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Leonardo's Sailors

A Review of the Economic Analysis of Wildlife Trade

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Contents

List of Tables and Figures

Leonardo's sailors: A review of the economic analysis of wildlife trade[1]

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Abstract. Illegal trade of wildlife has been recognised as an important driver of biodiversity loss. In many quarters the use of legal markets has been presented as the best policy option for conservation, giving way to the economic analysis of wildlife trade and markets. This paper focuses on the analytical framework used in these analyses and on its deficiencies, both at the conceptual or theoretical level, as well as from an empirical point of view. We examine the implications of using a partial equilibrium framework dominated by comparative statics in all models and the implications of ignoring market structure, strategic behaviour and multi-product operations in key segments of the supply chain. Furthermore, this review considers the way in which demand is conceptualised and the implications of ignoring the role of economic policies. Our study shows that the literature advocating trade as a conservation solution for endangered species relies on models that are based on simplistic and/or extremely restrictive assumptions. In most cases, these models also rely on conceptual tools that have been theoretically discredited. Failure to take into account the theoretical and empirical issues covered in this review undermines recommendations to adopt market-based policies in response to conservation problems.

Keywords. Economic theory, wildlife trade, markets, conservation

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Introduction

Economic theory is the guidepost for applied and policy oriented research. Without understanding its scope and limitations, applied research becomes a confusing enterprise. Advancing policy recommendations on the basis of inadequate command of economic theory is imprudent. In the field of policies for environmental and social sustainability the need to work with the greatest possible responsibility implies awareness of theoretical results and limitations of analytical tools. When dealing with matters of life and death, and wildlife trafficking is indeed a matter of life and death, paying due consideration to the law of unintended consequences is vital. Or, to put it in the words of Leonardo da Vinci, "he who loves practice without theory is like the sailor who boards ship without a rudder and compass and never knows where he may be cast".[4]

One of the most striking features in the economic analysis of wildlife trade is the level of misinformation concerning the evolution of market theory over the last six decades. To anyone who comes in contact with the corpus of literature on wildlife trade, and in particular the literature recommending the use of market-based policies, the uncritical use of theoretically discredited analytical instruments is a striking revelation. Perhaps the most important issue here is the conviction that markets behave as self-regulating mechanisms that smoothly lead to equilibrium allocations and therefore to economic efficiency. This belief is not sustained by any theoretical result, a fact that is well known in the discipline since at least the early seventies.[5]

In tracing the antecedents of the pro-market posture in endangered wildlife trade it is important to examine the intellectual heritage of Gary Becker (1968, 1992) and Coase (1960). According to Becker market analysis and market efficiency can be extended to many fields of social relations, from marriage and divorce, to crime and markets for organ transplants. The underlying premise of Becker's analyses is that neoclassical economic theory has succeeded in providing a solid foundation for the idea that competitive markets allocate resources efficiently. Coase's work on transaction costs is based on the premise that well-defined property rights can overcome the problems caused by externalities. According to Coase, the initial allocation of legal entitlements does not matter from the point of view of economic efficiency if they can be freely exchanged. This statement has been the foundation for several cap-and-trade schemes related to natural resource management (e.g. tradable quotas in fisheries) and climate change (e.g. trading of emissions' allowances). In the case of climate policy, the European Union Emissions Trading Scheme has been a resounding failure. It is important to note that Coase admitted that in the presence of transaction costs, this result would not be forthcoming. Thus, in the absence of transaction costs markets would attain the efficiency results normally attributed to them. The key problem here is that both Becker and Coase ignore the

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[4] In his "Prolegomena and General Introduction to the Book on Painting" (*The Notebooks of Leonardo da Vinci*, Jean Paul Richter, editor). Project Gutenberg: www.archive.org/stream/7ldvc09/7ldvc09.txt

[5] Exactly one hundred years after the publication of the work of Walras (1969) the Sonnenschein-Mantel-Debreu theorems showed there is no hope of demonstrating that stability is a standard property of market systems. We return to this point below.

shortcomings of partial equilibrium theory, bilateral monopoly and general equilibrium theory, particularly with regards to the poverty of results in the field of stability (for a comprehensive critique of Coase's theorem, see Nadal, 2007).

We return to this point below, but here it is important to underline the fact that the most sophisticated and developed mathematical models have shown that in general, markets need not be stable and thus competitive forces need not lead to unique equilibrium prices and allocations (for a detailed discussion see Ackerman and Nadal 2004). In fact, the work of Arrow and Hurwicz (1958) and Arrow, Block and Hurwicz (1959) showed that global stability was a property of the general equilibrium only under extremely restrictive conditions (gross substitutability for all goods or the weak axiom of revealed preferences at the market level). Although Arrow conjectured that these poor results were an indication that stability is a trait of the general equilibrium, Scarf (1960) used a counterexample to demonstrate this was not the case. The stability debate reached its climax with the papers published by Sonnenschein (1973), Mantel (1974) and Debreu (1974). These results show that the usual assumptions of general equilibrium theory allow the dynamics of the classic *tâtonnement* process to be essentially arbitrary. To avoid this, additional restrictions must be imposed on excess demand functions. Of course, this spells rather bad news for the theory.[6]

These mostly disappointing theoretical results have had vital implications for theoretical, empirical and policy oriented research. In fact, these results have marked the research programme of the discipline during the past forty years, leading to developments in almost every field of economics, from industrial organisation, to evolutionary, institutional and behavioural economics, and from debates in macroeconomic theory to work on complex and non-linear systems. Only the economic analysis of wildlife trade seems to be an exception: it appears to have been trapped in the backwaters of textbook economics. The objective of this literature review is to evaluate the scope and limitations of the economic analysis of wildlife trade that has been carried out in the past three decades. We believe this is an important task due to the implications of the policy recommendations that stem from this literature.[7]

Illegal trade in wildlife has been recognised as an important driver of biodiversity loss. The impact on endangered and threatened species has been well documented. It has been estimated that the economic value of illegal trade in wildlife may reach up to USD19 billion.[8] From poaching to retail markets, illegal wildlife trade involves a complex set of activities that frequently engage sophisticated organised criminal organisations. The policy option debate has been intensified recently by the accelerated growth in poaching rates of elephants and rhinos in

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[6] General equilibrium theory has other complications. The introduction of money poses insurmountable difficulties (see Hahn 1968) and the elimination of the auctioneer is a major problem that remains unsolved (see Fisher, 1983).

[7] There are to our knowledge no other literature reviews on wildlife trade; one exception is Campbell (2013), but its scope is limited to rhino-horn trade.

[8] Given its illegal nature, measures on the volume of wildlife trade vary broadly. Haken (2011) estimates between $7.8 to $10 billion; Wyler and Sheik (2009) mention a range between $5 and $20 billion, while others go as high as $22.8 billion (Engler & Parry-Jones, 2007).

Africa, as well as by the predicament of many other species. In the debate that ensued in order to put a brake on illegal poaching the idea of legalising markets soon gained traction as a key policy option. This scheme sprang from the idea that trade bans have become ineffectual in the struggle to ensure the long-term survivability of key wildlife species. These regulatory regimes have been portrayed as the main cause behind the existence of large-scale underground markets with high prices and profitability. This led to the development of a literature that supported the notion that legalising wildlife markets would be a better option.[9]

The approach we adopt in this review is based on two dimensions. The first pertains to economic theory and the need to use adequate analytical instruments. Many of the pro-trade models that appear in the literature are logically inconsistent and have been theoretically discredited. Failure to take into account these serious theoretical issues results in incongruities and misleading conclusions. This applies to papers that cover both supply and demand side considerations.

The second dimension pertains to the informational needs and gaps in empirical data that are crucial for any policy recommendation. In some instances the lack of information is a consequence of the clandestine nature of illegal trade in wildlife. This is understandable and clearly more work is required to reduce the informational gaps. However, there are other aspects of the illegal wildlife trade that could be covered by better data gathering exercises, especially with respect to final demand and consumer preferences.

The literature included in this review centres on the economic analysis of legal and illegal markets. Before 1990 wildlife economics was dominated by studies on natural resource management. Typically, the literature used models from fisheries' management or forestry and was essentially concerned with determining equilibrium levels of exploitation and maximum sustainable usage rates. Most models used Schaefer-style production functions and population dynamics were described by a Verhulst-Pearl logistic equation. In fisheries economics, the original model was delivered by Schaefer (1957) and Gordon (1954), while much of the research program was about relaxing restrictive assumptions in that model (J. M. Conrad & Clark., 1987; Neher, 1990). However, as trade liberalisation became a key policy priority in the early 1990s, the first references on wildlife trade *stricto sensu* began to appear. This type of literature, where prices and market processes are the centre of attention, is the fulcrum of this literature review.

Our review focuses on literature that examines different levels of price formation and the interaction between supply and demand. This review also considered studies and reports on the state of demand for wildlife products; these are very important studies and they advance our knowledge about consumer attitudes and some aspects of the retail markets. But we

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[9] In fact, the pro-trade posture can be seen as part of a larger view in which all wildlife is seen as a resource that can be used by humans to increase welfare. This naïve view of things involves a simplistic and dangerous perspective in which private property rights are seen as a superior form leading to greater efficiency in resource management. Frequently the notion of 'sustainable use' is sometimes used to lend support to the idea that 'greater efficiency' results from the appropriation of resources by anyone who has the power to exploit them.

concentrate on the economic analysis of markets, rather than on efforts to profile demand and consumption patterns. We do not cover literature on resource management, conservation and wild populations, etc. One critical issue here concerns the notion that farming can lead to wildlife conservation, without further specification of a specific regulatory regime that could avoid profit-seeking behaviour from dominating all other considerations. This important point falls beyond the scope of our review.

The corpus includes peer-reviewed articles in academic journals and technical reports. We also cover informally published material that is not traceable through the standard conventional or academic channels. This material includes self-published items, power point presentations, interviews and blog entries and falls in the category of 'grey literature', a term used in library and information science. Grey literature is more numerous given the ease of publication in comparison with peer-reviewed papers. The quantity of grey literature should not be confused with the quality of its claims or with the amount of public support for a given policy option.

The items in the grey literature category frequently ignore the need to support assertions with hard data or even to provide quotations of other reports or publications. In this sense, the grey literature is replete with opinions that carry no scientific weight. Because it has very little formal control over the arguments that it uses, grey literature conveniently jumps from assertions based on 'common sense' to sweeping policy recommendations on opening legal trade as if this reasoning was sustained by sound logic. Because this literature gets wide circulation it plays a very active role in persuading policy makers and leading public opinion to believe that pro-trade policies are the best option. Moreover, legalising wildlife trade is being increasingly proposed as a general solution, applicable to many species (even to wildlife in general) with disregard to reproduction rates or ecological traits, or the specifics of different economic contexts. Many of the items in the grey literature category belong more to the tradition of pamphleteering than scientific deliberation.

The structure of this literature review is as follows. Section 1 describes the main arguments and models making the case for legal wildlife trade. It focuses first on the canonical pro-trade argument and then on a series of formal papers that address the issue in a more systematic manner. The main assumptions and the line of reasoning of all these papers are examined.

Section 2 focuses on the capacity of models used in the literature to analyse market processes. Because models and policies that rely on market friendly policies need to deal with prices, we examine the power of these models to replicate or analyse price formation processes. Section 3 focuses on key factors of industrial dynamics that are ignored in the argument for wildlife trade legalisation: product differentiation, vertical integration, and sources of increasing returns. Section 4 examines issues related to the demand side of the equation. We concentrate on the way in which final consumer demand is formalised in the models found in the literature, as well as the implications of the gaps in data concerning price elasticity of demand. Finally, Section 5 deals with the way in which economic analyses of market-based instruments are affected by

economic policies. In general terms we find the literature on wildlife trade to have been neglectful of this important component of real-world economics.

This paper centres exclusively on the economic analysis of wildlife trade, where it is possible to identify a serious lack of theoretical rigour. Our conclusions, however, are relevant to the wider debate on the notion of natural capital (see for example the work of Sullivan, 2014) and to the debate concerning the need to establish prices for various environmental entities in order to attain good conservation and environmental stewardship (see for example Ackerman & Heinzerling, 2004).

1. Overview

1.1 The canonical pro-trade argument

The basic argument in favour of a legal market solution to the wildlife poaching crisis is developed in full or in parts in Biggs et al (2013), Conrad (2012), Eustace (2012), Lockwood (2011), Martin (2011), Moyle (2007, 2013), 't Sas-Rolfes (2012) and Loon (2012). Challender and MacMillan (2013) follow the same line of reasoning in their descriptions of legal wildlife trade (using simplistic supply and demand diagrams) but add the need to continue with regulatory efforts and supplement this with community development (without going into any details on what this implies in terms of economic policies). The formal model developed in Damania and Bulte (2007) concludes that a legal market policy will result in more poaching in Bertrand competition and less poaching under Cournot competition, but its description of the pro-market argument follows the same basic lines presented in this section. A surprising feature of the pro-market argument is that its authors apply it in general terms to elephants, rhinos, tigers, bears, alligators and many other species. Thus, the policy option of legal markets appears to be for many authors a one-size fits all recipe.

