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# Duration of U.S. forest products trade

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ABSTRACT

The United States has been a leading participant in the global forest products market. Duration analysis is employed to measure the duration of U.S. exports and imports of forest products over 1996–2016 and to examine the underlying determinants. Outcomes from the descriptive statistical analysis reveal that the duration of U.S. forest products trade is remarkably short, with a median duration of one quarter based on the quarterly data, or one year for the annual data. The duration of trade spells also varies across different types of forest products. Based on the discrete-time duration model, several determinants of export and import duration are identified at the country and product level. Gravity-type variables (e.g., distance and income) are found to affect the likelihood of trade ceasing. Better endowments in forest resources can improve the survival rate of forest products trade. In designing policies to reduce the pressure of import growth, promote exports of forest products, or have a better trade balance, the differences in trade direction and product features should be considered.

## 1. Introduction

The globalization of forest products market began in the 1960s and has continued since then (Perez-Garcia and Robbins, 2014). Forest products trade has increased worldwide as barriers to trade are reduced, and comparative advantages in resource endowments and production processes across countries are realized (Prestemon et al., 2003). Today, trade in forest products occurs at every level of the forest products supply chain. In particular, the United States has been one of the leading participants in this globalized market. The Food and Agriculture Organization (2018) reported that global exports of logs, lumber, plywood products alone had grown from US$138 billion in 1996 to $242 billion in 2016, and the annual share of the United States ranged between 9% and 12% of the total.

Forest products trade related to the United States has been examined at the bilateral level or in a global context. For instance, Baek (2007) examined the dynamic effect of exchange rate on bilateral trade of forest products between the United States and Canada. There was little evidence to support the J-curve phenomenon for U.S. forest products trade. Bonnefoi and Buongiorno (1990) measured the differences in comparative advantage for countries with forest products trade, including the United States. The measurement and ranking suggested a clear relationship between the comparative advantage of a country, its endowments in forests and other resources, and its domestic demand. Sun et al. (2010) estimated the impact of non-tariff barriers and tariffs through a global forest products trade model. Non-tariff barriers were found to have more prominent impacts on trade, production, and consumer expenditures than tariffs. More recently, Zhang et al. (2017) examined the change of U.S. exports, imports, and trade balance in forest products (mainly wood and paper products). U.S. dollar depreciation and changes in the purchasing power of trading partners were found to have a positive impact on the exports, while the economic recession in 2009 negatively affected the imports.

The question of whether a trade flow can survive over time has become the focus of emerging literature in recent years. In the seminal paper, Besedeš and Prusa (2006a) found that the survival of U.S. exports had a short duration. Following studies have examined the determinants of trade survival. For example, Besedeš and Prusa (2006b) examined the extent to which product differentiation has affected the duration of U.S. trade relationships. The hazard rate was found to be at least 23% higher for homogeneous goods than for differentiated products. Stirbat et al. (2015) analyzed the role of experience and networks as the critical determinants of export survival in Laos. Having prior experience with the export product or destination and strong networks of similar firms had a positive impact on the probability of export survival. Fugazza and Molina (2016) identified the determinants of trade duration across three country groups, i.e., the developing South, the emerging South, and the North. Trade duration was found to increase monotonically with the level of economic development in the exporting country. Saygili and Turkcan (2017) investigated the effect of economic integration agreements on the duration of machinery exports from Turkey. An economic integration agreement had a dual impact on

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the stability of export relationships: it increased the survival of exports which had already started before the agreement took place but reduces the survival of those that started afterward. Overall, this literature of trade duration has been growing fast in the past decade, and many aspects of trade duration across countries and sectors have been analyzed. Nevertheless, except for some broadly related work (e.g., Bojnec and Fertő, 2014), no study has ever examined specifically the duration of forest products trade so far.

The objective of this study is to examine the duration of U.S. exports and imports of forest products and the underlying determinants. The study is designed to focus on U.S. forest products trade only and cover 84 quarters or 21 years from 1996 to 2016. Forest products are composed of products under the headings of 44, 47, 48, and 94 in the Harmonized Trade System (HTS), and a total of 238 trading partners are covered. Nonparametric duration analysis and discrete-time hazard model are employed. The methods used will be able to reveal the different survival rates of trade by direction and product types. The covariates at the country and product level will allow us to evaluate these determinants and the magnitude of their impacts on the hazard rate.

This study makes several contributions to the literature of forest economics. First of all, the duration of U.S. forest products trade and its determinants are analyzed for the first time. The United States has been one of the leading countries in global forest products trade. The findings will reveal the fundamental characteristics of forest products flow from and to the United States. Second, the export and import duration will be compared in one framework. Previous studies in the literature of trade duration have examined either exports or imports only (e.g., Besedeš and Prusa, 2006b), but seldom compared them simultaneously. A comparison, however, can be revealing for forest products trade because there is a high degree of intra-industry trade in forest products worldwide, which is also true for the United States. Third, the unique aspects of forest products and forest resources endowments are incorporated into the analysis. Four major types of forest products are separately examined. Forest resource endowments of individual trading partners are included as a covariate. Overall, the outcomes from the analysis will provide valuable insights about the survival rate of U.S. forest products trade and the underlying determinants.

