Could a Regulated Market Approach for Rhinoceros Horns Work in South Africa? Some Practical Issues and Concerns*

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Abstract:
One of the proposals for fighting rhinoceros poaching is to legalise the trade in rhino horn and adopt a regulated market approach (RMA), which would require a vote at the 2016 CITES meeting in order to overturn the ban on the trade in rhino horn. The legal trade in rhino horn would enable the auctioning of stockpiles of horn and encourage captive breeding programmes. The aim of increasing the supply of horn is to reduce incentives to poach by driving down the price. This paper uses a conceptual/theoretical approach to consider the practical implications of the adoption of an RMA, drawing on demand, supply and production theory. The intention 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. To secure a stockpile for some species needs biological success in captive breeding programs (CBPs) but this varies across species and habitats. Rhinoceros herds in a CBP would need relatively spatially extensive terrain and costly permanent security measures, and only appear feasible for the less aggressive "white" rhino. Thus, market price would actually need to be sustained at a high level to cover the start-up and security costs of such a programme that are unlikely to fall significantly. This is a double-edged sword in that the persistent high price of rhino horn provides an incentive for continued poaching activities. Supplementary policy measures that differentiate among consumer groups may also prove necessary.

JEL classification: Q11, Q57, Q58

Keywords: Rhinoceros, price determination, regulated market approach, poaching, captive breeding programs

1. Introduction

Given that the number of rhinoceros are killed annually by poachers in South Africa to acquire their horns has nearly doubled between 2010 (333 poaching incidents) and 2012 (588 poaching incidents as of 27/11/2012), 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 Chinese Medicine (TCM) 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

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to poach, even in high risk situations, is likely to remain high. An additional factor is the 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).

Various economists have reconciled themselves, often reluctantly, to the need for some kind of regulated market approach (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 programs (CBPs) for rhinoceros herds and a small number of interviews (n = 3) 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 a 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 (CITES). 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 19th century, White rhino populations had recovered to 840 by 1960, and being found almost exclusively in what is now the Hluhluwe-Umfolozi Park in KwaZulu-Natal Province in South Africa. Through the development of game capture techniques, "Operation Rhino" was initiated in the 1960's to capture surplus White rhino in the Hluhluwe-Umfolozi Park, and

transport them to other protected areas in South Africa (Ezemvelo, 2012; '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 "conservation dependent", the White rhino is no longer regarded as threatened or endangered (TRAFFIC, 2012:9). The population of Black rhino is much smaller, at an estimated 4,880 worldwide, of which 1915 are found in South Africa. Black rhino are still listed as critically endangered (Evans, 2012; TRAFFIC, 2012).

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:ix), the average price of live rhino has fallen (Table 1). 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).

Table 1: Prices for White Rhino in South Africa 1982 - 2012

Year	Real Prices (2012) ZAR*	% change from previous data point	Average % change p/a	Source
1982	14,160			t' Sas-Rolfes (2010)
1986	81,400	475%	118.75%	t' Sas-Rolfes (2010)
1989	266,560	227.50%	75.84%	t' Sas-Rolfes (2010)
2004	389,326	46.00%	9.20%	Animal Rights Africa (2009)
2005	164,009	-137.40%	-137.40%	Animal Rights Africa (2009)
2006	200,473	22.23%	22.23%	Animal Rights Africa (2009)
2007	255,636	27.52%	27.52%	Animal Rights Africa (2009)
2008	295,997	15.80%	15.80%	Animal Rights Africa (2009)
2012	239,500	-19.10%	-4.78%	GFR Game Sale (2012)

* All data presented in 2012 prices, calculated using the Consumer Price Index (Statistics South Africa, 2012).

** The current exchange rate of R8.85:1US$; R14.26:1 UK Pound; R11.57: 1 Eur.

The above data 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 R400,000 (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 R390,000.

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 50% from an average of US$34,888 in 2000, to $17,393 in 2005, while the average price of Black rhino had dropped 21%. At the same time, the number of animals sold also declined. According to Fike, the manager of a large public reserve in South Africa (Pers. Comm., 2012), the drop in price and sales volumes can be

explained by a declining demand for live rhino 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 it illustrates 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 the 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). Violent encounters between poachers and wildlife rangers may also not be the answer, even where rangers may have an unofficial "shoot to kill" policy. Given South Africa's high rates of unemployment (25.5% according to the latest Quarterly Labour Force Survey) and poverty, the supply of poachers, often ex-military, according to Fike (Pers. Comm., 2012), who are willing to take the risk for huge rewards, is virtually limitless. A recent book by the South African investigative journalist, Julian Rademeyer (2012), makes this clear in an interview with a Zimbabwean rhino conservation manager:

> "'Killing poachers doesn't achiever 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: 22).

