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Assessing the Efficacy of CITES Restrictions on Malagasy Rosewood

by

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Honors Thesis

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## Abstract

This paper seeks to determine whether the CITES trade restrictions on rosewood have been effective. Effectiveness will be measured by the amount of illegal logging the restrictions reduce. The Matt Hansen Global Deforestation dataset, which measures deforestation from year to year, will be analyzed in the Google Earth Engine Code Editor to determine the yearly amount of deforestation in Madagascar. This output will then be loaded into R and assessed using OLS estimation techniques to determine whether the ban had a significant impact on the amount of illegal logging occurring in Madagascar. Because CITES restrictions are lifted and restored with varying degrees of severity, the analysis of this paper will focus on the most recent sanctions. These restrictions have been active for Madagascar species of rosewood since 2013 and for all other rosewood species since 2017. This period will be the focus of analysis because it has been the most consistently applied restriction era to date with all species within the genus of Dalbergia being categorized under appendix II (aside from the already more heavily regulated Brazilian Rosewood). The analysis suggests that the CITES restrictions increased the amount of rosewood harvested in Madagascar during the period observed.


## Introduction

The genus of Dalbergia (colloquially known as Rosewood), houses many species of tropical hardwoods with similar characteristics. These species are prized for their rich color, appealing grain patterns, resistance to rot, workability, and tonal characteristics. (Clowes 2016) For years products like cabinets, furniture, and musical instruments were manufactured with Brazilian Rosewood in the United States. (Hunter, 2017) Not only is the timber itself valuable, but byproducts of the tree are also sought after. The colloquial name rosewood was developed because of the sweet aroma the tree produces which is similar to that of rose flowers. This makes byproducts of the tree extremely valuable. Even the world-famous Chanel No.5 perfume originally utilized the tree's oil to create the signature fragrance that it is known for today. (Rohter, 2005) This practice was continued until the middle to late sixties when supplies became scarce and prices exorbitant. (Hunter, 2017)

While some of the blame for the endangerment of Brazilian Rosewood belongs to conventional harvesting to produce goods like the ones previously mentioned, a large portion of it also came from the shifting landscapes of Brazil. At that time, cities and coffee fields were expanding as Brazil was attempting to grow its trading capabilities. Unfortunately, this practice repurposed a large amount of land that was formerly a part of the rainforest which ultimately harmed the supply of rosewood. (Hobbs, 2020)

Even though the drastic reduction of supply and skyrocketing prices were a strong indication of the species becoming endangered, formal international regulation was not passed until 1992. (Oldfield, 2013) This regulation was passed by a governing body known as CITES. CITES is the acronym used for the Convention on International Trade in Endangered Species of Wild Fauna and Flora and was formally founded in 1975. The convention is now comprised of 184 parties which are nations that have agreed to abide by and enforce CITES policy. (CITES, 2021) While CITES does have the authority to create legislation, it does not have any direct method of enforcing its policies. Instead, it relies on the local governments of parties to the convention. (Oldfield, 2013) While this is a cost-effective method of implementation, it does come with some substantial drawbacks. These being corruption and an inconsistent capability to enforce policy. Corruption will always be an issue with this model, as government officials can use their position to take bribes and allow illegal activity or even actively participate. The other issue is that some countries, typically developing ones, do not have the resources to enforce policy to a satisfactory standard. What is particularly unfortunate, is that many endangered species exist within these countries with governmental resource shortages creating opportunity for illegal activity. (Oldfield, 2013)

After supplies of the prized Brazilian Rosewood dwindled and stock became difficult to come by, manufacturers began to look elsewhere for other species of rosewood. Countries like Madagascar, India, and the Republic of the Congo became leading suppliers of this prized timber. While demand was limited to niche interests like musical instrument making for quite some time, the reemergence of demand for a certain type of luxury furniture in China greatly stressed the rosewood market and pushed logging to unprecedented levels. (Hobbs, 2020) This put the rosewood logging industry on a trajectory that created a black market full of corrupt government officials, timber kings, and violence. (WWLC, 2020) In response to this progression, CITES began sanctioning many species of rosewood, notably including all species native to Madagascar in 2013, to combat the growing issue of forest exploitation along with the violence and corruption that accompanied this unethical marketplace. (Oldfield, 2013) It was not until 2017 that all species of rosewood were restricted in an effort to prevent suppliers shifting to other localities and in order to make enforcement easier since some species are virtually indistinguishable from one another. (Kukreti, 2019)

