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Issues and concerns in developing regulated markets for endangered species products: the case of rhinoceros horns

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A proposal for addressing rhinoceros poaching is to legalise the trade in rhino horn and adopt a regulated market approach, overturning the current trade ban. This orthodox economic prescription aims to reduce incentives to poach endangered wildlife by driving down the market price of their products via auctioned stockpile releases. Biologists are clear, however, that securing a stockpile for some species needs biological success in captive breeding programmes (CBPs), which varies markedly across species and habitats. Rhinoceros herds in a CBP would need spatially extensive terrain and costly permanent security measures; this only appears feasible for the less aggressive 'white' rhino. We argue that the market price would actually need to be sustained at a high level to cover protection costs over the longer reproduction cycles in CBPs and that, without extensive monitoring and the correct institutional structures being in place, legalising trade may encourage, rather than prevent, poaching. Supplementary policy measures that differentiate among consumer groups would also likely prove necessary.

Key words: Rhinoceros, Endangered species, Black markets, Poaching, Captive breeding programmes
JEL classifications: Q11, Q57, Q58

1. Introduction

Given that the number of rhinoceros killed annually by poachers in South Africa to acquire their horns has more than tripled between 2010 (333 poaching incidents) and 2014 (1,215 poaching incidents), there is an increasingly urgent policy imperative to help save them from extinction. The demand for rhino horn stems largely from its use in traditional Eastern medicine (TEM) in Thailand, China, Vietnam and Laos, but also as a speculative asset (Rademeyer, 2012). The very high price of rhino horn, which sold for approximately $65,000 per kilogram in 2011 ('t Sas-Rolfes, 2012), also means that despite costly increases in security to prevent poaching, the incentive to poach, even in high-risk situations, is likely to remain high. An additional factor is the

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vast price difference between the price of live rhino (approximately $30,000 in 2012 in South Africa) and the price of rhino horn, which has led to various illegal 'game farm' purchases of rhino (which are then killed for their horns) and pseudo-hunting activities, often with forged permits (Rademeyer, 2012).

Ostrom and Cox (2010) point out that there has been a tendency for social scientists to reduce environmental and natural resource governance problems to an overly simple choice between the market and the government, which they refer to as the panacea problem. As early as 1990, North (1990) pointed out that any particular institution exists in a network or matrix of other institutions that affects its functioning and outcomes. More recent debates (Boyer, 2005; Crouch *et al.*, 2005) have further explored the notion of institutional complementarity and hierarchy. According to Boyer (2005), two institutions are said to be complementary when the performance of one in conjunction with the other is better than when it exists alone (and vice versa). Institutions may be complementary because 'components of a whole mutually compensate for each other's deficiencies in constituting the whole' (Crouch *et al.*, 2005, p. 359). However it may also be related to institutional hierarchy, where a particular institutional form dominates others, so that those institutions further down the hierarchy must take into account the rules and regulations imposed by the dominant one (Helderman, 2007). In this case, Boyer (2005) argues that causality is implied, in that the institutions further down the hierarchy could not exist if those higher up were not present.

Helderman (2007) argues that rather than purely market-based forms (where multiple producers are motivated by profits and consumers gain benefits through competition) or purely government forms (command and control, motivated by welfare gains), most developed economies have a wide variety of mixed institutional forms. Regulated markets are an example of such a hybrid. The key question then becomes not so much which form of institutional governance will be chosen, but rather what their relationship will be and which one will be dominant. While Boyer (2005) argues that institutions can be designed to be complementary right from the start, Helderman (2007) suggests that complementarity is more likely to be discovered *ex post*, after a period of trial and error and learning by doing. In this case, institutions that are later understood to be complementary may initially be seen as competing with each other.

We argue that such a panacea problem currently plagues the debate on legalising the trade in rhino horn. The current failure of the government to effectively protect rhino has led to the call for trade in rhino horn to be legalised. This market approach is presented as an unproblematic and simple solution to rhino poaching, without any serious consideration of the context in which such an institution would operate. While not ruling out the potential role that a regulated market approach (RMA) could play in both funding conservation and managing rhino poaching in the long run, the paper argues that without extensive monitoring and the correct institutional structures being in place, legalising trade may encourage, rather than prevent, poaching. Fischer (2010) stresses that the absence of strong institutional structures will lead to overexploitation of the resource, without considering the impact on future harvesting possibilities.

Various economists have reconciled themselves, often reluctantly, to the need for some kind of RMA to be adopted, within a policy mix of instruments, in the service of wildlife conservation and the saving of many endangered species from extinction (Damania and Bulte, 2007; Fischer, 2004). The intention of this paper is explicitly to set out some practical concerns and issues that seem to have been underplayed or neglected in most published economic discourse on the subject. The underpinning

work is based on a number of commissioned practical economic assessments among the author team, a review of the scientific literature on captive breeding programmes (CBPs) for rhinoceros herds and two interviews with key informants in South Africa. The analysis is purely intended to help inform practical decisions on the feasibility of this economic prescription and to do so specifically in the context of rhinoceros herd conservation.

Various policy concerns relating to the introduction of an RMA are raised and illustrated, which may potentially be addressed with a range of additional or supplementary policy instruments geared to influencing market outcomes in one or both of the therapeutic use market segment and the speculative asset market segment for rhinoceros horn.

