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The Economics of Synthetic Rhino Horns☆

Frederick Chen

Department of Economics, Wake Forest University, Winston-Salem, NC 27109, USA

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ABSTRACT

To examine the potential impact of synthetic horns to reduce rhino poaching, a formal model of the rhino horn market in which there exist firms with the capability to produce high quality synthetic horns is presented and studied. The analysis shows that whether the availability of synthetic horns would decrease the equilibrium supply of wild horns—and how much the reduction would be—depends on market structure—i.e., how competitive the synthetic horn production sector is—and on how substitutable the synthetic horns are for wild horns. The implications of these results for conservation policies are derived and discussed. Synthetic horn producers would benefit more by promoting their products as being superior to wild horns, but this could increase horn prices and lead to more rhino poaching. For conservation purposes, it may be beneficial to incentivize firms to produce inferior fakes—synthetic horns that are engineered to be undesirable in some respect but difficult for buyers to distinguish from wild horns. The analysis also shows that promoting competition in the production of synthetic horns in general is desirable from a conservation standpoint as synthetic horn producers may prefer to keep prices at a high enough level that could still encourage significant amount of poaching.

1. Introduction

Rhino horns are highly valued in Asian countries such as Vietnam, and the rhino populations in Africa and Asia continue to be threatened by poaching (Biggs et al., 2013; UNEP, 2016). Poachers have become more sophisticated in recent years in terms of skill and equipment (UNEP, 2016)—no doubt a reflection of how lucrative trading in rhino horns is. In terms of price per unit weight, rhino horns are worth more than gold or diamond (Biggs et al., 2013).

To help deal with the poaching crisis, a few biotech companies have set their sights on developing synthetic versions of rhino horns using the latest science and technology (Corbyn, 2015). The premise behind such a strategy is straightforward: if synthetic horns that are biologically identical (bio-identical) to the real thing can be produced at a lower cost compared to the cost of supplying wild horns, the demand for wild horns would decrease as buyers shift consumption towards the synthetic products. This, of course, would reduce people's incentive to poach rhinos.

The idea of using synthetic horns as a form of anti-poaching measure is a controversial one in the conservation community. Major rhino conservation groups are strongly opposed to it for they fear that the availability of synthetic horns would actually increase the demand for wild horns—by, e.g., lending legitimacy to the rhino horn trade—and exacerbate the poaching problem (Save the Rhino International and International Rhino Foundation, 2015).

One reason why those who are concerned about the fate of the rhinos are locked in the debate over how beneficial synthetic horns would be as an anti-poaching solution is that there appears to have been little, if any, rigorous analysis of this issue based on formal economic theory. Further, beyond the question of whether synthetic horns would benefit or hurt the rhino population, there has been scant discussion about what would be the most effective way—in terms of reducing the supply of wild horns—to utilize the technological capability to produce high quality synthetic horns, and whether there are policies that can be implemented by governments or conservation groups that can enhance the potential of this technology to curtail rhino poaching. While biotech firms seem keen on producing bio-identical synthetic horns (Corbyn, 2015), what would happen to wild horn supply if these companies were to sell synthetic horns that are designed to be undesirable in some respect yet difficult for buyers to distinguish from the real horns? How does asymmetric information about horn quality affect the impact that synthetic horns can have on wild horn trading? Can synthetic horns bring about adverse selection in the horn market and drive out rhino poachers?

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E-mail address: chenfh@wfu.edu.

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To examine these issues rigorously, a model of the horn market in which there are profit maximizing firms with the capability to produce high quality synthetic horns is presented and analyzed. Due to the possible existence of asymmetric information in the market, the model here builds on Akerlof's famous model of the used car market (Akerlof, 1970). While the market in Akerlof's model is perfectly competitive, the model here allows for imperfect competition since biotech companies with the capability to produce synthetic horns may possess some market power over horn prices.

The existing literature in economics on the protection of endangered animals has looked at the potential effects of a few types of conservation policies. Several authors have considered the impact of ivory trade bans on the elephant population (Barbier et al., 2013; Bulte and van Kooten, 1999a,1999b; Heltberg, 2001). Other work examined how legalizing trade in wildlife goods derived from endangered animals—e.g., rhino horns—can affect people's incentives to poach these animals (Bulte and Damania, 2005, Damania and Bulte, 2007; Collins et al., 2016). There is also a small literature that investigates how policy-makers or speculators can strategically manipulate the stockpile of wildlife goods to affect the level of poaching (Kremer and Morcom, 2000; Brown and Layton, 2001; Mason et al., 2012). Besides the conservation implications of trade bans, Barbier et al. (2013) also considered the importance of aligning the incentives of all parties involved in regulating wildlife trade and giving local communities a vested interest in protecting endangered animals.