The goal of this paper is to assess the efficacy of CITES trade restrictions on rosewood. While conventional wisdom would suggest that the addition of any legislation would reduce the amount of Rosewood being logged, studies have shown that this may not be the case. Because Rosewood is surrounded with a stigma of endangerment and unethical practices, buyers are skeptical of any Rosewood that comes on the market. However, if the Rosewood is accompanied by a CITES permit, a buyer will be more inclined to purchase it without weighing environmental impacts since it is supposedly ethically and sustainably harvested. While a properly granted permit would be indicative of an ethical and sustainable harvesting, corrupt government officials often take advantage of their position and improperly award permits. (OCCRP, 2018) Because of these behaviors, previous papers have hypothesized that the implementation of a permit system exacerbates the issue of unethical logging. (Dumenu, 2019)

The research done for this paper is significant because of the impact illegal logging has on both local and global ecosystems. Additionally, the impact it has on local economies. Villagers are often pushed towards illegal logging because of a lack of income. While the short-term reward is a higher income for a small number of individuals, the aftermath of previous logging is showing that the societies bear a much higher cost than what the individuals receive collectively as payment. (Schuurman, 2009) The costs associated with illegal logging are extensive, but they most notably include deforestation, degraded ecosystems, and violence. (CITES, 2016)

This paper will examine the effectiveness of the CITES policy in a somewhat novel way. Previous studies have used methods like stump counting and seizure reports to quantify the unethical logging of rosewood. While these methods do provide granular data that is very insightful, they are prone to human error and a lack of generalizability. In order to approach this problem in a different way and perhaps gain some other insight, satellite data was used. This was done using the Matt Hansen Global Deforestation Dataset and analyzed using the Google Earth Engine Code Editor. While credibility has been attributed to this method in the past by CITES, it has not been used to assess the effectiveness of a policy after it was implemented. (Voiland, 2019) Since this methodology is very powerful, but also indiscriminate, the island country of

Madagascar was chosen for its involvement in illegal trade and rosewood forest density. (Anonymous, 2018)

This paper will continue by exploring previously established literature on the topic of illegal rosewood harvesting and investigating papers written about other resources that are known for unethical trade because of a paucity of literature on this topic specifically. This will be followed by a description of the data, the processes used to analyze it, the results, and will end with a conclusion that discusses the significance of these findings and what further steps could be taken going into the future.

## Literature Review

Many papers have attempted to find the root cause of illegal logging. While greed constitutes a great deal of the motivation behind this behavior, it still does not fully capture the reasoning behind some of the people who participate in the action; particularly, the villagers. Much of the actual cutting is performed by natives who are compensated, albeit less than the cost of environmental damage, for their work. (Innes, 2010) It creates a tragedy of the commons as the land is often tribally or communally owned and some exploit its resources while others fight to save it in order to preserve subsistence harvesting and cultural significance. (Beard, 2019)

A paper by Jones et al. explored the motivations behind local illegal loggers. They sought to determine why villagers would illegally log in their own community if it created more environmental harm than they were being compensated for while also making them societally frowned upon for destroying communal property. Their hypothesis was that they were illegally logging because of a lack of alternatives. This study was performed on the island of Borneo, which is partially controlled by Malaysia. The locals are very poor in rural areas often having trouble with paying for essentials. They conducted an experiment where villages could agree to have a subsidized health clinic and, in some cases, an educational facility operate in their locality in exchange for information about illegal logging. These clinics provided low-cost care that could also be bartered for. What the study found, was that the reduction of cost for essentials like healthcare dramatically reduced the amount of illegal logging when compared to neighboring countries without the same reform. This intervention was estimated to have reduced illegal logging by a staggering 69.8%. This reduction in above ground carbon lossage, when evaluated according to the standards set forth by the European Emissions Trading System, saved around 65.3 million dollars over the ten-year span of the intervention. After factoring in the amount of sickness and death that was also averted by this program, the total value created and saved was sizeable enough to warrant further exploration as a method to combat deforestation going into the future. (Jones et al., 2020)

Although the savings attributed to the intervention are impressive and the ramifications for these conclusions large, the main significance of Jones et al.'s findings to this paper is that villagers illegally log to pay for necessities. Because of the direct relation illegal logging has to the wellbeing of natives, it is imperative that this is considered when assessing current policy.

