Canadian Journal of Forest Research
Revue canadienne de recherche forestière

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Journal:	<i>Canadian Journal of Forest Research</i>
Manuscript ID	cjfr-2015-0163.R1
Manuscript Type:	Article
Date Submitted by the Author:	06-Aug-2015
Complete List of Authors:	Lu, Ziyi; University of Washington Ganguly, Indroneil; University of Washington Eastin, Ivan; University of Washington
Keyword:	zero inflated model, Lacey Act, Trade Legislation, Wood products' trade, US-China Trade

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**A Categorical Modeling Approach to Analyzing the Impacts of the Lacey Act
2008 Amendment on Chinese Companies’ Export Cost and the Implications on
Their Sourcing Behaviors**

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Abstract

The US Lacey Act 2008 Amendment (LAA) is a timber legality regulation which requires US importers to monitor and minimize the risk of illegally harvested wood products within their supply chains. This paper empirically examines the effect of the LAA on Chinese companies' export costs to the US. The study uses 138 responses from two surveys in Shanghai, China in 2013, 5 years after the LAA was implemented. Given the high proportion of zero export increase indicated by the Chinese companies, a zero-inflated ordered-probit model was used to model Chinese companies' export cost increases to the US. The research results demonstrate that pre-LAA raw material sourcing patterns are primary indicators of the respondents' export cost increase to the US as a result of the LAA. From the results it can be inferred that log and lumber importers from suspect regions are taking additional measures, by changing their procurement practices, to ensure the legality of their raw material which is adding to their cost structure. The results also indicate that smaller companies, given their flexibility with raw material procurement, were less likely to experience a post-LAA cost increase relative to their larger counterparts.

Key words: Lacey Act, Zero Inflated Model, Trade Legislation, Wood products' trade, US-China Trade, Environmental Legislation

Introduction

Illegal logging is a prevalent problem that threatens forest conservation around the world, and thus has come into the spotlight of global forest policy. The problem of illegal logging is especially severe in temperate countries such as China and Russia, that both supply and process wood, as well as in tropical countries (Contreras-Hermosilla et al. 2007). However, the role of consumer countries cannot to be ignored as the demand for wood products in these countries increases the incentives for illegal logging in high-risk countries (Duncan 2005). Recent years have seen a growing familiarity with the issues of illegal logging and the responsibility of consumer countries in helping to develop a solution to illegal logging (Fripp 2006).

The US Lacey Act 2008 Amendment (LAA) was the first and remains one of the most important timber legality regulations because it requires US importers to monitor and minimize the risk of illegally harvested wood products within their supply chains. The LAA was the world's first ban on the trade of illegal wood, a precedent in the fight to eliminate the trade of illegally-harvested wood and wood products (EIA 2009). The LAA was designed to eliminate imports of illegally-harvested wood products and requires that importers document the foreign sources of wood-based products (Wang et al. 2010). US companies are required to practice "due care" under the LAA in order to guard against liability (EIA 2010); although it is important to note that it is the responsibility of the US Government to enforce the LAA. Failure to comply with the LAA can result in civil administrative penalties, forfeiture of the imported goods, criminal fines, or imprisonment. As one of the major importers of forest products in the world, most of the efforts that the US has taken to tackle illegal logging and deforestation are related to the

implementation of the LAA (Lawson and McFaul 2010). Inspired by the LAA and its ability to cover all countries simultaneously, the EU Council and Parliament adopted the “EU Timber Regulation” in 2010, which also requires importers to avoid illegal timber (Cashore and Stone 2012).

Most of the previous studies assessing the impacts of the LAA on trade flows at the macro level have acknowledged the positive effects of the Lacey Act on curbing illegal logging (Bridgam 2014; Gan et al. 2013; Prestemon 2015). This paper employs a micro-level analysis and explores the impacts of the LAA on exporting companies in China, the largest supplier of wooden furniture and flooring in the world and the second largest exporter of wood products to the US. China is in the world’s spotlight regarding its impact on forests and forest industries globally given its role as the largest importer and exporter of wood products in the world (White et al. 2006). China’s furniture and flooring industry is heavily dependent on imported logs and lumber as a raw material input (Ganguly and Eastin 2011). Moreover, China is the largest purchaser of illegal wood from many of the countries that have been affected by the scourge of illegal, and most of China’s wood product manufacturers source their wood materials from countries where illegal harvesting and other legal violations have been well documented (Gregg and Porges 2008). As a result, there are potential risks that wood products manufactured in China might be manufactured in part or wholly from illegally harvested wood, which is addressed by the LAA as a trade measure.

Given the large volume of trade in wood products between China and the United States, the LAA plays an important role in the flow of wood products between these two countries. This paper is interested in investigating the effect of the LAA on Chinese companies’

international competitiveness by examining its impact on Chinese companies' export costs. Although the LAA does not intend to increase the cost of exports, it requires Chinese companies to do more paperwork in order to keep track of and declare the species, quantity, value, and origin of wood used in their products (as required in the Plant Product Declaration Form 505). These additional documentation requirements are burdensome and can impose substantial costs on companies, particularly small-sized firms (Cashore and Stone 2012; Tanczos 2011).

The LAA may create a strong incentive for Chinese companies exporting to the US to reduce additional paperwork by importing wood raw materials from legal sources (e.g., the US, Canada, the EU and other lower-risk/non-suspect countries) (Wang et al. 2010). Strong international competition leads to a heightened cost sensitivity by exporters (Carlin et al. 2001) and purchasing legal wood products is likely to be more expensive than their illegal alternatives (Tacconi 2007), potentially adding to export costs. Some literature indicates that the LAA has impacted the forest-product trade between China and the US by raising production and export costs for Chinese companies, thereby reducing the Chinese companies' international competitiveness (Wu et al. 2009).

