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economics

Recycling, Certification, and International Trade of Paper and Paperboard: Demand in Germany and the United States

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On the basis of data from 2000 to 2010, we investigated the separate effects of the uptake of forest certification and the usage of recycled paper on imports of paper and paperboard into Germany and the United States. Using panel data methods and based on a conventional Armington trade model, we find that the effects of two main forest certification schemes—the Programme for Endorsement of Forest Certification (PEFC) and the Forest Stewardship Council (FSC)—differ between markets. In Germany, the PEFC was negatively related to imports. In the United States, imports were preferred from PEFC-dominated countries. The recycled paper utilization rate interacted negatively with imports, irrespective of import country. We also found that price and income elasticities of demand for both countries were within ranges found by other authors: the long-term relative price elasticity of total import demand ranged from −0.70 to −0.78 for Germany and from −0.78 to −0.89 for the United States. The elasticity of demand for economic activity was also smaller (between 0.74 and 0.87) for Germany than for the United States (between 0.87 and 0.97).

Keywords: paper and paperboard, forest certification, paper recycling, panel data, import demand, regulation

Markets for paper and paperboard have been turbulent since 2000, and they have faced large-scale structural changes caused by, for example, digitalization, declining real prices of paper and paperboard products, and the growing importance of fast-growing plantations (Hetemäki et al. 2013). Simultaneously, the exports of paper and paperboard relative to total global production grew from 27% in the 1990s to 30% in the 2000s (Hetemäki et al. 2013). The emerging countries have been increasing their share of global exports, putting pressure on the "traditional" producers in North America and Europe to find ways to compete in foreign markets (e.g., Dieter and Englert 2007, Wear et al. 2016).

The responsiveness of forest products' import demand to price and other economic factors has been the focus of many studies in the past (e.g., Gan 2006, Hänninen and Toppinen 1999, Turner and Buongiorno 2004). Some trade models have been extended to include the effects of urbanization and the rapid increases in electronic media that are reducing the demand for printing and writing paper (Bolkesjø et al. 2003, Hujala 2011, Zhang and Buongiorno 1997). The key factors in the paper and paperboard markets include the steady decline in the production and demand for paper in the United States that has occurred from the late 1990s onward, the erosion in domestic demand for certain categories of paper used in traditional print media, and a deep recession in the United States and Europe. Despite this, North America and Europe remain the largest consumers and importers of paper and paperboard.

The growing environmental awareness of consumers has become an important market and policy driver during the past 2 decades (Gan et al. 2013, Iraldo et al. 2011). There is considerable debate on how regulations should be structured and their implications for the economy and the environment (Press and Mazmanian 2013). Furthermore, despite increased awareness among consumers about the potentially harmful environmental aspects of international trade (e.g., Gan et al. 2013), empirical forest product import demand modeling has largely excluded their consideration. Despite potentially significant recent shifts in market dynamics, there is currently a dearth of research published in the 2010s even on the effects of driving economic variables.

This study provides information on paper and paperboard (excluding newsprint) import markets at the country level in Germany

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Table 1. Econometric studies on paper and paperboard FE elasticities of demand using panel data (excluding elasticities of substitution).

Author (year), period of study, sample	Price elasticities: long term/short term	Income elasticities: long term/short term
Buongiorno (1978), 1963–1973, 43 countries	Long term: Printing and writing paper: –0.20 Other paper and paperboard (excluding newsprint): –0.30	Long term: Printing and writing paper: 1.60 Other paper and paperboard (excluding newsprint): 1.40
Baudin and Lundberg (1987), 1961–1981, 56 countries	Long term: Printing and writing paper: –0.50 Other paper and paperboard (excluding newsprint): −0.70	Long term: Printing and writing paper: 1.00 Other paper and paperboard (excluding newsprint): 1.00
Chas-Amil and Buongiorno (2000), 1969–1992, 15 European countries	Long term: Printing and writing paper: –0.89 Other paper and paperboard (excluding newsprint): –0.30 Short term: Printing and writing paper: –0.30 Other paper and paperboard (excluding newsprint): –0.13	Long term: Printing and writing paper: 1.07 Other paper and paperboard (excluding newsprint): 0.41 Short term: Printing and writing paper: 0.36 Other paper and paperboard (excluding newsprint): 0.18
Turner and Buongiorno (2004), 1970–1987, 64 countries	Long term: Printing and writing paper: –0.94 Other paper and paperboard (excluding newsprint): –0.57 Short term: Printing and writing paper: –0.57 Other paper and paperboard (excluding newsprint): –0.34	Long term: Printing and writing paper: 1.58 Other paper and paperboard (excluding newsprint): 0.97 Short term: Printing and writing paper: 0.77 Other paper and paperboard (excluding newsprint): 0.52
1988–1997	Long term: (Arellano-Bond): Printing and writing paper: −1.20 Other paper and paperboard (excluding newsprint): −0.74 Short term: Printing and writing paper: −0.67 Other paper and paperboard (excluding newsprint): −0.39	Long term: (Arellano-Bond): Printing and writing paper: 1.47 Other paper and paperboard (excluding newsprint): 1.14 Short term: Printing and writing paper: 1.64 Other paper and paperboard (excluding newsprint): 1.45
McCarthy and Lei (2010), 1961–2000, four regions: Asia, Europe, NAFTA, and South America	Long term: Paper and paperboard: –0.05 Short term: Paper and paperboard: –0.04	Long term: Paper and paperboard: Europe 1.07 and for NAFTA area 0.67 Short term: Paper and paperboard Europe 0.77 and NAFTA area 0.48

and the United States, 2000–2010. We use panel data methods to empirically measure the effects of price and economic activity on import demand as well as the effects of the two relevant sustainability instruments: certification uptake and recovered paper utilization. The remainder of this article is structured as follows. We review the literature on the paper and paperboard market, describe the theoretical underpinnings of our empirical analysis, and outline our data sources. We then report our results, discuss them, and draw conclusions.

Previous Panel Data Studies on Paper and Paperboard Demand

Previous studies that used panel data methods to evaluate paper and paperboard markets had simultaneously focused on aggregate global or regional demand for various forest products in several cross-sectional units (results are summarized in Table 1). The previous studies also group different importing countries together; thus, the results are not fully comparable with findings of this study. Individual market-level analysis is needed because attribution of regional-level findings to individual countries can lead to "a classic ecological fallacy" (McCarthy and Lei 2010, p. 143). Moreover, none of the earlier studies included the market turbulence that has ensued since 2000.

According to the previous literature, the price elasticity of long-term demand for printing and writing paper has been found to vary between −0.20 and –1.20. The variation seems to be time and sample specific. There is a tendency for elasticity estimates to be larger when the time series data span more recent years. Similarly, the more homogenous the unit of analysis, the higher the estimated elasticity. For example, Baudin and Lundberg (1987) found a long-term price elasticity of demand of −0.50 for printing and writing paper, using data for 56 importing countries, 1961–1981, whereas Chas-Amil and Buongiorno (2000) reported a price elasticity of −0.90 when the sample was limited to 15 European countries, 1969–1992. With the exception of Turner and Buongiorno (2004), most studies found prices to be inelastic. Long-term estimates tended to be larger in their absolute values than the short-term estimates.