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 (27/11/2012).

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, 2006:58).

A related problem is the slow prosecution rate of rhino poaching-related cases, despite the announcement by the Minister of Water and Environmental Affairs in 2011 that rhino poaching cases would be "prioritised". At the same time, the Minister announced that various other strategies were being considered, including placing a moratorium on rhino hunting, but starting with stricter

rules for legal hunting, such as requiring an official to be present, and collecting DNA samples from legal trophies to prevent the re-use of permits (Molewa, 2011).

There have also been numerous calls for the South African Government to sell existing stockpiles, accumulated from de-horning, natural mortality, and the seizure of illegal horns, in order to generate funds for conservation efforts. Currently held stockpiles in South Africa are estimated to be worth more than R1 billion (Pillay, 2012).

Another controversial intervention, which has been hotly debated, is the dehorning of rhino. At the National Rhino Summit in 2010, the South African Department of Environmental Affairs commissioned a dehorning impact assessment (Lindsey and Taylor, 2011). The report found that dehorning has been practiced 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 population to smaller, more defensible areas away from boarders) 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. There is no doubt, however, that dehorning reduces the profit earned by poaching syndicates, and may even reduce the market price, where “unnatural” stumps may not be valued as highly (SADC-RPRC, 2006).

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

Studies on the dehorning of rhino found that the mortality risk to rhino is as low as one per cent (SADC-RPRC, 2006), and other medical complications experienced in the 1990s (such as deformed horn regrowth if the horn is cut too close to the base) have been overcome (Lindsey and Taylor, 2011). Less is known about the social and behavioural impacts of dehorning (Fike Pers. Comm., 2012), and the commissioned report (Lindsey and Taylor 2011) calls for further research, both on the impact of dehorning on rhino and on the likely changes in poacher motivation.

As with security, the cost of dehorning rhino is not insignificant. A recent estimate by a private game reserve in the Eastern Cape Province of South Africa put the price of dehorning at between R6,000 and R10,000 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 that 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 in the southern African region (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, 2011:6).

2.1 The Regulated Market Approach (RMA)

The underlying logic of a 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 a 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 reports pointing to cases where CBPs have been associated with reductions in poaching levels. However, these are often in the context of poaching across a large range of wild animals, including for 'bush' meat or for wild bird egg collectors. On more detailed scrutiny of the evidence, the strength of the inferred causality is often fragile, sometimes based on a single case study program which 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 time 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: 338).

Additional analytical problems emerge since the path to any overall market equilibrium for many such endangered species goods is extremely difficult to observe and monitor. Given the current state of market knowledge, it may be quite legitimately characterised, in many cases, by a lurching from one disequilibrium position to another. This distinct possibility arises because much of the illegally traded endangered species goods that enter an illegal supply chain typically form part of a series of intermittent, bilateral trades. These feature heavily concealed information flows linked to them, which mask the hidden interplay of different criminal syndicates, enterprises and illegal end-use consumers. As such, reliable and credible market information is scarce. Further, while legitimate wildlife auction prices seemingly offer some insight to 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, 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 for 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 mainly 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 use is as a ground-down ingredient in Traditional Chinese Medicine (TCM) used, hitherto, in the context of serious 'life or death' 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 have helped drive this significant market expansion that support this extension of its usage. That said, there is no credible medical evidence of any genuine therapeutic benefit for any ailment arising from the use of rhinoceros horn, aside from possible placebo-type effects. Its use in both of these medical contexts has been promoted by word-of-mouth dynamics among individual 'believers' and TCM practitioners. It has also been supported through the aid of planted false news stories, which highlight particular 'miracle cases' of medical recovery.

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. 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 TCM users, even despite the potentially huge scale and growth of market

demand, individual believers and TCM 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 a 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 somewhat 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 suggests a more species-specific characterisation is necessary to capture the likely dominant market characteristics relating to rhinoceros horn, sourced specifically from South Africa. 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, it is argued that 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.