The pro-market argument starts from the premise that poaching and illegal trade are a consequence of trade bans imposed by bodies like CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora). Demand is assumed to be large and stable, rooted in ancient cultural patterns. Given that demand of wildlife products is persistent and relatively insensitive to price movements, the supply reduction provoked by the trade ban inevitably stimulates the black market and drives prices up. The high prices in the illegal markets constitute powerful incentives that compensate for the costs and risks of wildlife trafficking. The trade ban thus fails to achieve its goals as demand and supply are funnelled underground into relatively contained illegal markets where prices and profits are very high.

In addition, it is also claimed that the illegal character of the market makes it very difficult to monitor changes in demanded, supplied and stockpiled quantities of wildlife products. The argument also emphasises the inherent inefficiency of the regulatory regime based on trade bans, as budget-constrained conservation authorities are hamstrung and cannot fight poaching effectively. In addition, authorities accumulate stockpiles of potentially valuable products (either

from natural deaths or from confiscations) that cannot be sold because of the trade ban. In the end, conservation and enforcement costs rise rapidly as the incentives for trafficking increase and this leads to greater financial pressure on agencies charged with conserving wildlife.

According to this line of reasoning, scarcity produces high prices in the context of a trade ban and this leads to higher poaching rates. Instead of combating illegal poaching, scarcity should be eliminated through a flow of legal supply. Legal agents (farmers with legitimate property rights and park authorities) can effectively offer large quantities of wildlife products from captive breeding, natural mortality, culling, and stockpiles. In this manner they can take control of market supply and drive prices down, thus rendering poaching unprofitable. A legal supply of wildlife products will out-compete illegal suppliers through lower prices, providing in turn an additional revenue source to finance conservation. In addition, a legal market would enable conservationists to monitor market trends.

Naturally, in order to provide the proper institutional framework for trading, property rights on wildlife must be defined or put in place. The literature recommending legalising wildlife markets assumes property rights on wildlife need to be enforced so that market incentives may work appropriately. Of course, there are many types of property regimes and in some cases this is readily recognised in the literature, although a predominant private property regime is usually considered to be the best option (Moyle, 2007; 't Sas-Rolfes, 2011). In many instances it is explicitly suggested that private property rights are better than 'shared rights' ('t Sas-Rolfes, 1990). No rational explanation is provided to justify this notion.

Moreover, privatisation is promoted and presented as the reduction of government involvement in industry in order to ensure that market forces act as a 'regulating factor' instead of government intervention. 't Sas-Rolfes (1990: 3) uses privatisation "in its broadest sense, namely that of reducing state involvement in industry and commerce". This view of privatisation is shared by Moyle (2007) who affirms that "tigers need privatization too" as if this could guarantee their conservation. All of this assumes that private action is better than public agency.

The canonical pro-trade model also carries the assumption that returns from legal sales will be re-invested into conservation. There is no mechanism that guarantees this and, moreover, the objective of depressing prices in order to eliminate the incentives to poaching goes in the opposite direction. Thus, it appears that legalising markets would have two contradictory objectives, reducing or even eliminating profitability for poachers while maintaining high returns that can be appropriated by legal suppliers. The only way in which these two objectives can be attained is by skilfully manipulating prices, and this implies eliminating laundering or the porosity between legal and illegal markets, something that is not always forthcoming.

The canonical model of wildlife trade appears to be a consistent story, at least on the surface. But a consistent story does not necessarily imply accuracy and is not equivalent to a robust theoretical analysis capable of supporting policy recommendations. As we shall see, its main

weaknesses derive from the use of the wrong analytical instruments and from its reliance on very stringent and highly unrealistic assumptions.

In these models competition is typically presented as perfect competition, meaning that suppliers are price-takers. When this is not the case, competition is presented in very rudimentary terms. Value chains are described as if market supply was vertically integrated, reducing to one link the intermediation between poachers and final consumers. Key agents in the supply chain are presented in many cases as crime syndicates, but no serious analysis is undertaken to unravel their economic logic. Products are treated as being homogeneous and this is why it is assumed that legal trade flows are able to fully substitute illegal ones. In the pro-market account, there is no room for strategic behaviour on the part of the illegal suppliers. Finally, there is complete independence between supply and demand, and thus the legalisation of trade has no expansionary effects whatsoever on demand. Each one of these assumptions will be revised in detail in the following sections. It is important to point out that once any of these assumptions is relaxed even the standard neoclassical model of partial equilibrium yields a cautionary result *against* the legalisation of wildlife trade.

1.2 Institutional arrangements

Most analyses of market-based policies treat in a very superficial manner the issue of institutional arrangements.[10] In general terms, most authors in this camp assume that market-friendly policy instruments are more efficient than command-and-control mechanisms. This is an old idea associated with the notion that private decentralised markets are not based on regulation, that contracts and agreements are self-enforced and that there is less room for corruption. In fact, this perception is inaccurate: in many cases legal markets require higher levels of intervention by public agencies in order to monitor and enforce new standards and regulations. Legal markets in and by themselves are no panacea against the scourge of corruption. Therefore, the analysis of legal markets as policy regimes necessitates careful consideration of the legal and administrative environment that should surround a new legal wildlife market. This is something that is not easy to find in the literature recommending the adoption of legal wildlife markets as the best policy option.

One of the institutional arrangements frequently discussed in the literature corresponds to central selling organisations (CSO). This type of organisation is similar to a cartel and is based on an agency that controls virtually all supply and marketing channels, and in this manner is able to manipulate prices at will in order to maximise profits and control demand. The system works as long as it can keep all other suppliers in line and in order to do this, the CSO must be able to manage its stockpiles in order to bring any would-be defector back into the cartel.

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[10] There is an extensive literature on the consequences of ignoring institutions in economic analysis (see Hodgson, 2006 for a concise overview of the issue). Institutions are not only critical social components that solve key market failures (Coase, 1937), and facilitate exchange (Alchian, 1950), but more fundamentally they constitute pre-existing social structures shaping the decision environments of both producers (North, 1991) and consumers (Bowles, 1998).

Several publications present this as a viable alternative (Eustace, 2011; Biggs et al., 2013), but these recommendations are not well supported.

In fact, the description by Biggs et al. (2013) of how a CSO would function relies on assumptions rather than analysis. For example, these authors state that a CSO can be structured to manage the uncertainties and risks that may emerge from a legal trade in rhino horns because it would be the only authority legally empowered to sell horns to legal buyers and because at the onset of its operations it would attract buyers to the legal trade and away from the black market. This statement assumes that the legal source of supply will take the market away from the illegal traders without proving just how this will be achieved. This is equivalent to saying that legal markets work better because they are legal markets. In addition, Biggs et al assume that the CSO "should work in partnership with the governments of demand countries to ensure that strong penalties are enforced for any buyers who operate outside the legal market". It remains to be seen how under a CSO laundering and law enforcement become manageable and cease to be the big problems the pro-trade community thinks are closely associated with a trade ban. Just how this is to come about remains unexplained.

A recent example describing the functioning of a central selling organisation can be found in the final report on "Decision-Making Mechanisms and Necessary Conditions for a Future Trade in African Elephant Ivory" (R. B. Martin, Cumming, Craig, Gibson and Peake, 2012). This report was commissioned by the CITES Secretariat following the adoption of a decision by the COP 10 (Conference of the Parties to UNFCCC, Doha). The report proposes the establishment of a central ivory selling organisation (CISO). It concentrates on the creation of a CISO and the administrative and management aspects of this particular institutional arrangement. It skirts around the most critical issues of the problem, and (as in Biggs et al 2013) it assumes there will be no laundering and that law enforcement will now proceed robustly. There is no comparative assessment considering other alternatives and the document simply assumes this would be the best option.

Even the discussion on the experience with DeBeers is careless. The authors omit any reference to why the diamond cartel subsisted or why it eventually fell apart and the relevance of this for a legal ivory market. The report also ignores that DeBeers engineered one of the most dramatic campaigns for the expansion of demand for diamonds, which was crucial to its survival. The report follows the same recipe that has been recommended for rhino horn markets by at least one of its authors (see Martin, 2011), as if the same recipe could be applied to such different cases. But even this cartelisation of the global ivory trade is not the object of any meaningful analysis in terms of prices, quotas or the creation of breakout incentives. Even if it is assumed (and nothing justifies this assumption) that the CISO based on the supply from four countries (Botswana, Namibia, South Africa and Zimbabwe) can discipline the illegal market and its supply sources in the other twenty-eight or so range states, breakout incentives would need to be examined.

In essence, the report does not contain any economic analysis. The issue of price levels is treated with superficiality and summarily disposed of in two short paragraphs (Martin et al., 2012: 29, 32). The central message in these paragraphs is that prices should not be too high, or too low. It is very difficult to have this capacity for 'fine-tuning', especially when there is space for rogue competitors and old cartel members who may find incentives to break away from their commitments with the CSO. There is no analysis of just how this could be done, in spite of all the technical rhetoric displayed in the report.

Another serious problem in Martin et al. (2012) is that it does not look at the demand side of the equation. The report states that "understanding the market in which commodities are to be traded needs to be based on sound empirical data dealing with consumer preferences, attitudes and behaviour, particularly if consumers are to be influenced by pricing structures and certification, or green labelling". Unfortunately, the report fails to provide any data on demand and does not present any analysis of the evolution of consumers' preferences.

1.3 Comparative statics and the ambiguous effects of trade

There are several publications on the effects of legalising wildlife trade containing formal analyses based on comparative statics and a partial equilibrium approach. Most of the time they start with a high level of generality, in the sense that these models could in principle be applied to any species or market. But as the argument unfolds and models are expanded, these papers tend to focus on the specificities of particular markets. Sometimes the formalisation is accompanied by simulations or model calibration (i.e., inserting real values for certain parameters and then generating data series for the relevant variables) in order to further examine whether the model(s) yield reasonable results.

The general method of analysis of comparative statics can be summarised as follows. First, markets are characterised to reflect the current state of affairs (or, alternatively, a conceptually useful market structure to be used as a benchmark). This is done by defining supply and demand functions, according to a set of key characteristics, like the degree of competition (described by the number of agents operating in each market, and the degree of product substitutability), the level of interdependence between agents (indicated by the cross-elasticity of firms' products and prices), ease of entry, and so forth. These features of markets are then fined-tuned to provide empirical content and relevance to wildlife trade. A key step in this characterisation relates to the assumptions on the shape of supply and demand functions (that is, the variables and parameters that determine constants, slope, and degrees of functions relating quantities to prices) and their subjacent functions (for example, those relating poaching efforts to market supply). Typically, market demand functions are assumed to be downward sloping and a linear function of price. Supply functions vary though, reflecting the different ways poaching effort and its relationship to supply are modelled.

The second step is to derive equilibrium conditions for the current state of affairs, in order to obtain output, poaching, and price levels under the current market regime. Third, parameters or functions are modified one at a time in order to expand the model and describe modified

market conditions or alternative hypotheses about agents' behaviour or market arrangements. Finally, new equilibrium conditions are derived from these expanded models in order to compare the levels of quantities and prices under different market conditions or arrangements.

The analytical strategy followed by these papers thus consists in defining a state of the market followed by the introduction of different market conditions to examine the case of trade legalisation. In the end, the market outcome is examined under alternative hypotheses. The publications that engage in this process explore a broad range of possible market configurations, removing one or two critical assumptions at a time.

A first line of reasoning in these formal models is to explore different assumptions on demand. As we noted above, the argument for legal trade in wildlife assumes that there is a clear-cut independence between supply and demand. Supply increases then have no effect on the quantities demanded, on consumer preferences, or on the strategies of suppliers with regard to those. The market outcome is straightforwardly derived: if the market demand curve is assumed to be downward sloping with respect to price, any price reduction increases the quantity demanded along that curve, but shifts of the demand curve itself are assumed to be disconnected from changes in supply. There are, however, many reasons why this may not be a reasonable assumption. Fischer (2004) argues that market legalisation can reduce the social stigma associated with the consumption of illegal goods, causing an expansionary effect on the final demand for illegal products. Her argument is based on rejecting the notion of perfect substitutability of products and the resulting perfect merging between legal and illegal markets. On the contrary, these markets may remain separated, and at the same time intertwined in complex ways: "while consumers in the illegal markets may care only about price, as in the traditional model, law-abiding consumers also care about the source of the product" (Fischer, 2004: 927). Market legalisation can thus increase the willingness to pay of law abiding consumers, reducing at the same time the perceived costs for illegal consumers, and consequently increasing total demand both ways.