In recent years, there have been a few papers that bring into question the efficacy of CITES policy enforcement. Some have even gone so far as to suggest that CITES policies actually increase the illegal logging of protected timber. While this may seem counterintuitive, the way these policies are enforced does add some potential methods of exploitation for a well-connected smuggler. (Dumenu, 2019)

A paper written by Dumenu in 2019 pointed out that the cycle of enforcing and lifting restrictions creates a natural experiment to determine the impact of CITES policy. It is a well-established trend that CITES will introduce legislation to protect a certain species and then lift it later without much explanation. One reason why restrictions are lifted, is to salvage confiscated logs since they would go to waste if left where they are. This relieves illegal loggers from the burden of corruptly obtaining CITES permits or falsifying documentation, but also can make it harder to sell as the verification of ethical sourcing becomes much harder to prove. In theory, this could increase the amount of logging during times of CITES restrictions since sourcing verification can be obtained from corrupt government officials and passed on under less suspicion. (Dumenu, 2019)

The Dumenu paper specifically discussed salvage permits, which are supposed to only be used to utilize trees felled by natural events or confiscated logs that would otherwise go to waste. He argues that this creates a significant loophole which is commonly exploited by timber smugglers. To assess this claim, the data was gathered from reports filed with CITES. The study looked at what rosewood was reportedly exported from Ghana (the exporting country focused on in this paper) and what rosewood was reportedly imported into China from Ghana. The discrepancy between these two figures served as a proxy for illegal logging. The assessment found that China reported much more rosewood intake than the Ghana export data accounted for. Not only that, but the discrepancy became much larger, and the total volume of Ghana originating rosewood imports increased during the time the policy was introduced. The data suggests that illegal logging in Ghana increased by 129% after the restrictions were set in place. Dumenu suggests that the obtaining of illegitimately granted CITES permits makes it harder to discern whether the logging was done properly or not. It also gives the importing country, in this case China, a certain degree of impunity since they can claim that they had no idea the timber was illegally and unethically sourced. This gives way to what is known as “lawful but awful trade" which is believed to be a common issue with these permit structures when enforced and handled by corrupt governments. (Dumenu, 2019)

While there is relatively little literature specifically about the illegal rosewood trade, a market that has many similarities and garners much more international attention is the ivory market. This trade has received much more attention because of the alarmingly rapid decline in population and the inherently cruel methods of ivory harvesting. While the two commodities are quite different in their harvest and nature, they are both regulated by CITES and share similar market characteristics. Therefore, it stands to reason that a great deal of insight on the structure and incentives of the rosewood market can be gained from the existing literature surrounding the ivory trade.

A paper by Michael Burton explored the market incentives and responses of poachers in the ivory market. The ivory market was banned for many years up until 1997 when a few African countries successfully argued that they receive a quota restriction since they had demonstrated an ability to curtail illegal activity. Burton and other writers of the time noted that this creates a natural experiment to explore the effectiveness of a ban versus a quota restricted market. (Burton, 1999)

While many previous writers had attempted to determine effectiveness using traditional statistical analysis, Burton highlighted the lack of insight that these assessments provided because of the small number of observations and the skewing of report data due to an increase in the amount of patrolling. These studies often found that bans had an adverse impact on the population of elephants, which is unlikely to be the case because of the aforementioned skewing of the data. Because of these data constraints, Burton decided to expand upon previous efforts to construct a model of profit maximization for poachers to determine the incentives of this market using the best available data. He argued that this method provided more useful insight to guide regulation in the future. (Burton, 1999)

The model was built by linking the price of ivory to the number of trips a firm (poacher) would take in a season and using the assumption that gangs would join until there is no profit. The costs in this model were counted as the possibility of getting fined and a technology factor was added in to account for the improvement of guns and other hunting equipment. The data was derived from the firsthand experience of scientists that had previously attempted to construct a profit maximizing equation for poachers. The assessment found that the equilibrium elephant mortality rate was 91.9% with a linear production function and 97.9% with a non-linear production function. When the elasticities were derived for the firms and the market as a whole, it was found that elasticities for the firm were relatively high in response to the price of ivory and the size of the fine, but not in response to the wage (output/trips). (Burton,1999)

The conclusion notes that this model signals that a weakly enforced ban has little impact on the amount of poaching and that any slippage results in a large incentive for poachers to harvest ivory. (Burton, 1999) One could hypothesize that the response to wage is less pertinent since the countries that have a large issue with poaching tend to have less stable employment opportunities with large amounts of the population living beneath the global poverty line. Because guaranteed work is hard to come by, the potential for profit is weighed more heavily than the wage. This is represented by the more elastic response to ivory prices and fine amounts.