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 broadly accurate. However, there are some key points of departure. Foremost among these being 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 are comprised of 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 programs.

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. If there were some very large, more marginally profitable private game reserves, then perhaps these could consider conversion to a CBP location and cease to operate as a visitor attraction-financed reserve. That said, this would not be feasible without very substantial upfront bridging finance provided by the state or some other body to support CBP establishment, which may take decades to achieve a sufficient herd size to make a significant contribution to the regulated supply chain. Thus, the most likely location options for a CPB 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, Pers. Comm., 2012).

3. The Current Market Context

Traditional single market models for endangered species indicate that bringing onto the market legally harvested and confiscated goods reduce the 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 on-going, episodic sales of rhinoceros horns for reducing poaching incentives**.** Following the market typology and stylisation of Fischer (2004), the prevailing market circumstances can be accurately characterised, as depicted in that work, by the case of a complete trade ban with purely illegal supply but with demand arising, in this case, from purely noncompliant consumers.

There are some minor differences in the market context and some future refinements that could be considered in future model frameworks geared to rhinoceros herds in South Africa. These relate to:

(i) The poaching rate being derived from the number of rhinoceros kills is likely to be a misleading indicator of the actual level of enforcement effort needed and of the level of poaching effort actually expended. This is because of their being many unreported incidents of 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 should be in some cases relaxed. In many instances of 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, Pers. Comm., 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 and following the theoretical work of Fischer (2004), 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. Accordingly, following Bergstrom (1990) and Fischer (2004), both would seem likely to advocate the introduction of a regulated market supplier to release stockpiles of endangered species goods.

4. Introducing Regulated Suppliers

From the literature on the rhinoceros poaching market, the weight of evidence does suggest that demand is indeed inelastic and thus greater enforcement effort will increase poaching, *ceteris paribus*. Following Bergstrom (1990), this could motivate a policy of reselling the confiscated rhinoceros horns to drive the price down to where poached supply intersects demand to achieve a more desirable market outcome. In theory, this would mean that an increase in enforcement would unambiguously decrease poaching. This case is clearly set out in graphical terms within Fischer (2004).

However, this approach bypasses a number of key steps before the potential benefits of such market adjustments could even begin to be realised. Some of these steps are, however, rather unhelpfully inconsistent in their requirements.

Firstly, a sufficient, sustainable and reliable stock of rhinoceros horn would need to be sourced and available, in such quantities as to meet a sufficient fraction of market demand, such that it could actually influence the market price downward in the attempt to reduce poaching incentives. The scientific evidence in this specific market context suggests that starting many CBP operations from scratch will be unlikely to yield a sustainable herd in many cases and that sufficient volumes provided at a sufficient rate for the market cannot be biologically assured. The illegal fringe thus will still have significant market share opportunities for a long period, even if they do not existentially threaten CPBs in the meantime.

Second, given that CBPs would need large geographic areas to be successful in reproductive terms, the high costs of security would actually necessitate a sustained high market price for the rhinoceros

horn, not a low price, in order for CBPs even to approach a breakeven cost level of operation. However, population growth is negatively related to stocking density. Starting from a population of 1000 rhinos, to approach a population of 2000 may take up to 70 years at a 1% per annum growth rate, or eight years with a 9% per annum growth rate (SADC-RPRC, 2006), depending on stocking density (see Figure 1). However, given that most discussions of CBPs imply high stocking densities, then the slower reproduction rates are more likely. This suggests a long start-up period for CBPs, during which they will have very high security costs and low income (*ceteris paribus*).

