An Econometric Analysis of the CITES (International Trade Restrictions) on Endangered Species Populations

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Abstract:

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) restricts the trade of endangered specimens to ensure international trade does not threaten the survival of the species. This international agreement has been around for 40 years and yet there has been no analysis of the effects these trade restrictions actually have on endangered animal populations. This is a preliminary study on the relationship between CITES and the trend of endangered species populations. The purpose of this paper is to start a conversation about ensuring that our animal conservation methods do not just sound good, but produce their intended results. As the World continues to become more global, the need for conservation methods that work becomes more critical. In order to ensure the efficacy of such methods, a definitive way to measure their effects must be established. This study attempts to draw initial conclusions about the success of the CITES convention.

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Introduction

In the last five hundred years, over eight hundred species of plant and animal have been forced into extinction due to human activity.[1] As more of the World develops, so do concerns for the environment. For the past several decades conservation has been given international attention. Global World-leaders and scientists have made issues of environmental conservation and protection priorities. There is a growing concern that we need to protect the world to preserve natural beauty, maintain scarce resources, curb pollution and protect our wild animals.

It has become increasingly clear that humans are playing a large role in the destruction of habitats necessary for the survival of plant and animal species. It is estimated that one half of endangered species live in the rainforest. At the same time, the Amazon rainforest has lost nearly 17% of forest cover due to human activity in the last decade.[2] It has also become clear that due to the global nature of a majority of the World's economies, species conservation is an issue that one country cannot fix on its own. For example, while the majority of the Worlds' rhinoceroses live in South Africa, the majority of the demand for rhino products comes from Asia. That is, Vietnam uses the rhino horn for a party drug and cancer cure. The price of one horn goes for around $50,00 per kilogram[3]. Similarly, fashion jewelry from rhino horn is in high demand in China. The trade in shark fins, from sharks in oceans all over the world, over the last fifteen years has led to the decline in some shark populations of up to 98%. [4] One of the biggest markets for tiger products including wines, pills, powders and meats is Japan with the parts coming primarily from India. [5]

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1 www.endangeredearth.com

2 World Wildlife Fund. "Habitats: Forests." WorldWildlife.org. Accessed April 16, 2014, ,http://worldwildlife.org/habitats/forests>
3 http://qz.com/159902/chinas-obsession-with-rhino-horns-is-sending-south-african-rhino-deaths-through-the-roof/
4 IUCN Redlist
5 Tigersincrisis.com

Seeing as the issue is one involving global trade, countries interested in the protection of animal species (there were 80 of them) met in Washington DC on March 3, 1973 for the Convention on International Trade In Endangered Species of wild fauna and flora. The convention or CITES, is now an international agreement between 180 governments whose aim is to ensure that international trade does not threaten the survival of animals and plants. [6] Today, it offers varying degrees of protection for 35,000 species of plant and animal in an effort to safeguard them from over-exploitation. The convention is a voluntary agreement. Those parties who have agreed to be bound by CITES provides a framework to be for each party to adopt its own domestic legislation to ensure the agreement is implemented at the national level.

That being said, most developed countries have domestic restrictions and regulations to conserve wildlife including plants, animals and fish species native to their respective countries. The United States passed the Endangered Species Act in 1973 as a comprehensive program for the conservation of threatened and endangered species. Australia has the Endangered Species Protection Act of 1992. Also in 1992, the EU governments adopted what is called the Habitats Directive. In 2002 the Species at Risk Act was passed in Canada. The aim was once again to protect species and their habitats.

This legislation was particularly controversial in the United States and therefore domestic analysis of the act has been done over the past thirty years. Estimating animal populations and gathering reliable data can be difficult however, experts in environmental economics have created fairly sophisticated analysis. In 2007, Paul Ferraro's study, *The Effectiveness of the US endangered species act: An econometric analysis using matching methods*, was published. The conclusion was "that listing a species under the ESA is, on average, detrimental to species

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[6] http://cites.org/eng/disc/what.php

recovery if not combined with substantial government funds." [7] The speculation behind this conclusion is fairly obvious. The Endangered Species Act was created in such a way to produce negative externalities by incentivizing property owners to pre-emptively destroy potential habitats for endangered species or, even kill the species outright. This phenomenon was coined the phrase "shoot, shovel and shut up." The fact is if a property owner had an endangered species, or potential habitat for one, the state could restrict the use of the land. To avoid such restrictions, eliminating the species before anyone could find out is an option.