In the earlier studies, the long-term responses of demand for paper product to changes in income as measured by the gross domestic product (GDP) were elastic, within the range of 1.00–1.64, except for imports of other paper and paperboard in European countries, which was 0.41 (Chas-Amil and Buongiorno 2000). The short-term demand proved to be inelastic with respect to income across the studies, regardless of the time or countries covered. In the most recent study, by McCarthy and Lei (2010), the long-term demand was elastic and short-term inelastic for Europe in 1961–2000. For the North American Free Trade Agreement (NAFTA) countries, the demand proved to be inelastic with respect to income in both cases during the respective time span. This indicates that the consumption of paper and paperboard was more sensitive to income changes in Europe than in NAFTA countries during the period of study.

Evolving Certification and Recycling

Given the rapid growth in the trade-in market pulp over the past 20 years, particularly in Asia (FAOSTAT 2014a, 2014b), it is becoming clear that access to sustainable wood fiber has become an increasingly important strategic economic issue in forestry. The policy measures emphasizing consumer responsibility are likely to affect the competitiveness of different supplier countries in international trade, particularly those with significant suspected high rates of illegal fiber sourcing, as found in a study of the effects of the 2008 Lacey Act Amendment (Prestemon 2015; see also Cashore et al. 2007).

Although many of the legally binding environmental regulations generally have been argued to suffer from cost inefficiency, long negotiation times, and a lack of operator incentives to move beyond compliance, many flexible and proactive nonlegally binding soft-law mechanisms have emerged (Howlett 2004, Ribeiro and Kruglianskas 2015). Forest certification is the preeminent example of a private governance, a market-based mechanism that has gained an important position in the markets as an assurance of raw material sustainability. The area of certified forests has increased substantially in the past decade. By 2016, approximately 466 million hectares, or approximately 12% of the world's 3.9 billion hectares of forests, were certified. Programme for Endorsement of Forest Certification (PEFC) had 275 million hectares and the Forest Stewardship Council (FSC) had 192 million hectares enrolled in 2014 (FSC 2016, PEFC 2016). FSC and PEFC schemes may be considered as competitors for global recognition and market share. The FSC scheme has a greener market image and a higher level of acceptance by some consumers in the European Union, the United States, and Japan (Overdevest 2010), whereas the PEFC national schemes have more popular appeal for small landowners in the northern hemisphere and the traditional timber management companies in North America (Moore et al. 2012).

The European Union Timber Regulation 995 (EUTR) and the 2008 amendments to the US Lacey Act are likely to accelerate the uptake of forest certification in the countries that had earlier shown less interest, although neither of the policies require certification per se (Cashore and Stone 2012, Johansson 2014). For example, the EUTR does mandate due diligence on the part of importers into European Union member states to ensure that imported products are legally produced, and certification is a primary tool of legality assurance because the certification standards align with the requirements of due diligence of the EUTR. Our analysis provides a first attempt to measure the potential impacts on international trade of legality assurance in the European Union. In the United States, certification can be used to provide information about due diligence of Lacey Act amendment compliance regarding sources and species of timber, but there is no federal policy explicitly supporting privately certified products. Certification may be considered by some importers as a risk reduction technique given the 2008 plant and timber amendments to the Lacey Act. Although certification is not mandated by law, it can be seen as an influential market driver in the forest sector.

Recycling policies are under scrutiny as nations seek to enhance resource use efficiency and promote a green "bioeconomy," in which production systems are transformed from linear to circular, wherein the raw materials are more efficiently collected and reused (European Union 2014). Policies that aim for increased resource efficiency and rate of recycled fiber use will affect the manufacturing processes of forest products (Arminen et al. 2013, Berglund and Söderholm 2003) and cause shifts in market demand of pulp and paper products from different countries and regions with different levels of regulatory compliance (Korhonen et al. 2015). An example of the pressure for tightening regulations is the announcement by the European Commission that calls for the target for recycled material content for fiber packaging to be raised from the current 60% to 90% by 2030 (European Union 2014). In the United States, there are no legally binding regulatory measures imposed on the recycled contents. However, the pulp and paper industry has been voluntarily partnering with the US Environmental Protection Agency, and as of 2014 it had succeeded in increasing the recycling rate of paper and paperboard to 64.7% of generation (US Environmental Protection Agency 2016a). Furthermore, current federal government procurement guidelines in the United States suggest a minimum of 30% postconsumer waste in federal paper purchases (US Environmental Protection Agency 2016b). Already, more than one-half of fiber currently used in paper and paperboard production at the global level comes from recycled sources (Mansikkasalo et al. 2014). There is large variation in recycled paper utilization rates across different supplier countries (Arminen et al. 2015), but no previous studies exist that have assessed the impact of rates of recycled paper utilization on international paper markets.

In this analysis, we seek to quantify the potential effects of policies encouraging or mandating certification and minimum rates of recovered paper utilization on demand for paper imports. To test the hypotheses that certification and paper recycling of exporting countries affect import demand, we estimate import demand functions that include historical rates of forest certification and the rate of paper recycling observed in import source countries. Although forest certification and minimum recycling rates are not necessarily required by law in source country markets, evaluation of the effects of these variables on imports does constitute an evaluation of the expected effects of any number of potential policies and programs that promote or mandate certification or higher rates of recovered paper utilization.

Theory and Methods

We apply the idea espoused by Armington (1969) regarding international trade theory and assume that paper and paperboard products from different countries are imperfect substitutes for each other. The demand for a secondary forest product is a negative function of price of the imported good relative to the competing substitute (p_i/p) and a positive function of total imports (X), the measure of economic activity (see e.g., Chou and Buongiorno 1983,Gan 2006, Laaksonen et al. 1997, Sauquet et al. 2011):

$$D_i = a_0\left(\frac{p_i}{p}\right)^{a_1} X_i^{a_2}$$

where D_i = the physical quantity of the consumer country's paper and paperboard imports sourced from country i, p_i = the consumer country's import price of paper and paperboard from country i, p = the mean import price from all source countries, X_i = the value of the consumer country's total imports of forest products from country i, a_0 = constant, a_1 = an estimated parameter interpreted as the (constant) elasticity of substitution, and a_2 = an estimated parameter interpreted as demand elasticity with respect to the economic activity, which is measured by the total import value.

Applying a logarithmic transformation and adding an error term, we obtain an empirical model:

Table 2. The main supplier countries of paper and paperboard excluding newsprint in Germany and the United States in 2010.