Because Burton's paper examines a ban market regulated by CITES in countries similar to Madagascar, the findings can be used to inform research on the Malagasy rosewood trade. The findings of Burton's paper are particularly pertinent to illegal logging in Madagascar because rosewood loggers are operating under a ban CITES ban after the year 2013. (Vyawahare, 2019)

The inclusion of this paper in the literature review serves to establish the market forces that drive illegal loggers to harvest rosewood in Madagascar.

With all these findings established, the goal of this paper is to assess the efficacy of CITES trade restrictions on Malagasy rosewood. This would serve as a continuation and extension of the type of work Dumenu did in his analysis to see whether his results hold on a more global level. Additionally, since the rosewood market in Madagascar is operating under a ban, this study could provide insight as to whether a total ban could be more effective in curtailing illegal activity than a permit system. This paper will also utilize different estimating techniques to assess illegal logging and the policies used to curtail this activity that could greatly decrease the amount of time required to collect data for future studies on different countries.

## Data

Perhaps the hardest part of this paper is finding a way to somehow quantify illegal activity. There is no definitive source on any sort of illicit behavior because, by its very nature, it goes unreported. While there are many ways to proxy for illegal logging, as exemplified in the Dumenu paper, the analysis in this paper will use satellite data that measures deforestation. The dataset used is known as the Matt Hansen Global deforestation dataset and has been used for many other projects of a similar nature. This data comes from the University of Maryland's department of geographical services and the deforestation figure is measured as the disappearance of tree cover from year to year by satellite imagery. (University of Maryland, 2020) Although this is not a perfect measure to assess the logging of rosewood trees specifically, the amount of rosewood on the island and previous research suggest that the total deforestation figure should be highly correlated with the extraction of rosewood logs. (Patel, 2007)

This method offers a novel approach to the issue of tracking illegal rosewood harvesting from year to year. Some previous investigators have used data scraping methods to extrapolate information from seizure reports and others have used customs data to find discrepancies between export records from the source country and the import records at the final destination. While these two approaches have their advantages, they both suffer from well-hidden violations, corruption, and human error. (Ke, 2017) The satellite data analysis can be used to draw conclusions on a more global scale and with a different type of measurement that could serve to capture a different part of the story which has not been explored with previous research.

The dataset was analyzed using the Google Earth Engine Code Editor. The analysis began by confining the returned amount of forest loss to the island of Madagascar. Next, code was run to return a summary of the yearly forest loss on the island. Along with the deforestation data, the yearly price of vanilla bean was sourced and entered into an excel spreadsheet to explore another cause for the deforestation in Madagascar. This comprises all the data that was entered into R for the analysis which will be described in the proceeding section.

## Methods

The satellite data gathered from the Matt Hansen dataset provided yearly deforestation data for the years 2000-2020, resulting in twenty observations to use for analysis. Even before formal analysis in R, the graph of the raw deforestation data seems to indicate correlation with the implementation of the rosewood harvesting ban. In figure 1, a clear jump in deforestation can be seen in the year 2013 which was the year CITES restrictions were enacted for the island of Madagascar. After this initial spike, a new trend is established as deforestation continues to rise peaking in 2017, then returning to the previously established heightened level for the remainder of the observed period.