The objective of this research is to empirically verify whether Chinese companies' export costs to the US have increased because of the LAA, and to identify the impact of the LAA on the material sourcing behavior and other specific characteristics of Chinese companies that may cause or contribute to an export cost increase. Three research questions are addressed: (i) has the LAA resulted in a cost increase for Chinese wood exporters, (ii) if so, what type of sourcing activities have contributed to the export cost increase, and (iii) what are the characteristics of the companies that reported export cost increases?

Methods

Survey and Data Preparation

Data for this study was collected using a structured questionnaire administered at two trade shows in Shanghai, China. The first trade show was the DOMOTEX Asia/CHINAFLOOR Show in March 2013, and the second was the FMC China (Furniture Manufacturing & Supply China) trade show in September 2013. There were 40,000 visitors and 1,100 exhibitors in the DOMOTEX Asia/CHINAFLOOR 2013 Show, and 33,834 visitors and 790 exhibitors in the FMC China 2013 Show. These shows were selected for the survey because they are the largest wood flooring and wood furniture trade shows in China. The DOMOTEX Asia/CHINAFLOOR is the largest international flooring trade exhibition in the Asia-Pacific region (China Exhibition 2013). FMC China is the third largest furniture show in the world and the leading furniture trade show in China (10times 2013). The convenience sampling method was adopted for the surveys as it is a cost effective way to survey a readily available target population (Greene 1981). Given the sampling method adopted, the selection of survey venue is critical for ensuring the representativeness of the target population. Hence, the selection of the two most influential international wood furniture/flooring trade shows in China ensured strong industry representation from the dominant wood products manufacturing and trading regions of the country.

A total of 226 valid questionnaires were collected, 106 from the DOMOTEX Asia/CHINAFLOOR show, and 120 from FMC China show, representing respondents from 20 out of 34 provinces and regions in China. Moreover, the survey had high representation from all of the five forest-product manufacturing centers in China (China wood group Co., Ltd 2014), located in (i) the Pearl River region, (ii) the Yangtze River region, (iii) the Bohai Sea region, (v)

the Northeastern region, and (v) the Southwestern region. Out of 172 respondents who indicated that they were aware of the LAA, 154 responded to the question of whether they have had an export cost increase due to the LAA. We deleted another 16 respondents who have no sales to the US market, as this study aims at examining the direct impacts of the LAA on the companies who have sales to the US. This resulted in a total of 138 valid responses, of which 47 (34%) respondents reported that they did not have an export cost increase.

The companies who indicated nonzero export cost increases were then asked to estimate the percentage of their export cost increase as a result of the LAA. The answers to this question displayed a high proportion of responses that were multiples of 5%. Such rounding suggests that the percentage values indicated by most of the respondents are likely to be approximate values. Hence, instead of using the actual percentage values, the percentage-increase variable of the export cost was monotonically transferred into four ordinal levels of export cost increases (Winship and Mare 1984) as was used in Ganguly et al. (2010). The four categories, or levels, of the export cost increases were: 1) no increase with a variable value equal to 0; 2) small cost increase (between >0 and $\leq 5\%$) with a variable value equal to 1; 3) moderate cost increase ($>5\%$ and $\leq 10\%$) with a variable value equal to 2; and 4) large cost increase ($>10\%$) with a variable value equal to 3.

In the survey, inquiries about the companies' sourcing regions included Russia, the US, Canada, Southeast Asia, Africa, the European Union (EU), Latin America and China. These 8 regions are mutually exclusive and respondents were asked whether they had sourced wood from these regions. For modeling purposes, an exploratory factor analysis was conducted to reduce the dimensions of the data and to eliminate the multi-collinearities among the regional

procurement variables (Lattin et al. 2003). The Kaiser stopping criterion is used to decide how many factors to extract based on all factors with eigenvalues greater than 1 (Kaiser 1958). Varimax rotation was used to facilitate the interpretation of the factor analysis results by maximizing the sum of the variances of the squared loadings, or the squared correlations between variables and factors (Abdi 2003), Table 1. Finally an orthogonal solution is obtained by varimax rotation as new variables for regression. The factor analysis reduced the original 8 regions to 3. The first group is composed of the US, Canada, EU, and Russia. These countries are in temperate regions dominated by temperate softwood, and thus form the “sourcing from temperate regions” group. The second group is composed of Southeast Asia, Latin America and Africa. These countries are in the tropical regions dominated by tropical hardwood, and thus form the “sourcing from tropical regions” group. The third group is composed only of China, and is called the “sourcing from local China” group. Companies who are required to change their sourcing region may experience an increase in the cost of raw material imports as a result of LAA compliance (Wang et al. 2010; Prestemon 2015).

For the three groups identified, the factor scores were obtained as composite variables which provide information about an individual’s placement on the factor as well as being used as variables in subsequent modeling (DiStefano et al. 2009). The factor scores are standardized results, so the new variables for “sourcing from temperate regions,” “sourcing from tropical regions” and “sourcing from local China” range from -3 to 3 with a mean of 0. A high value for a factor score means that the respondent possesses multiple sources from the sourcing group, and a low value indicates single or no sourcing from that group.