Another way by which demand from illegal products can be stimulated from market legalisation is through the laundering of products from poached wildlife. Laundering of wildlife products has been documented over a range of regulatory regimes, and for the cases of tigers (Hemley & Mills, 1999), ivory (IFAW, 2006), porcupines (E. G. E. Brooks, Roberton and Bell, 2010), green pythons (Lyons & Natusch, 2011), and orchids (Phelps, Carrasco and Webb, 2014). If laundering is possible, the legalisation of wildlife trade will have ambiguous effects on poaching. To the extent that the costs and barriers to market access for illegal supply are reduced, the introduction of a legal supply will fail to reduce the level of poaching (Abbott & van Kooten, 2011; Bulte & Damania, 2007; Bulte & van Kooten, 1999).

Moyle (2013) claims to challenge the hypothesis of a positive relationship between legal and illegal markets, with a case study on the alligator farming industry in Louisiana. This study examines the relationship between the quantities of alligator skins from wild harvest and farms for the period 1972-2008. A set of standard econometric tests show that the production

(output) decisions of both 'products' are unrelated to each other. The author concludes that the hypothesis that a legal supply can expand the market for illegal products cannot be sustained. But this study does not examine the illegal market at all. It is based on the implausible assumption that poachers behave like legal hunters (Moyle 2013: 1664). This spurious association eliminates ex-ante any possible stigma effects (as skin buyers are acquiring a perfectly legal product) as well as the main feature of poaching, being an illegal activity. Moreover, the author's conclusions completely ignore the fact that neither hunters nor farmers actually make autonomous decisions on quantities, since "the number of alligators that can be taken is controlled by hunting tags issued by the Louisiana Wildlife and Fisheries" and farmed output comes "from eggs that are collected under quantity permits" (Ibidem: 1665 and 1666). With these qualifications it is hard to sustain the author's main claim. The reduction of poaching in Louisiana, which Moyle himself asserts occurred before the industry became regulated, may be more a result of strong law enforcement in the U.S. than a result of legal trade. We don't know enough about the impact of alligator skin trade on poaching, in the U.S. or abroad, to suggest that legal trade is the cause of reduced poaching.

The most detailed examination of the economics of wildlife trade is found in Damania and Bulte (2007). This paper analyses the effects of trade legalisation on poaching levels for a broad set of market configurations, that is, for different combinations of assumptions on structure and the behaviour of agents. The authors not only address explicitly the issue of demand expansion through stigma reduction and laundering, but also consider more refined models of structure and competition on the supply side. Like other exercises, they start by constructing a poaching model that relates incentives (price) to effort. In turn, they de-compose the supply chain by distinguishing between poachers and wildlife traders. They assume first that traders control the supply chain by exercising market power in their transactions with poachers, but have no ability to influence the price set by final demand. In other words, traders behave like monopsonists 'upstream' (with the ability to fix the price paid to poachers) but as price takers 'downstream'. This last assumption is then removed in order to put together a monopoly model of illegal traders that is used as a benchmark to examine the effect of introducing legal supply. This means the authors introduce imperfect competition as a more realistic description of real-world illegal trade.[11] The paper tries out two different models of competition between traders and legal suppliers (farmers), a quantity-setting model (Cournot) and a price-competition model (Bertrand). Damania and Bulte then find that once imperfect competition is introduced, the case for trade as a poaching control is severely damaged. If suppliers compete by setting prices, poaching is reduced only in the case when there are no laundering or stigma-reduction effects. If, however, competition takes place under a price-setting regime, illegal traders may respond to legal competition by increasing the quantity supplied (aiming at conserving total revenues with a reduced price); the latter result is true even in the absence of laundering or reduction of stigma.

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[11] As the authors write, "Imperfect competition is thus at the heart of commercial endangered species poaching, and failure to acknowledge this fact could have detrimental consequences for wildlife" (Damania & Bulte, 2007: 470).

Perhaps the most important result of this paper is that the combined effects of imperfect competition, a simplified version of strategic behaviour and legal-illegal market interactions produce highly cautionary results regarding trade legalisation. Introducing a captive-breeding source of supply can have both negative and positive impacts on traders' costs, and the overall effect is difficult to determine ex-ante (Damania and Bulte, 2007: 470). However, it "may be detrimental if it induces aggressive competition, and whether this occurs will depend critically upon the form of competition that eventuates in the market. The picture becomes more complex because of the instability of consumer preferences and because transaction costs of the illegal trade are affected when a parallel legal trade develops" (*ibid.*).

A key point to keep in mind at this stage is that this is the best formal model available. It shows that when a fully developed theoretical framework of conventional neoclassical economics is used legal markets are not necessarily the best policy option. The models used in Damania and Bulte show that in most cases poaching may increase, and this result will worsen if demand grows and if the linkages between legal and illegal markets do not disappear.

Table 1 (below) summarises the main assumptions and results of the literature on the economics of wildlife trade, according to the different market typologies and agents' behaviour. In general, most results indicate that the elimination of the trade ban would have ambiguous effects on poaching, and that the more realistic the market configuration, the more certain it is that legal trade stimulates poaching activities.

Table 1. Market typologies and assumptions

Market typologies and assumptions

article	species	market structure	supply chain levels	product differentiation	strategic behavior	stigma	laundering	Effect of trade on poaching
Damania & Bulte (2007)	general/rhino	Oligopoly (Bertrand)	2		✓			↑
Damania & Bulte (2007)	general/rhino	Oligopoly (Bertrand)	2	✓	✓	✓	✓	↑
Damania & Bulte (2005, 2007)	general/rhino	Oligopoly (Bertrand)	2	✓	✓			↑
Damania & Bulte (2007)	general/rhino	Oligopoly (Cournot)	2			✓	✓	↑
Damania & Bulte (2007)	general/rhino	Oligopoly (Cournot)	2					↓
Fisher (2004)	rhino	Perfect competition	1	✓		✓		↑
Bulte & van Kooten (1999)	elephant	Perfect competition	1			✓	✓	↑
Abbott & van Kooten (2011)	tiger	Perfect competition	1			✓	✓	↑
Abbott & van Kooten (2011)	tiger	Perfect competition	1					↓
't Sas-Rolfes (1997)	rhino/elephant	undefined	1					↓
Eustace (2012), Martin (2011)	rhino/elephant	undefined	1					↓

1.4 Implicit assumptions

The formal models reviewed clearly show that the argument in favour of wildlife trade only holds logically, within a neoclassical mindset, when competition is perfect (in the sense that suppliers are unable to set prices), supply is vertically integrated, laundering and stigma effects are inexistent, there is no product differentiation, and agents do not behave strategically. If any of these assumptions is relaxed, a legal trade would more likely stimulate poaching. But how appropriate and consistent is the neoclassical model of market that underlies all this literature? How robust is orthodox economics as a knowledge base for substantiating policy options?

All of these models share the basic assumptions of neoclassical partial equilibrium analysis: 1) agents are perfectly rational optimisers; 2) decreasing returns are pervasive over the range of relevant production and consumption decisions; 3) supply and demand functions are known, continuous, differentiable, and convex; 4) market demand curves are linear, downward sloping functions of price; 5) the rest of the economy is in a state of equilibrium; 6) equilibrium points exist, are unique and stable; and 7) time does not play a role in market decisions or interactions.[12] These assumptions are not at all discussed in the literature, neither is any consideration about the uncertainty of results included. These assumptions eliminate all sources of instability, overshooting and maladjustment in price formation processes. As we show in the following sections, removing these assumptions by relying on alternative theories about the workings of markets tends to reinforce the cautionary recommendation against legalising wildlife trade.

2. The analysis of market processes

The analysis of legal and illegal markets of endangered wildlife has been carried out through partial equilibrium models. These are models designed to analyse how different equilibrium points are formed through the interplay of supply and demand schedules. It is a useful analytical framework for the schematic study of prices and quantities in the restricted frame of a one-commodity economy.[13] The key assumption in partial equilibrium models is that what happens in other markets or sectors of the economy have no effects on the market being considered.[14] The main advantage of a partial equilibrium model lies in its minimal informational requirements and its tractability. However, partial equilibrium modelling is of

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[12] Leibenstein (1950, p. 188) made the point that static analysis means, rather than a "timeless" situation, "one in which the order of events is of no significance". This implies, on the one hand that the order in which decisions on production (consumption) and actual production (consumption) occur is irrelevant; on the other, that the transit from one equilibrium point to another takes place under fully reversible conditions.

[13] Partial equilibrium analysis owes much to Alfred Marshall's work in his *Principles*.

[14] This is equivalent to assuming that all other markets have reached a position of equilibrium. In equilibrium allocations market forces have ceased to work and nothing is happening (all agents have maximized their payoff functions and prices have rendered all individual plans compatible). But this is of course a very strong assumption.

limited use in theoretical and in policy discussions. There are three serious problems arising from the use of partial equilibrium models: one commodity economics, the role of relative prices and the dynamic adjustment or price formation process. In the following, we address each of these in turn.

2.1 One-commodity worlds

The first problem with using partial equilibrium models is that in these models it is impossible to take into account the role of other prices in economic decision-making. In partial equilibrium models the decisions of agents depend on only one price, that of the commodity whose market is being analysed. In other words, the parameters of the supply and demand functions depend only on the price of the one commodity being analysed: formally, $D_i(p_i)$ and $S_i(p_i)$. This is a very strong and unrealistic assumption.

In real world decision-making, supply and demand depend on at least a constellation of other prices (for example, on the prices of substitute goods or complementary goods). While this model may appear to make more tractable the complex set of issues involved, it generates deceiving results and fails to represent any real world economic phenomena.

Of course, one may be tempted to introduce the fiction that in a partial equilibrium framework in which two goods are present, one of them is a composite commodity made up of several (all) goods. The modeller could use the so-called composite commodity theorem that states that any group of commodities whose relative prices remain unchanged can be treated as a single commodity (Hicks, 1946; Samuelson, 1947).[15] Another way to describe this assumption is to say that all the relative prices of the goods that make up that composite commodity change in the same proportion. This is an equally abusive assumption that has been used in the analysis of aggregate demand (money is one of the two goods and the other good is made up of the entire set of commodities for which the set of relative prices remains unchanged).

Partial equilibrium models attempting to analyse wildlife trade do not escape the so-called law of one price (in reality, this is an assumption, not a 'law'). This notion states that identical goods must sell at one price in all locations; this implies that consumers have perfect information regarding the features of all products in the market. This is a rather strong assumption: it implies that already all arbitraging operations have taken place. In the framework of partial equilibrium it means that all firms and all consumers will sell and buy at a unique price.[16] This is another simplifying assumption that carries serious distorting effects in the context of wildlife trade. Every firm that has to survive in a competitive market will cater to

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[15] This is an alternative manner of presenting partial equilibrium analyses, where consumer preferences are examined in relation to lines depicting the relative prices of two goods.

[16] The law of one price has a long history in economics. This is a rather strong assumption because having a uniform price for identical products is in itself the result of an arbitraging and dynamic market process. The price of aspirin A may be initially higher than that of aspirin B, but because customers have perfect information they will buy more aspirin B and bid the price of aspirin A downwards. This arbitraging process is supposed to lead to a uniform price (the question of whether it leads to an equilibrium is different one). In the general n-commodity case there are as many prices as trading trajectories and arbitraging does not lead to price uniformity.

different segments of the market by differentiating their products, whether by altering or modifying its physical characteristics or features, or by packaging it with a bundle of other goods or services. In many commercial strategies differentiating means selling the same product at different prices, searching for the segments of a market that respond best to this strategy, sometimes within the same geographical location. Selling the same product with a different wrapping or a different format (i.e., pieces versus powder) allows firms to deepen this process.[17]

In the case of wildlife trade, it is not entirely implausible that a trader (working on his own or for a crime syndicate) will sell large chunks or pieces of a rhino horn to one market, and powder to another segment of the market. Prices will be different in order to adjust to different budget constraints. This is a strategy that will be especially important in markets with intense disparities in income distribution. The bottom line here is that this will allow traders of endangered wildlife to expand their commercial base and even to subsist for longer periods of time in the context of competition once a legal market has been opened.

2.2 Relative Prices

The second difficulty arising from using a partial equilibrium framework is that these models are not suitable for the study of relative price dynamics. In partial equilibrium the analysis is limited to one commodity and thus it is impossible to compare the evolution of this price with changes in the prices of other commodities. The simplistic use of textbook diagrams of supply and demand curves that abounds in the wildlife trade literature can lead to all sorts of misleading conclusions (Challender and MacMillan, 2013, is a very good example).

Without recognising the limitations inherent to one-commodity models, it is impossible to determine if the price of the commodity being studied is falling or rising because this depends critically on the evolution of the other prices in the economy. For example, the price of commodity i may appear to be dropping (in terms of a given standard or *numéraire*), but if the prices of the other j commodities are falling at a faster rate, then it can be said that the price of commodity i is in fact increasing in relative terms.