Externalities are important byproducts of institutions and legislation. When it comes to something as important as conserving the World we live in, we cannot afford to ignore the potential for unintended consequences. For this reason, it is surprising to note that the Convention on International Trade In Endangered Species of Wild Fauna and Flora has yet to be assessed. There have been no economic analyses of the effects of the trade restrictions on the well being of the populations of species who are at risk of becoming extinct. This is problematic because economic history tells us that when there is demand for a product, markets do not disappear with the criminalizing of the trade.

With the vast number of plants and animals currently on the list of endangered species it is important to ensure the consequences of the convention are those that were intended purpose. It is important to understand that we are doing everything we can to truly protect the 16,456 animals endangered of becoming extinct. Understanding the viability of CITES may also have implications on the way the World works together on environmental conservation efforts moving forward.

[7] http://www.sciencedirect.com/science/article/pii/S0095069607000629

This study attempts to draw a conclusion about the relationship between the CITES convention and the population status of endangered animal species. This is a preliminary examination of the trade restrictions in comparison to the animal population trends, as this topic requires fairly sophisticated analysis. The intent of this paper is to gather and consolidate the data on the convention and animal populations and look for any indication that a relationship might exist. Hopefully, this will begin a conversation about the best way to protect our animals and plants and how to appropriately measure this success.

Review of Literature

As previously stated, there has been no formal analysis of the CITES convention versus the trend status of endangered species populations. This may well be in large part due to the difficulty in gathering viable data to asses. There was therefore a need to look at analysis of domestic endangered species protection such as the United State's Endangered Species Act. There is a range of studies done on this topic. The most recent, and relevant to this study is "The effectiveness of the US endangered species act: An econometric analysis using matching methods. "In this study Ferraro, McIntosh and Ospina offer new insight on methodology for conservation scientists evaluating biodiversity loss. The stress the necessity for a counterfactual in order to show how the animal would have faired if it were not listed as an endangered species in order to have a real conclusion about the effects. They also found it necessary to use "charisma" variables for the animals including if it is a mammal or bird because people tend to appreciate them more. This is the most comprehensive analysis on measuring animal species populations versus some form of legislation. Beyond this domestic research, there is nothing related to this field on an international level.

Data & Methodology

A. Initial Linear Regression

The first method used was a simple linear regression in order to determine if there was any correlation and what direction the relationships appeared to be. For this model we used the following data:

a. Population Trend

This is the status of the animal population according to the International Union for Conservation of Nature' Red List. The Red List is the most comprehensive list of threatened and endangered animal and plant species. The IUCN Red List Index (RLI) measures overall trends in extinction risk for groups of species based on genuine changes in their Red List status over time.[8] Assessors use IUCN Red List Categories and Criteria to determine whether the species is Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, and Extinct. The current Red List includes assessments using both the 1994 system and the more updated version from 2001. We have included species in this study using both versions of assessment. We gathered data on 117 species including mammals, amphibians and reptiles for this study. Data was gathered from year 1986 to 2013. In order to run a linear regression we manipulated the categories into numbers as follows: Least Concern=10, Near Threatened=20, Vulnerable=30, Endangered=40, Critically Endangered=50 and Extinct=60.

b. Cites Listing

This variable indicates the trade restrictions on an endangered animal species set forth by the CITES convention. CITES is an international agreement between governments to ensure that international trade in wild animals and plants does not threaten the survival of these species. It

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[8] http://www.iucnredlist.org/technical-documents/categories-and-criteria

works by subjecting the international trade of the species to controls. Imports and exports of the species covered in the convention are authorized through a licensing system. The species are listing in 3 appendices according to the degree of protection it is deemed they need. The appendices are as follows: Appendix I is species threatened with becoming extinct and therefore has the tightest controls. Trade of these species is permitted in only exceptional circumstances. Appendix II includes species that are not necessarily becoming extinction but trade must be controlled in order to avoid overuse that would threaten their survival. Appendix II species are those that are protected in at least one country, which has asked other Parties for assistance in controlling trade of it. These animals may be imported and exported with appropriate documentation. In other words, appendix I imposes the most restrictions of the trade of the animal or any product that comes from the animal. Appendix II is medium restriction with permits require which may be difficult to obtain and appendix III restrictions require a permit but are much less restrictive. For this model the data was: appendix I=1, appendix II= 2, appendix III=3.

c. Number of Countries

This variable simply lists the number of countries in which the species resides. The purpose of this variable was to capture the potential “popularity” of the animal. In other words, we assumed that the more countries a species was located the more recognition it probably received on a worldwide basis. This could have either a negative or positive effect on its survival. If it is well known and people feel strongly towards its survival and conservation efforts, or it is popular with consumers.