Zero Inflated Ordered Probit (ZIOP) model specification

With regards to the sourcing activities associated with the Chinese companies’ export cost increase, this study explores the Chinese companies’ raw material sourcing patterns since the introduction of LAA, and the impact of any changes in these sourcing patterns on their export costs. The two specific aspects of raw material sourcing considered in the models are: (i) the respondents’ use of chain-of-custody (CoC) certification for material sourcing, and (ii) the respondents’ sourcing of raw material from different regions of the world. The corresponding independent variables are obtained from the survey and are presented in table 2.

In China, certification favored by timber legality legislation such as the LAA is increasingly seen as a means to protect the timber processing industry’s position within the global market (Putzel 2009). The implementation of the LAA is likely to encourage the spread of private certification and legality verification systems (Brack and Buckrell 2011). In addition, the illegal logging issues and associated trade are highly suspicious in tropical areas (Glastra 1999), and tropical hardwood receives the most attention with respect to illegal activity (Seneca Creek 2004). The LAA seeks to discourage the trade in illegally harvested wood and may indirectly affect imports from suspect countries (Prestemon 2015) particularly those in tropical regions. At the same time, there is a very low risk of US hardwoods and softwoods being derived from illegal or controversial sources (Goetzl and Ekström 2007). To export finished wood products to the US market, Chinese companies may be encouraged by the LAA to import wood raw materials from the US and other reliable and low-risk sources (Wang et al. 2010). Given this situation, the model seeks to discover the impacts of the Chinese companies’ adoption of CoC certification, as well as changes in their supply chains, on their export costs.

With regards to the characteristics of the companies that reported export cost increases, the model takes into account the Chinese companies' familiarity with the LAA, company size, and industry type: wood flooring versus wood furniture (table 2). We assume that the companies' familiarity with the LAA may affect their export costs. The company's size and industry type are factors that are frequently analyzed in the business field as well as in the forest product marketing research. Previous research indicates that under market pressure, small and mid-sized manufacturing enterprises (SMEs) are not motivated to undertake voluntary actions for the benefit of wider stakeholders and society, so regulations have a vital part to play in improving the environmental and social practices of SMEs; SMEs will generally try to comply with, but not go beyond, environmental regulations (Williamson et al. 2006). Previous general business research also reveals that inducing firms to adopt corporate environmentalism requires the use of different agents of influence according to industry type; where the industry type moderates the influences of public concern, regulations, and competitive advantages on top managers (Banerjee et al. 2003).

In this research the dependent variable, Chinese companies' export cost increase due to the LAA, is grouped into four levels indicating the extent of the Chinese companies export cost increase to the US (Table 2). In the case of ordinal variables, the categories are ranked in an increasing/decreasing order, however, the relative distances between adjacent categories are unknown (Long 1997). Accordingly, the classical regression approach assuming a scalar dependent variable is not appropriate for categorical dependent variable (Liao 1994). This study first employs an ordinal probit modeling approach for estimating the relationship between the ordinal and discrete dependent variable and the independent variables previously described.

For a standard ordered probit model, a single latent variable, y^* , ranging from $-\infty$ to ∞ is mapped to an observed variable y (Long 1997).

$$\begin{aligned} (1) \quad & y_i = m \text{ if } \mu_{m-1} \leq y_i^* < \mu_m \text{ for } m=1 \text{ to } j \\ (2) \quad & y_i^* = \beta'x_i + \varepsilon_i, i = 1, 2, \dots, n \end{aligned}$$

Where, the μ 's are the thresholds or cutpoints between the categories and j is the total number of categories for the ordinal variable. For each observation i , y_i^* is the latent-response variable of interest, x_i is a vector of the independent variables, β' is a vector of parameters, ε_i is a random disturbance term, and y_i^* is unobserved and is considered as the underlying tendency of the observed phenomenon y_i . We assume that ε_i follows a normal distribution with zero mean in the probit modeling approach.

In addition, the discrete ordered dependent variable has another distinguishing feature in that 47 (34%) of 138 respondents indicated that they did not observe a cost increase, which suggests that there may be an “excessive” number of zero observations. Failure to account for the extra zeros may result in biased parameter estimates and misleading inferences (Lee et al. 2006). In addition, these “excessive” zero observations of the dependent variable may be driven by two different systems of individual behavior. Hence, to address the econometric issues in which the dependent variable is characterized by excessive zeros related to two distinct data generating processes, a zero-inflated model is suggested in the literature (Greene 1994). In this research, the zero-inflated ordered probit model is used as a comparison with the standard ordered probit model to investigate the Chinese companies’ export cost increase under the context of the LAA.

Since its enactment in 2007, the LAA has only been enforced twice: two individual cases against the Gibson Guitar Corporation concerning the import of ebony wood from India and Madagascar (Pryce 2012), and the seizure of Peruvian hardwood from the Amazon (Nogueron and Hanson, 2010). While the LAA imposes severe penalties on companies caught importing illegally harvested wood, it doesn't necessarily detect or eradicate all illegally sourced wood from the supply chain. Some companies that are not sourcing completely legally may not be impacted by the LAA or suffer from an export cost increase. Therefore, the first type of zero cost increase would be reported by companies who have always had legal sourcing and are thus unaffected by the LAA. Specifically in case of a cost increase associated with the LAA, companies who are stochastically associated with the first type of zero, in a zero-inflated model, form a cohesive group and are not likely to report a LAA-related increase in their export cost under a different condition. The model stochastically assigns some respondents who have reported no increase in their export cost to the second group, because their characteristics align with the non-zero responders, and they are statistically more likely to report an increase in their export cost under a different situation or in the near future. In other words, companies who are assigned to the second type of zero group exhibit characteristics similar to other companies who reported experiencing an actual export cost increase.