Importer = Germany			Importer = United States		
Supplier	Quantity (million tons)	Percentage of total imports	Supplier	Quantity (million tons)	Percentage of total imports
Sweden	2.4	25.0	Canada	4.5	55.4
Finland	1.9	19.8	Germany	0.5	6.3
Austria	1.2	12.3	Republic of Korea	0.4	4.6
France	0.8	9.2	Finland	0.3	4.1
Belgium	0.6	6.7	Indonesia	0.2	2.5
Switzerland	0.6	6.6	China	0.2	2.3
Netherlands	0.5	5.5	Brazil	0.2	2.2
Italy	0.5	4.8	Japan	0.2	2.0
Poland	0.4	3.8	Portugal	0.1	1.6
United States	0.3	3.4	Mexico	0.1	1.5
Rest of the world	0.3	2.8	Rest of the world	1.4	17.3
Total	9.5	100.0	Total	8.2	100.0

Source: FAOSTAT (2014b).

$$\ln D_i = a_0 + a_1 \ln\left(\frac{p_i}{p}\right) + a_2 \ln X_i + \varepsilon$$

where a_1 is expected to be negative *and as* a_2 positive.

A major restriction of the Armington model is that each country's market share at the export destination is assumed to be determined by the relative prices of the same product across supplier countries. This assumption further implies that the size of the market does not affect each supplier country's market share and that the expenditure elasticities are the same. If imports are differentiated between different origins, so that the imports from each origin give a different utility, then an increase in a buyer's budget may not be allocated in the same proportion to the imports from different origins.

We relax the constant market share restriction and allow the demand for paper and paperboard imports to depend on the compliance of two different types of environmental sustainability indicators (recycled fiber content and forest certification) in the countries of origin. We include two variables, φ_{1i} and φ_{2i}, that allow each supplier country's demand to shift as a function of the rate of forest certification uptake and as a function of the utilization rate of recycled paper. φ_{1i} is calculated by dividing the certified area by the productive forest area. φ_{2i} is calculated by dividing the recovered paper consumption quantity by the total domestic paper and paperboard production quantity. (More detailed descriptions of these empirical variables can be found in the data description portion of the next section of this article.) The econometric specification is

$$\ln D_i = a_0 + a_1 \ln\left(\frac{p_i}{p}\right) + a_2 \ln X_i + a_3 \ln\varphi_{1i} + a_4 \ln\varphi_{2i} + \varepsilon$$

where a_3 and a_4 can be either positive or negative.

We would expect, other things held constant, the two sustainability-related variables to affect the demand for paper from that country positively in general. Therefore, in the case of forest certification, we would expect a positive sign on the estimate of a_3. However, if the two competing forest certification schemes (PEFC and FSC) are included in the model, then their signs can be either positive or negative. The recycled paper utilization rate is still mostly driven by regulation in supplier countries and, to a lesser extent, by consumer demand for recycled products in consuming countries (Arminen et al. 2013, Berglund et al. 2002); therefore, a_4 could be either positive or negative, depending on whether consumers have a preference for (positive) or against (negative) recycled fiber in their imported products. Therefore, in this study estimated elasticities will capture the aggregate net (upward or downward) shift in demand among the supplier countries targeting the German or the US market.

The classical Armington model assumes constant elasticities of substitution between imports from different source countries. The constant elasticity assumption implies that the elasticity of substitution between the supplier countries is independent of the quantity demanded and is the same between any countries. In our study, this restricts responses of demand for paper and paperboard imports from each country to a change in price to be the same for imports from different countries. However, the shift in demand might also affect the elasticity of import demand with respect to price.

Because we cannot separate out the quantity of policy compliant and noncompliant products in the import data, we estimate the aggregated (mixed compliant/noncompliant) import demand function for Germany and for the United States, with the implicit assumption that the two products are not perfect substitutes. Therefore, we test this assumption by including the interaction of price and the policy variables in addition to separate inclusion of the policy variables. If the estimated coefficients for the interaction terms are not statistically significant, then we would conclude that the two products (policy compliant and noncompliant) have the same elasticities of import demand with respect to price. The empirical import demand equation to be estimated can now be written as

$$\ln D_i = a_0 + a_1 \ln\frac{p_i}{p} + a_2 \ln X_i + a_3 \ln\varphi_{1i} + a_4 \ln\varphi_{2i} + a_5 \ln\frac{p_i}{p} \times \ln\varphi_{1i} + a_6 \ln\frac{p_i}{p} \times \ln\varphi_{2i} + \varepsilon_i$$

where a_5 and a_6 represent the elasticities of the interaction terms of relative price and policy indicators. On the basis of the above discussion, we expect that the signs of the estimated coefficients of a_1 to be negative; a_2 to be positive; and that a_3, a_4, and cross-effects can be either positive or negative.

Data Description

This analysis focused on aggregate paper and paperboard (excluding newsprint) import demand (D) in the world's two largest importers of this paper category, Germany and the United States, 2000–2010 (Table 2). Aggregating demand for various countries and different parts of the world has been done in many of the demand-related studies in the forestry sector. In contrast, this study

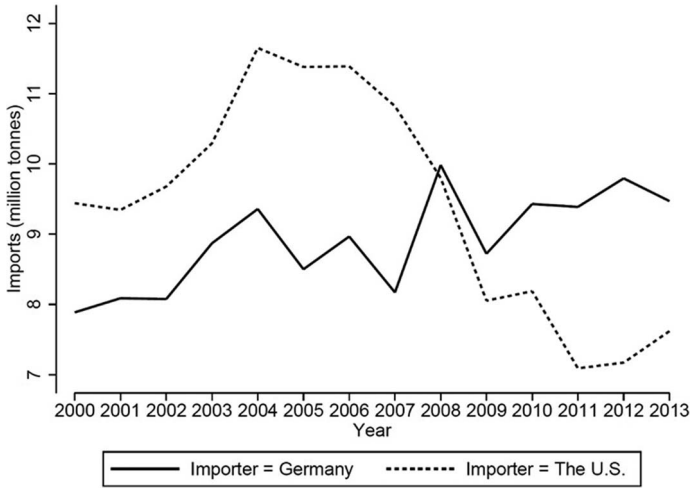

Figure 1. Import quantity of paper and paperboard to Germany and the United States, 2000–2013. Source: FAOSTAT (2014a).

separately models imports from the supplier countries with the largest market share in the German and US markets in 2010. The data were obtained from the FAOSTAT (2014b) trade flows database, in which the annual data are available only for the aggregated sum of printing and writing paper plus other paper and paperboard products, excluding newsprint.

Trends suggest that the consumption of paper and paperboard in the developed economies at the country level is saturated. Thus, a further rise in income per capita in these countries is not likely to raise consumption per capita of these products. Despite this, Germany and the United States are globally the two largest importers of paper and paperboard. Excluding newsprint, Germany imported 9.5 million tons and the United States imported 8.2 million tons of paper and paperboard in 2010 (FAOSTAT 2014a). However, the trade patterns of the United States and Germany are different. Paper and paperboard imports have been growing in German markets since the beginning of the 21st century, whereas in the United States the corresponding demand has trended downward since 2005 (Figure 1). The consumption of these products also shows a similar pattern. Sources of imports of paper and paperboard products to the US market are geographically more diverse than in the case for Germany (Tables 2 and 3). In terms of quantities, the German imports are more diversified than are US imports. The sources of imports for Germany are dominated by European countries (FAOSTAT 2014b). The largest share of US imports are from Canada, which accounts nearly for 60% of the total US import quantity.