In spirit, the model presented here is close to the one in Damania and Bulte (2007). In that model, there is a legal farmed sector that produces substitutes for the wildlife products provided by poachers; moreover, there is imperfect competition in the farmed sector so that producers of the substitute products have significant ability to affect the price of these goods. In the model here, the biotech sector produces synthetic goods that serve as substitutes for the wildlife goods, and the biotech companies—like producers in the farmed sector in Damania and Bulte (2007)'s model—are assumed to be price-makers. However, unlike their model, in which buyers can costlessly distinguish between wildlife goods and their substitutes, the model here assumes that buyers are not able to tell apart the synthetic substitute products from the wild ones. Hence, there is asymmetric information in the market analyzed in this paper.

The analysis here shows that whether the availability of synthetic horns would decrease the equilibrium supply of wild horns—and how much the reduction would be—depends on market structure—i.e., how competitive the synthetic horn production sector is—and on how substitutable the synthetic horns are for wild horns. The implications of these results for conservation policies are derived and discussed. Synthetic horn producers would benefit more by promoting their products as being superior to wild horns, but this could increase horn prices and lead to more rhino poaching. For conservation purposes, it may be beneficial to incentivize firms to produce inferior fakes—synthetic horns that are engineered to be undesirable in some respect but difficult for buyers to distinguish from wild horns. This would drive down demand for rhino horns and could depress horn prices sufficiently to drive out rhino poachers from the market. The analysis also shows that promoting competition in the production of synthetic horns in general is desirable from a conservation standpoint as synthetic horn producers may prefer to keep prices at a high enough level that could still encourage significant amount of poaching.

The exposition is organized as follows. In Section 2, a model of the horn market is presented. In Section 3, the concept of an equilibrium of the market is defined formally and its existence is established. The main results of this paper are given in Section 4, which looks at how the presence of synthetic horn producers impacts the supply of wild horns in the model. The policy implications of the analysis for rhino conservation are discussed in Section 5. Section 6 concludes.

2. The Model

Suppose there are two types of goods in the market for rhino horns: wild horns, and synthetic horns. The market consists of: a continuum of buyers; a continuum of sellers of wild horns; and a monopoly producer of synthetic horns. (A discussion of alternative market structure is deferred to Section 5, which examines how the level of competition in the production of synthetic horns affects the wild horn supply.)

2.1. Sellers of Wild Horns

Each seller of wild horns can procure and sell one unit at cost $c > 0$. This cost can differ across sellers: the distribution of c among the sellers is given by the cumulative distribution function $F(\cdot)$. The number[1] of sellers is $N_S > 0$. For simplicity, assume that $F(\cdot)$ is continuous. Further, assume that there is some minimum cost $\underline{c} > 0$ of supplying wild horns so that $F(c) = 0$ for all $c \leq \underline{c}$ and $F(c) > 0$ for all $c > \underline{c}$.

All wild horn sellers are price-takers: given price p for horns, a wild horn seller chooses whether to supply one unit of the good or not. Therefore, for a seller with cost c, it is profit maximizing to supply one unit of wild horn if $p \geq c$, and not to sell any otherwise. With the given distribution function for c, the total supply of wild horns at price p is thus $N_S F(p)$.

2.2. Monopoly Producer of Synthetic Horns

The monopoly can produce any non-negative amount Q of synthetic horns at cost $C(Q)$, where $C(\cdot)$ is an increasing, continuous, and differentiable function. The monopoly's objective is to maximize its profit by choosing Q. Assume that the monopoly has a cost advantage over the wild horn sellers in the sense that the monopoly's marginal cost of producing the q-th unit of synthetic horn is lower than the marginal cost of supplying the q-th unit of wild horn for all q.

2.3. Buyers

The number of buyers is $N_B > 0$. The synthetic horns are of high quality in the sense that buyers cannot distinguish between the two types of horns (equivalently, the cost of testing or differentiating between the two is prohibitive). The value of the wild horn to a buyer is $V_W \geq 0$, while the value of the synthetic horn is $V_S \geq 0$. The distribution of V_W among the buyers is given by the continuous cumulative distribution function $G(\cdot)$. To avoid trivialities, assume that $G(\underline{c}) < 1$ so that wild horns would be traded in the market if no synthetic horns are available. For convenience, let us refer to a buyer whose valuation of the wild horn is V_W as a type-V_W buyer. Assume that the value of the synthetic horn to a type-V_W buyer is given by $h(V_W)$, i.e., $V_S = h(V_W)$, where h is some non-negative, strictly increasing, and continuous function.

Remark 1. The model can be generalized to accommodate a wider range of relationship between a buyer's valuation of the wild horn V_W and the buyer's valuation of the synthetic horn V_S. This can be done by specifying the distribution of V_S for each value of V_W, i.e., how the buyers' preference for the synthetic horn is distributed in the population as a function of their valuation of the wild horn. However, such a generalization is not necessary for the main points of this paper, and the assumption that V_S is monotonically and continuously related to V_W is adopted here to simplify the proof of the existence of a market equilibrium (Theorem 4).

[1] Technically speaking, the number of sellers (buyers) is the measure of sellers (buyers).