The zero-inflated ordered probit model (ZIOP) is an extension of the standard ordered probit model, with an ordinal-probit equation nested within a splitting-probit equation (Harris and Zhao 2007). The ZIOP model involves a system of a probit "splitting" model and an OP model which relate to potentially differing sets of covariates. This model splits the observations into two regimes so that the Chinese companies in this research are modeled as overcoming

two hurdles: whether their export costs have increased or not, and then, conditional on the situation of increased export cost, the levels of the export cost increase. Companies who have no export cost increase fall into Regime 0, and companies who have an export cost increase (actual and potential) fall into Regime 1. The split between Regime 0 and Regime 1 is indicated by r , where $r=0$ indicates zero export cost increase (regime 0), and $r=1$ indicated an actual or potential export cost increase (regime 1). Within Regime 1 (where $r=1$), export cost increase levels are represented by $\hat{y}$ (in this case $\hat{y} = 0, 1, 2 \text{ and } 3$). Note that, importantly, Regime 1 also allows for a zero export cost increase as might be indicated by companies who are in the process of transitioning towards legal sourcing and thus may be incurring a potential export cost increase. Though variables r and $\hat{y}$ are not individually observable, they can be observed through the variable y . For ZIOP, the relationship between the observed variable y_i and the latent variable $\hat{y}_i^*$ and r_i^* can be stated as follows:

(3)
$$y_i = r_i \times \hat{y}_i^* = \begin{cases} 0 & \text{if } r_i^* \leq 0 \text{ or } r_i^* > 0, \hat{y}_i^* \leq 0 \\ 1 & \text{if } r_i^* > 0 \text{ and } 0 < \hat{y}_i^* \leq \hat{\mu}_1 \\ 2 & \text{if } r_i^* > 0 \text{ and } \hat{\mu}_1 < \hat{y}_i^* \leq \hat{\mu}_2 \\ 3 & \text{if } r_i^* > 0 \text{ and } \hat{\mu}_2 < \hat{y}_i^* \end{cases}$$

The ultimate data-generating process here can be seen as coming from two separate underlying latent variables. The underlying function r is generated by a splitting probit model through the underlying latent function r^* , and $\hat{y}$ is generated by an ordinal-probit model through the underlying function $\hat{y}^*$ as follows:

(4)
$$r_i^* = \alpha'v_i + \varepsilon_{1i}$$

(5)
$$\hat{y}_i^* = \gamma z_i + \varepsilon_{2i}$$

Where,

v_i is a vector of predictor variables that determines the choice of zero-category regime

272 z_i is a vector of explanatory variables for determining the levels of export cost increase

273 α' is a vector of unknown coefficients for vector v

274 γ is a vector of unknown coefficients for vector z .

275 Equation (3) can be translated to a set of probability functions in the following form:

$$(6) \quad Pr_j = \begin{cases} Pr(\hat{y} = 0 | z, v) = Pr(r = 0 | v) + Pr(r = 1) Pr(\hat{y} = 0 | z, r = 1) \\ Pr(\hat{y} = 1 | z, v) = Pr(r = 1 | v) Pr(\hat{y} = 1 | z, r = 1) \\ Pr(\hat{y} = 2 | z, v) = Pr(r = 1 | v) Pr(\hat{y} = 2 | z, r = 1) \\ Pr(\hat{y} = 3 | z, v) = Pr(r = 1 | v) Pr(\hat{y} = 3 | z, r = 1) \end{cases}$$

$$= \begin{cases} Pr(\hat{y} = 0 | z, v) = [1 - \phi(-v'\alpha)] + \phi(v'\alpha)\phi(-z'\gamma) \\ Pr(\hat{y} = 1 | z, v) = \phi(-v'\alpha)[\phi(\hat{\mu}_1 - z'\gamma) - \phi(-z'\gamma)] \\ Pr(\hat{y} = 2 | z, v) = \phi(-v'\alpha)[\phi(\hat{\mu}_2 - z'\gamma) - \phi(\hat{\mu}_1 - z'\gamma)] \\ Pr(\hat{y} = 3 | z, v) = \phi(-v'\alpha)[1 - \phi(\hat{\mu}_2 - z'\gamma)] \end{cases}$$

276 In this way, the probability of a zero observation has been “inflated” as it is a combination
277 of the probability of “zero export-cost-increase” companies from the OP process plus the
278 probability of “unaffected” companies from the splitting probit model.

279 Once the full set of probabilities has been specified and given an identically and
280 independently distributed (i.i.d) sample of size N from the population on (y_i, v_i, z_i) , $i=1, \dots, N$,
281 the parameters of the full model $(\beta', \Upsilon', \mu')'$ can be consistently and efficiently estimated using
282 maximum likelihood (ML) criteria, yielding asymptotically normally distributed maximum
283 likelihood estimates (MLEs). The log likelihood function is

$$(7) \quad \iota(\theta) = \sum_{i=1}^N \sum_{j=0}^J h_{ij} \ln[Pr(y_i = j | v_i, z_i, \theta)]$$

284 Where the indicator function h_{ij} is

$$(8) \quad h_{ij} = \begin{cases} 1 & \text{if the company has an export cost increase, and the increase level is category } j \\ 0 & \text{if the company is unaffected} \end{cases} \quad (i = 1, 2, \dots, N; j = 1, 2, \dots, J).$$