This is of course a very old and fundamental question in economic theory, but it is not only a question related to abstract models. It pertains to an issue of great relevance in empirical or applied research. However it is ignored by all studies or models that have been used in the study of wildlife trade. It certainly has been ignored in all models that recommend legalising markets for wildlife.

For example, given a legal market for rhino horn, the evolution of rhino horn prices will not be well understood without data concerning the evolution of other prices, whether they are regarded or not as substitutes of rhino horn. The role of other prices in shaping the demand for rhino horn cannot and should not be ignored. Yet not a single model found in the literature on wildlife trade, and especially in the literature that recommends legalising markets for rhino

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[17] It may be argued that changing the format is already a way to differentiate products and thus this example does not correspond to the law of one price.

horn and other wildlife products, covers the evolution of relative prices. The conclusions of these models concerning the drop in prices (as per the canonical model) are devoid of any sense.

Of course, this poses a serious problem in terms of informational needs. But the difficulties posed by this do not justify trying to assume away the problem. The implications of turning a blind eye on these problems cannot be ignored. Recommendations to legalise markets of endangered wildlife hinge critically on the notion that prices for these products will drop and that the incentives to continue illegal harvesting will therefore vanish. But ignoring the complex web of relations with other relative prices makes this forecast an impossible proposition. Proposing to legalise markets should at the very least present a more serious platform supporting these policy recommendations.

Papers analysing illegal wildlife trade frequently state that poaching is determined, among other things, by the opportunity cost of spending time in this activity and running the risk of getting caught (Abbott & van Kooten, 2011; Bulte & van Kooten, 1999; 't Sas-Rolfes, 2012). This means that other forms of income or expected returns can be expected to play a role in defining this opportunity cost. Of course, a modeller can always introduce or assume the existence of a parameter that helps take into account these alternative sources of revenue. This might be useful to examine how poachers may react to changes in opportunity costs. But we have not seen this in the literature because of the pervasive use of a partial equilibrium framework. All that this assumption will be doing is to introduce a black box that simply assumes the presence of alternative sources of income.[18] The same can be said with respect to alternative 'uses' for some species (for tourism and recreational purposes). In order to have access to a more rigorous assessment, rural wages and wages in off-farm sites, prices of land, crops, food and many other items would need to be incorporated into the analysis. In other words, this implies that other relative prices need to be taken into account. None of the studies reviewed have even made an attempt to approach these questions in depth.

2.3 Dynamic Adjustment (Market) Processes vs. Comparative Statics

The third problem with the use of partial equilibrium models concerns the absence of any true dynamic market processes. This is another deep theoretical problem that cannot be ignored, especially in the context of making market-oriented policy recommendations.

Supply side models used to analyse and recommend legalising wildlife markets that rely on a partial equilibrium framework concentrate on comparative statics, that is, the comparative

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[18] For example, Damania and Bulte (2007: 262) state that "Entry in the 'poaching sector' takes place as long as the returns to poaching for the marginal entrant exceed the returns to effort elsewhere in the economy, and exit occurs when the reverse is true. Assume that the marginal cost of poaching effort increases in effort, and that individuals can supply one unit of effort (so that aggregate effort is identical to the number of poachers). Increasing marginal poaching costs are caused, for example, if individuals have to be attracted from other increasingly profitable alternative occupations". The price structures that would make these other occupations intelligible are confined in a black box. Bulte and Horan (2003) build a model where villagers choose between land and hunting, and where agricultural activities and prices play a role, but all of this is done in a black-box fashion.

analysis of unique equilibrium positions as supply and demand parameters change. But they avoid the thorny issue of how a given market can find its way to one of these equilibrium positions. In other words, while in these models an equilibrium point is supposed to be attained, the models say nothing about the actual process through which market forces lead (if at all) to these equilibrium positions. In a way, models like in Damania and Bulte (2007) or 't Sas-Rolfes (1993) are simply telling us how individual agents make their own subjective calculations, but the models say absolutely nothing about the dynamics of the process that would lead to these positions.[19] For example, in the perfect competition model described in Damania and Bulte (2007) traders start with given prices in the final market and then proceed to calculate their payoff functions (considering the price they pay to poachers a cost element in their calculations). The authors then proceed to describe an imperfect competition model in which competition takes place through quantities (Cournot) or prices (Bertrand). Here the model becomes a little more interesting as reaction functions of traders are determined. But once again these reaction functions respond to subjective calculations of agents and there is no description of the dynamic process through which the market finds its way to these equilibrium positions. In other terms, we do not know if the market leads to these outcomes at all.

The problem with partial (and general) equilibrium models is that even if one accepts all the assumptions required by the model, there is no guarantee that this equilibrium point will be attained. In these partial equilibrium models the dynamic adjustment process is described through a process of 'groping' in which an auctioneer calls out prices and suppliers and consumers announce their planned supplies and demands. The auctioneer retrieves these plans and calculates the excess demands in order to proceed to a new price, until an equilibrium price is found, i.e., a price that clears the market for commodity i, $S_i(p_i) = D_i(p_i)$. This groping, or *tâtonnement,* process is due to Walras (1969) and is an important headache for economists. This is essentially a trial and error process through which 'the market' finds an equilibrium price and an equilibrium allocation of goods.

There are several problems with this model. One pertains to the role of the auctioneer: this is a centralising authority that has very little to do with a decentralised private ownership economy.[20] The second problem is that in this *tâtonnement* process there is no trading until equilibrium prices have been found. This is of course a rather artificial manner to rule out trading at disequilibrium prices; it is also an important aspect of the partial equilibrium models being used that is never mentioned in the wildlife trade literature. Trading at disequilibrium prices is a headache in this theoretical frame of analysis because firms will produce the 'wrong' quantities and consumers purchase the 'wrong' amounts of commodities and this prevents a well-behaved price formation process. This can be avoided with a *tâtonnement* (groping) process but at a very high price: this is a most unsatisfactory description of a real-world market process.

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[19] In 't Sas-Rolfes (1993) the problem is more like the one faced by a social planner that maximizes payoff functions without any reference to a market process.

[20] The auctioneer plays a rather fundamental role in partial and general (n-commodity) equilibrium models. We need to explain this briefly and show how silly economic theory can become and also contribute to demystify market theory.

This is why the wildlife trade literature does not have a single model describing a dynamic market process (whether it converges to equilibrium or not).

The nature of these disequilibrium prices is completely ignored by the literature recommending legal wildlife markets. For example, in 't Sas-Rolfes (2012:4) we find the following statement: "Prices provide the most significant indicator of what is happening in the market. They reflect information about scarcity". This is plain wrong. In neoclassical theory prices indicate something about scarcity and maximisation functions only when equilibrium positions have been attained. In disequilibrium, prices do not indicate anything. This is why trading in disequilibrium is avoided by these models. We return to this point below, but it is useful to point out that exercises concerning the valuation of the environment ignore this and tend to think of prices as simple indicators of scarcity, overlooking the fact that market prices convey more information about market power and income distribution.

If the problematic figure of the auctioneer is eliminated, the agents in the model will be in charge of determining prices and quantities. For example, in so-called imperfect competition models à la Cournot or Bertrand quantities and prices are determined by the competing firms to maximise their payoff functions. However, if one looks carefully at these models (for example in Damania and Bulte, 2007) it is possible to observe that in reality, nothing is happening at the market level. Agents are calculating payoff functions and from these equilibrium quantities and prices can be inferred, but all that has been happening is that agents are carrying out these calculations without a (dynamic) adjustment process-taking place at the market level.

This is why Damania and Bulte (2007: 465) state that "it is possible to consider the Nash equilibrium that eventuates when players are allowed a free choice of the instruments of competition-prices or quantities". This is accurate, but fails to point out that a Nash equilibrium is essentially a static concept. In a Nash equilibrium each player's strategy is optimal against those of the others (Nash, 1950).[21] In the words of the classic paper by Aumann and Brandenburguer (1995), if each player knows his own payoff function, is rational and knows the (pure) strategy choices of the other players, then these choices will constitute a pure Nash equilibrium. In other words, no single player by changing his own part of the set of strategies can obtain higher utility if the other players stick to their parts. But the key issue here is that there are no 'natural' dynamic processes leading to Nash equilibrium, where 'natural' refers to adaptive, simple and efficient processes (Hart & Mas-Collel, 2013). To conclude, the wildlife trade models used in a partial equilibrium have nothing to offer in terms of a description of plausible market processes.

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[21] In Nash's work Kakutani's fixed point theorem is used. The topological properties of convexity, closedness and boundedness allow for the application of this fixed point theorem for upper semi-continuous correspondences. The problem is that this mathematical prowess takes place in a static and timeless world. For a detailed discussion on the role of each of these assumptions see Nikaido (1968).

To close this sub-section, it is important to observe that there is a significant amount of confusion in the literature on wildlife trade with respect to the use of categories like 'equilibrium prices'. Speaking of the rhino horn market, Eustace (2012) states "supply and demand are brought into equilibrium by the price of $40,000/kg. Above that price, volumes sought decline; below it, price sellers are reluctant to sell". Lockwood (2011) begins a power-point presentation by affirming that we should start "with something that we may have a chance of knowing" and he refers to the price and quantity sold of horn in final markets as the equilibrium price and quantity respectively. Then, he continues, we can proceed to estimate other points in the demand function.[22] And he culminates his assertions by announcing that "price elasticity around the current equilibrium price is a key variable in any model of the market". In fact, price elasticity is a notion that can be applied to any price, and not just to prices in the vicinity of an equilibrium point. Thus, from one slide to another, we literally slip into the absurd proposition that observed prices are equilibrium prices. These statements reveal disregard for the most basic or fundamental notions in economics, both at the theoretical and empirical levels. They ignore that the key question concerns the precise dynamic mechanism through which the market actually reaches an equilibrium point (Fisher 1983: 26).

3. Supply

The supply side of wildlife trade appears in the reviewed literature in a highly simplified form. The behaviour of wildlife products' suppliers is represented there as that of an optimising, price-taking, homogeneous group of agents, vertically integrated to produce an undifferentiated product. The exception here is Damania and Bulte (2007), who distinguish between poachers and traders and introduce market power in the exchanges between them. In this relatively more complex case, suppliers (legal or illegal) are initially introduced as price-takers in final markets. Strategic behaviour and competitive interaction (understood as decision-making under consideration of the rival's decision) is introduced later, but this is done with the highly simplified apparatus of neoclassical 'oligopolies', i.e., Bertrand and Cournot duopolies, by means of including expectations about the competitor's price (quantity) in each agent's objective function.

The most significant features of modern industrial structures, like market power, a deep division of labour, market segmentation and organisational dynamism, are notoriously absent in wildlife trade economic analysis. Everything beyond textbook versions of market supply, including neoclassical analysis of asymmetric information, transaction costs, monopolistic competition, or contested markets (just to name a few), is blatantly ignored in these models.

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[22] Lockwood's market demand curve is a downward sloping function in prices. This assumption is not justified as we show below. But in the context of Lockwood's enthusiasm it is interesting to recall the words of Baumol (1977: 227) in his chapter on the empirical determination of demand relationships: "Demand functions, as they are defined in economic analysis, are rather queer creatures, somewhat abstract, containing generous elements of the hypothetical and, in general, marked by an aura of unreality. The peculiarity of the concept is well illustrated by the fact that only one point on a demand curve can ever be observed directly with any degree of confidence, because by the time we can obtain the data with which to plot a second point the entire curve may well have shifted without our knowing it".

This is a major flaw of the literature and severely weakens its ability to guide policy decisions affecting a highly dynamic activity. Of course, simplification is always necessary in scientific analysis and discourse. But the question then becomes one of knowing when the analysis is carried out at the proper level of abstraction. We contend that the textbook level of abstraction of economic models of wildlife trade with regard to its supply structure is misplaced, and that therefore most of its claims are restricted to a very small, and most likely irrelevant set of possible market configurations.

To begin with, as argued in the preceding section, comparative statics of partial equilibrium analysis (CS-PEA) is not a proper tool for examining economic change in the sense of historical change (see Nelson and Winter, 1982 for a complementary discussion). Furthermore, it has been argued several times that neoclassical orthodoxy lacks a theory of the basics of industrial dynamics: how firms grow, how industries develop, what determines the boundaries of firms, and what are the sources of competitive advantages (Nelson & Winter, 1982; Nelson, 1981; Penrose, 1959; Teece & Pisano, 1998). We believe these are highly relevant aspects of economic analysis, especially because the assessment of wildlife trade as a conservation tool implies the dislocation of illegal markets through the development of a new industrial regime, which is inherently a dynamic process. Knowledge (and its counterpart, uncertainty), cumulative processes, and heterogeneity are factors that profoundly affect change and adjustment in economic processes, yet they are fully incompatible with the optimising-agent model of CS-PEA. The assumptions that neglect diversity in production techniques and internal organisation, imperfect information, firm-specific assets, and sources of increasing returns, severely reduce the field of relevant problems that can be meaningfully examined under an equilibrium approach. In the following paragraphs we examine three instances in which the oversimplified version of supply structures in a comparative statics and partial equilibrium frame of analysis can lead to mistaken conclusions about wildlife trade.