The paper is organised in the following manner: the next section reviews the scientific and institutional evidence and literature that can inform the economic analysis of rhinoceros conservation supplemented by the analysis of some interview data with game reserve and expert scientific informants. Particular attention is given to the practical requirements for accumulating a stockpile of rhinoceros horns for auction via CBPs and licensed reserve management and/or trophy hunting. Consideration is given to the likely effects, in this specific wildlife context, of the introduction of additional suppliers that are state sanctioned and regulated and the possible need for further supplementary policy instruments and supportive measures. Policy implications arising are then discussed followed by a summary and some concluding remarks.

2. Rhinoceros conservation in the South African context

There are currently five species of rhinoceros worldwide, two of which are found in Africa: the southern white rhino (*Ceratotherium simum simum*) and the black rhino (*Diceros bicornis*) (Emslie *et al.*, 2007). All species are listed in the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES), which was open for signature in 1973, came into force in 1975 and has been ratified and amended many times subsequently. Since 1977 there has been a complete international trade ban on rhino horn, although a limited number of hunting permits for white rhino are granted, which includes the right of the hunter to remove trophies ('t Sas-Rolfes, 2012; TRAFFIC, 2012). Nearly 95% of white rhino and 40% of black rhino are found in South Africa (Borchert, 2012; TRAFFIC, 2012).

The conservation of the white rhino is regarded as something of a success story. Although hunted almost to extinction in the nineteenth century, white rhino populations had recovered to 840 by 1960, but were found almost exclusively in what is now the Hluhluwe-iMfolozi Park in KwaZulu-Natal province in South Africa. Through the development of game capture techniques, Operation Rhino was initiated in the 1960s to capture surplus white rhino in the Hluhluwe-iMfolozi Park and transport them to other protected areas in South Africa ('t Sas-Rolfes, 2010). Since then, the number of white rhino has increased dramatically, from 6,736 in 1993 to an estimated 16,723 in 2007 (Animal Rights Africa, 2009), to 18,800 in 2012 (TRAFFIC, 2012). Although it is deemed conservation dependent, the white rhino is no longer regarded as threatened or endangered (TRAFFIC, 2012, p. 9). The population of black rhino is much smaller, at an estimated 4,880 worldwide, of which 1,915 are found in South Africa. Black rhino are still listed as critically endangered (Evans, 2012; TRAFFIC, 2012).

International trade in rhino horn was banned under CITES in 1977, although trade within South Africa was legal until 2009, when a moratorium on internal trade was put

in place by the government as a response to reports of illegal exporting of horn sourced from private rhino owners and government stockpiles (Government Gazette, 2009). However a study was commissioned by the Department of Environmental Affairs (DEA) to determine the feasibility of relaxing the ban on legal trade in rhino horn within South Africa (DEA, 2014). The report concluded that without the implementation of extensive monitoring (such as DNA tracking and regular auditing of private and public stockpiles), lifting the national moratorium would only encourage illegal practices such as laundering of illegal horn through legal markets. It was thus recommended that 'South Africa should not lift the national moratorium at the present time' (DEA, 2014, p. 12). However the report did make the point that the complete ban was not a long-term solution and that national systems required to make a regulated market function should begin to be put in place (DEA, 2014).

The next CITES meeting, where pro-trade lobbyists hope that the CITES body will lift the ban on international trade in white rhino horn, is to be held in Johannesburg in 2016. However if the national moratorium is still in place, it would weaken the case for lifting the CITES international trade ban (Mouton, 2012). In 2012, a private rhino owner who had already invested in CBPs initiated legal action against the DEA in an attempt to force the government to lift the national ban on rhino horn trade, joined in 2015 by another private owner (Cruise, 2015A). The DEA appointed a committee of inquiry in 2012. Originally kept secret, membership of the committee was later revealed and criticised by the media (see, e.g., Cruise, 2015B) for being made up of mostly pro-trade lobbyists. However, to date, the committee has not yet made a recommendation.

In contrast to the exceptionally high prices paid for rhino horn on the black markets of Asia, where it is 'worth more per kilogram than gold, cocaine, platinum or heroin' (Rademeyer, 2012, p. ix), the average price of live rhino has fallen. Table 1 presents some illustrative points showing the dramatic fall in prices for live rhino, especially after the upsurge of poaching in 2005 and 2008, which led to the national moratorium on the sale of rhino horn inside the country in 2009. The DEA (2014) feasibility study identifies similar trends. Further, some of these comparator commodities are actually appropriate given the nature of the illegal criminal networks involved in the rhinoceros supply chain, some of whom are also suspected of trading in narcotics and issuing death threats as a routine operational tactic (Mouton, 2012).

The data in Table 1 may give a somewhat mixed picture, since average auction price does not take into account differences in price for male and female animals, the condition, size and age of the animals and the sale of more than one animal (usually a mother and calf) as a single unit. For example, the auction price of a mother and calf in 2012 was R 400,000 (GFR Game Sale, 2012). At this same auction, of the six single adult white rhinos offered for auction, only two were sold (two females), while three males and a female were not sold. What is apparent is that rhino prices dropped dramatically in 2005, since which time they have recovered slowly, but never to the peak 2004 average price of nearly R 390,000.

