1979–88, presented in Barbier et al. (1990; Tables 1.3 and 2.2). All quantities and values refer to kilogram of ivory. The regression result (with \( t \)-statistics in parenthesis) is
\[ \ln(D_0) = 20.7 - 1.7 \ln(p); \quad R^2 = 0.91, \quad n = 10. \] (25.1) (\( -8.9 \))
This gives \( \gamma = 1.7 \) and \( k = \exp(20.7) = 9.85 \times 10^4 \). Due to the small sample size, this demand elasticity is not estimated very precisely. Therefore, sensitivity analysis is carried out with a lower value of \( \gamma \), as explained below.

Second, for supply, \( Q^L \) was fixed at 20% of the 1979–87 mean ivory trade flow, or 161 500 kg, in accordance with ITRG (1989) estimates. For poachers’ supply elasticity, \( \delta = 0.9 \) was chosen. This is in the lower range of values that can be calculated from linear optimization models based on Zambian data (Heltberg, 1998; Milner-Gulland and Leader-Williams, 1992). No good estimate exists for the constant in the supply equation, \( l \), as well as for the moral demand-reduction effect, \( m \), and for additional interceptions, \( t \). This problem was addressed in the following manner. The constant term, \( l \), was used to calibrate the model to historical trade flows. That is, \( l \) is adjusted so that, at the mean 1979–87 price, predicted supply equals predicted demand.

The lack of estimates for \( m \) and \( t \) make it impossible to use the model to produce a plausible ‘forecast’ or point estimate for the level of post-ban poaching. If, for example, \( (m, t) = (0.1, 0.1) \) the model predicts a poaching increase of 1.2%, while for \( (m, t) = (0.5, 0.4) \) the model implies 33% less poaching. Clearly, the model is very sensitive to choice of parameter values for \( m \) and \( t \). Because these parameters relate to illegal transactions, there is no obvious way to acquire the data necessary to estimate them. However, the model can be used in an exploratory manner to chart the combinations of \( (m, t) \) that imply the same, more and less poaching than before the ban. Through this kind of analysis, it is possible to trace the implications of the model and to pinpoint the key factors necessary for a trade ban successfully to curb poaching.

The \( (m, t) \) parameter combinations that result in constant poaching levels may be referred to as ‘iso-poaching curves’. They are plotted in Fig. 2. The ‘iso-poaching curves’ represent pairs of \( (m, t) \) that imply 5% more poaching than in the pre-ban period, same level of poaching, 20% less poaching and 40% less poaching, respectively. From Fig. 2 it can be seen that poaching is decreasing in both \( m \) and \( t \). More importantly, it can also be seen that given the assumptions embodied in this example, it appears that a trade ban will result in less poaching unless customs interceptions and consumer demand remain largely unaffected by it. Thus, if demand falls by more than 20% due to a ban (i.e. \( m > 0.2 \)) poaching decreases irrespective of what happens to interceptions. And if at least an additional 30% of smuggled goods can be intercepted after a ban (i.e. \( t \geq 0.3 \)), poaching will decrease (for any given level of demand). Assume, for example, that the ban caused demand to cease altogether in North America and Europe, as evidence indicates. These countries imported around 34% of world ivory production prior to 1988. If \( m = 0.34 \), the model predicts less poaching for the entire range of \( t \). What this example suggests is that it is likely that the
reaction in many consumer countries has been to reduce or eliminate demand sufficiently to make a trade ban result in lower prices and less poaching.

As mentioned, the estimate for the elasticity of ivory demand, $\gamma$, is relatively uncertain. In order to explore the sensitivity of the results, a different value for $\gamma$ was tried. Barbier et al. (1990; ch. 4) estimate a price elasticity of Japanese ivory demand of $-0.7$. Hence, the model was also run with $\gamma = 0.7$ instead of $1.7$. Results are not very different. In this case $(m, t) = (0.1, 0.1)$ increase poaching with $7.8\%$, and $(m, t) = (0.5, 0.4)$ lead to $24\%$ less poaching. The ‘iso-poaching curves’ for this parameter configuration are shown in Fig. 3. Fig. 3 reveals that when demand is inelastic, the level of $t$ matters much less for poaching than $m$. This result complies with basic economic intuition that for an inelastic demand curve, changes in the supply curve (induced through $t$), generate relatively small changes in quantities traded. It is still found that a trade ban is likely to reduce poaching. Specifically, it continues to hold that as long as demand reduces by more than $20\%$, poaching will decrease irrespective of the level of interceptions.
4. Discussion

The purpose of a CITES trade ban is noble: to protect biodiversity by halting unsustainable exploitation of endangered species. Yet, trade bans are rarely completely enforced and illegal consumer markets persist, as in the case of elephant ivory, rhino horn, live parrots, orangutans and many other endangered species. One may find such black markets and the poaching that supplies them immoral, but ignoring their role by assuming them away may lead to misguided conservation policies.

This paper has analyzed how a trade ban on elephant ivory is likely to affect ivory prices on the illegal markets and the incentives to engage in elephant poaching. It was found that a trade ban is likely to improve the protection of endangered species from poachers if (i) it has a large moral demand-reducing effect; (ii) it facilitates interception of smuggled goods; (iii) there is little ivory from official production piling up; and (iv) it does not negatively affect law enforcement effort. Results indicate that, for the most plausible parameter values available, the ivory trade ban is likely to have reduced poaching incentives, everything else equal. The model suggests that closely monitored and limited trade in elephant ivory and hides stemming from official production is worth considering as a means of reducing illegal market prices and fund conservation, provided illegal ivory can be excluded.

All estimates presented in this study should be regarded merely as quantitative examples. The lack of firm empirical data and the simplicity of the model do not permit one to make population projections from this analysis. A proper evaluation of CITES' ivory trade ban would require time-consuming and costly field studies of poaching, illegal markets and prices as well as elephant population counts.

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References