Model Selection and Evaluation

The log-likelihood function above is maximized to provide model estimates with discrete dependent variables. The maximized value of the log-likelihood function of the full model is the direct and primary indicator of the model's fit (Greene 2002). However, the zero-inflated probit model used in this study incorporates complexity in terms of the number of covariates in the modeling process, which is also an important criterion when comparing the maximized log-likelihood values of the competing models. Various information criteria are used in this study for comparing and selecting the best approximating model among the competing models. Akaike's entropic information criterion (AIC) has had a fundamental impact in statistical model evaluation problems (Bozdogan 1987). The corrected AIC (AICc) method provides a greater penalty for extra parameters, thus providing substantially better selection than AIC (Burnham and Anderson 2002). The Bayesian information criterion (BIC) has become a popular method of model selection in sociological research (Weakliem 1999). While AIC represents the approach of information-theoretic selection based on Kullback-Leibler (K-L) information loss, the BIC represents the other well-known approach of Bayesian model selection based on Bayes factors (Burnham and Anderson 2004). The AIC, AICc and BIC are used in this study for selecting the best approximating model and inferences are drawn using the most appropriate model.

The Vuong test is a hypothesis testing approach for the selection between nested and non-nested models (Vuong 1989). In this study, the Vuong test is used to test the zero-inflated model against its non-zero-inflated counterpart, the standard ordered probit model (Greene 2002). Vuong's test can be described as a suitably normalized version of the log-likelihood ratio test. Hence, if Vuong's test-statistic is greater than 1.96, the ZIOP is considered a better approximating model than the ordinal probit; whereas, if Vuong's test-statistic is less than –

1.96, and the ordinal probit is a better approximating model than ZIOP, at the 95% confidence level. If the test-statistic lies between -1.96 and 1.96 , then the models are not statistically distinguishable from each other (Ganguly et al. 2010).

For the purpose of interpretation, the estimated model coefficients are translated into probability values. The effect of each of the significant explanatory variables on the dependent variable is calculated by fixing the values of all other explanatory variables in the model at their respective means and varying the value of the explanatory variable under consideration (Ganguly et al. 2010). To obtain the bootstrapped estimates, 300 simulations were run using the variance–covariance matrix and the parameter estimates for the models. The simulation codes were programmed using R (the R Core Team 2005). To understand the precision of the estimated probability values, single standard-deviation zones, representing 68% confidence intervals (CI), are shown around the estimated probability curves.

Results and Discussions

The sample used for the study consists of 138 respondents from Chinese wood flooring and wood furniture manufacturers. All 138 respondents indicated that they were aware of the LAA and have direct exports to the United States. Of the total respondents, 47 (34%) respondents indicated that they had no export cost increase due to the LAA. Twenty five (18%) respondents indicate that their export cost increase was smaller than 5%, while 36 (26%) respondents indicated that they had a moderate export cost increase of between 5% and 10% and 30 (22%) respondents indicated that their exports increased by more than 10%. The respondents in the survey were located in 19 of the 34 administrative regions in China. The sample included 50 (36.2%) small companies, 41 (29.7%) medium companies and 47 (34.1%) large companies. A

total of 62 companies (44.9%) were furniture manufacturers and 43 (31.2%) were flooring manufacturers. The export cost increase of the respondents is modeled using ordinal-probit and zero-inflated ordinal-probit models. The evaluation results are presented in Tables 3 and 4 along with the coefficient estimates of each of the covariates, model selection, and evaluation criteria. All of the independent variables are entered twice in the zero-inflated model—once in the splitting section (splitting the zeros) and once in the ordered section. The estimated parameters in the splitting section indicate the role of the covariates in the companies' probability of having an export cost increase because of the LAA, whereas the parameters in the ordered section of the model indicate the role these covariates play in the levels of the export cost increase, if any.

Modeling Results

The zero-inflated ordinal-probit (ZIOP) model estimates more parameters than the ordinal-probit (OP) model. Thus, the log-likelihood ratio test is biased towards the ZIOP model. However, the corrected Akaike information criteria (AICc) and the Bayesian information criteria (BIC) judge the models by comparing the proximity of the fitted parameter values to those of the true values while adjusting for the number of parameters estimated in the models. In this study, both the AICc and BIC tests favor the ZIOP model as an efficient estimator of the data relative to the OP model, because the BIC and AICc values of the ZIOP model were estimated to be lower than those of the OP model. Hence, the ZIOP model is favored over the OP model as a closer approximation of the 'true' model. It is worth noting that the BIC values of the ZIOP models are lower than that of the OP model by a difference of 38 for the full model and 35 for the best model, indicating strong evidence that the zero-inflated model has done a superior job

of predicting the companies' export cost increase patterns (Weakliem 1999). Further, Vuong's test also favored ZIOP as a better approximating model than OP with p-values less than 0.001, indicating that the nested version of the model (zero inflated model) is a better estimator than its non-nested counterpart (ordinal model). Hence, the zero inflated model was chosen as the model of choice for this study, and the remainder of the paper focuses on the parameter estimates of the ZIOP model. Further analysis is based on the final ZIOP model displayed in Table 4.