Using data for average auction prices received for rhino sold in KwaZulu-Natal from 2000 to 2005, Spenceley and Barnes (2005) found that the price for white rhino had dropped by 50% from an average of US$34,888 in 2000 to $17,393 in 2005, while the average price of black rhino had dropped by 21%. At the same time, the number of animals sold also declined. According to B. Fike (game park manager, Grahamstown, personal communication, 2012), the manager of a large public reserve in South Africa,

the drop in price and sales volumes can be explained by a declining demand for live rhino. The decrease in demand is due to the costly increases in security required in order to keep them alive, as well as the risks of losing them to poachers despite spending on security. An example of the increase in security costs to a reserve in South Africa that is known to have rhino is given in Appendix Table A1. What the data illustrate is that the costs of keeping and protecting rhino in the wild have increased dramatically, without any offsetting increase in revenue. It is thus not surprising that market prices for live rhino have declined.

What is also becoming apparent is that despite numerous awareness and fundraising campaigns, the current policy focus of increased security in both public and private parks known to have rhinos is not an effective deterrent. As shown in Table 2, poaching-related arrests have by no means increased at the same rate as poaching incidents (DEA, 2012). South Africa has high rates of unemployment (25.2% according to the Quarter 1 2015 Labour Force Survey; Statistics South Africa, 2015) and poverty. In 2011, 45.5% (23 million people) were living below the poverty line and 20% (10 million people) were living in 'extreme' poverty (Statistics South Africa, 2014). Given

Table 1. *Prices for white rhino in South Africa, 1982–2012*

Year	Real prices (2012) ZAR[a]	% change from previous data point	Average % change per annum	Source
1982	14,160			't Sas-Rolfes (2010)
1986	81,400	474.9%	118.7%	't Sas-Rolfes (2010)
1989	266,560	227.5%	75.8%	't Sas-Rolfes (2010)
2004	389,326	46.1%	9.20%	Animal Rights Africa (2009)
2005	164,009	−57.9%	−57.9%	Animal Rights Africa (2009)
2006	200,473	22.2%	22.2%	Animal Rights Africa (2009)
2007	255,636	27.5%	27.5%	Animal Rights Africa (2009)
2008	295,997	15.8%	15.8%	Animal Rights Africa (2009)
2012	239,500	−19.1%	−4.8%	GFR Game Sale (2012)

Note: The current exchange rate of R9.86:1US$; R15.85:1 UK Pound; R13.43: 1 Eur.
[a]All data presented in 2012 prices, calculated using the Consumer Price Index (Statistics South Africa, 2012).

Table 2. *Annual numbers of rhino poaching incidents and arrests in South Africa*

Year	Rhino poaching incidents	Arrests
2010	333	165
2011	448	232
2012	588	246

Source: DEA (27 November 2012).

these figures, the supply of poachers, often ex-military (according to Fike, personal communication, 2012), who are willing to take the risk for huge rewards is virtually limitless. The Kruger National Park, who have lost more rhino to poaching than anywhere else, make this link explicit: 'With a large amount of poverty in South Africa and unemployment rates escalating, finding people that are willing to sacrifice being caught while going out to poach a rhino is not difficult, as the benefits potentially outweigh the consequences' (Nicholson, 2014).

A recent book by the South African investigative journalist Julian Rademeyer makes this clear, in an interview with a Zimbabwean rhino conservation manager:

> 'Killing poachers doesn't achieve anything', Leatham says. 'There are so many poor guys out there and criminal elements that are prepared to take the risk to make quick bucks. No matter how many of them you shoot or arrest, you'll never stop it. The only way is to cull the market. You have got to get the guys at the top.' (Rademeyer, 2012, p. 22)

Despite the acknowledgement that poaching syndicates are highly sophisticated and driven by mafia-style bosses at the top of long supply chains (Rademeyer, 2012), most arrests are of on-the-ground poachers, not syndicate leaders. For example, of the 246 arrests make in 2012, 217 were poachers, 18 were couriers and only 11 were receivers (DEA, 2012). Guidelines for rhino conservation strategies in the region (SADC-RPRC, 2006) make a similar point, arguing that increasing encounters between poachers and rangers is also not necessarily a sign of the success of conservation efforts, even where all or most of these encounters are won by rangers: 'Once diverse groups of poachers have started frequent incursions, the situation deteriorates into a "poaching war" and the rate at which rhinos are lost can soon become unsustainable' (SADC-RPRC, 2006, p. 58).

There have also been calls for the South African Government to sell existing stockpiles, accumulated from dehorning, natural mortality and the seizure of illegal horns, in order to generate funds for conservation efforts and a proposal for a one-off sale of such stockpiles may be put to the CITES body in 2016 (*News24*, 2015). Currently held stockpiles in South Africa are estimated to be worth more than R 1 billion (Pillay, 2012).

Lopes (2015) uses a bioeconomic model to demonstrate the likely outcomes of the rise of high-technology, sophisticated poaching operations on African elephants if (i) stockpile release and regulated trade reduced the price of ivory and (ii) if there is an increase in anti-poaching security. His findings show that 'the optimal number of planned poaching expeditions was found to be insensitive to the black-market price of ivory, but quite sensitive to the probability of interception by anti-poaching patrols' (Lopes, 2015, p. 102). He points out that his model could be extended to other natural resources that are harvested illegally, such as rhinos, and concludes that focusing effort on anti-poaching methods would be more likely to work as a conservation strategy than trying to influence the black market price of these goods.