Even the most developed CS-PEA models like Damania and Bulte (2007) rely upon highly restrictive assumptions about agent's knowledge and information capabilities. For example, the Cournot model in that paper depicts the trader's (farmer's) production decision as based on an ex-ante perfect forecast of the farmer's (trader's) *optimising* supplied quantity. One is then confronted with one of two options. Either 1) both legal and illegal agents behave in the same way and each one knows the exact shape of the other agent's production conditions (his marginal product curve), as well as the exact shape of a total demand curve with no counterpart in past experience; or, 2) one accepts that the model is a simplified representation of an adaptive process in which this knowledge is acquired gradually through several trials. However, the second option is incompatible with the assumption of maximising agents and equilibrium (see section 2). So, the model only makes sense if one is ready to accept that agents have indeed perfect information.

3.1 Competition and Variety

The supply-side argument for trade in wildlife is based on the idea that legal supplies can, and necessarily will, out-compete illegal sources. In pro-trade models this goal is achieved through price reduction.[23] Since poaching efforts are proportional to expected revenues, any mechanism that reduces those revenues is assumed to reduce poaching. However, increased supply is neither a necessary, nor a sufficient condition to bring the price of a commodity down. What actually leads to price reductions is additional competition. In turn, this outcome depends on the structure of the market, entry barriers and the degree of market power that agents brandish. When markets are controlled by a relatively small number of agents, they will have a powerful incentive not to lower prices in order to keep their monopoly rents. The excess supply will be kept under control and will not reach final consumers. This can be done through collusion or hoarding, for example. Typically, new competition will bring down prices if it has succeeded in abating costs (through an alternative and cheaper source of supply) and if it finds it in its interest to actually offer a substitute product at a sufficiently lower price. Thus, with its lower-cost structure, new competition will put lower prices on the shelf for the benefit of consumers. However, there are many reasons why legal suppliers of wildlife products may not outcompete illegal traders from the market.

A first point in this discussion is the assumption that illegal supply is inherently more costly than legal supply and that the first can only survive if prices remain high, an assumption made with no empirical grounds. Damania and Bulte (2007) put forward the case that if poaching costs are lower than costs of farming, and competition in the industry is based on prices (as in a Bertrand duopoly), then illegal traders would gain control of all the market. Naturally, differences between poaching and farming costs are likely to vary broadly depending on the species, as well as on specific hunting and controlled farming conditions. However, the relative competitiveness of both production strategies must reflect on additional costs. The costs of bribing, smuggling, and backyard selling (or laundering) should be compared to the costs incurred by export, import, selling, and (where pertinent) advertising activities. Without attention to more detailed geographical and regulatory conditions, relative cost advantages become more and more difficult to predict ex-ante. In sum, variability in agents' cost structure cannot be simply assumed away.[24]

There are, however, many strategies that allow agents to neutralise competition forces and conserve (or gain) market share. The existence of differentiated production techniques (including organisational traits), differentiated product characteristics or market *niches*, and of

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[23] One can of course imagine additional non-market regulation mechanisms that can also fulfil this task, like permits, certification, and monitoring processes at different points of the supply chain. However, the attractiveness of the price mechanism is its alleged power to make other controls less important.

[24] In equilibrium analysis, the process of market selection is assumed to be efficient in the strong sense that only the most efficient producers can remain in place. The process by which all other agents are eliminated and surviving agents increase their market shares, is assumed to be instantaneous or, equivalently, irrelevant for the outcome. This, in turn, implies that in equilibrium all agents must be identical in terms of their production techniques. This explains why variety in techniques must be assumed away in equilibrium.

entry barriers, then becomes relevant for the argument of competition. Market power, understood as the outcome of factors that restrain competition, has many different sources. Industrial organisation theory identifies many important sources of market power that are relevant for the case of wildlife trade: the number of competitors, capacity constraints, product differentiation, scale economies and economies of scope, the existence of segmented product markets, and privileged access or control of strategic assets.

Thus, sources of market power are a relevant theme for discussion. Without adequate information it becomes very difficult to predict the effect of a legal flow of wildlife products entering the supply chain. It is not obvious that prices will fall and, if they do, that this will entail a reduction in the incentives for poachers. In the event of a new flow of supply from a legal source, market conditions will be shaken and shares will be redistributed. The incumbents may start to find their monopoly rents begin to fall if other agents succeed in establishing direct contact with retailers and final consumers at lower costs. The market shares of suppliers that offer a smaller price will grow, but only to an extent proportional to their supply capacity. This may not necessarily exhaust all rents and market niches for illegal products. Moreover, legal and illegal supplies may not even compete with each other but actually expand reciprocally, with illegal suppliers acting as occasional contractors for legal traders if there is excess demand. The presence of laundering may as well be taken as an indicator of capacity constraints of legal products, of lower extraction (poaching) costs, or of product differentiation and the existence of segmented markets (or a combination of them), and therefore as a signal of supply variability conditions and entry barriers. Also, incumbent firms may have access to scope economies and this will enhance their capacity to withstand the pressure of legal sources of supply (we return to this point below).

3.2 Vertical Integration

Reducing international wildlife trade to a one-stage market exchange is a serious oversimplification. Its main drawback is that it fails to take into account the various stages involved in the supply chain. Each one of them has a different role in value added and different conditions for determining transaction prices, which at each stage serve to transfer profitability. Ignoring these structural aspects leads to a very inaccurate perception of market organisation and leads to faulty assessments of the possible outcomes of legalising markets. The general structure of illegal supply chains of wildlife products has been described, by many different sources, as a set of multilayered commercialisation channels divided in a number of stages: planning, poaching, local trading, smuggling, transporting along international trade routes, wholesale and local distribution, as well as retail trade.[25] In this network of parallel flows participate a number of poachers, a smaller number of local traders, and an even smaller group of large traders, who in turn distribute to a relatively broad base of manufactures or directly to

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[25] This structure has been described consistently, for example, for ivory (Douglas-Hamilton, 1979: 59), rhino-horn (Milliken & Shaw, 2012), tigers (Kumar & Wright, 1999), and wildlife in general (Felbab-Brown, 2011).

retail traders. Knowledge about this structure is key for understanding the process of price formation and the transmission of effects of changing market conditions.

Price formation along market chains, especially when they have an international character, depends closely on the cost structure supported by agents at every point in the chain, and by the distribution of market power between them (Gereffi, 1996). Agents at each stage in the supply chain will plausibly exhibit different degrees of specialisation, market concentration, and different bargaining positions and these will affect their ability to obtain profits and shift costs to their buyers. Many reasons lead to the supposition that transactions along this illegal supply chain are most likely to be highly controlled by the largest organisations of traders. Illegal markets are by definition strongly opaque, not only because of the unlawful nature of these activities, but because access to cost information is purposely concealed, as this kind of information embodies traders' competitive advantages. Moreover, carrying on international smuggling operations involves considerable fixed investments in logistics, transport infrastructure, and financial capability, as well as protection networks and ability to use violence and threat. For this reason the value distribution along the supply chain is more likely to be concentrated in the intermediate and final links of the chain. Figure 1 (below) shows anecdotal data on price formation along the supply chain of illegal wildlife trade markets, supporting the hypothesis that the direct suppliers of wildlife reap a very small share of the final value of the good.

Figure 1: Examples of the value chain of illegal wildlife (estimates, 2002)
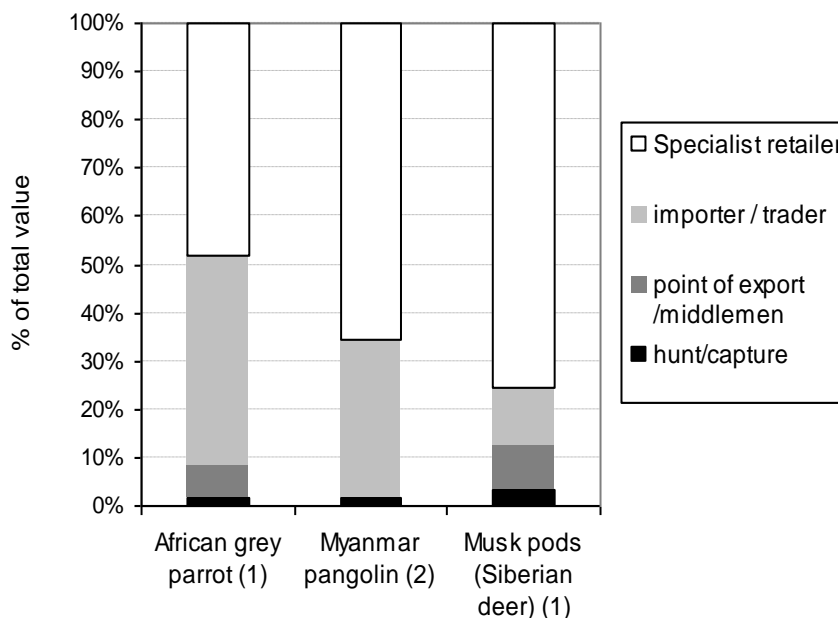
Sources: (1) Brack and Mayman (2002); (2) TRAFFIC, The State of Wildlife Trade in China, (2008:13).

The distribution of market power along the supply chain will also likely affect the transmission effects of changing market conditions, like those resulting from a new flow of legal supply, making it very difficult to predict how price and quantity signals will be transmitted along the chain. Intermediaries (i.e., wholesale and retail traders, manufacturers) are profit-oriented firms with the power to exert an influence on consumer demand through inventories' policies. This applies both to legal and illegal operations. To the extent that intermediaries enjoy specific or strategic assets that yield market power (like geographic advantages, trading permits, exclusive trade, logistics and information networks), traders are relatively shielded against competition and can store high value products when they perceive future increases in prices, finding a value in sacrificing present for future sales. Moreover, high prices and market uncertainty also provide incentives for price discrimination, arbitraging and other practices of market manipulation that allow traders to expand their profit margins, as consumers are willing to accept high prices in response to the threat of even higher prices in the future.

With market power and asymmetric rents along the chain, incumbents may respond to price competition by redistributing rents, shifting the burden of adjustment to the agents with the weakest position. Of course, the extent of this 'buffering' effect would depend on a number of factors and may most likely have a lower bound. A price reduction from legal suppliers will only force traders out of the market if it goes beyond a certain price threshold and persists during a certain period of time. Any additional factor mitigating the impact of price drops (for example, through product differentiation, economies of scale and scope, strategic assets, or demand expansion) will shift this threshold price downwards, preserving the space for rents from illegal trade.

To the extent that distribution channels are of an oligopolistic nature and market barriers in intermediate links of the product chain are high, the reaction to changing market conditions in the supply of wildlife products is difficult to predict. Unless a set of conditions along the value chain are aligned, the prediction that higher product volumes will lower prices at the point of final demand cannot be sustained.

3.3 Scale, Scope, and Other Dynamic Economies

A key assumption for individual behaviour of suppliers in CS-PEA is that returns are decreasing all over the relevant decision space. In fact, optimisation requires marginal returns equal to zero. This means that the process of internal adaptation of agents has reached the limits for economising at existing prices. They operate at maximum efficiency and would only find it rational to increase the quantity supplied if price increases; for the same reason, they will be forced to cut down supplied quantities if prices go down. As pointed out by Piero Sraffa in a classic paper (Sraffa, 1926), the dominance of the law of diminishing returns required by Marshallian partial equilibrium analysis severely reduces the scope of industries susceptible to be meaningfully described by that approach. The fact that decreasing costs (as those derived from economies of scale and scope) are incompatible with perfect competition, means that the theory cannot explain one of the most characteristic features of industrial production. And this

may be pertinent to wildlife trade as suggested by the increasing scale of seizures data by the ETIS (Elephant Trade Information System, see below).