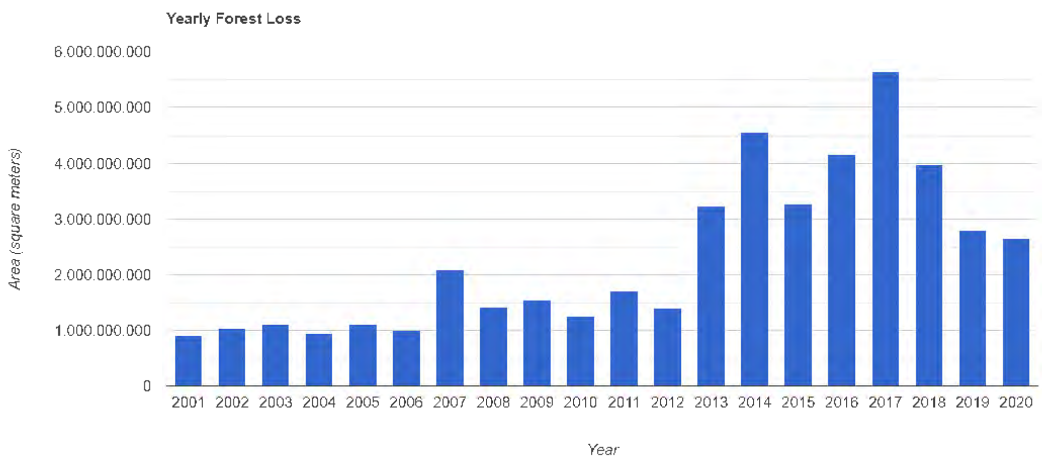


*Figure 1*

In order to formally test for any effect that can be associated with the new rosewood legislation, the data was loaded into R and analyzed using a series of regressions with different specifications. Due to the limited number of data points and the lack of panel data, very few regressors could be used to assess this issue while maintaining the validity of results.

The first specification uses only one variable to assess the data and estimates:

(S1) $$Y=\beta_0+\beta_1(Post)+\varepsilon$$

With *Y* representing the amount of yearly deforestation in Madagascar and *Post* being a simple categorical variable that returns False for years the ban was inactive (2001-2012) and true for the years the ban was active (2013-2020). This simplistic analysis measures $\beta_1$, which estimates the mean shift after the policy was enacted.

However, this first specification does not take into account any trends that were established before the policy was introduced. In order to account for these trends, a second specification was attempted which estimates:

(S2) $$Y = \beta_0 + \beta_1(Post) + \beta_2(\tau) + \varepsilon$$

This second specification includes the variable $\tau$, which is a linear time variable. This serves to represent the progression of time and account for trends established before the policy's introduction reflected in the data.

While the first two specifications estimate a mean shift in deforestation data, ostensibly resulting from the ban, they both do not assess trends established within the post period. This type of analysis can be important for policy assessment as it can take time for enforcement to take hold with certain systems. To incorporate this type of behavior into the estimation, results will be reported from a third specification that fits:

(S3) $$Y = \beta_0 + \beta_1(Post) + \beta_2(\tau) + \beta_3(Post*\tau) + \varepsilon$$

This third specification includes an interaction variable which estimates the effect of trends occurring after the policy is introduced. This would mean that the total effect associated with the implementation of the CITES rosewood restriction policy would be measured by $\beta_1 + x\beta_3$. (x being the number of years after the ban is introduced for the period being analyzed)

With this type of analysis however, it is also important to consider alternative explanations as to why the dependent variable could shift. Madagascar is well known for the production of vanilla. Just a few years ago, more than 70% of the world's vanilla came from Madagascar and, due to supply difficulties, the price of vanilla skyrocketed to rival the price of silver. While the rosewood harvesting and vanilla producing industries are tied together by their management, vanilla has been cited as one of the reasons for rampant deforestation in Madagascar. (Sharife, 2018) For this reason, data on the price of raw vanilla bean was sourced. Unfortunately, data on vanilla prices could only be sourced for the years 2010-2020. (Wamucii, 2020) As such, the analysis had to be shrunk to only include 11 observations which greatly limits the amount of regressors that can be used.

The fourth specification attempted to use all of the previously used variables in addition to the price of raw vanilla to estimate the effect associated with the introduction of the CITES rosewood policy. This fourth regression fits:

(S4) $$Y = \beta_0 + \beta_1(Post) + \beta_2(\tau) + \beta_3(Post^*\tau) + \beta_4(Vanilla\ Price) + \varepsilon$$

Since, in some circumstances, market incentives can take time to affect change in the economy, a fifth specification was estimated that instead uses the price of vanilla lagged by one period (one year) and fits:

(S5) $$Y = \beta_0 + \beta_1(Post) + \beta_2(\tau) + \beta_3(Post^*\tau) + \beta_5(Vanilla\ Price\ lagged) + \varepsilon$$