't Sas-Rolfes and Fitzgerald (2013) argue that a regulated market for rhino horn could play an important part in helping to conserve rhinos through both reducing the price of the horn and increasing the numbers of rhino (since they would be farmed commercially). They do, however, acknowledge that for such a market system to work, institutional systems, such as the development of a DNA database for the horn and regulation and frequent inspection of stockpiles, would be needed. They also agree that 'The science of rhino husbandry is still nascent' ('t Sas-Rolfes and Fitzgerald, 2013,

p. 13) and that not much is known about likely start-up costs and production rates in commercial breeding programmes.

Another controversial intervention, which has been hotly debated, is the dehorning of rhino. At the National Rhino Summit in 2010, the South African DEA commissioned a dehorning impact assessment (Lindsey and Taylor, 2011). The report found that dehorning has been practised in South Africa to a limited extent in private game reserves. Dehorning is also done routinely when rhino are translocated in order to reduce the risk of injury to the rhino in transit or due to fighting amongst newly released individuals to establish dominance in the new setting (SADC-RPRC, 2006). In other African countries, such as Zimbabwe, Namibia and Mozambique, dehorning, along with other measures (such as increased security and moving vulnerable populations to smaller, more defensible areas away from borders), has been effective (Lindsey and Taylor, 2011; SADC-RPRC, 2006).

However an important finding (Lindsey and Taylor, 2011) is that if dehorning is not accompanied by increases in security and other anti-poaching measures, it is not effective. Lindsey and Taylor report on at least five incidents in South Africa between 2008 and 2011 where dehorned rhino were killed by poachers, since the high price of horn makes even the horn stumps a worthwhile target.

Rhino horn grows at a rate of about six centimetres per year and dehorning would thus need to take place every 12–24 months to be effective under conditions of severe threat (Fike, personal communication, 2012; Lindsey and Taylor, 2011). In order to dehorn rhino legally and to store the horn, a permit is required from the South African DEA. The permit-issuing process is regarded by some reserve managers to be cumbersome and long-winded, but also dangerous, as it indicates to outsiders that rhino are present in the reserve (Fike, personal communication, 2012).

As with security, the cost of dehorning rhino is significant. A recent estimate by a private game reserve in the Eastern Cape province of South Africa put the price of dehorning at between R 6,000 and R 10,000 per rhino per year, depending on how many animals were being dehorned (*Grocott's Mail, 2012*). Dehorning is only likely to be effective if entire rhino populations are dehorned, as suggested by Milner-Gulland (1999) and reiterated in the commissioned report (Lindsey and Taylor, 2011). However where these two sources differ is that Milner-Gulland (1999) suggests there is a choice between spending on security *or* dehorning. While the budget constraint is of course relevant, both the commissioned report on dehorning (Lindsey and Taylor, 2011) and the guidelines for rhino conservation strategies (SADC-RPRC, 2006) strongly emphasise that dehorning is unlikely to be effective without *accompanying* increases in security, 'otherwise rhinos are highly likely to be poached, regardless of their horn status' (Lindsey and Taylor, 2011, p. 6).

3. The current market context

Traditional single market models for endangered species indicate that bringing onto the market legally harvested and confiscated goods reduces incentives to poach. However the specific case of rhinoceros poaching is different. While the scope for marketisation has been considered and suggested, the balance of studies and arguments would suggest in the context of South Africa that there are strong biological, ecological and market opportunity constraints that limit the scope for ongoing, episodic sales of rhinoceros horns for reducing poaching incentives (DEA, 2014; Lopes, 2015). The

prevailing market circumstances currently comprise a complete trade ban with purely illegal supply, but with demand arising from purely non-compliant consumers.

The general orthodox pro-trading literature such as espoused in Fischer (2004) neglects many widely discussed and known institutional characteristics and constraints in this particular species context. These relate to:

(i) The poaching rate being derived from the number of rhinoceros kills is likely to be a highly misleading indicator of the actual level of enforcement effort needed and of the level of poaching effort actually expended. This is because there are many unreported aborted poaching expeditions following engagement with security staff, as well as unreported poacher mortality (Rademeyer, 2012). Adopting the same tactics as some poachers, some private game reserves have been known to hire professional hunter/trackers to 'live' in the reserves for a period of time and shadow the rhinoceros herds, so that they may ambush poachers on the ground. Given the vast expanses of land available to bury in shallow graves and the presence of predators such as lions, bodies of poachers ambushed are unlikely to be recovered. Further, given the extreme nature of this game reserve security tactic, it is typically not formally reported to the police authorities.

(ii) The assumption that the confiscation rate (used by Fischer, 2004) to describe the amount of poached material received following arrest or apprehension of poachers) is entirely exogenous to market actors and set by government would be fallacious in this specific context. In many instances of rhino poaching, there are more than strong suspicions of corruption and complicity by some government officials (at various levels) furnished by threats, illicit side payments and commission payments (Rademeyer, 2012; Fike, personal communication, 2012). This can be set against a background of common knowledge regarding high rhinoceros horn sale prices. In these circumstances the likelihood of poaching-serving corruption and transmission of insider information would inevitably decrease the confiscation rate.

(iii) Currently, horn stockpiles from natural mortality and the exercise of legitimate game reserve herd management are never legally sold on the market to the criminal supply chain.

Without resale of confiscated goods, greater enforcement may increase total poaching if the price increase outpaces the additional confiscation and critically this depends on the price elasticity of demand for rhinoceros horn.