Independent Variables

Relative import prices (*RP*; the real unit price of imports from country *i* divided by the trade-weighted mean real unit price of imports from all countries) were calculated from data reported by the Food and Agriculture Organization (FAO; 2014b) in nominal US dollars and then deflated using each country's GDP deflator (2005 base year; Table 3). In the case of Germany, prices were first converted to euros (World Bank 2014). The c.i.f. prices of imports include the freight and insurance costs of transporting a product from one country to another.

The total value of forest product imports (*X*) is correlated with the quantity of total forest product imports and aggregate economic activity (Table 3). Hence, we included this value as our index of the part of aggregate economic activity relevant to paper and paperboard demand of the importing country. The value was converted into real terms following the same procedure as for prices.

Table 3. Descriptive statistics of the economic variables for Germany and the United States, 2000–2010.

Country	Import quantity of paper and paperboard (1,000 tons)	Relative real price	Real value of total imports in local currency (millions: 2005 euros for Germany, 2005 dollars for the United States)
Germany			
Mean	797,160	1.100	1,137,149
Max	2,761,544	5.967	4,745,116
Min	105,871	0.340	278,801
SD	615,223	0.596	970,324
N	121	121	121
United States			
Mean	909,480	1.294	2,328,182
Max	7,596,483	4.801	22,529,221
Min	1,110	0.234	1,264
SD	1,733,603	0.733	4,970,779
N	121	121	121

Table 4. Policy implementation among supplier countries to Germany, 2000–2010.

Variable	*N*	Mean	*SD*	Min	Max
Productive forest PEFC certified, %	121	29.4	32.5	0.0	100.0
Productive forest FSC certified, %	121	29.8	37.9	0.0	100.0
Utilization rate among suppliers	121	43.4	19.1	0.0	82.9

Table 5. Policy implementation among supplier countries to the United States, 2000–2010.

Variable	*N*	Mean	*SD*	Min	Max
Productive forest PEFC certified, %	121	27.3	44.0	0.0	100.0
Productive forest FSC certified, %	121	6.4	17.0	0.0	100.0
Utilization rate among suppliers	121	52.1	25.9	3.5	100.0

Forest certification (PEFC and FSC) data (hectares certified) were obtained from the United Nations Environmental Programme (UNEP; 2015) environmental data explorer database as compiled by PEFC and FSC (Tables 4 and 5). Many of the large supplier countries endorsed their first PEFC certificates during the 2000s (Overdevest and Zeitlin 2014) whereas FSC certification had been introduced in the countries by 2000 (UNEP 2015). If a country had introduced FSC certification by 2002 when the data set starts, then the years 2000 and 2001 were estimated by linear retroextrapolation for those countries from the 2002 data set. To increase the number of observations, the 0-ha values for certification areas were replaced with 1 ha in the data set. These replacements allowed us to include in our data set the variation offered by countries with very low rates of certification uptake. In the estimations, the certified area was divided by productive forest area; thus, the indicator captured the degree of certification uptake in each country of origin. The certification rate for both PEFC and FSC was higher among countries that supplied the German market than was observed for countries that supplied the US market. The difference between Germany and the United States was larger for FSC than for PEFC (Tables 4 and 5).

The recovered paper utilization rate (*UR*) is defined in this study as the domestic recycled paper apparent consumption (recovered paper production – recovered paper exports + recovered paper imports) divided by total domestic paper and paperboard production

(Berglund et al. 2002) in the import source countries. Values were calculated using FAOSTAT (2014a) data (Tables 4 and 5).

Estimation Methods

Estimation is based on the panel data models, which collate and use information between countries and within a single country over a defined time period. These methods have proven to possess major advantages over the conventional cross-sectional and time-series data (Hsiao 2007). The application of panel data methods has brought generality in import demand elasticity estimates in the forestry sector (Turner and Buongiorno 2004), but as far as we are aware, no study has used panel data for examining the determinants of demand at a single country's import market level.

Data were first examined visually for potential outliers, and then correlations of independent variables were examined to detect possible multicollinearity. No outliers or exceptionally high correlations were identified. Subsequently, data were normalized with a logarithmic transformation, and White's robust standard errors were used to account for residual heteroscedasticity. The stationarity of dependent variables was tested by Levin-Lin-Chu t* test, which rejected a unit root at less than 1% significance for both Germany and the United States, whereas the Im-Pesaran-Shin test, the ADF-Fischer χ^2 test, and the PP-Fisher χ^2 test all rejected a unit root null at 2% or stronger for both countries as well. The Breusch and Pagan Lagrange multiplier test confirmed that simple ordinary least regression was not suitable for either country (Germany, $P < 0.001$; United States, $P < 0.001$). These test results permitted model specification that control for directly unobservable differences among cross-sectional units. According to the Hausmann test (Hausman 1978), random-effects (RE) models were consistent for Germany ($P = 0.247$), but the result for the United States was weaker ($P = 0.074$). We report the results of both RE and fixed-effects (FE) models. In addition, the Arellano-Bond model (Arellano and Bond 1991) was used to examine a dynamic version of the estimated models. This estimation relies on an assumption that there is no second-order serial correlation in model residuals. The existence of second-order serial correlation was evaluated with an Arellano-Bond test, and no evidence of second-order serial correlation was found for Germany ($P = 0.186$) or the United States ($P = 0.185$). A Sargan test, testing for the validity of instruments, indicated that overidentification assumptions were valid for the United States ($P = 0.696$) and Germany ($P = 0.594$). However, the Sargan test was only possible using nonrobust standard errors. The robust and nonrobust errors were found to be close to each other. Different model specifications were also evaluated against each other, according to their consistency with the theory, statistical significance of variables, and goodness of fit based on the adjusted R^2.

FE Estimation

FE estimation allows for the correlation between explanatory variables and unobserved country-specific effects, allowing for heteroscedasticity across cross-sectional units. The model assumes that explanatory variables are exogenous and thus uncorrelated with the error term. The FE model is efficient in controlling omitted variables biases; therefore, it is often found to be the most suitable for analyzing cross-section time-series data with a relatively small number of cross-section units. However, the FE model requires within-cross-section variation in all included explanatory variables. The FE specification in our study is

$$\ln D_{it} = a_{0i} + a_1 \ln RP_{it} + a_2 \ln X_{it} + a_3 \ln PEFC_{it} + a_4 \ln FSC_{it} + a_5 \ln UR_{it} + \varepsilon_{it}$$

where a_{0i} is a constant, a_1–a_5 are estimated coefficients interpreted as elasticities, ε_{it} is the uncorrelated error term, i is the source (country) of imports, and t is time. $RP_t = p_{ti}/p_t$, where p_{ti} is the import price from a particular source country i divided by the mean import price obtained from all source countries at time t. X_{it} is the total value of imports of all forest products from a country i at time t. $PEFC_{it}$ is the rate of PEFC certification uptake, FSC_{it} is the rate of FSC certification uptake, and UR_{it} is the utilization rate of recovered paper in source country i at time t.