The model for the simple linear regression was therefore: Trend= (Listing, Countries).

B. Multivariate Logistic Regression

Next, we ran a multivariate logistic regression using Trend as the dependent, categorical variable. The dependent variable had 6 categories: Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered and Extinct. Endangered was used as the reference category. Listing in this case was used as a dummy variable with appendix II set to 1 if appendix II and 0 if other and appendix III set to 1 if appendix III and 0 if other. Again, countries was included as an independent variable. The generalized logit procedure was used. The model was therefore:

Logit (trend) = α + Countries * X; where X is the dummy variable for Listing.

C. Linear Regression with GDP

The ability for a country to protect its endangered species could play a role in the trend of the animal populations. Therefore, we added the variable “GDP”. Because many of the animals span across multiple countries the only way to capture this variable was to limit our data to animals that only live in one country. We then included the Gross Domestic Product in 2014 USA dollars for those countries. For this equation we also added the variable Species. This is a dummy variable that captures whether the animal is a reptile, amphibian or mammal. The thinking was that the type of animal may play into conservation efforts. For example, a tiger or giraffe may have more popularity among the public than a lizard. This was also a simple linear regression to form an initial idea about the relationship between the variables. The model for this was: Trend= (GDP, Listing, Species).

D. Multivariate Logistic Regression with GDP

We then did the same multivariate logistic regression as above with the dataset for the animals only living in one country. We did not include the variable Species here. Extinct was used as the reference category for Trend. The model was: logit(trend) = a +GDP * X; where X is the dummy variable for Listing. The initial testing of the model resulted in Quasi-complete separation of data points and was therefore completely unreliable. We then re-ran the model using the Firth estimation method to help correct for the separation of data points.

Econometric Results

A. Initial Linear Regression (See Table A)

The r-squared indicates that the model explains 95% of the variability. In other words, the model is a good fit. The regression equation produced is Trend= 41.7-2.74Listing-0.52Countries. Both variables are shown to have statistically significant predictive capability at the 1% level. The relationship explained by this model is that if the restriction value goes up (less restriction), then the trend of the animal population goes down (there is less threat of extinction). This model would seem to show that the CITES restrictions are doing their job in protecting the animal species from extinction.

B. Multivariate Logistic Regression (See Table B)

According to the likelihood ratio, this model was also a good fit. The overall effects of Listing and Countries are listed under "Type 3 Analysis of Effects", and both are significant. Under the analysis of maximum likelihood estimates the estimates are significant for the following relationships: all of the intercept and trend categories, CITES appendix II and Least Concern, Near Threatened and Vulnerable, CITES appendix III and Vulnerable, Number of Countries and Critically Endangered, Least Concern, Near Threatened and Vulnerable. The Relationships here can be explained in the following way:

1. Listing appendix II relative to appendix I is associated with a 1.7 increase in the log-odds of the animal population being Least Concern vs. Endangered.
2. Listing appendix II relative to appendix I is associated with a 0.7 increase in the log-odds of the animal population being Near Threatened vs. Endangered.

3. Listing appendix II relative to appendix I is associated with a 1 increase in the log-odds of the animal population being Vulnerable vs. Endangered.
4. Listing appendix III relative to appendix I is associated with a .46 increase in the log-odds of the animal population being Vulnerable vs. Endangered.
5. A 1 unit increase in the variable Countries is associated with a 0.14 decrease in the log-odds of the animal population being Critically Endangered vs. Endangered.
6. A 1 unit increase in the variable Countries is associated with a 0.11 increase in the log-odds of the animal population being Least Concern vs. Endangered.
7. A 1 unit increase in the variable Countries is associated with a 0.11 increase in the log-odds of the animal population being Near Threatened vs. Endangered.
8. A 1 unit increase in the variable Countries is associated with a .07 increase in the log-odds of the animal population being Vulnerable vs. Endangered.

In general, the model is demonstrating a positive relationship between the number of countries a species is found in, and their population trend. In other words, the more countries the species lives, the better-off their population is. The relationship it is showing in terms of the CITES trade restrictions is that in 4 cases, the *lower* trade restrictions is associated with a better off animal population. For example, appendix II (medium restrictions) relative to appendix I (most restrictions) is associated with an increased log-odds of 1.7 that the animal population is Least Concern versus Endangered.