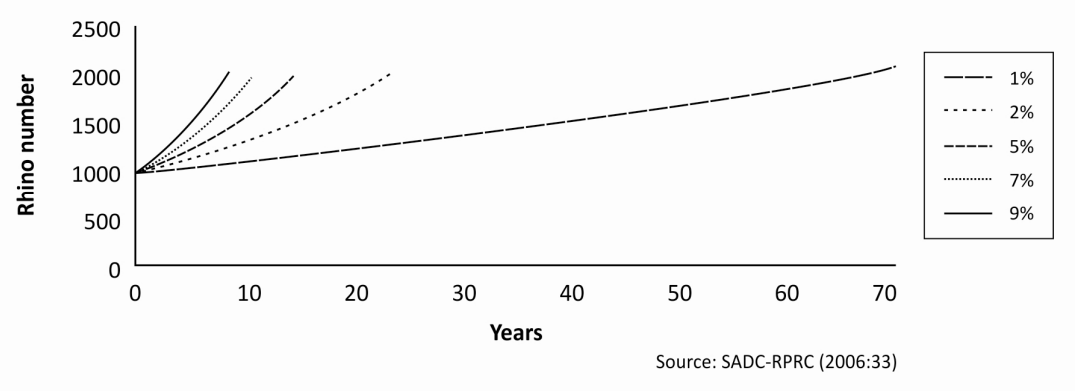

Figure 1: Rhino population growth rates from 1000 to 2000 animals

Multiple species CBPs may, however, help secure some limited scale and scope economies in some locations. That said, it cannot be stated strongly enough that a densely stocked herd occupying a necessarily large geographical area is vulnerable from both airborne (helicopter) and land vehicle-based poachers who have incentives to both acquire the horns and also sabotage the functioning of any CBP to retain market power. As described earlier, some existing game reserves in South Africa do not only rely on the elite anti-poaching police forces (who have not contradicted claims of a shoot first policy to deter poachers). In some cases, they have hired professional tracker/hunters and these services are extremely costly.

Thirdly, the auction institutions conducting the sale process would require identity revelation even if through agents. Potentially the exercise could be seen as a 'sting operation' and so to be credible this might likely have to be accompanied by an amnesty for past poaching-related crime. This may or may not be politically feasible.

Fourthly, the whole supply chain leading to the auction would need to be subject to stringent regulatory monitoring such that it could be ensured that illegal goods were not brought to this legal market auction (i.e. laundered).

Yet it is difficult to see how, in practice, these four key steps in this specific market could only be met by:

(i) Assuming rhinoceros CBPs in South Africa will successfully function in a biological sense, when the scientific evidence is quite mixed.

(ii) Assuming CBPs could work in a biological sense, but then assuming they could be indefinitely kept secure enough to operate in the face of globally powerful criminal syndicates fighting a 'turf war' to eradicate them for undermining their revenue base.

(iii) Holding a successful auction with the presumed cooperation and participation of many agents of known criminals and criminal associates who have long governed the distribution channels to end-use consumers in Asia and,

(iv) In the face of the heightened security requirements (amid likely turf war activity), expecting the cash flow of start-up CBPs and game reserves in the private and/or public sector to be able to readily absorb the additional security costs. Presumably, the expectation is that these would be more than fully met through receiving their (uncertain) share of some intermittently auctioned stockpiled horn sales revenue.

These are very real practical concerns and given that avoiding extinction is the highest order priority then this would seem to warrant the introduction of additional backstop policy measures to help sustain a sufficient market price to cover the start-up and security costs for CBPs from the outset. Such additional instruments could also potentially exploit the different incentives facing the two types of currently illegal consumers present in the global market for rhinoceros horn.

In the light of the above, a more rhinoceros-specific and hence more accurate depiction of the likely short-run context, without any supplementary policy instruments to stockpile auctions is presented in Figure 2.