The model is also estimated with interaction terms for the policy variables, as

$$\ln D_{it} = a_{0i} + a_1 \ln RP_{it} + a_2 \ln X_{it} + a_3 \ln PEFC_{it} + a_4 \ln FSC_{it} + a_5 \ln UR_{it} + a_6 \ln PEFC_{it} \times \ln RP_{it} + a_7 \ln FSC_{it} \times \ln RP_{it} + a_8 \ln UR_{it} \times \ln RP_{it} + \varepsilon_{it}$$

where $\ln PEFC_{it} \times \ln RP_{it}$ is an interaction term for PEFC certification uptake, $\ln FSC_{it} \times \ln RP_{it}$ is the interaction between the FSC certification uptake and the relative real price, and $\ln UR_{it} \times \ln RP_{it}$ is the interaction term for the utilization rate and relative real price.

RE Estimation

The RE estimator is appropriate when the unobserved effects are uncorrelated with all of the explanatory variables. Although the FE model assumes that the unobserved country effects are constant, the RE model allows for different unobserved effects for different countries. The model is estimated using generalized least squares. The RE specification for the empirical model is

$$\ln D_{it} = a_0 + a_1 \ln RP_{it} + a_2 \ln X_{it} + a_3 \ln PEFC_{it} + a_4 \ln FSC_{it} + a_5 \ln UR_{it} + \varepsilon_{it}$$

where $\varepsilon_{it} = a_i + \nu_{it}$, a_i is the permanent component of error, and ν_{it} is the idiosyncratic component of the error term.

Similarly, for the FE versions, the model is estimated with interaction terms for the policy variables as

$$\ln D_{it} = a_0 + a_1 \ln RP_{it} + a_2 \ln X_{it} + a_3 \ln PEFC_{it} + a_4 \ln FSC_{it} + a_5 \ln UR_{it} + a_6 \ln PEFC_{it} \times \ln RP_{it} + a_7 \ln FSC_{it} \times \ln RP_{it} + a_8 \ln UR_{it} \times \ln RP_{it} + \varepsilon_{it}$$

Arellano-Bond Estimation

The Arellano-Bond estimator (Arellano and Bond 1991) was applied to assess the dynamic nature of the import demand and obtain consistent estimates in cases in which residual autocorrelation is present. The Arellano-Bond estimator is a linear dynamic panel-data model in which the unobserved panel-level effects are correlated with the lags of the dependent variable. The method allows us to introduce a lagged demand variable in the model and relax the assumption of exogeneity of the explanatory variables. The following equation was estimated with a general method of moments estimator:

Table 6. Results from import demand models for Germany, 2000–2010.

Variable	Elasticity (*P*)				
	RE	FE	Interaction[a] (RE)	Interaction[a] (FE)	Arellano-Bond
Relative real price	−0.781*** (0.070)	−0.761*** (0.071)	−0.557 (0.605)	−0.257 (0.643)	−0.700*** (0.089)
Total value of forest product imports	0.869*** (0.111)	0.869*** (0.118)	0.858*** (0.113)	0.850*** (0.116)	0.735*** (0.121)
PEFC certification/productive forest area	−0.015*** (0.008)	−0.020* (0.010)	−0.014* (0.008)	−0.018* (0.009)	−0.011 (0.011)
FSC certification/productive forest area	−0.004 (0.012)	0.017 (0.018)	0.009 (0.009)	0.036* (0.016)	0.089* (0.051)
Recycled paper utilization rate	−0.034** (0.016)	−0.028** (0.009)	−0.035 (0.025)	−0.039* (0.021)	−0.014 (0.013)
Relative real price × PEFC	–	–	−2.97e−07 (1.15e−07)	−3.10e−07** (1.07e−07)	–
Relative real price × FSC	–	–	−0.023 (0.024)	−0.015 (0.025)	–
Relative real price × utilization rate	–	–	−0.024 (0.159)	−0.098 (0.169)	–
Constant	1.585 (1.560)	1.555 (1.619)	1.752 (1.580)	1.850 (1.615)	
Lagged imports	–	–	–	–	−0.036 (0.089)
N	121	121	121	121	99
R^2 within	0.554	0.557	0.577	0.580	
R^2 between	0.803	0.759	0.802	0.718	
R^2 overall	0.752	0.717	0.752	0.686	
Breusch-Pagan test	(*P* = 0.000)				
Hausman test	(*P* = 0.247)				
Sargan test					(*P* = 0.594)
Arellano-Bond test					(*P* = 0.186)

***,**,* represent statistical significance of the elasticity coefficients at the significance levels of 1, 5, and 10%, respectively. Parentheses indicate standard errors of the coefficient estimates.
[a]Relative real price and policy interaction terms included.

$$\ln D_{it} = a_0 + a_1 \ln RP_{it} + a_2 \ln X_{it} + a_3 \ln PEFC_{it} + a_4 \ln FSC_{it} + a_5 \ln UR_{it} + a_6 D_{it-1} + \varepsilon_{it}$$

where $D_{it} - 1$ is the lagged dependent variable and a_6 is the coefficient measuring its effect on current period import demand.

Results

Germany

As Table 6 indicates, the Hausman test favored the RE over the FE, but the estimated and statistically significant coefficients from the two specifications were close in magnitude. The Hausman test result likely derives from the fact that the between variation exceeds the within variation, a situation that favors the RE estimator (Woolridge 2009, p. 493). The parameter estimates for the dynamic model were slightly lower in magnitude than estimated with the static models, as expected, but the coefficient on the lagged dependent variable was statistically insignificant, indicating that the static models' results would be preferred. Overall, the results were consistent with theory and expectations for price and economic activity, and model fit was reasonable, accounting for approximately 70% of the total variation in the sample.

The models for Germany showed that import demand was inelastic, as determined by coefficients on the relative price variable, ranging from −0.56 to −0.78. The positive effect of the total import value of forest products was also inelastic and varied between 0.74 and 0.87. The coefficient on the PEFC forest certification rate was significant at the 1% level in the RE model, and a low negative elasticity (−0.020) was estimated. PEFC was also significant in the FE model and for the RE and FE interaction models, with low estimated elasticities (−0.014 and −0.018, respectively). Furthermore, and as expected, the coefficient on FSC was positive but significant only at the 10% level, and only for the FE interaction and Arellano-Bond models (and not significant in the other models). The recovered paper utilization rate was significant at the 5% level, also with negative elasticities of approximately −0.03 in each of the RE and FE models estimated.

The models with interaction effects generally did not support the hypothesis that price elasticities differ between countries according to their degree of participation in FSC or in their rates of recovered paper utilization. In other words, we can assume the same price elasticity for the products with different levels of forest certification and wastepaper recycling.

United States

For US import demand, statistical tests suggest a preference for the panel structure and the RE specification. However, the Hausman test rejects the hypothesis of uncorrelated random effects only at the 7% significance level (Table 7). Similar to the German models, the lagged dependent variable in the dynamic model was not statistically significant, indicating better fit for static models for the United States as well. The model fit was good overall, with models accounting for approximately 80% of the total variation in imports.