Many reports and research articles show that agents involved in illegal wildlife traffic tend to be involved in several other activities, just as multi-product firms (EIA, 2014; Felbab-Brown, 2011; Milliken & Shaw, 2012; Wyler & Sheik, 2009). This feature indicates the potential for these organisations to access scope economies, that is, the ability to produce more cheaply a combination of products, in comparison to the costs of producing the same quantities of each product individually. In other words, multiproduct firms spread fixed costs (and risks) along different lines of products or services that are carried along common fixed investments (Chandler, 1990). Thus, this explains why product diversification is a good mechanism for maximising rents. In the case of agents involved in illegal activities, the control of marketing channels is an important asset that lends itself to a series of illicit activities. For example, the cost of distribution is minimised when there are several products to be sold instead of a single one. Crime syndicates involved in wildlife trafficking not only operate with multiple species, they also work with multiple lines of production: illegal logging, drugs, arms and people. The advantages of product bundling and multi-product synergies strengthen scope economies and this may be of relevance in the operations of crime syndicates. The competitive capabilities of criminal networks involved in wildlife trade rely heavily on exclusive information and contacts, access and codes to corruption channels (Julie, 2012), as well as on means to exercise violence, and other 'assets' of general application in these activities that can be considered as fixed investments (Fiorentini, 1999). Scope economies confer powerful advantages to a crime syndicate engaging in wildlife trafficking. Its profitability is not tied to results in one market, but to the interplay between various (very different) lines of production. Scope economies allow firms to hedge against the vagaries of one market by conferring the capacity to withstand price wars for longer periods of time. Thus, even if price reductions are achieved in one product, a multi-output organisation may be able to remain in operation for a long period of time. Access to scope economies may reveal a competitive advantage of illegal trade channels, with respect to wildlife farmers and their hypothetical trading channels. Legalising trade, even in one product line, will in these circumstances strengthen syndicates and criminal networks in their whole range of operation.

As noted above, many authors participating in the debate on wildlife markets recognise the fact that highly organised crime syndicates may be taking part in the poaching crisis. Seizure data also suggests this, for example, through the number of seizures of large-scale ivory shipments (defined by ETIS as shipments of at least 800 kilograms, Underwood, Burn and Milliken, 2013). The presence of multi-product lines of activity has been confirmed by reports of multi-product seizures (INTERPOL, 2013). The presence of scope economies in wildlife trafficking is one of the most important factors that have been neglected in the policy debate.

There exists some evidence that wildlife smuggling may be exploiting scale economies as well. Fiorentini and Peltzman (1995) think that organised crime is more likely to thrive in the presence of economies of scale and monopoly power. In examining ivory trade flows,

Nellemann et al. (2013) have found indications of increasing occurrence of large scale ivory shipment. CITES (2012) also reports an increasing trend in the average size of large-scale seizures. As argued by Chandler (1990) scale and scope economies are complementary, and fundamentally based on increased throughput. To what extent this applies to agents operating in specific markets of wildlife trade is something that needs to be examined in detail by future research. Equilibrium analysis cannot capture these endogenous forces in any significant way, but Chandler's business history analysis shows that firms become more efficient platforms for capital accumulation as they diversify product lines and engage in product differentiation. In Chandler we find evidence that scale and scope economies are factors that stimulate endogenous market growth. If, as evidence suggests, crime syndicates have access to scale and scope economies, they will actively resort to a strategy of expanding their markets.

Other sources of increasing returns are relevant for the analysis of wildlife markets. In dealing with illegal supply channels, it is probable that conditions of imperfect and asymmetric information prevail. Moreover, the strategic aspect of communication in developing commercial networks, marketing know-how, specialisation, and personal contacts, increases the importance of firms' informational structures. Arrow (1974) convincingly argued that these informational structures have the properties of fixed, irreversible assets, influencing the distribution of costs among agents and introducing path-dependent features to the process of resource allocation, competition, and adjustment to changing market conditions. Path dependency is very important because its presence implies that, if any stochastic elements are involved in market adjustments, the resulting equilibrium positions will not only be multiple, but also impossible to determine ex-ante. Sunken costs, learning, network externalities, and technical standards are other relevant sources of path-dependency (Arthur, 1988; 1989) that could shape in similar ways the development of wildlife markets.

A final aspect to highlight is that the range of response of both incumbent agents and new entrants to changing market conditions may be far more difficult to determine than assumed by partial equilibrium analysis. As noted in Drechsler et al. (2007), unlike ecological models, economic models of ecological phenomena tend systematically to ignore uncertainty and its consequences. This deficiency becomes clearer when considering that the adjustment to a stream of legal supply will fundamentally alter the industry's functioning and generate uncertainty at a fundamental level. The shift to a new competitive regime like the one supposed by wildlife trade legalisation may in some critical dimensions be similar to the introduction of an innovation, and thus, it will generate uncertainty in the strong sense that consequences of choices and their underlying distribution cannot be specified ex-ante (Cyert & March, 1963). Assessment of different degrees of uncertainty and the correlated risks should be considered in an economic analysis of legalising wildlife trade, including those arising from complementarities between legal and illegal markets.

4. DEMAND

The literature recommending market-based policy instruments centres on the supply side of the equation. When it comes to the analysis of demand, we find a very serious set of deficiencies, both at the theoretical level, as well as the empirical dimension. In most studies the question of how demand responds to price variations is either ignored altogether, or treated superficially. In many cases where demand is considered in the analysis, it is brought in through anecdotal references that carry no serious analytical weight. In fact, the issue of how markets are developed by firms, or the question of how markets evolve over time are treated cursorily. A good example is Moyle (2011), who believes we should "ban the phrase trade fuels demand". This rhetoric is used to promote the idea that legal markets do not lead to increased demand. But it ignores the fact that any business enterprise in a capitalist economy needs to develop its market and will thus invest resources in fostering the expansion of demand. The forces of competition in the marketplace lead to this process and Chandler's classic study of business history reveals how capitalist enterprise goes about doing this (Chandler, 1977, 1990). Ironically, analyses that favour the use of market-friendly policy instruments ignore how business reacts and how the forces of competition work in the marketplace.

The demand side of the economic analysis of trade in wildlife is marked by two serious difficulties. The first problem is that all the literature on wildlife trade assumes that there is a market demand curve that is downward sloping. This notion corresponds to the well-established textbook version of supply and demand economics and to the 'intuitive' notion at the individual level that when prices drop a consumer will typically purchase greater quantities of a given product. As we shall see, this idea is not valid at the market (aggregate) level.

The second problem is related to the empirical side of demand in final markets. The literature recommending the use of market-based policies to solve the poaching crisis typically states that demand is stable, robust and is part of long standing cultural traditions. According to this perspective, policies based on demand reducing campaigns are inadequate. Some papers acknowledge the fact that demand reduction should always be part of a long-term strategy, but because there is little time to waste, market-based instruments are a preferable option. This perspective on demand is based, once again, on a simplistic appraisal of the role of consumer preferences in economic theory. This has been accompanied by a very limited supply of hard data on consumer preferences and, more important, on price elasticity of demand. These two problems are related to each other, but for the sake of simplicity we deal with each one of them separately in the next two sub-sections.

4.1 Downward Sloping Market Demand Functions

The assumption that market demand functions are downward sloping is used in all of the studies on wildlife trade and trafficking (Damania and Bulte, 2007; Challender and MacMillan, 2013; Lockwood, 2011; Moyle, 2013, 't Sas-Rolfes, 2007). The literature relies on this

assumption unflinchingly. But consensus does not imply theoretical soundness or empirical accuracy.

According to 't Sas-Rolfes (t Sas-Rolfes, 1995: 41) "the most fundamental of economic axioms" is the law of supply and demand: "Basic principles of economics tell us that when the quantity demanded exceeds the quantity supplied at a given price, market prices tend to increase. When prices increase, the quantity demanded drops and the quantity supplied increases and a new equilibrium is reached". Unfortunately, this assumption (it is not an axiom) is not justified and, in fact, constitutes one of the most important aggregation fallacies that exist in economic theory. As we will see in the next few paragraphs, this is a well-known result that destroys this "most fundamental of economic axioms".

Because this assumption is not justified, relying uncritically on it will lead to misleading conclusions. In many cases, debates on wildlife trade and markets have been framed around this assumption, with both proponents and critics of the legal-market policy option embracing the idea that a downward sloping market demand curve is a good description of economic reality. A good example is the debate in the journal *Science* (starting with an article in its "Policy Forum" by Biggs et al 2013). The letters by Collin, Fraser and Snowball (2013), Prins and Okita-Ouma (2013) and Lichtfield (2013) do not question this assumption. In their response, Biggs et al (2013) argue that "basic economics dictates that the price of a product continually changes and is determined by the interaction of supply and demand" and cite in support of their contention a well-known introductory economics textbook, Mankiw (2009). This textbook illustrates our point: it believes one can build a market demand curve by adding hypothetical or real individual consumers' demand schedules and thus ignores the problems we discuss in this section. Mankiw's texts are well known in the discipline as exercises where key theoretical problems are assumed away and the belief in market stability is a fundamental feature.[26]

A downward sloping market demand function can be constructed in the case of an economy made up of one agent and one commodity (or one commodity and the *numéraire*). As soon as we move to an economy with more agents and many commodities this is no longer possible. What was true for a Robinson Crusoe economy ceases to be valid in an economy where Friday has made his appearance.

Economists have always assumed that a rational individual consumer has a downward sloping demand curve. This means that consumer A will buy more of one good when its price drops and less when it increases. But prices adjust and respond to <u>market</u> demand curves and not to the urges of one isolated individual. So a crucial question is, do market demand curves possess the same properties as those of a single individual? After a long quest economists have reached a negative conclusion. In order to appreciate the implications of this result we need to understand why this is so.

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[26] A student walkout from Mankiw's class (November 2, 2011) and an open letter from his students have attracted attention to this aspect of this work (see http://harvardpolitics.com/harvard/an-open-letter-to-greg-mankiw). Although a student walkout may not be the best way to transmit the message that economic teaching and its textbooks need a serious reality check, it should not be dismissed as a show of indolence or arrogance.

Changes in prices have two types of effects. The first one is known as the substitution effect and is related to the fact that when income and other prices are held constant, an individual agent will normally purchase more goods at the lower price. In general, the substitution effect is negative (the sign of the change in demand will be the opposite of the change in price). This is the effect that is normally considered in the literature on wildlife trade. However, price changes have a second effect, the income or wealth effect: when the price of a commodity falls the consumer's real income increases.[27] This has critical implications because it means the market demand curve of a given good can slope upwards at certain intervals because consumers may be able to consume more of a good as its price increases.

Economists have been able to isolate the action of these two effects by assuming that when prices change, the distribution of income remains unaltered. In this case, the effect of a price reduction (resp. increase) is the growth (resp. reduction) in demand. But when you have several agents and many commodities in a given economy, this is no longer possible and one has to allow for income effects as price change. When the price of a given product falls, the income effect means that the overall wellbeing of a consumer may improve and in this case he can consume more of the product in question or of other products. What appeared as a simple and straightforward exercise in the case of a single consumer now becomes a complex affair when more than one individual is introduced in the model. This is of course indispensable in deriving a market demand curve.

In the first half of the seventies the Sonnenschein-Mantel-Debreu theorems proved that market-level excess demand functions are not restricted by the usual rationality conditions on individual demands (Debreu, 1974; Mantel, 1974; Sonnenschein, 1973). The SMD theorem shows that the aggregate (or market level) excess demand functions that are supposed to be the underpinning of general competitive equilibrium have some of the properties of an individual agent's demand function: continuity, homogeneity of degree zero, as well as the fulfilment of Walras' law. But these properties are not enough to characterise the market excess demand in such a way that it guarantees stability (and uniqueness) of equilibrium. The market excess demand curve has no structure and can have any shape. This means the graph of the market excess demand function is not that of a downward sloping demand curve as depicted in the literature on wildlife trade. It also means that a market demand curve may have segments with an upward or positive slope, regardless of the type of goods we are dealing with. This implies that in some cases, demand will expand for goods whose prices are growing.

It is important to note that this has vast implications for microeconomic theory and practice. After the SMD theorem it is impossible to have blind faith in the capacity of markets to reach equilibrium allocations through the action of the competitive forces of supply and demand. Stability is not a property of markets unless arbitrary assumptions are imposed on the market demand functions, but that is truly bad news for a theoretical construct. In essence, the

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[27] One aspect of this conundrum is well known in economic theory: the demand for so-called 'inferior' goods may increase as their price increases or vice-versa, their demand can fall as their price falls. The problems discussed in this section do not depend on the particular characteristics of goods being considered in the analysis.

movement of relative prices becomes almost unintelligible, affecting every part of the analytical edifice (including budget constraints). Why should the economic analysis of wildlife trade ignore these results and rely on downward market demand curves?

Summarising, the standard assumptions at the microeconomic level (i.e., the level of the individual agent) have no equivalent at the market level or at a macroeconomic level. The rational individual gives way to the irrational market and thus having faith in the self-regulating properties of markets, whether in the realm of wildlife 'products' or financial derivatives is unjustified. When we encounter interdependent markets the economic equilibrium need not be attainable by any 'normal' market process (it will be essentially unstable).[28]

What are the empirical implications of these negative results on uniqueness, stability and comparative statics? In the field of macroeconomics, for example, the fact that it is not possible to preserve the rationality at the micro level in aggregate structures calls into question the notion of micro-foundations of macroeconomics and the theoretical integrity of the representative agent.[29] Even in the field of partial equilibrium and imperfect competition it is recognised these results should play an important role in re-shaping the entire research program (Roberts & Sonnenschein, 1977). The economic analysis of wildlife trade should be no different. Carrying out policy research on wildlife trade as if the SMD theorem didn't exist is equivalent to entering a dark forest without a compass.