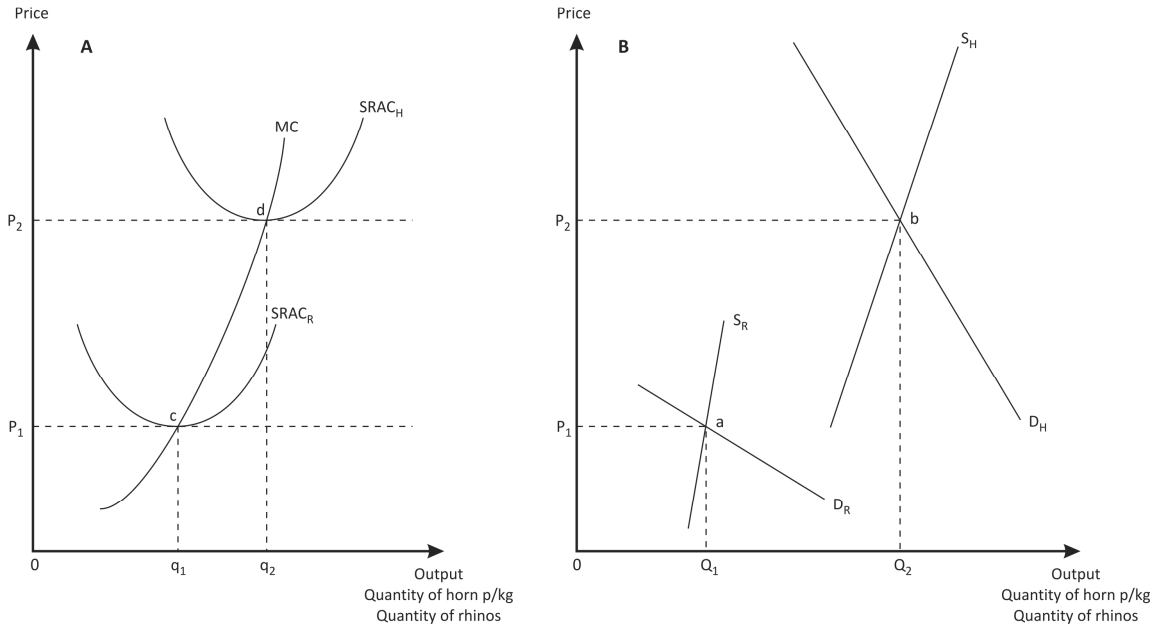

Figure 2: Cost functions and market demand and supply functions for live rhinos and rhino horn

In quadrant (B), we show a relatively inelastic supply schedule and an elastic demand schedule for live rhinoceros at auction with a market-clearing price of P_1 per animal. The associated regulated supplier cost conditions in quadrant (A) if earning normal profits are shown at point ***c***. The inelastic supply and inelastic demand for rhinoceros horn are shown in quadrant (B) depicting a market

clearing price of P_2 per kg. The associated cost conditions for regulated suppliers (not the poachers who have far lower costs!) to sustain normal profits with market clearing in the horn market is shown in quadrant (A) at point ***d***. The differences in the cost conditions reflect in large part the additional security costs necessary to protect the CBPs and reserves from poaching and turf war related attacks. Rising real income growth in the Asian markets is adding to the cost pressures by shifting the demand for horn to the right (see Figure 3) leading to escalated poaching effort and the need for escalating security costs to be met (resulting in an equilibrium adjustment from point b to point f).

In the short-run therefore, some subsidy or soft loan arrangements are warranted to provide security in order to enable the CBPs sufficient time to build up a sustainable herd over a long time period of potential exposure to poaching attacks and to routinely contribute a sufficient supply of horn for auction. If existential threats are met without supply interruption, there is a possibility of the long run supply schedule being 'allowed' to exhibit greater elasticity, which, in turn, could lower the market price and reduce poaching incentives. However, addressing short-run market conditions are first necessary if Keynes's (1936) assertion regarding the long-run does not become true for rhinoceros herds.