4. The regulated market approach

The underlying logic of an RMA is that through a series of sales of state-sanctioned stockpiles of confiscated endangered species products and/or endangered species products from CBPs, the market price can be influenced downwards. It is contended this would reduce the incentive to poach and thus reduce the rate of poaching-related killing of endangered wildlife. That said, even strong advocates of an RMA in this context typically acknowledge that the actual outcome of such a policy remains highly uncertain, given that for some endangered species products, demand seems both very persistent and highly inelastic (Brown and Layton, 2001; Conrad, 2012). Accordingly, there remains a fear that latent demand may well be stoked to such a degree by legalised trading that poaching activity accelerates and extinction progresses more swiftly.

There are some reports pointing to cases where CBPs have been associated with, or considered as a possible means of achieving, reductions in wild animal hunting and poaching levels (see, e.g., Wright *et al.*, 2001, Lee *et al.*, 2014, Steyn, 2015). However these are often in the context of poaching across a range of wild animals, including for 'bush' meat or wild bird eggs. On more detailed scrutiny of the evidence, the strength of the inferred causality might in some cases be reasonably deemed to be fragile. It is sometimes based on a single captive breeding programme that may now be defunct and/or where evidence is difficult to disentangle from other effects, which may have led to some reductions in poaching activity, but only at a particular geographical location, for a particular species and during a particular limited period. Further, some biologists contend that CBPs are high-cost responses and should only be seen 'as a last resort in species recovery, and not a prophylactic or long-term solution because of the inexorable genetic and phenotypic changes that occur in captive environments' (Snyder *et al.*, 1996, p. 338).

Additional analytical problems emerge since the path to any overall 'market equilibrium' price for many such endangered species goods is not readily transparent and thus extremely difficult to observe and monitor, if it can reasonably be said to exist at all. Equilibrium-orientated economic analyses may inform understanding of stationary states or steady, balanced market or economy-wide growth. However the rhino horn market could be said to be characterised by systematic disequilibrium given that it features complex dynamics and irregular fluctuations (in biological, spatial and economic terms), overlapping waves of structural/institutional changes and also market evolution (Day, 1987). These features may be seen, for example, in the context of variety in the pattern of conservation effort and deployment of protection resources and also as a consequence of actions following domestic or international political/legal decisions and treaties.

Further, for some poachers who are part of a strongly vertically integrated illegal supply chain, there is simply no external price for the poached horn that enters the supply chain. For those poaching gangs functioning outside such strongly vertically integrated operations, the illegally traded endangered species goods that enter the supply chain will typically form part of a series of intermittent, secretive bilateral trades. Grapevine price-relevant information transmission between other suppliers (poachers) and buyers is thus likely to be a very noisy and fuzzy signal of even fairly recent actual transaction prices.

The dynamics of expanding demand conditions and the inevitably secretive nature of bilateral trading amongst illegal buyers and sellers create suitable conditions for persistent and considerable price dispersion. Hence, in this context, fixating on a single overall market price has little value. Any discerned criminal grapevine price is also likely to diverge from earlier bilateral transaction prices for strategic bargaining reasons during negotiation of the price for commissioned future poaching expeditions. Such expeditions will also vary widely in terms of access difficulty and other location-specific characteristics such as the outcome of reconnaissance assessments of potential security resistance to be anticipated.

Other price-relevant information is also likely to be deliberately censored to mask the hidden interplay of different criminal syndicates, enterprises and illegal end-use consumers in order to obstruct criminal and journalistic investigation. As such, any reliable and credible market information is very scarce indeed. Further, while legitimate wildlife auction prices seemingly offer some insight into the value of

the endangered species goods, they are in practice a very misleading guide. This is because hammer prices at such auctions are only a small fraction of the generalised cost of maintaining a valuable live asset among a relatively small pool of game reserve owner-bidders. Given that the remaining rhinoceros herds are being aggressively poached in South Africa, a very substantial element of the total cost of sustaining the herd are the very high asset protection costs (Amin *et al.*, 2006). These comprise the cost of recruiting and retaining well-paid, skilled, armed security staff signalling qualities of professional integrity (in an attempt to minimise collusion with poachers) as well as extensive deployment and maintenance of sophisticated anti-poaching technology over extensive and often isolated terrain (SADC-RPRC, 2006).

These costs have escalated so rapidly that it has had the effect of markedly depressing the auction prices achieved for live rhinoceros such that they are cheaper than the cost of the removed horn in illegal trading (as shown in Table 1). Additionally, it has had the effect of encouraging camouflaged participation in the auction markets to service illegal rhinoceros horn trading. Nevertheless, as some wildlife is on the verge of extinction, then some urgent policy activity and experimentation seems warranted. Indeed for some species of rhinoceros (e.g. black rhinoceros) remaining in South Africa, there is little time left to act before it is too late.

However policy prescriptions that feature in some of the economic literature on endangered species conservation do seem to suggest that a generic or similar RMA could be adopted for various endangered species, even though there are known to be enormous differences in the market demand and institutional, bioeconomic, ecological, physiological and veterinary conditions that apply among such species. Damania and Bulte (2007), for example, point out that some supply-side policies can often neglect the institutional framework within which the wildlife trade takes place and ignore the potential strategic responses of economic agents. At a mundane, practical level, this study aims to give a fuller account of this framework and those responses.