The full model (Table 3) includes all the variables of interest. The backward stepwise selection was conducted to find the most parsimonious model with the best AICc and BIC values for the ZIOP models. The independent variables "Industry (flooring versus furniture)," "Hardwood (%)" and "Domestic Sales (%)" were not found to be statistically significant and were not included in the final model (Table 4). The independent variables "Size of the Company," "LAA: Familiarity," "CoC Certified wood (%)" and "Sourcing from TEMPERATE/HD/Local Regions (5 years)" are significant in either the splitting or the ordered part of the final ZIOP model. The full model and the final model are robust with the consistent parameter estimates across the models (Table 3 and 4).

Effects of Sourcing Behaviors

The relationship between the Chinese companies' sourcing behaviors and their export cost increase due to the LAA is the fundamental question in this study. The research design of this study allows us to understand the Chinese companies' export cost increase in relationship to their sourcing behaviors from two distinctly different aspects: 1) the influence of the companies' sourcing behaviors on the export cost increase from a binary perspective by distinguishing

between companies that have an export cost increase and those that do not; and 2) the influence of the companies' sourcing behaviors on the various levels of export cost increase for companies that already have an export cost increase. In this study, the variables of the companies' "CoC Certified Wood %" and the companies sourcing regions such as "Sourcing from Temperate Regions," "Sourcing from Tropical Regions" and "Sourcing from Local China" are statistically significant in the final model results.

CoC sourcing: Chain-of-custody certification involves tracking the origin of forest products throughout the supply chain and documenting that products meet specific content requirements (Auld et al. 2008). The splitting section of the model indicates that the companies that source a higher amount of CoC certified wood were more likely to have an export cost increase, as evidenced by the significant estimated parameter for "CoC Certified Wood %" at the 95% confidence level. However, there is no evidence that the levels of the companies' export cost increase are associated with the companies' usage of CoC certified wood, with an insignificant parameter for "CoC Certified Wood %" in the ordered part. As can be observed in the first panel of Figure 1 (Panel 1.1), the probability of having a higher export cost increases as the companies utilize more CoC certified wood. This suggests that Chinese companies regard CoC certification as an extra export cost brought about by the LAA. Given the fact that the LAA is a fact-based rather than a document-based statute (EIA, 2010), the CoC certificates are neither proof of legality nor required by the LAA. However, documents such as CoC certificates contribute toward demonstrating due care in assessing legality. From the model results, it can be inferred that as a result of the LAA, Chinese companies tend to increase their use of CoC certification.

Sourcing from Temperate Regions: The results obtained for the role of “sourcing from temperate regions” show that both coefficients of this particular covariate in the splitting section and the ordered section are significant. However, the coefficient estimate for the splitting parameter is significantly negative while that of the ordered parameter is significantly positive (Table 4). This result indicates that the companies with more sourcing from temperate regions are less likely to have an export cost increase. However, among the companies that have indicated an export cost increase, those using multiple temperate sourcing regions are more likely to indicate a higher level of export cost increase than those using fewer temperate sourcing regions.

In Figure 2 the first panel (Panel 2.1) indicates that the respondents with no raw material sourcing from “temperate regions” are more likely to indicate a cost increase as a result of the LAA relative to companies with sourcing from temperate regions. The negative slope in the splitting section of the model (Panel 2.1) indicates that if a company has established sourcing routes from temperate regions they are less likely to be required to make any sourcing changes as a result of the LAA and therefore their export costs are less likely to increase.

Panel 2.2 represents the minority of the respondents that import raw material from temperate regions but who have reported having a cost increase. The steep positive slope of the ‘notable increase’ curve in this section indicates that respondents resorting to multiple sources within the temperate region have a higher likelihood of indicating a notable cost increase as a result of the LAA. This may be due to the fact that the importers need to ensure proper documentation from all their suppliers across multiple sourcing regions, which may add to their export costs.

Sourcing from Tropical Regions: For sourcing from tropical regions, there is a positive and significant coefficient estimate of “sourcing from tropical region” in the splitting section of the model. In Figure 3, Panel 3.1 shows that when companies have more sourcing from tropical regions they are more likely to have an export cost increase. Under the context of the LAA, sourcing from tropical regions is more likely to result in an export cost increase. This modeling result provides evidence that the LAA may be effective at discouraging imports from suspect countries.

Sourcing from China: In the case of “Sourcing from Local China,” there is no evidence that the Chinese companies’ sourcing from local China has an effect on their export cost increase in the splitting (increase versus no increase) section, as the estimated parameter is not significant (Table 4). However, the significant parameter for “Sourcing from Local China” in the ordered section of the model indicates that for companies who have already experienced an export cost increase, the levels of their export cost increase lessen with more sourcing from local China. In Fig. 4 Panel 4.2, the probability that the Chinese companies will have a notable export cost increase goes down when the companies increase their sourcing from China’s domestic market. This implies that sourcing from local China can help Chinese companies avoid a high level of export cost increase to the US which may reflect the convenience of acquiring document/paperwork and CoC certificates in China.

Effects of Companies’ Demographic Characteristics

Similar to the analysis of the companies’ sourcing behaviors, there are two possible ways of interpreting the companies’ export cost increases given certain characteristics of the companies: determining whether the characteristics of the companies tend to cause an export cost increase,

and whether these characteristics raise the level of the export cost increase. The predictor variable of the companies' characteristics is included twice in the model, first as a covariate in the splitting section of the model and second in the ordered part. The splitting section differentiates between companies who have an export cost increase and companies who do not based on their characteristics. The ordered part predicts levels of export cost increase influenced by the firm's characteristics. According to the model results presented in Table 4, the "size of the company" and "LAA Familiarity" both proved to be significant.