The price elasticity was highly significant and varied between −0.78 and −0.89, confirming inelastic import demand. The measure of output, the total value of imports, varied between 0.91 and 0.97 and was highly significant in all model specifications. PEFC demonstrated a strong positive effect on US imports for all FE and RE models, including those with interaction terms. The FSC was not significant but had systematically negative coefficients. The recovered paper utilization rate was not significant in any of the estimated models for the United States. The recovered paper utilization rate interacted negatively with price, and the interaction term was also significant, indicating different price elasticities for countries with different recovered paper utilization rates.

Study Limitations

We recognize that one limitation of this study is in the short period of time and the relatively small sample size used, raising the prospect of Type II errors in testing. However, we believe that focusing on the postmillennium time period is justified not only because of recent structural changes in the paper markets

Table 7. Results from import demand models for the United States, 2000–2010.

Variable	Elasticity (*P*)				
	RE	FE	Interaction[a] (RE)	Interaction[a] (FE)	Arellano-Bond
Relative real price	−0.784*** (0.188)	−0.821*** (0.193)	0.991 (0.766)	0.847 (0.671)	−0.891*** (0.219)
Total value of forest product imports	0.930*** (0.108)	0.971*** (0.125)	0.912** (0.099)	0.947*** (0.119)	0.865*** (0.136)
PEFC certification/productive forest area	0.064*** (0.012)	0.083*** (0.010)	0.063*** (0.015)	0.077*** (0.008)	0.009 (0.028)
FSC certification/productive forest area	−0.039 (0.027)	−0.041 (0.034)	−0.030 (0.031)	−0.026 (0.040)	−0.019 (0.037)
Recycled paper utilization rate	−0.099 (0.164)	−0.422 (0.312)	−0.093 (0.146)	−0.326 (0.284)	−0.217 (0.362)
Relative real price × PEFC	–	–	−8.26e−07 (8.84e−07)	−8.22e−07 (8.61e−07)	–
Relative real price × FSC	–	–	0.011 (0.037)	0.003 (0.038)	–
Relative real price × utilization rate	–	–	−0.420** (0.183)	−0.397** (0.163)	–
Constant	0.807 (1.126)	1.540 (1.082)	1.038 (1.073)	–	–
Lagged imports	–	–	–	–	0.034 (0.068)
N	121	121	121	121	99
R^2 within	0.793	0.796	0.805	0.807	
R^2 between	0.863	0.821	0.859	0.834	
R^2 overall	0.833	0.795	0.834	0.811	
Breusch-Pagan test	(*P* = 0.000)				
Hausman test	(*P* = 0.074)				
Sargan test					(*P* = 0.696)
Arellano-Bond test					(*P* = 0.185)

***,**,* represent statistical significance of the elasticity coefficients at the significance levels of 1, 5, and 10%, respectively. Parentheses indicate standard errors of the coefficient estimates.
[a]Relative real price and policy interaction terms included.

but also based on recent and substantial diffusion of influential environmental policies since 2000. The available data on forest certification and recovered paper utilization for finer temporal units forced us to conduct the analysis with annual observations and for a period starting in 2000. Replacing observations of certified forest area equal to 0 with 1 to enable logarithmic transformation of this regressor in the estimation data set might also have introduced some bias in model estimates. For a comparison, the analysis was performed with 0.1 and 10 ha, and results were not markedly different. In addition, our data were highly aggregated (i.e., across more finely specified paper products), but because the main interest was to analyze the economic impact of different types of policy measures, the finer separation between different types of paper and paperboard product categories may not be necessary. In contrast, our analysis overcame to some extent the problems of limited data by applying panel data methods at the country level, an advantage compared to several previous studies. Furthermore, disaggregation of paper and paperboard into finer product specifications may lead to greater uncertainty because the origins of imports for finer product categories typically vary greatly over time.

Discussion and Conclusions

We found that the elasticity of substitution with respect to the relative real price between supplier countries was practically the same in Germany and the United States. The demand for imported paper and paperboard proved inelastic with respect to price with elasticity around −0.8 in both German and US markets, despite their different and diverse collection of supplier countries. The demand elasticities of the relative price in this study are also in line with most of the general import elasticities obtained in previous studies (see Table 1), which, with few exceptions, reported that the demand for paper and paperboard imports was inelastic with respect to the import price.

Import demand for paper and paperboard in the United States was slightly more sensitive to fluctuations in economic activity (elasticities between 0.87 and 0.97) than it was for Germany (elasticities between 0.74 and 0.87). Compared with the import demand study by Turner and Buongiorno (2004), which was based on data through 1997, the elasticities found in this study were lower, and they were closer to the consumption-based elasticities of McCarthy and Lei (2010). Furthermore, the elasticities found in this study were lower for Germany and higher for the United States than the respective elasticities for Europe and NAFTA countries, confirming the risk of the "ecological fallacy" of using regional elasticities as a policy tool in individual countries, as presented by McCarthy and Lei (2010).

Our results indicate that although implementation of forest certification has a statistically significant effect on the quantity of paper and paperboard imported into German and US markets, the effects differ between the two countries and between the certification programs. The models for Germany actually demonstrated a dislike for imported PEFC-certified products, and FSC certification only showed a weak positive effect in one of the models examined. This is interesting because the FSC and PEFC certification rates (areas of certified forest divided by areas of productive forest) are almost equal among the German supplier countries. The negative PEFC effect means that demand from those supplier countries that have implemented PEFC certification has shifted downward. In other words, it means that these countries lost market shares over the period of study. Despite the weak statistical significance of FSC certification in the models, it can be deduced that the suppliers of FSC-certified paper and paperboard have gained market share, in part at the expense of PEFC.

The US model estimates indicated a positive effect of PEFC on imports. Some of these findings may be due to traditional trade patterns among the strong PEFC countries of Canada and others to the United States. To test that these PEFC results were not only driven by trade with Canada, we also estimated the models by excluding Canada from the sample; the result of this exclusion was that the magnitude of price elasticities changed very little. For example, in the RE model, the price elasticity changed from −0.78 to −0.61, and the elasticity for total imports dropped slightly, from 0.93 to 0.90. Exclusion of Canada did not affect the conclusions based on the significance of the variables. Therefore, we argue that the dominant share of Canada is not decisive in this analysis. Furthermore, panel data methods are designed to account for the variation within

and between cross-sectional units (countries) over time. Canada's share of paper and paperboard imports has been rather constant, slightly diminishing over the period of study (FAOSTAT 2014a); therefore, imports from Canada produced only a small share of the variation in US imports over time in the data. These results indicate that, in contrast to Germany, in US markets, the use of PEFC was enough to fulfill the requirement for sustainable forest management during the period of study.