Results

Yearly Forest Cover Lossage in Square Meters

| | **S1** | **S2** | **S3** | **S4** | **S5** |
|---|---|---|---|---|---|
| $B_1$ (Post) | 2.497e9*** | 2.275e9** | 2.483e9*** | 8.337e8 | 3.607e9 |
| $B_2$ (t) | | 2.216e7 | 6.063e7 | 6.641e8 | -5.317e8 |
| $B_3$ (Post*t) | | | -1.695e8 | -6.029e8 | 4.328e8 |
| $B_4$ (Vanilla Price) | | | | 7.224e6 | |
| $B_5$ (Lag Vanilla Price) | | | | | 2.804e6 |
| **Adjusted $R^2$** | .769 | .758 | .772 | .554 | .264 |

R Studio Code can be found in the appendix

***Significant at the 1% level

**Significant at the 5% level

*Significant at the 10% level

The results reflect phenomena similar to those found in the Dumenu paper. It can be seen that in all specifications the post variable is associated with a large increase in deforestation and is reported statistically significant in the first three regressions. While this statistical significance does not continue through the final two specifications, this can in part be attributed to the lack of observations and increased amount of regressors. The specification reported to have the highest explaining power is the third one, as it has an adjusted $R^2$ of .772. This regression estimates the *Post* coefficient significant at the 1% level. Because this model estimates the total effect of the export ban by calculating $B_1$+x$B_3$, the policy is associated with an increase of the annual deforestation figure by 1649.5 kilometers squared when looking at the ban 5 years after implementation.

Another interesting finding from this analysis is that the price of vanilla is reported to have little predicting power for the amount of tree cover lost. Many have speculated that a great deal of deforestation in Madagascar is a result of the high prices of vanilla driving farmers to clear land to produce more. (Carver, 2020) The lack of data may be skewing the results. To test if it was only the added regressor weakening the predicting power of the analysis, the variables from the third specification were ran on the limited dataset with only 11 observations. The adjusted $R^2$ was considerably lower (at a value of .504) than the first attempt labeled as S3 which utilized the larger dataset. This suggests that there could be more validity to the vanilla regressors than is being revealed by the model due to a lack of data.

The only figure that resulted from this analysis that seems to contradict the intuition established in the Dumenu and Burton papers, is the coefficient for the interaction variable in the fifth specification. This estimation associated the interaction of the *Post* and τ variables with a substantial increase in deforestation. According to established logic, this figure is expected to be negative as it is for all the other specifications in which it is used. It is worth noting however, that the fifth specification has an adjusted $R^2$ of .264.

It must be stated that this analysis has many caveats that limit the strength and validity of all the coefficients reported. Perhaps the largest caveat to these findings is that the figure reported is not specific to the amount of rosewood logged, but that it is just a figure of total forest cover loss on the island. This does present an issue in that the figure being used to measure rosewood harvesting does not only measure the amount of rosewood logged, however the deforestation figure is also expected to be highly correlated with the amount of rosewood logged for reasons outside the blatantly obvious. Field research has shown that mass deforestation is symptomatic of rosewood harvesting. Research found that after loggers come in and harvest all the valuable timber, locals are more likely to completely level the forest because they see it as already damaged. They can then turn the land into a farm of some kind (likely for vanilla bean). Because of this phenomenon, mass deforestation has been viewed as symptomatic of rosewood poaching. (Patel, 2007)

## Conclusion

The results of the analysis for this paper are counterintuitive and alarming, but not altogether surprising given the previous research on this topic. While the findings are strikingly similar to the Dumenu paper, the implications are different because this paper is investigating a ban structure. Dumenu found that a permit system corresponded to a 129% increase in the amount of rosewood logged. (Dumenu, 2019) After averaging the totals in the periods prior and dividing the $B_1+5B_3$ (total impact associated with the ban 5 years after implementation) by this averaged yearly value of deforestation for the prior periods, the ban was found to increase yearly deforestation by approximately 127.6%. This suggests that a ban is not much more effective than a permit system at preventing deforestation and the harvesting of rosewood. Interestingly, these findings resemble the ones found in Burton's paper on ivory poaching. Burton's paper found that any slippage in the ivory ban market structure would result in high incentives for poachers thereby decreasing the impact of a ban versus a permit structure. (Burton,1999) This research has found that a similar phenomenon can be observed in the market for rosewood.