In the case of "Size of the Company," it can be observed that the coefficient estimate in the splitting section of the model is significantly ($p < 0.05$) positive. This indicates that larger companies are more likely to have an export cost increase. The parameter estimate for "Size of the Company" is not statistically significant in the ordered section of the model. This indicates that for companies who already have an export cost increase, companies of all sizes are equally likely to have an export cost increase at any level. Fig. 5 clearly demonstrates that smaller companies are more likely than big companies to have no export cost increase. This may be due to the fact that smaller companies have greater flexibility to adjust to the requirements of the LAA, and their subsequent ease and ability to shift to activities favored by the LAA.

The coefficient for the variable "LAA: Familiarity" is significantly negative at the splitting section of the model. Data demonstrates that companies that are not familiar with the LAA are more likely to have an export cost increase than are companies that are familiar with the LAA. In the ordered section, the statistically insignificant coefficient for the variable "LAA: Familiarity" indicates that the export cost increase levels for companies familiar/not familiar with the LAA are not differentiable.

Conclusions

This research provides useful insights regarding the impact of the Lacey Act 2008 Amendment (LAA) on Chinese wood products exporters. The results obtained from the zero inflated ordered probit model indicate that the impact of the LAA on Chinese wood products export costs are dependent on the procurement practices and the demographic characteristics of the companies. Empirical evidence suggests that the LAA has affected the Chinese companies' export costs to the US market to varying degrees. In the context of the LAA, both the sourcing behaviors and the sourcing characteristics of the Chinese companies are factors that influence their export cost increases.

The modeling results also indicate that if a company has established sourcing routes from temperate regions, they do not feel the need to make any sourcing changes as a result of the LAA, and their export cost is not adversely affected. Conversely, the probability of an export cost increase because of the LAA is higher for companies who primarily source their raw materials from tropical regions. Using these results, we can infer that the LAA is likely to provide a comparative advantage to forest product companies located in the temperate regions, including the US. Similarly, the LAA places the forest product industry located in tropical regions at a competitive disadvantage. The Chinese respondents who primarily source raw material from domestic China indicated lower export cost increases as a result of the LAA, which may be due to the convenience of acquiring the LAA compliance paperwork in China. However, the Chinese domestic sourcing of wood raw material by the furniture and flooring industry cannot meet the demand of Chinese manufacturers in the near future. Given a series of Chinese domestic policies such as the National Forest Protection Program to restore forest base,

domestic wood production in China has been kept low and will not be able to satisfy the sourcing needs of Chinese companies (White et al. 2006).

During the interviews in China the researchers got an overwhelming sense that respondents perceive that chain-of-custody certification, (both through the FSC and PEFC programs), is one of the ways to comply with the LAA. The modeling results support this anecdotal information. The Chinese respondents who use a higher percentage of CoC certified raw material procurement are more likely to report an increase in export costs as a result of the LAA. This may be due to the fact that the additional procurement costs associated with CoC certified raw material are considered to be a cost of complying with the LAA. However, while it may be easier to prove compliance if the manufacturers use CoC certified wood, it is important to note that the use of CoC certified wood is neither necessary nor sufficient to demonstrate LAA compliance (EIA 2009). With regards to the demographic characteristics of the companies, the smaller sized manufacturers/exporters are less likely to experience a post-LAA cost increase relative to their larger counterparts. This follows the basic principles of economics, where smaller companies are more adaptable to changing market conditions (Ganguly et al. 2010) and are better able to adjust to the requirements of the LAA.

Acknowledgement

We gratefully acknowledge the support of the USDA Federal State Marketing Improvement Program (FSMIP), award no. 12-25-G-1519 and the McIntire-Stennis Formula Fund for providing financial support to this study. We also thank the Softwood Export Council for funding the international travel, and the American Hardwood Export Council for their help with the data collection.

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Tables

Table 1. Grouping Results of the

	Softwood Dominant Regions	Hardwood Dominant Regions	China Local	Factor Analysis
Russia	0.683			
US	0.809			
Canada	0.77			
EU	0.794			
SE Asia		0.817		
Africa		0.775		
S. America		0.555		
China			0.932	

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Table 2. Introduction of the variables

	name of variable	variable description	related survey question and data manipulation
dependent variable	Export Cost Increase	In the past 5 years 0: no increase 1: small increase (≤ 5%) 2: moderate increase (5%< ≤10%) 3: great increase (> 10%)	If the respondents were aware of the Lacey Act Amendment, they were asked whether and how much their export cost had increased due to the Amendment. Their answered were grouped into the 4 groups as the dependent variable
independent variables	COC Certified Wood (%)	continuous variable %	percentage of COC certified raw material
	Hardwood (%)	continuous variable %	percentage of tropical hardwood raw material
	Domestic Sales (%)	continuous variable %	percentage of domestic sales
	Industry		Companies are asked whether they are furniture, flooring or plywood manufacturers, and whether they are exporter or importer of wooden products.
	furniture	1: yes 0: no	Level of familiarity with the Lacey Act. Respondents who are not aware of the Lacey Act Amendment are excluded from this research
	flooring		
	Lacey Act: Familiarity	0: aware but not familiar ; 1:familiar	
	Size of the Company	1: small companies (2012 revenue < \$6,504,065) 2: medium companies (2012 revenue < \$16,260,163 3: large companies (2012 revenue ≥ \$16,260,163	company sales revenue in 2012
	Sourcing from SD Regions	These three variables are the results of the explorative factor analysis for all the 8 sourcing regions. They are continuous variables with standardized values from -3 to 3	The companies' sourcing activities from each of the regions in the past 5 years: no source (0); decrease (1); remain the same (2) and increase (3)
	Sourcing from HD Regions		
	Sourcing from Local		

- a. SD regions stand for “softwood dominant” regions. In this research, “softwood dominant” regions include the United States, Canada, the European Union and Russia according to the results of the explorative factor analysis.
- b. HD regions stand for “hardwood dominant” regions. In this research, “hardwood dominant” regions include Southeast Asia, Africa and South America.