It is possible that the burgeoning number of ecolabels and growing trade regulations will lead to a convergence in the features of competing forest certification schemes. This could happen as the certifying organizations seek to expand their market shares in various destination markets. Some harmonization between FSC and PEFC is already taking place. For example, both certification schemes have recently revised their standards to comply with the EUTR and the amended Lacey Act (Kistenkas 2013). Alternatively, producers in source countries may increasingly obtain dual certification (i.e., certification by both PEFC and FSC). Although the environmental benefits of dual certification are not clear (Visseren-Hamakers and Pattberg 2013), from an economic standpoint, dual certification could add an extra cost to production. Higher costs would lead to lower profits, unless dual certification leads to expansion in market share and higher revenues sufficient to offset the extra cost.

The results of this study also indicate that Germany and the United States do not prefer imports from countries for which the paper and paperboard production is dominantly based on the use of recycled fiber. The estimated parameters for this variable were negative for most of the models for Germany or, for the United States, nonsignificant. This suggests that setting regulatory quotas for the utilization of recycled paper can be especially problematic in supplier countries with extensive production based on vast resources of virgin fiber and for which the paper consumption remains low (Berglund and Söderholm 2003, Zhu and Buongiorno 2002). This suggestion a priori derives from the fact that some of the leading suppliers of paper and paperboard, such as Canada, Finland, and Sweden, are forest resource (virgin fiber) rich and sparsely populated; therefore, they generate low flows of domestic wastepaper relative to their paper production outputs. Hence, to meet minimum recycled fiber content requirements, such countries are forced to import recovered paper from abroad, adding extra costs to production. More voluntary policy tools or moderate proportions of required recycled content might balance the environmental benefits of recycling with their associated economic costs and might also allow firms to choose the optimal combination of recycled and virgin fibers in paper and paperboard production. Overall, this might also encourage some companies to go "beyond the compliance" to reduce the environmental footprint of their supply chains (Tuppura et al. 2016).

Overall, despite the caveats, there was considerable agreement among the different models used in the estimated signs of the coefficients, significances, and absolute values of the effects of potential trade and sustainability indicators. Therefore, the study provides relatively consistent findings across different models on import demand differentiated by the supplier countries applying the Armington (1969) approach. This study extends prior literature and research into the current era, which has been marked by turbulent global markets, and the analysis enabled identification of important effects of environmental policies affecting international trade.

For future research, it would be interesting to examine the effects of certification and recycled fiber content on imports into other major paper-importing countries (e.g., China and India) that are at different stages of market maturity compared to Germany and the United States. Investigation of these effects using data on finer product categories could also be examined in more detail, but such analysis would require data on imports by country for these finer categories, data that are often not publicly available. The findings from this study reveal an effective econometric framework on which to launch further analyses, perhaps in studies focused on testing the various effects of a broader suite of environmental policies and trade-related measures. As the outcomes of policies are context specific, varying by country and market, these studies are all the more critical when considering how rarely forestry-related environmental measures are subjected to objective scrutiny in terms of their revealed impacts on affected economic sectors.

Literature Cited

ARELLANO, M., AND S. BOND. 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Rev. Econ. Stud.* 58(2):277–297. doi:10.2307/2297968.

ARMINEN, H., M. HUJALA, K. PUUMALAINEN, A. TUPPURA, AND A. TOPPINEN. 2013. An update on inter-country differences in recovery and utilization of recycled paper. *Resour. Conserv. Recy.* 78:124–135. doi:10.1016/j.resconrec.2013.07.008.

ARMINEN, H., M. HUJALA, AND A, TUPPURA. 2015. Emerging market patterns in the recycled paper trade. *J. Environ. Plan. Manage.* 58(3):537–553. doi:10.1080/09640568.2013.866544.

ARMINGTON, P.S. 1969. A theory of demand for products distinguished by the place of origin. *Staff Papers (IMF).* 16(1):159–178. doi:10.2307/3866403.

BAUDIN, A., AND L. LUNDBERG. 1987. A world model of the demand for paper and paperboard. *For. Sci.* 33(1):185–196. http://www.ingentaconnect.com/contentone/saf/fs/1987/00000033/00000001/art00019.

BERGLUND, C., AND P. SÖDERHOLM. 2003. An econometric analysis of global waste paper recovery and utilization. *Environ. Resour. Econ.* 26(3):429–456. doi:10.1023/B:EARE.0000003595.60196.a9.

BERGLUND, C., P. SÖDERHOLM, AND M. NILSSON. 2002. A note on inter-country differences in waste paper recovery and utilization. *Resour. Conserv. Recy.* 34(3):175–191. doi:10.1016/S0921-3449(01)00101-X.

BOLKESJØ, T.F., M. OBERSTEINER, AND B. SOLBERG. 2003. Information technology and the newsprint demand in Western Europe: A Bayesian approach. *Can. J. For. Res.* 55(9):1644–1652. doi:10.1139/x03-083.

BUONGIORNO, J. 1978. Income and price elasticities in the world demand for paper and paperboard. *For. Sci.* 24(2):231–246. http://www.ingentaconnect.com/content/saf/fs/1978/00000024/00000002/art00015.

CASHORE, B., G. AULD, S. BERNSTEIN, AND C. MCDERMOTT. 2007. Can non-state governance "ratchet-up global environmental standards? Lessons from the forest sector. *Rev. Euro. Comp. Environ. Law.* 16(2):158–172. doi:10.1111/j.1467-9388.2007.00560.x.

CASHORE, B., AND M.W. STONE. 2012. Can legality verification rescue global forest governance? Analyzing the potential of public and private policy intersection to ameliorate forest challenges in Southeast Asia. *For. Policy Econ.* 18:13–22. doi:10.1016/j.forpol.2011.12.005.

CHAS-AMIL, M.L., AND J. BUONGIORNO. 2000. The demand for paper and paperboard: Econometric models for the European Union. *Appl. Econ.* 32(8):987–999. doi:10.1080/000368400322048.

CHOU, J., AND J. BUONGIORNO. 1983. United States demand for hardwood plywood imports by country of origin. *For. Sci.* 29(2):225–237. http://www.ingentaconnect.com/content/saf/fs/1983/00000029/00000002/art00006.

DIETER, M., AND H. ENGLERT. 2007. Competitiveness in the global forest

industry sector: An empirical study with special emphasis on Germany. *Euro. J. For. Res.* 126(3):401–412. doi:10.1007/s10342-006-0159-x.

EUROPEAN UNION. 2014. *Moving toward circular economy.* European Commission, Environment DG, Brussels, Belgium. Available online at http://ec.europa.eu/environment/circular-economy.

FAOSTAT. 2014a. *Global forestry statistics database.* Food and Agricultural Organization of the United Nations, Rome, Italy. Available online at http://www.fao.org/forestry/statistics/84922/en/.

FAOSTAT. 2014b. *Forestry trade flows database.* Food and Agricultural Organization of the United Nations, Rome, Italy. Available online at http://www.fao.org/forestry/statistics/84922/en/.

FOREST STEWARDSHIP COUNCIL. 2016. *Facts and figures*. FSC International, Bonn, Germany. Available online at https://ic.fsc.org/en/facts-figures.