The odds ratio shows the strength of association between our predictor variables (Countries and Listing) and the response of interest, which is the population trend. The results from this table show that it is more likely for an animal listed under appendix I (most restricted) to be Critically Endangered versus Endangered and Extinct versus Endangered than an animal listed under appendix II (medium restriction). It is more likely for an animal listed under appendix II than I to be Least Concern versus Endangered, Near Threatened versus Endangered and Vulnerable versus

Endangered. It is more likely for an animal listed under appendix I to be Critically Endangered versus Endangered than an animal listed under appendix III (least restricted trade). Likewise for Extinct versus Endangered, Least Concern versus Endangered and Near Threatened versus Endangered. In other words, the animals listed under appendix II, which is medium restrictive trade, are less likely to be worse off than the animals listed under appendix I (the most restrictive) and appendix III (the least restrictive).

C. Linear Regression with GDP (See Table C)

Due to a very low R-squared this model was rejected and we could not use it. The kind of species (amphibian, reptile and mammal) shows not to be statistically significant here.

D. Multivariate Logistic Regression with GDP (See Table D)

Due to the lack of fit with the linear regression we were unsurprised to find the multivariate logistic regression using the same dataset was also not a good fit. The results of the Firth estimation are problematic and should be reviewed with caution. The Firth estimation show a good fit of the model and the Analysis of Penalized Maximum Likelihood Estimates shows all of the parameters to be statistically significant. Due to the problematic nature of this model we have included the results in the appendix for review but will not draw any conclusions from it.

Conclusion

Because a viable counterfactual was not used in this study, the results listed here should serve as an initial examination of the relationship between the CITES restrictions and the welfare of animal species. The results here seem to indicate that the animals under the most restricted appendix (I) on CITES are more likely to be in critical condition than the slightly less restrictive appendix II. This could mean the most restricted animals are being traded more on the black market or it could just be that those animals listed under appendix I suffer from something unseen in this study. From the first two models we can conclude that there is in fact a relationship between the CITES restrictions and the well-being of the endangered animals. Beyond that, the study is inconclusive without the inclusion of more variables.

Further study on this topic should include a viable counterfactual in order to draw a real conclusion about how animals fair under the CITES convention versus not being listed. In addition, there should be variables that capture how much money is spent domestically on conserving the animal species, and how that money is actually spent. Other factors that affect animal populations should also be included in further studies including what kind of habitat they occupy. Because the assessment of the animal trends varies between species, there should be an attempt to make a cohesive dataset, or find a better dependent variable that captures the well-being of the endangered species. There needs to be further study on this topic so that the World can conclude that we are really doing what is best for these animal species.

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Appendix:

Table A. Initial Linear Regression Results

Number of Observations Used 2822

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	31554	15777	147.13	<.0001
Error	2819	302278	107.22863		
Corrected Total	2821	333831			

Root MSE	10.35513	**R-Square**	0.0945
Dependent Mean	34.57123	**Adj R-Sq**	0.0939
Coeff Var	29.95302		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	**1**	41.70764	0.53079	78.58	<.0001
LISTING	**1**	-2.74793	0.30666	-8.96	<.0001
COUNTRIES	**1**	-0.52854	0.03810	-13.87	<.0001

Table B. Multivariate Logistic Regression Results

Model Information

Response Variable	Trend
Number of Response Levels	6
Model	generalized logit
Optimization Technique	Newton-Raphson

Number of Observations Used	2822

Response Profile

Ordered Value	Trend	Total Frequency
1	10	200
2	20	164
3	30	1104
4	40	909
5	50	390
6	60	55

Logits modeled use Trend=40 as the reference category.

LC=10, NT=20, V=30, E=40, CR=50, EX=60

Class Level Information

Class	Value	Design Variables	
Listing	**1**	0	0
	2	1	0
	3	0	1

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	8110.605	7566.657
SC	8140.331	7685.561
-2 Log L	8100.605	7526.657

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	573.9471	15	<.0001
Score	476.2076	15	<.0001
Wald	367.6507	15	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
Countries	5	202.9699	<.0001
Listing	10	189.4761	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	Trend	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	**10**	1	-2.8514	0.1598	318.5044	<.0001
Intercept	**20**	1	-2.5693	0.1539	278.7685	<.0001
Intercept	**30**	1	-0.6527	0.0828	62.0581	<.0001
Intercept	**50**	1	-0.2342	0.0982	5.6921	0.0170
Intercept	**60**	1	-2.3793	0.2143	123.2432	<.0001
Countries	**10**	1	0.1099	0.0146	56.9129	<.0001
Countries	**20**	1	0.1076	0.0157	46.8832	<.0001
Countries	**30**	1	0.0799	0.0100	63.3706	<.0001
Countries	**50**	1	-0.1448	0.0192	56.7370	<.0001
Countries	**60**	1	-0.00894	0.0340	0.0691	0.7927