Table 3. Estimated coefficients for OP and ZIOP models for the impacts of the LAA on the Chinese companies' export cost (full model)

	Ordered Probit (OP)		Zero-Inflated Order Probit (ZIOP)	
	Estimates	p-value	Estimates	p-value
Splitting parameters				
Constant	--	--	-0.094	0.916
Industry				
<i>furniture</i>	--	--	0.366	0.557
<i>flooring</i>			-0.065	0.928
Size of the Company	--	--	0.698**	0.042
LAA: Familiarity	--	--	-1.365**	0.040
COC Certified Wood (%)	--	--	0.022*	0.059
Hardwood (%)	--	--	-0.002	0.799
Domestic Sales (%)	--	--	-0.011	0.180
Sourcing from SD Regions (5 years)	--	--	-0.804***	0.010
Sourcing from HD Regions (5 years)	--	--	1.438**	0.028
Sourcing from Local (5 years)	--	--	0.175	0.555
Ordered parameters				
Constant	0.131	0.759	1.871	0.002
Industry				
<i>furniture</i>	0.088	0.752	-0.140	0.698
<i>flooring</i>	-0.363	0.170	-0.419	0.199
Size of the Company	0.143	0.295	-0.111	0.511
LAA: Familiarity	-0.274	0.235	0.355	0.236
COC wood (%)	0.003	0.374	-0.005	0.162
Hardwood (%)	0.001	0.744	-0.106	0.447
Domestic Sales (%)	-0.001	0.861	0.006	0.455
Sourcing from SD Regions (5 years)	-0.021	0.834	0.436***	0.001
Sourcing from HD Regions (5 years)	0.208	0.082*	-0.106	0.447
Sourcing from Local (5 years)	-0.130	0.200	-0.231*	0.056
Tau 1	0.514	0.000	0.866***	0.000
Tau 2	1.237	0.000	1.820***	0.000
Diagnostics - model evaluation and model selection				
Log Likelihood at maximum	-174.4		-155.3 (ZIOP favored)	
Akaike information criteria (AIC)	374.8		336.5 (ZIOP favored)	
Bayesian information criteria (BIC)	475.7		437.5 (ZIOP favored)	
AIC Corrected for Sample Size (AICC)	377.4		339.1 (ZIOP favored)	
Vuong's test (OP v/s ZIOP)	Non-nested hypothesis test-statistic: 3.56044 (p-val: 0.0002)			

-- : not applicable

*: Values are significant at p<0.1.

**: Values are significant at p<0.05.

***: Values are significant at p<0.01.

Table 4. Estimated coefficients for OP and ZIOP models for the impacts of the LAA on the Chinese companies' export cost (best model)

	Ordered Probit (OP)		Zero-Inflated Order Probit (ZIOP)	
	Estimates	p-value	Estimates	p-value
Splitting parameters				
Constant	--	--	-0.174	0.793
Size of the Company			0.717**	0.023
LAA: Familiarity	--	--	-1.500***	0.009
COC Certified wood (%)	--	--	0.016**	0.040
Sourcing from SD Regions (5 years)	--	--	-0.762***	0.002
Sourcing from HD Regions (5 years)	--	--	1.291***	0.008
Sourcing from Local (5 years)	--	--	0.102	0.643
Ordered parameters				
Constant	0.163	0.322	1.750	0.000
Size of the Company	0.085	0.504	-0.160	0.313
LAA: Familiarity	-0.227	0.312	0.423	0.133
COC wood (%)	0.003	0.338	-0.005	0.191
Sourcing from SD Regions (5 years)	-0.017	0.861	0.416***	0.002
Sourcing from HD Regions (5 years)	0.172*	0.094	-0.177	0.151
Sourcing from Local (5 years)	-0.116	0.238	-0.237**	0.050
Tau 1	0.504	0.000	0.849	0.000
Tau 2	1.217	0.000	1.775	0.000
Diagnostics - model evaluation and model selection				
Log Likelihood at maximum	-176.2		-158.8 (ZIOP favored)	
Akaike information criteria (AIC)	370.3		335.5 (ZIOP favored)	
Bayesian information criteria (BIC)	440.2		405.4 (ZIOP favored)	
AIC Corrected for Sample Size (AICC)	371.5		336.7 (ZIOP favored)	
Vuong's test (OP v/s ZIOP)	Non-nested hypothesis test-statistic: 3.435662 (p-val: 0.0003)			
-- : not applicable	*: Values are significant at p<0.1.			
** : Values are significant at p<0.05.	***: Values are significant at p<0.01.			

Figure captions

Fig. 1 Relation between CoC Certificates Adoption and Export Cost Increase

Fig.2 Relation between Sourcing from Temperate Regions and Export Cost Increase

Fig.3 Relation between Sourcing from Tropical Regions and Export Cost Increase

Fig.4 Relation between Sourcing from Local China and Export Cost Increase

Fig.5 Export Cost Increase by Size