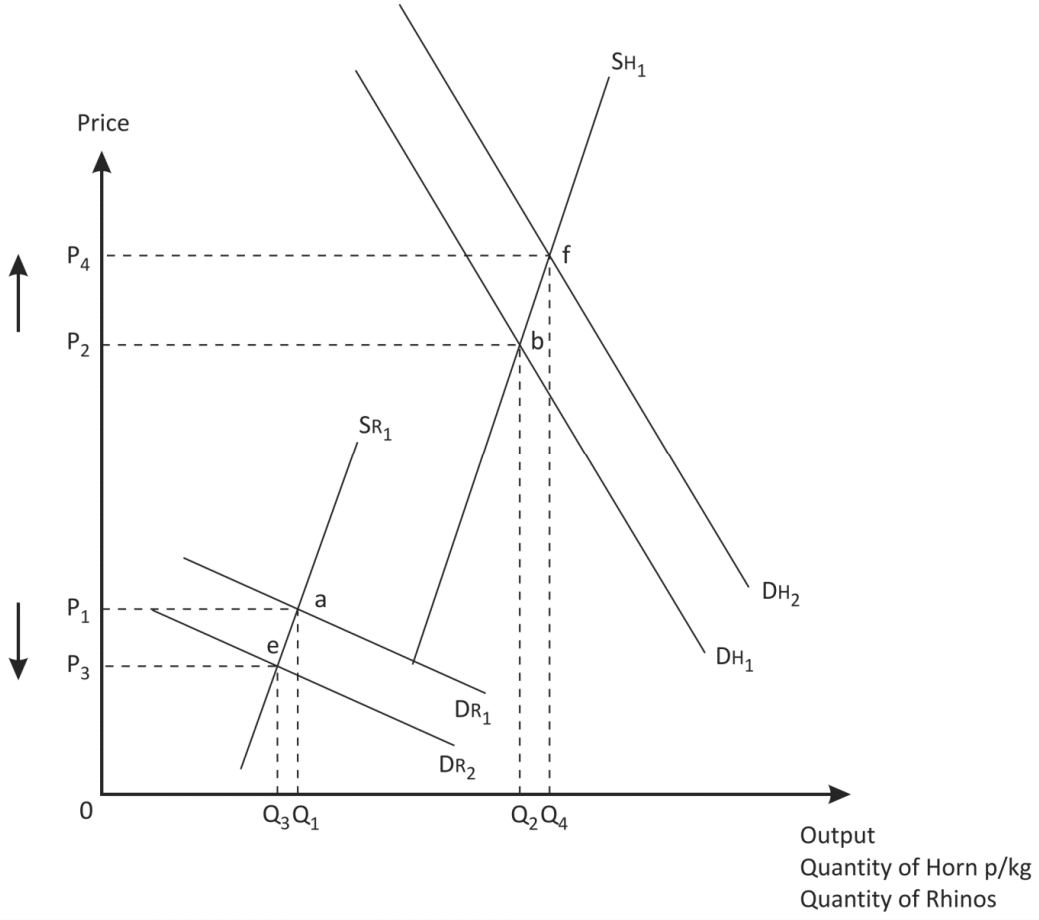

Figure 3: The effect of changes in demand on the prices and quantities of live rhinos and rhino horn

5. Supplementary Policy Instruments

Given the need to financially support CBPs during start up and for many years and possibly decades ahead of their possible contribution to any regulated supply chain, then either all the operations would have to be supported by Government subsidy or some 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 be substantial contributors to financing these transfers.

Security requires on-going 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, and 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 some floor revenue share from auction proceeds.

Focussing on TCM practitioners and its believers, it is possible that the market could be re-orientated 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 emphasize pharmaceutical purity and quality assured marques for 'ready ground' horn and potentially this could be done in association with state sanctioned and widely known and respected Chinese/Thai/Vietnamese commercial pharmaceutical stakeholders. This perhaps offers a more promising route to displace the illegal Asian market supply chains into 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 for state contracts in South Africa. Professional and effective campaigns could thus be assured to support the pharmaceutical grade and 'safe' regulated product.

The market segment seeking complete rhinoceros horns pose a real problem given their 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 these 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 Fowlds (Pers. Comm., 2012), 60 to 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 relates to the associated fake rhino horn market. Currently, fake complete horns are a smaller element of the market but more 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 available real rhino horn 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 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 routinely to contribute horn in a regulated supply chain. This process requires a high market price to be sustained and 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 on-going basis by current stockpiled reserve releases and game reserves and CBPs own revenues, at least in the short-run. Some supplementary policy instruments will be needed to allow a RMA to have the potential to work in the long-run. Currently, stockpiled horn releases at auction and CPBs 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 a RMA is uncertain in the face of demand persistence and strongly inelastic and growing demand. Some consumer market action in the Asian market side of the market 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	R40,000 – R160,000
Dehorning (ideally once a year)	R6,000 – R10,000 per rhino
Fitting of transmitter devices for monitoring, including helicopter, veterinary drugs and bracelet transmitter	R8,000 – R10,000 per rhino
Helicopter support program	R400 per hour of flying
Additional security personal (Net monthly cost of employment) Entry-level ranger Scout (Ranger with experience and advanced weapons training	 R3000 – R4000 R6000 +
Dedicated anti-poaching vehicle	R6,000 per month (including running costs)
Bullet proof vests	R4,000 each
Security personal uniforms	R2,500 each
Handheld radios	R2,200 each
Night vision binoculars	R17,000 each
Normal binoculars	R2,000 each
Thermal imagery vehicle pathfinder camera	R36,000
Handheld thermal imagery camera	R68,000
Spotlight	R1,500
Telemetry aerial	R1,200
Telemetry receiver	R7,000
Horn implant device	R2,750 each

Sources: Grocott's Mail 4/12/2012:14; Fowlds 2012