In this study we explain, for example, why even though elephants and rhinoceros are both slow-growing, large mammals, the scope and scheme design issues for stockpiling tusks and horns via regulated hunting and CBPs are very different for these two animals. These differences are shown to have an important bearing on the scale and type of RMA that is feasible and the nature of the relevant trading market and bioeconomic modelling.

In the context of our example, there are many potential substitutes for ivory, but sadly, there seems to be no currently discernible effective substitute for rhinoceros horns among consumers. Furthermore, unlike ivory, there are currently no legal market uses for rhinoceros horn. The horns are now currently used for two main purposes, each of which may require different emphases and instruments in the design of any set of policy responses. Bergstrom (1990) is not entirely correct that is it primarily used as an aphrodisiac or libido enhancement. The main application is as a ground-down ingredient in TEM, hitherto used in the context of very serious or life-threatening illnesses. This goes some way to explaining the highly inelastic nature of this market. More recently and rather worryingly for rhinoceros conservation, the powdered horn has become popular for even minor ailments such as colds, light fevers and flu. Rising real income growth among middle- and high-income groups in China, Thailand and Vietnam

has helped drive this significant market expansion that support this extension of its usage. Nonetheless, there is no credible medical evidence of any genuine therapeutic benefit.

The second main use of rhinoceros horn is as a status gift and/or speculative asset, mainly in China, Thailand, Laos and Vietnam, for politicians, dignitaries and senior executives (Rademeyer, 2012; Hance, 2013). For these consumer-investors, such horns serve as relatively compact and mobile stores of value at the current market price. The horns must increase in value with any increase in regulatory stringency and as extinction approaches. In the case of TEM users, even despite the potentially huge scale and growth of market demand, individual believers and TEM practitioners at least have some incentive to try to retain continued access to a supply of powdered rhinoceros horn. In the latter case, possessors of complete horns held as just speculative assets actually have an incentive to accelerate extinction. Thus it is suggested that as perceived rarity increases, then incentives to poach also increase (Hall *et al.*, 2008). One key theme that emerges in this paper is the importance of considering the specificity of particular endangered species goods markets in the design of polices involving an RMA. Using rhinoceros horn as an example, we show how scientific and institutional factors do serve to limit the efficiency and constrain the operation of a generic endangered species RMA design. An attempt is made to trace the necessary design and implementation requirements for a more rhinoceros horn-specific regulated market and highlight key differences in this context as compared with other endangered species goods market studies. To improve the probability of success, it is contended that the RMA would need to form but one of a range of policy elements within a given policy mix (including increased enforcement levels) in order to retard the path to extinction for some species of rhinoceros.

Departing markedly from Fischer's (2004) general characterisation of law-abiding (stigma-conscious) consumers and illegal consumers operating in dual markets (for the general case of endangered species-based goods trading), this paper sets out a species-specific case study to capture the likely dominant market characteristics relating to rhinoceros horn, sourced specifically from South Africa. While the Fischer (2004) paper is a good generalisation of the intricacies of endangered species product markets, the case of rhinoceros horn has specific characteristics that warrant further detailed exploration. It is argued that an analytical resolution based (at a minimum) on this level of market specificity would be necessary in practice. In this way, economists would begin to be more adequately informed by the often geographically specific and complex layering of scientific, institutional and market factors that would shape the working dimensions and operation of a regulated market for a specific endangered species product.

Fischer (2004) presented a theoretical model to explain the market for the products of endangered species. She used a dual-market model where consumers either acquire only legally certified products or are indifferent to the source of the product. The suppliers of the product consist of those who have acquired the product through illegal means (poachers) and legal entities dealing in certified goods (government or enforcement agencies).

The supply in the illegal market is a function of the amount confiscated, with the cost of increased supply increasing as the catch increased. The supply functions for the illegal and legal markets, respectively, are as follows:

$$S^{u} = \varphi K$$

$$S^{c} \leq H + (1-\varphi)K$$

where S^{u} and S^{c} are the total quantity of illegal and legal products, respectively, K is the amount of poached product, H is the product harvested legally and φ is the share of the illegal product that is not impounded by the authorities.

The demand relationships are more complex, especially for law-abiding consumers. Law-abiding consumers are assumed to purchase only from legal sources, but increased amounts of illegal product on the market will increase the stigma attached to acquiring the product and reduce utility. On the other hand, consumers of the illegal product are not afflicted by the same stigma and their satisfaction is derived solely from consumption. The utility-maximising relationships for the law-abiding consumers and recalcitrant consumers, respectively, are as follows:

$$V\left(Q_{L}^{c}, \sigma, K\right) - P^{c}Q_{L}^{c}$$

$$U\left(Q_{N}^{c} + Q^{u}\right) - P^{c}Q_{N}^{c} - P^{u}Q^{u}$$

where Q_{L}^{c} is the consumption of the certified product by law-abiding consumers, σ is the stigma rate, P^{c} is the price of the certified product, Q_{N}^{c} and Q^{u} are the quantities of certified and illegal product consumed by recalcitrant consumers and P^{u} is the price of the illegal product.

The demand and supply relationships in Fischer's (2004) model are influenced by a number of crucial factors. The supply relationship in the illegal market is restricted by the proportion of the catch confiscated by authorities and the certified market is influenced by the amount of the impounded product that is sold on the legal market. The quantity demanded on the legal market is negatively affected by the stigma attached to the proportion of illegal product on the market and the repulsion connected with poaching.