In fact, what should be recognised is that demand patterns of these wildlife 'products' are determined by many factors and not only by movements of the price of these items. These other factors include the system of relative prices and income distribution (and not only the growth of per capita income, as we find in many publications), as well as culturally determined factors like social prestige and emulation.[30] Explicit recognition of these theoretical results will provide greater opportunity to develop new perspectives in applied research, strengthening our capacity to address difficult questions and enhancing our ability to deliver better policy recommendations.

This is indeed a very disturbing result for economic theory and one of deep implications for policy-oriented research. The significance of these results for policy research is something that needs to be taken into account, especially when dealing with recommendations that rely on

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[28] These results came not as a surprise to those who had followed the discussion on stability. The results of Arrow and Hurwicz (1958) and Arrow, Block and Hurwicz (1959) on stability analysis depended on the arbitrary assumptions of gross substitutability or on the validity of the weak axiom of revealed preferences at the market level. In the absence of these assumptions, Scarf (1960) was able to show with the aid of a counterexample that instability would be the general rule. In spite of these essentially negative results, it is surprising to find a dogmatic commitment to the notion that somehow markets do self-regulate. After the SMD theorems economists must learn to live with the fact that markets are not well behaved and that they do not converge to equilibrium allocations.

[29] For a non-mathematical discussion on the representative agent, see Kirman (1992).

[30] There are many indications that the demand for wildlife products is strongly influenced by the prestige associated with the conspicuous consumption of products that are considered highly valued, rare, exquisite, etc. (Milliken and Shaw, 2012; Sheperd and Magnus, 2012; Felbab-Brown, 2011). The dynamics of emulation described in the classic work by Veblen (2001) shows how underlying social institutions can produce exactly the opposite reaction to prices in consumer responses, as that assumed by equilibrium theory.

market-based instruments. The notion that market demand functions for rhino horn, tiger bones, ivory or bear-bile are all well behaved and downward sloping is nothing more than an assumption. We have seen that, as such, it is not justified. And although some papers in the literature may present what appears to be an appealing set of empirical observations for the demand of these wildlife 'products', in reality we have nothing more than a set of isolated annotations of shaky validity. Once again, the weaknesses in the instruments used to make these observations and collect data make it impossible to reach conclusions about the direction of changes in the prices of these commodities and to make inferences on demand dynamics. It is clear that the simplistic assertions about the direction of demand as prices change need to be reconsidered in view of the theoretical results examined in the previous paragraphs.

The Sonnenschein-Mantel-Debreu theorem has another set of relevant implications. Because microeconomic rationality at the micro (individual agent) level is not preserved at the macro level, aggregation is not possible and it is wrong to reason in terms of 'representative agents'. This fact is crucial when discussing macroeconomic models, especially dynamic stochastic general equilibrium models, where we typically encounter a representative agent that is the result of aggregating individual utility-maximising (or profit-maximising) agents or categories of agents. This is of relevance in resource management models such as the one used in 't Sas-Rolfes (1993) where the problem is defined in terms of maximising a social welfare function. These models have been theoretically discredited beyond repair.

4.2 Empirical Information on Demand and Endogenous Preferences

The results of the Sonnenschein-Mantel-Debreu theorem are deceivingly simple. In a nutshell, the theorem states that given any function $f(\mathbf{p})$ on the price simplex that satisfies Walras' law, it is possible to find an Arrow-Debreu economy such that $f(\mathbf{p})$ is its aggregate excess demand on the price simplex. What this implies is that all the normal assumptions at the micro level (convexity, homogeneity of degree zero, completeness, nonsatiation, boundedness, etc.) are insufficient to allow for a normal (well-behaved) price formation process. The empirical implication of this is that in order to make qualitative forecasts about demand, economists must possess detailed data on excess demands. This is something that does not abound in the economic analysis of wildlife trade.

Recommendations of market-based instruments to contain the poaching crisis and loss of wildlife in general are typically accompanied by assertions that demand is stable, robust and will be with us for a long time. The corollary of this is that demand-reducing campaigns will normally be ineffective and, although they should be continued, the need for legal markets is the way to proceed. In general terms, we could not find in our review professional analyses with hard data that give support to these assertions. This is a major gap in the literature and one that has major implications on at least three fronts: price elasticity of demand; size and trends in demand; the question of endogenous preferences.

4.3 Price-elasticity, income-elasticity and endogenous preferences

The canonical pro-market model found in the literature typically asserts that a reduction of poaching can be brought about through the reduction of prices and thus the elimination of the incentives to poachers. This is something that legal markets will bring about because of their stable supply and reduced production and transaction costs, etc. However, this analysis is seriously deficient because it ignores the delicate question of what happens to demand as prices go down.

We have criticised above the notion of a downward sloping market demand curve, but here we need to question the literature on its own grounds. Let's assume a given market is confronted with a downward sloping market demand curve, and that in the short term and under a given market structure configuration, a reduction in prices takes place. What will happen to demand? The model would respond that as we abstract from income effects, we would slide along the downward sloping market demand curve. But we do not know how much demand will expand. In order to have a responsible estimate of the potential expansion of quantities demanded at the new prices, we would need information on the price elasticity of demand. And here is a place where we find a very serious gap in hard data in the literature. Although many papers do mention price elasticity, this is done in an almost perfunctory manner and very little analysis centres on this. In addition, there is a lot of anecdotal evidence about market demand for many wildlife 'products', but there is virtually no reliable quantitative information that could be used to systematically tackle the question of how price reductions may affect demand. A case in point is Martin et al. (2012). The report states that "understanding the market in which commodities are to be traded needs to be based on sound empirical data dealing with consumer preferences, attitudes and behaviour, particularly if consumers are to be influenced by pricing structures and certification, or green labelling". Unfortunately, the report contains no considerations on the evolution of demand given what we know about past trends and historical surveys.

Lack of reliable data on price elasticity may very well be the most serious blind spot in all the pro-trade literature. It should also be noted that price elasticity is different between products and between market segments, and this adds to the complexity of demand reactions to changes in relative prices. Recommending legal markets under these circumstances is irresponsible and reminds us of Leonardo da Vinci's sailors (see above).

Price elasticity of demand is not the only relevant concept that lacks adequate attention in this literature. Income elasticity of demand (the response of demand to changes in income) is also a very important aspect of the problem that is virtually absent in all analyses covered in this review. Once again, the literature contains some dutiful references to how growth of income per capita in Asian countries has or is affecting demand for rhino horn or ivory, but there is no serious analysis of elasticity. Lockwood (2011) appears to confuse income elasticity with simple projections of higher rhino horn prices that he finds are supported by higher incomes in China and Vietnam. His presentation does not include any discussion on product formats in the final

consumer market. Unfortunately, he does not disclose the sources of information or any methods used to attain his conclusions. References to income groups ignore the fact that preferences are not homothetic and therefore income elasticity of demand is different between income groups or deciles and this may have serious implications for legalising markets. For example, price reductions or income growth may rapidly expand markets in countries where there is currently a high dormant demand. Income growth and income distribution are key variables affecting consumption patterns, and this leads us to the question of how consumer preferences are shaped.

Markets do more than allocate resources. They are social institutions that shape the evolution of values and tastes by framing the context and scope of consumer choices, as well as the nature of rewards (Bowles, 1998). Moreover, consumer preferences in any country are not static and they are not entirely resistant to structural changes in an economy. Some consumption patterns may be more rigid than others, but economic history shows they do change under the pressure of product and process innovations, market development, advertising and government regulation. This evidence contradicts the notion that demand for wildlife products is a rigid structure and that demand-reduction campaigns should not be relied upon to bring about a halt in poaching. Even when demand is related to traditional products or practices of traditional medicine, structural change in consumption patterns can take place in a relatively short period of time. The studies by Vigne and Martin (2010, 2013) are good examples of how structural change affected and is affecting demand for ivory in Japan and Yemen. There is a long list of in-depth research on other wildlife consumption markets (S. E. Brooks, Allison, Gill and Reynolds, 2010; Gabriel, Hua and Wang, 2012; IFAW, 2006; E. Martin & Stiles, 2004, 2008; Milliken & Shaw, 2012; Nishihara, 2012; Shepard & Magnus, 2012; Stiles, 2004; Van-Song, 2008; Wu & Phillips, 2002). These studies are important and useful in advancing our knowledge on how consumer preferences are shaped, but there is a need to move to more detailed and disaggregated data sets in order to proceed with stronger theoretical models.

Data on demand in illegal markets is difficult to obtain. However, well-designed surveys can produce reliable data for policy debates. The best example is in the market of illegal drugs, where the National Survey on Drug Use and Health (NSDUH) has been carried out during many years in the United States. The survey covers the entire US territory and involves interviews with 70,000 individuals. The sample is a well-designed and selected random sample that is fully representative. Data from the survey is available online (NSDUH, 2012). In the realm of debates on wildlife trade, funding should go to serious consumer surveys that will generate data for a rigorous analysis of consumer preferences, trends and policies. Information on stigma effects and possible consumer reactions to opening legal markets or maintaining trade bans require this type of information. Most of the countries where it is thought consumption of endangered wildlife is concentrated have the capabilities to implement this type of high-quality survey.

Demand reduction policies need better information and much can be done through adequate surveys. Although these surveys may be costly, they would not always encounter the obstacles that characterise other parts of the illegal wildlife trade supply chain, for example. And even the inquiry of delicate points like social stigma and openly admitting use of illegal products can be overcome with adequate consumer survey techniques.[31]

5. Economic policies

One of the most striking features in the literature on the economics of wildlife trade is the almost complete absence of references to economic policies. This is also a trait of most of the literature focusing on privatisation and 'sustainable use'. This lacuna is surprising because any attempt to evaluate the performance of trade bans or of legal wildlife markets should take into account the combined impact of economic policies, both at the sector and macroeconomic levels. Estimates of costs of biodiversity conservation indicate there is an urgent need to analyse macroeconomic policies and their implications (McCarthy, Donald, Scharlemann and Al., 2012; Waldron, Mooers, Miller and et al., 2013).

Economic forces do not operate in a policy vacuum: many of the most critical variables operating in the sphere of economics are shaped by public policies. Perhaps the best example concerns interest rates, an exogenous variable that is fixed by monetary authorities (and not by a mythical loanable funds market). But there are many other aspects of economic policy that need to be taken into account because it affects structures for capital accumulation, as well as markets, whether they are legal or not. At the macroeconomic level, fiscal and monetary policies have important effects on the rate of economic activity and investment, as well as income distribution (for a detailed analysis of macroeconomic policies and their relation to debates on sustainability, see Nadal, 2011). They can also contribute in bringing about structural or deep economy-wide transformations. Monetary, financial and fiscal policies are the main pillars (but not the only elements) of macroeconomic policy, and they have a huge impact on activity levels and resource allocation. Macroeconomic policies affect price stability and key variables such as interest rates, exchange rates and energy and food prices, productive strategies, natural resource usage rates and resource management practices of every agent in the economy, from large corporations to small scale subsistence farmers. All of these variables have significant effects on supply and demand decisions in wildlife trade. For example, a study supported by the International Fund for Animal Welfare (Gabriel et al., 2012) found that currency manipulation by Chinese monetary authorities led to enhanced purchasing power for ivory (being sold in US dollars). According to Douglas-Hamilton (1979) Ian Parker's 1973 study

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[31] NSDUH coverage includes potent illegal drugs that are associated with stiff sentences. The data shows that with adequate survey techniques consumer preferences for illegal products can be analysed and this information can be used in demand reduction policies. See Substance Abuse and Mental Health Services Administration, *Results from the 2012 National Survey on Drug Use and Health: Summary of National Findings*, NSDUH Series H-46, HHS Publication No. (SMA) 13-4795. Rockville, MD: Substance Abuse and Mental Health Services Administration, 2013.

highlighted the properties of ivory as a wealth store and currency, arguing that its spectacular rise in value in the 1970s should be considered as an important driver of poaching. If this is the case, it may be possible that in the near future the policy response to the global financial crisis (in terms of massive injections of liquidity into the banking system (through the different phases of 'quantitative easing' or the Outright Monetary Transactions posture of the ECB) can be related to the intensification of poaching. Why have macroeconomic policies been neglected by most studies on wildlife trade?