This does pose some questions as to how poachers and corrupt government officials are getting away with operating within a ban if CITES is supposed to be monitoring the situation. Many have hypothesized how Madagascar prevents CITES from gathering evidence on poaching activities. One theory that has been corroborated by field investigation is that government stockpiles are used as fences to transport freshly harvested logs. After the ban was enacted in 2013, government and private stockpiles of rosewood were formed. These stocks are not to be sold, just guarded to prevent market incentives and yet another way to sell illegal timber. What happens in practice though, is that the logs are sold and replaced with freshly harvested ones. This maintains the amount of stock each location is supposed to have while selling the older wood that would otherwise rot if not sold on the market. (Vyawahare, 2022) Other poachers simply use their own shipping networks to move freshly harvested rosewood off the island. This is rather easily done as the smugglers are well connected and Madagascar's budget for enforcement is incredibly low. Most shipping containers holding rosewood are labeled as vanilla to disguise the valuable timber until it reaches another country. (Sharife, 2018) After that point it is as simple as labeling the cargo as generic rosewood to ship it to the desired final destination. (Sharife, 2018) The relabeling Madagascar Rosewood as generic rosewood was a loophole that was closed in 2017 with the introduction of a permit system for all other species of rosewood. (Malagasy rosewood is still subject to a CITES export ban) Since then, Smugglers have had to find alternative ways to ship their goods to buyers.

These qualitative investigations reflect that subverting a permit market is very similar to the methods used to operate during a ban. In fact, after further consideration, a CITES ban may make things easier. Because a ban does not require the enforcing of permits for each tree, patrols are reduced since all rosewood has to travel through a port which should hypothetically already be monitored. This is the reasoning behind many activists advocating for a ban. Developing countries with lower budgets can focus enforcement money on more controlled areas making it more cost effective and likely to be more successful. (Burton, 1999) However, under CITES implementation, the countries themselves manage enforcement making the existence of corruption even more likely because many government officials were already involved with the rosewood trade. The ban also removes the CITES oversight that is involved with the permit system.

In conclusion, the analysis of this paper found that the CITES Madagascar Rosewood ban is associated with an increased amount of deforestation on the island which was used as a proxy for the harvesting of rosewood. The implications of these results suggest that a ban is not much more effective than a permit system under the CITES model and that increased legislation may in fact have a negative impact on the wellbeing of forests.

## Appendix

R code for the dataset with 20 observations

```
#Creating post CITES groups
df$Post<-df$Year>2012
#Regression 1 (Post)
```

**S1**

```
Reg1<-lm(df$Forest_Loss_sqm~df$Post)
summary(Reg1)
#Regression 2 (Post+Tau)
```

**S2**

```
Reg2<-lm(df$Forest_Loss_sqm~df$Post+df$t)
summary(Reg2)
#Regression 3 (Post+Tau+Post*Tau)
```

**S3**

```
df$PT<-df$Post*df$t
str(df)
Reg3<-lm(df$Forest_Loss_sqm~df$Post+df$t+df$PT)
summary(Reg3)
```

R code for the dataset with 11 observations

```
#Creating post CITES groups
df$Post<-df$Year>2012
#Regression 1 (Post)
Reg1<-lm(df$Forest_Loss_sqm~df$Post)
summary(Reg1)
#Regression 2 (Post+Tau)
Reg2<-lm(df$Forest_Loss_sqm~df$Post+df$t)
summary(Reg2)
#Regression 3 (Post+Tau+Post*Tau)
df$PT<-df$Policy*df$t
str(df)
Reg3<-lm(df$Forest_Loss_sqm~df$Post+df$t+df$PT)
summary(Reg3)
#Regression 4 (Post+Tau+Post*Tau+Vanilla Price)
Reg4<-lm(df$Forest_Loss_sqm~df$Post+df$t+df$PT+df$Vanilla_Price)
summary(Reg4)
#Creating lagged Vanilla Variable
library(dplyr)
df$lagVP<-lag(df$Vanilla_Price, 1)
#Regression 5 (Post+Tau+Post*Tau+lag Vanilla Price)
Reg5<-lm(df$Forest_Loss_sqm~df$Post+df$t+df$PT+df$lagVP)
summary(Reg5)
```

S4

S5

# References


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