In this study context, we assert that the simple theoretical model of Fischer (2004) relating to the case of a full trade ban situation is not appropriate in the context of rhino horns. There are some key points of departure. Foremost among these is that there are no legal and stigma-conscious consumers. Instead, all consumers are best classified as members of one of two groups of illegal consumers. Group 1 comprises 'believer' consumers who simply wish to retain access (albeit misguidedly) to a source of powdered rhinoceros horn, in order to access its purported therapeutic benefits. Group 2 comprises consumers who seek more complete rhinoceros horns to serve as assets (stores of value). These two groups of consumers do not face the same incentives and they are all served by illegal suppliers.

The illegal suppliers of rhinoceros horn operate through a complex supply chain of criminal syndicates. These syndicates feature from the lower to upper reaches: Asian market distributors, rhinoceros herd intelligence acquisition and reconnaissance operatives—sometimes involving the sourcing of corruptible local stakeholders and, of course, the actual poaching team in the field. These suppliers also face a range of incentives and not just in relation to varying their effort level with respect to the level of risk and reward. Illegal supplier incentives would clearly change in the regulated market

context, where the same consumers feature, but in addition there also exists a regulated supplier participant. Given it challenges their market power and revenue streams, illegal suppliers would have an incentive to undermine CBPs via turf war activity as in other illegal supply chains and markets, such as for crack cocaine, heroin, etc. As such, CBP locations could reasonably expect retaliatory strikes of intensive poaching activity on relatively densely stocked CBP rhinoceros herds. Unlike some other wildlife species, they would biologically require very extensive geographical reserve areas to sustain successful breeding. This renders a CBP extremely costly in security terms and thus a very high market price for rhinoceros horns would need to be sustained to establish from scratch and then continue to support an adequate number of these programmes.

It is important to make clear that given the relevant security concerns and issues, suitable CBP operations cannot be co-located with the vast majority of private game reserves, which need reasonable public access, large flows of visitors/tourists and ancillary services customers (accommodation/shops/restaurants) that comprise the main revenue stream. Poacher reconnaissance teams have often posed as tourists and visitors (Rademeyer, 2012). Accordingly, many private game reserves would actually be unwilling to host CBPs. This arises because it may adversely impact on (i) owners' lifestyles and (ii) other game reserve revenue streams, as they become an even more attractive and regular high-profile target for poaching teams. Thus the most likely location options for a CBP would be a remote and unused part of an existing state-owned national wildlife park or a remote, wholly new facility that first required extensive land purchases and/or compulsory state land acquisition. Ideally, a CBP operation for rhinoceros herds would be characterised by very extensive geographical terrain offering suitable flora coverage for shade and protection within a remote region with difficult public access (Fike, personal communication, 2012).

5. Beyond the single panacea: other instruments and institutions in the policy mix

The paper argues that regulation of a legal market for rhino horn would be difficult given that the illegal market is already well established and well-resourced syndicates already have in place extensive networks of suppliers and buyers. As was found in other cases, and is highlighted in the historical branch of new institutional economics, path dependency suggests that the carefully established strategic relationships comprising these extensive networks are likely to endure, irrespective of any changes to national policy or regulation (Bartley *et al.*, 2008). Further, given that poaching syndicates have invested in and deployed sophisticated specialist equipment and trained personnel, then such significant sunk costs will only very reluctantly be abandoned.

Rumours of current dubious practices amongst government officials themselves, such as turning a blind eye to the multiple use of permits and selling information about where rhinos are located to poaching syndicates (Rademeyer 2012), indicate that incentives for government to effectively regulate a legal market would be low. The costs of regulation would be high and the rewards for turning a blind eye to ongoing illegal trade would be significant.

Without careful institutional design, as well as a period of experimentation and learning by doing observed in other cases of institutional redesign (i.e. drawing on pilot studies and other conservation projects/policies in other country and species contexts) (Helderman, 2007), an RMA may lead to a significant worsening of the situation. Potentially this could feature systematic overexploitation of the resource if the overall

outcome is unduly dominated by less fettered market forces (the market institution), rather than a government (regulated) institution informed by biological and conservation scientists. In this study context, it could potentially drive rhino numbers towards or below minimum viable herd sizes and have dire consequences for rhino conservation outcomes. Rather than presenting the market as a straightforward and simple alternative solution to the problem of rhino poaching, we argue that the institutional design must be carefully considered, with a focus on the complementarity of command and control and profit-driven systems and with careful consideration of institutional hierarchy and complementarity in a multifaceted policy mix.

For example, given the need to financially support CBPs during start-up and for many years ahead of their possible contribution to any regulated supply chain, then either all the operations would have to be supported by direct government subsidy and/or institutions supporting soft loan-financing arrangements would have to be secured for audited and approved business expenditures, including security technology and staff. Fairness criteria might suggest South Africa and others bring pressure to bear on China, Thailand, Laos and Vietnam to become substantial partner contributors and stakeholders in financing these transfers.

Security requires ongoing expenditures and if relying on auction revenue shares as the main vehicle of financial support, then there is a possibility that the share of the proceeds from the auction sales may not always be sufficient to cover these costs, at least in the years and decades before a sustainable herd can make substantial regulated supply contributions. Accordingly, along the lines of agricultural price support systems, consideration could be given to the introduction of institutional mechanisms responsible for the disbursement of some floor revenue share from auction proceeds.