In addition, macroeconomic policy priorities condition the amount of resources devoted to environmental stewardship and conservation (including law enforcement). For example, typical fiscal policy priorities emphasise balanced budgets and tightening of public spending in order to generate a primary surplus. In general, expenditures on environmental conservation are negatively affected, diminishing the capabilities of agencies responsible for conservation and law enforcement. In the context of fiscal austerity trade bans may be affected not because of the 'law of supply and demand' (as many pro-trade analysts contend) but because macroeconomic policy priorities dictate inadequate levels of funding for conservation.

The work of Leader-Williams and Albon (1988) is an excellent reference pointing in the direction of taking into account economic policies. According to their analysis "the rates of a species' decline are related directly to conservation effort and spending". Despite official rhetoric to the contrary, public spending in environmental conservation is normally not a priority. Rosen and Smith (2010) conclude that a greater allocation of national resources to on-the-ground enforcement and conservation is urgently needed. Even a country like South Africa allocates a very small percentage of its total expenditures to environmental affairs: in 2011/2012 appropriations for environmental affairs reached ZAR4,201 million, equivalent to 0.8% of total appropriations by vote (National Treasury data for 2012). Not all of this goes directly to conservation in national parks, although additional funds are available from other budgetary items. The quantities involved are clearly insufficient and do not correspond to the gravity of the current poaching crisis.

In spite of this conclusion there are very few publications containing hard data and rigorous analyses of the costs of conservation policies in the range countries of large mammals. Inexplicably, the literature on wildlife trade has not taken up the task of incorporating economic policies into the discussion on trade bans, legal markets and demand reduction campaigns.

The need to consider economic policies as a key dimension of the analysis of wildlife trafficking applies to all regions and countries. In the next few paragraphs we focus on Africa and provide an example that is germane to the discussion on the poaching crisis. Understanding the African experience in economic policy-making is an important backdrop for an objective assessment of conservation policies and the weaknesses in policy implementation.

The macroeconomic policy paradigm in Africa during the two decades before 2008 was based on fiscal consolidation in the context of structural adjustment programs. This macroeconomic

policy posture led to stringent deficit-reduction programs that had significant economic costs. One of these is related to the dramatic drop in public investment in almost all sectors, adding to the already heavy deficit in transport, communications and energy. Public sector downsizing led to the deterioration of basic social services. Social costs were intense and associated with a rapid deterioration in unemployment, living standards, inequality and poverty (Akyuz & Gore, 2001). As a result, real per capita income dropped (Artadi & Sala-i-Martin, 2003), while poverty increased throughout the 1980s and even today most of the countries in the region remain under the grip of low productivity and poverty traps (World Bank, 2005). Most African countries will not be attaining the Millennium Development Goals.

The 'Africa Rising' meme is used to convey the message that greater growth rates in Africa are a clear sign that the economic landscape is fast changing. But two words of caution are required here. First, these growth rates are based on intensive reliance on exports and rely heavily on exploitation of natural resources. They are thus not only prone to boom and bust cycles, but in many cases they entail serious environmental costs (including in some cases depleted populations of endangered wildlife). In addition, these GDP figures hide many structural imbalances. Deeper scrutiny reveals serious disarticulations between sectors and branches in most African economies: while industry lags behind, energy, extractive industries and basic commodity production still dominate the landscape. Exporting resource-intensive commodities cannot and will not be the key to Africa's development (Sindzingre, 2013). Africa may be ensnared in the low-productivity trap of primary exports for decades to come. This may be the policy context that debates on wildlife conservation need to take into account.

Second, the trickledown effect of these exports is not enough to change the structure of Africa's income distribution patterns and will not be the key to a rising African middle class. Low productivity activities and large-scale extractive industries typically involve low wages and will not provide the platform for structural transformation in Africa. The expansion of the services sector will not be enough to provide adequate job opportunities to the millions of unemployed young Africans. Rural poverty is pervasive in Africa, especially sub-Saharan Africa (SSA). Approximately 71% of the continent's poor are located in rural areas and depend on agriculture and other land-based resources (including wildlife) for food and livelihood. Extreme poverty is another trait affecting 230 million people in SSA. Poverty rates have marginally declined, but poverty levels remain unacceptably high and inequality has augmented (World Bank, 2013). Agricultural policies have not improved the lot of people in rural Africa and this is quite relevant to the analysis of the poaching crisis in that continent. Clearly, wildlife conservation in Africa (and elsewhere) cannot be discussed without making references to economic policies.

An analysis of data compiled by CITES' Monitoring of the Illegal Killing of Elephants (MIKE) in 2012 confirms the importance of taking into consideration economic policies (CITES, 2012). MIKE evaluates relative poaching levels based on the Proportion of Illegally Killed Elephants (PIKE), calculated as the number of illegally killed elephants found divided by the number of elephant carcasses encountered by monitoring teams and aggregated by year for

each site. The MIKE analysis evaluates the relationship between poaching levels and a wide range of factors at the site and country levels (the model explains 65% of variations in PIKE). At the site level, infant mortality in and around MIKE sites is used as a proxy for poverty levels and continues to be the single strongest site-level predictor of PIKE: sites suffering from higher levels of poverty experience higher levels of elephant poaching. On the other hand, both livestock density and crop occurrence (used as a proxy for food security) are negatively related to PIKE. In general terms, this analysis found that

> the relationships between poverty, food security and PIKE highlight a close linkage between the well-being of local communities and the health of elephant populations, and suggest that there may be a greater incentive to facilitate or participate in the illegal killing of elephants in areas where human livelihoods are insecure. (CITES 2012: 12)

The devastating effects of the global economic crisis on food security in Africa do not bode well for efforts to deter poaching (FAO, 2009; UNDP, 2012). This is a clear warning that a serious discussion of the impact of policies is urgently needed in the debate on poaching and the ivory market, particularly around the effects of macroeconomic austerity policy and the unmet goals of securing basic levels of subsistence. Rosen and Smith (2010: 24) concur that effective control of poaching and illegal wildlife trafficking "will require a multi-pronged approach including community-scale education and empowering local people to value wildlife".

Rural poverty and food security are critically affected by agricultural policies. The MIKE results suggest they must be taken into account in the analysis of elephant poaching. In fact, the agricultural and livestock sector is a key component of most developing economies and plays a very important role in conservation. Small-scale agricultural producers are also curators of genetic agro-biodiversity and are crucial in environmental stewardship. In spite of this, they have been under severe pressure on many fronts. Fiscal retrenchment has had a negative impact on investments in roads, irrigation projects, land management and post-harvest storage facilities. Financial policies and deregulation of credit and banking operations have led in many countries to a serious drop in agricultural loans. Subsidies and supply management policies have also been reduced as a consequence of fiscal priorities. All of this has taken place at the same time that trade liberalisation has put small-scale farmers in direct competition with the heavily subsidised agricultural systems of developed economies. With this policy package it is no coincidence that rural poverty continues to be pervasive in Africa. This is not only relevant for poaching, but for the long-term survival of protected areas, regardless of their governance structures. Underfunded and under-staffed protected areas and biosphere reserves will not survive as islands in a sea of rural poverty. The analyses by Le-Saout, Hoffman et al (2013) and Nadal and García-Rañó (2011) underscore this conclusion.

Finally, although the World Bank and the International Monetary Fund officially favour poverty reduction strategies, fiscal retrenchment continues to be, in open contradiction to the former goal, a key priority. Even in the context of the global economic crisis pro-cyclical fiscal retrenchment will continue to have serious negative social costs. All of this is critically important in understanding the drop in public spending in conservation and environmental

stewardship. Law enforcement capabilities of African countries will continue to be seriously affected by these economic policies.

To summarise, although the literature is full of simplistic references to the notion that "trade bans aren't working" (Conrad 2012 is one of many examples) little or no attention has been given to the analysis of economic policies that are relevant to conservation and wildlife protection, including the fiscal resources needed for effective institutional capacity. If inadequate levels of funding are being allocated to conservation policies, what may be 'not working' is a failed model of macroeconomic and sector level policy-making (Nadal, 2011). As a result of these policy priorities, public investment in conservation and environmental stewardship is expected to drop significantly in most African countries, as occurred in Latin American countries where a similar macroeconomic policy stance has been promoted.

Conclusion

Trade mechanisms and legal markets for endangered wildlife have attracted attention as policy instruments capable of aiding in conservation and bringing an end to the scourge of poaching. These instruments are seen by many as being efficient, less susceptible to political manipulation and capable of delivering results in the short term. Given the recent intensification of poaching, with all its brutal ramifications, enthusiasm for alternative policy instruments may be understandable. However, using market forces in an attempt to solve the poaching crisis or as a tool in conservation policy is a delicate matter. The textbook narrative on market-based instruments can be simple and attractive, but it is also misleading.

Economic analysis of all relevant aspects of supply and demand requires using adequate tools and these must come from economic theory. There is no immediate 'access to reality' and 'facts' do not self-organise into theories. 'Common sense' is not a reliable conduit to understand the dynamics of prices or income distribution. Some kind of theory (or 'vision', in the terms of Schumpeter) is always present at the start of all empirical studies, whether explicitly or in an implicit form. The economic analysis of wildlife trade is no exception.

Economic theory is something more than the contents of textbook economics and research cannot rely on the well-behaved concepts taught in undergraduate courses. The results on stability theory in the late 1950s and early sixties, as well as the outcome of research on aggregate excess demand functions reveal that there is no reason to believe in the storytelling capacity of introductory textbooks.

It is important to clarify that our critical stance on the economic analysis of wildlife trade covers two dimensions. First, we stand against the use of theoretically discredited analytical instruments. Here we emphasise the importance of working with theoretical concepts that are able to withstand the standard tests of scientific deliberation and debates. Applied and policy-oriented research cannot be of use if it relies on ill-conceived concepts. Here the problem is not one of lack of realism but of lack of logical consistency. For example, we find fault in the

facile assumption that the market demand function is downward sloping because it is logically inconsistent. The deeply negative results of the Sonnenschein-Mantel-Debreu theorem cannot be assumed away because they reveal deep properties of the price system and its impact on income distribution. Research on wildlife trafficking and conservation needs to take these results into account. Failure to do this entails the risk of unleashing forces that are not well understood and that may lead to negative consequences.

Second, we also critique the literature on the grounds of lack of realism in its assumptions. For example, we disapprove of the use of comparative statics because they invite simplistic modes of reasoning. The narrative of static models (and all of the models we have examined fall in this category) is misleading in many ways, but its worst defect is that it does not depict in any reasonable manner how market processes unfold. The absurdity is not without irony: those that propose the use of market-based policy instruments carry out an analysis in which there are no veritable market processes! Moreover, they predict future outcomes without any dynamic or temporal analysis capable of theorising iterative change. The fact that these models fail to do this should remind us of the results of models used in the financial sector. In the words of Colander et al. (2009: 4),

> many of the financial economists who developed the theoretical models upon which the modern financial structure is built were well aware of the strong and highly unrealistic restrictions imposed on their models to assure stability. Yet financial economists gave little warning to the public about the fragility of their models. (...) In our view economists, as with all scientists, have an ethical responsibility to communicate the limitations of their models and the potential misuses of their research.

Clearly, this applies to economists who recommend using market-based policy instruments. We have shown the serious limitations of their models and the weaknesses of their conclusions. Thus far, these economists have failed to discharge this responsibility.

Another example is related to the use of partial equilibrium models. These carry with them the simplistic assumption that what happens in all other markets has no impact on the market being analysed. This is tantamount to assuming that all other markets are in equilibrium because at that point market forces have ceased to function. This extremely simplistic view of markets eliminates market interdependencies and the role of a system of relative prices.

The economic analysis of wildlife trade also adopts extremely simplistic views of the key agents in wildlife trafficking. The units carrying out the activities that lead from poaching to sales to final consumers are frequently depicted as crime syndicates. Whether they fall in the strict *de jure* definition of 'organised crime' or not, there is much evidence suggesting these operate as multi-product firms. Various studies and research projects, as well as information on seizures of illegal contraband indicate these organisations work with illegal logging, drugs and arms, in addition to trafficking with many animal and plant species. This means that these organisations have access to both scale and scope economies that radically alter the rules of the game. It is wrong to think that the analysis of market-friendly mechanisms with single-product firms has any degree of accuracy when applied to multi-product firms.

In closing we would like to remind readers that the global economic crisis that erupted in 2008 was the direct result of instability in highly deregulated markets. This came without surprise to those familiar with the work of Hyman Minsky and other post-Keynesian economists. Minsky's views on the role of markets are summarised in this paragraph from one of his books (Minsky 2008: 112):

> The general view sustained by [our] analysis is that while the market mechanism is a good enough device for making social decisions about unimportant matters such as the mix of colours in the production of frocks, the length of skirts, or the flavours of ice cream, it cannot and should not be relied upon for important, big matters such as the distribution of income, the maintenance of economic stability, the capital development of the economy, and the education and training of the young.

Clearly, conservation and environmental stewardship could be added to that list.

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