Analysis of Maximum Likelihood Estimates

Parameter		Trend	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Listing	**2**	**10**	1	1.6988	0.1705	99.2201	<.0001
Listing	**2**	**20**	1	0.7032	0.1845	14.5362	0.0001
Listing	**2**	**30**	1	1.0480	0.1031	103.4081	<.0001
Listing	**2**	**50**	1	-0.1851	0.1502	1.5191	0.2178
Listing	**2**	**60**	1	-14.0769	263.2	0.0029	0.9574
Listing	**3**	**10**	1	-13.5114	281.5	0.0023	0.9617
Listing	**3**	**20**	1	-0.0950	0.3453	0.0756	0.7833
Listing	**3**	**30**	1	0.4589	0.1644	7.7870	0.0053
Listing	**3**	**50**	1	-0.2411	0.2339	1.0628	0.3026
Listing	**3**	**60**	1	-14.5589	551.3	0.0007	0.9789

Odds Ratio Estimates

Effect	Trend	Point Estimate	95% Wald Confidence Limits	
Countries	**10**	1.116	1.085	1.149
Countries	**20**	1.114	1.080	1.148
Countries	**30**	1.083	1.062	1.105
Countries	**50**	0.865	0.833	0.898
Countries	**60**	0.991	0.927	1.059
Listing 2 vs 1	**10**	5.468	3.914	7.638
Listing 2 vs 1	**20**	2.020	1.407	2.900
Listing 2 vs 1	**30**	2.852	2.330	3.490
Listing 2 vs 1	**50**	0.831	0.619	1.115
Listing 2 vs 1	**60**	<0.001	<0.001	>999.999
Listing 3 vs 1	**10**	<0.001	<0.001	>999.999
Listing 3 vs 1	**20**	0.909	0.462	1.789
Listing 3 vs 1	**30**	1.582	1.146	2.184
Listing 3 vs 1	**50**	0.786	0.497	1.243

Odds Ratio Estimates

Effect	**Trend**	**Point Estimate**	**95% Wald Confidence Limits**	
Listing 3 vs 1	**60**	<0.001	<0.001	>999.999

Table C. Linear Regression with GDP Results

Number of Observations Used 781

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	12291	4097.11956	43.36	<.0001
Error	777	73414	94.48377		
Corrected Total	780	85705			

Root MSE	9.72028	**R-Square**	0.1434
Dependent Mean	40.49936	**Adj R-Sq**	0.1401
Coeff Var	24.00106		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	**1**	50.57276	1.33520	37.88	<.0001
Listing	**1**	-5.79108	0.56343	-10.28	<.0001
GDP	**1**	1.96269E-12	3.40224E-13	5.77	<.0001
Species	**1**	-0.98607	0.56330	-1.75	0.0804

Table D. Logistic with GDP Results:

Model	cumulative logit
Optimization Technique	Fisher's scoring

Number of Observations Read	781
Number of Observations Used	781

Response Profile

Ordered Value	Trend	Total Frequency
1	10	13
2	20	24
3	30	231
4	40	185
5	50	299
6	60	29

Probabilities modeled are cumulated over the lower Ordered Values.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
561.9911	8	<.0001

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	2144.486	2021.911
SC	2167.789	2054.536
-2 Log L	2134.486	2007.911

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	126.5746	2	<.0001
Score	129.2714	2	<.0001
Wald	114.7805	2	<.0001

Analysis of Penalized Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	**10**	1	-5.9970	0.3541	286.7819	<.0001
Intercept	**20**	1	-4.9237	0.2717	328.4439	<.0001
Intercept	**30**	1	-2.3958	0.1992	144.5809	<.0001
Intercept	**40**	1	-1.2604	0.1844	46.7237	<.0001
Intercept	**50**	1	1.8537	0.2435	57.9326	<.0001
GDP		1	-392E-15	7.04E-14	31.0197	<.0001
Listing		1	1.1317	0.1133	99.7737	<.0001

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
GDP	1.000	1.000	1.000
Listing	3.101	2.483	3.872

Association of Predicted Probabilities and Observed Responses

Percent Concordant	65.0	**Somers' D**	0.414
Percent Discordant	23.6	**Gamma**	0.467
Percent Tied	11.4	**Tau-a**	0.293
Pairs	215694	**c**	0.707