Focusing on TEM practitioners and their believers, there is the possibility that the market could be reorientated such that it was directed to rely more exclusively on sustainably managed rhinoceros horn by pursuing a 'medicalisation' route for the regulated supply chain. In this way, it may be possible to emphasise pharmaceutical purity and quality-assured marques for 'ready ground' horn and potentially this could be operationalised via strategic alliances and international joint ventures with state-sanctioned and market-leading Chinese/Thai/Vietnamese commercial pharmaceutical stakeholders. This perhaps offers a more promising route to displace the illegal Asian market supply chains in the longer term. In the transition period, it may be possible to secure high-quality *pro bono* marketing effort from leading marketing agencies who wished to participate in state contracts in South Africa. Professional and effective campaigns could thus be assured to support the safe, pharmaceutical-grade regulated product.

The market segment seeking complete rhinoceros horns poses a real problem given its incentives without or with a regulated supply. Whatever the market outcome, speculators will exist and given their incentives in the face of extinction, one may take a firm line that this market segment should be undermined by all means possible.

Undermining the market segment could take the form of degrading the product through the application of indelible dyes and/or or anti-tick poison. This could also be supplemented by embedding a tracking device in the horn (Rhino Rescue Project, 2012). To enhance the methods, it is suggested as many observers as possible (press and employees) should be present to monitor the process and spread the message. In addition, it is recommended that signage near access points and entrances indicating the use of these dyes and poisons should be prominently displayed. According to

W. Fowlds (veterinarian, Grahamstown, personal communication, 2012), 60–70 rhino have received the treatment in South Africa to date. None of these treated rhinos has been poached, although one died because of the anaesthetic administered during the application of the treatment.

Another means of undermining the market for genuine rhino horn is through infiltrating it with fake horn, which may undermine consumer confidence in the product and reduce prices. Currently, fake complete horns are a smaller element of the market but a greater active toleration of producers of fake complete horns could be helpful to introduce lemon good aspects into this market at the South African part of the supply chain. However individuals who can afford a complete horn should also be able to afford biochemical analysis to prove the horn is wholly rhinoceros keratin. That said, such analysis might not be readily available within South Africa for illegal consumers. It may also be possible to consider institutionalising routine DNA analysis to verify the source of the rhino horn to support the regulated market. Confusingly, but possibly useful to the pursuance of a lemons market tactic, it has been the case in Vietnam that sellers of rhino horn have been allowed to use the term fake horn to signal they have real rhino horn available for sale (Brown, 2012).

Another lower-cost approach to reduce incentives to poach is to raise deterrence even further. One means of doing this is explicitly to legitimise a shoot first policy against poachers, to legitimise the use of ambush trackers and to allow keratin detection inside embassy diplomatic bags, which have been found to be a key trade route in some illegal supply chains (Rademeyer, 2012). In this way, data that are more accurate may also emerge on the level of poaching effort.

6. Summary and concluding remarks

This study draws on various sources of evidence in South Africa regarding the plight of rhinoceros herds against a depressing onslaught of poaching activity, which, if left unchecked, could soon lead to the extinction of some species of rhinoceros and ultimately existentially threaten all species in South Africa, which is the their main habitat. We show that the market price of a live rhinoceros is a mere fraction of the price of just its horn because of the reserve and CBP management costs and more significantly the high costs of poaching avoidance. This price disparity will continue in the short run, as CBPs have to be established from scratch to be able to routinely contribute horn in a regulated supply chain. This process requires a high market price to be sustained, potentially for decades, to ensure sufficient herds remain without threat of extinction.

The high costs of anti-poaching security simply cannot be met on an ongoing basis by current stockpiled reserve releases and game reserve and CBP revenues, at least in the short run. Some supplementary policy instruments will be needed to allow an RMA to have the potential to work in the long run. Currently, stockpiled horn releases at auction and CBPs without additional financial and market support are unlikely to be able to help save some rhinoceros species from extinction in the short run. Even then, the outcome from an RMA is uncertain in the face of demand persistence and potentially inelastic and growing demand. Some consumer-market action in the Asian countries involved seems essential and warranted, even if it is just premised on using more sustainable and pharmaceutical grade rhino horn. There are some signs that the necessity of deploying an international diplomatic approach is increasingly becoming acknowledged (Brown, 2012).

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Appendix

Table A1. *Estimated costs of anti-poaching rhino security measures*

Expenditure item	Cost (in South African rand)
Rehabilitation (if possible) of surviving rhino that have been violently dehorned	40,000–160,000
Dehorning (ideally once a year)	6,000–10,000 per rhino
Fitting of transmitter devices for monitoring, including helicopter, veterinary drugs and bracelet transmitter	8,000–10,000 per rhino
Helicopter support programme	400 per hour of flying
Additional security personnel (net monthly cost of employment)	
Entry-level ranger	3,000–4,000
Scout (ranger with experience and advanced weapons training)	6,000+
Dedicated anti-poaching vehicle	6,000 per month (including running costs)
Bullet-proof vests	4,000 per unit
Security personnel uniforms	2,500 per unit
Handheld radios	2,200 per unit
Night-vision binoculars	17,000 per unit
Normal binoculars	2,000 per unit
Thermal imagery vehicle pathfinder camera	36,000
Handheld thermal imagery camera	68,000
Spotlight	1,500
Telemetry aerial	1,200
Telemetry receiver	7,000
Horn implant device	2,750 per unit

Sources: Grocott's Mail (2012); Fowlds (personal communication, 2012).