## 2. Duration analysis

Duration analysis, also known as survival analysis, is employed in this study to examine the duration of U.S. forest products trade and its determinants. As a class of statistical method, duration analysis is designed to analyze the occurrence and timing of events (Allison, 2010). Duration analysis can be divided into several broad categories, and each has some merits in specific situations (Singer and Willett, 2003). Given the data features, study objectives, and power of different duration models, both nonparametric and parametric duration analyses are adopted in this study. The nonparametric duration analysis has rich graphics features and allows for visual examination of survival rates. The discrete-time hazard model is utilized to quantify the impact of various factors on trade duration simultaneously.

In the beginning, several terms need to be defined explicitly. A trade relationship exists when there are exports or imports between the United States and a trading partner for a specific product within the study period, e.g., exports of softwood lumber from the United States to Japan. A trade spell is defined as the period with an uninterrupted trade flow in a trade relationship. In general, a trade relationship can contain multiple trade spells over a study period. The event of interest here is the termination or death of a trade spell. The focal variable is the duration or length of a trade spell.

The duration of U.S. forest products trade will be analyzed in four settings: quarterly or yearly exports from the United States, and quarterly or yearly imports by the United States. The period covered is from 1996 to 2016, with a total of 84 quarters or 21 years. All products are classified by the Harmonized Tariff Schedule at the six-digit level (e.g., 440320 for coniferous roundwood).

### 2.1. Nonparametric duration analysis

In duration analysis, the key interest is on the variable of duration, i.e., the time elapsed until the occurrence of an event. There are several equivalent ways to characterize the duration as a random variable (Allison, 2010). Two unique ways in duration analysis are the survivor function and hazard function. The survivor function measures the probability that an event time will be greater than a specific time. The hazard function represents the instantaneous rate of an event occurring at a time, given that the event has lasted up to the time. The method of Kaplan-Meier (KM) product limit estimator has been widely used to calculate survival proportions and times, which is also employed here.

In this study, the duration of a trade spell refers to the time between its start and end, e.g., the duration of 12 years between 2001 and 2012. Let the survival rate of $S(t)$ denote the probability or rate that the trade termination has not occurred by time $t$, where $t$ can be any non-negative number. If all trade spells terminate within the study period, then the KM estimator, $\widehat{S}(t)$, is just the sample proportion of observations that have not terminated by $t$ (Allison, 2010). The estimator can also take censoring information into the calculation. Mathematically, the KM estimator can be expressed as:

$$\widehat{S}(t) = \prod_{j:t_j \leqslant t} \left(1 - \frac{d_j}{n_j}\right) \tag{1}$$

where at each period $j$, $t_j$ is the spell length, $n_j$ is the observations at risk, and $d_j$ is the number of trade spells that cease.

The survival rates can be calculated for an entire dataset as well as for individual groups separated by some characteristics of the data. These survival rates can be shown in a figure, and the graphic representation will reveal any heterogeneity of survival behavior. In this study, the survival rates will be computed by two key features. One is at the two-digit codes of HTS 44, 47, 48, and 94. They represent distinct forest products categories. The other is the size of initial value in a trade spell. Given that trade value is continuous, two threshold values will be chosen and used to divide the sample into three groups, i.e., the small, medium, and large size of initial trade values.

While the nonparametric duration analysis is flexible and easy to implement, it does not contain any formal modeling framework. Furthermore, it is hard to consider several features of the data or the impact of several factors on the duration of trade spells simultaneously. In contrast, parametric duration analysis can provide a complete characterization of the relation between spell duration and explanatory variables.

### 2.2. Discrete-time hazard model

One way to classify parametric duration models is based on whether the duration is measured as continuous or discrete time (Singer and Willett, 2003). In the literature, it has been common to use a continuous-time duration model, particularly the Cox proportional hazard model, to evaluate determinants of trade survival (e.g., Nitsch, 2009; Tian et al., 2014). However, Hess and Persson (2012) has shown that the Cox model is inappropriate for several reasons. Trade data usually contains many tied observations (i.e., spells of the same length), and using the Cox model can lead to biased model estimates. It is also difficult to control for unobserved heterogeneity (or frailty). In addition, the Cox model makes a restrictive assumption about proportional hazards, which is unlikely to hold empirically. Instead, Hess and Persson (2012) concluded that the best choice was a discrete-time duration model with proper controls for unobserved heterogeneity in the longitudinal data. That is followed in this study.