GAN, J. 2006. Substitutability between US domestic and imported forest products: The Armington approach. *For. Sci.* 52(1):1–9. http://www.ingentaconnect.com/content/saf/fs/2006/00000052/00000001/art00001.

GAN, J., B. CASHORE, AND M.W. STONE. 2013. Impacts of the Lacey Act Amendment and the Voluntary Partnership Agreements on illegal logging: Implications for global forest governance. *J. Natur. Res. Policy Res.* 5(4):209–226. doi:10.1080/19390459.2013.832479.

HÄNNINEN, R., AND A. TOPPINEN. 1999. Long-run price effects of exchange rate changes in Finnish pulp and paper exports. *Appl. Econ.* 31:947–956. doi:10.1080/000368499323661.

HAUSMAN, J.A. 1978. Specification tests in econometrics. *Econometrica.* 46(6):1251–1271. doi:10.2307/1913827.

HETEMÄKI, L., R. HÄNNINEN, AND A. MOISEYEV. 2013. Markets and market forces for pulp and paper products. P. 99–127 in *The global forest sector. Changes, practices, and prospects*, Hansen, E., R. Panwar, and R.P. Vlosky, R. P. (eds.). CRC Press, Boca Raton, FL.

HOWLETT, M. 2004. Beyond good and evil in policy implementation: Instrument mixes, implementation styles and second generation theories of policy instrument choice. *Policy Soc.* 23(2):1–17. doi:10.1016/S1449-4035(04)70030-2.

HSIAO, C. 2007. Panel data analysis—advantages and challenges. *Test.* 16(1):1–22. doi:10.1007/s11749-007-0046-x.

HUJALA, M. 2011. The role of information and communication technologies in paper consumption. *Int. J. Bus. Inform. Sys.* 7(2):121–135. doi:10.1504/IJBIS.2011.038507.

IRALDO, F., F. TESTA, M. MELIS, AND M. FREY. 2011. A literature review on the links between environmental regulation and competitiveness. *Environ. Policy Governance* 21(3):210–222. doi:10.1002/eet.568.

JOHANSSON, J. 2014. Why do forest companies change their CSR strategies? Responses to market demands and public regulation through dual-certification. *J. Environ. Plan. Manage.* 53(3):349–368. doi:10.1080/0964058.2012.743882.

KISTENKAS, F. 2013. Concurring regulation in European forest law. Forest certification and the new EU timber regulation. *GAIA: Ecol. Persp. Sci. Soc.* 22(3):166–168. doi:10.14512/gaia.22.3.7.

KORHONEN, J., S. PÄTÄRI, A. TOPPINEN, AND A. TUPPURA. 2015. The role of environmental regulation in the future competitiveness of the pulp and paper industry: The case of the sulfur emissions directive in Northern Europe. *J. Clean. Prod.* 108:864–872. doi:10.1016/j.jclepro.2015.06.003.

LAAKSONEN, S., A. TOPPINEN, R. HÄNNINEN, AND J. KUULUVAINEN. 1997. Cointegration in Finnish paper exports to the United Kingdom. *J. For. Econ.* 3(2):171–185.

MANSIKKASALO, A., R. LUNDMARK, AND P. SÖDERHOLM. 2014. Market behavior and policy in the recycled paper industry: A critical survey of price elasticity research. *For. Policy Econ.* 38:17-29. doi:10.1016/j.forpol.2013.08.011.

MCCARTHY, P., AND L. LEI. 2010. Regional demands for pulp and paper products. *J. For. Econ.* 16(2):127–144. doi:10.1016/j.jfe.2009.11.001.

MOORE, S.E., F. CUBBAGE, AND C. EICHELDINGER. 2012. Impacts of Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) forest certification in North America. *J. For.* 114(3):79–88. http://www.ingentaconnect.com/content/saf/jof/2012/00000110/00000002/art00004.

OVERDEVEST, C. 2010. Comparing forest certification schemes: The case of ratcheting standards in the forest sector. *Socioecon. Rev.* 8(1):47–76. doi:10.1093/ser/mwp028.

OVERDEVEST, C., AND J. ZEITLIN. 2014. Assembling an experimentalist regime: Transnational governance interactions in the forest sector. *Regul. Govern.* 8(1):22–48. doi:10.1111/j.1748-5991.2012.01133.x.

PRESS, D., AND D.A. MAZMANIAN. 2013. Toward sustainable production—Finding workable strategies for government and industry. P. 130–255 in *Environmental policy new directions for the 21st century eight edition,* Vig, N.J., and M.E. Kraft. (eds.). CQ Press, Washington, DC.

PRESTEMON, J.P. 2015. The impacts of the Lacey Act Amendment of 2008 on U.S. hardwood lumber and hardwood plywood imports. *For. Pol. Econ.* 50:31–44. doi:10.1016/j.forpol.2014.10.002.

PROGRAMME FOR ENDORSEMENT OF FOREST CERTIFICATION. 2016. *PEFC global statistics: SFM & CoC Certification*. PEFC Council, Geneva, Switzerland. Accessed online at http://www.pefc.org/images/documents/PEFC_Global_Certificates_-_March_2016.pdf.

RIBEIRO, F., AND I. KRUGLIANSKAS. 2015. Principles of environmental regulatory quality: A synthesis from literature review. *J. Clean Prod.* 96(1):58–76. doi:10.1016/j.jclepro.2014.03.047.

SAUQUET, A., F. LECOCQ, P. DELACOTE, S. CAURLA, A. BARKAOUI, AND S. GARCIA. 2011. Estimating Armington elasticities for sawnwood and application to the French Forest Sector Model. *Resour. Energy Econ.* 33(4):771–781. doi:10.1016/j.reseneeco.2011.04.001.

TUPPURA, A., A. TOPPINEN, AND K. PUUMALAINEN. 2016. Forest certification and ISO14001: Current state and motivation in forest companies. *Bus. Strateg. Environ.* 25(5):353–368. doi:10.1002/bse.1878.

TURNER, J.A., AND J. BUONGIORNO. 2004. Estimating price and income elasticities of demand for imports of forest products from panel data. *Scan. J. For. Res.* 19(4):358–373. doi:10.1080/02827580410030127.

UNITED NATIONS ENVIRONMENTAL PROGRAMME. 2015. *Environmental Programme Database.* UNEP, Nairobi, Kenya. Available online at http://web.unep.org.

US ENVIRONMENTAL PROTECTION AGENCY. 2016a. *Advancing sustainable materials management: 2014 fact sheet*. United States Environmental Protection Agency, Office of Land and Emergency Management, Washington, DC. Available online at https://www.epa.gov/sites/production/files/2016-11/documents/2014_smmfactsheet_508.pdf.

US ENVIRONMENTAL PROTECTION AGENCY. 2016b. *Comprehensive procurement guidelines for paper and paper products*. US EPA, Washington, DC. Available online at https://www.epa.gov/smm/comprehensive-procurement-guidelines-paper-and-paper-products.

VISSEREN-HAMAKERS, I.J., AND P. PATTBERG. 2013. We can't see the forest for the trees. The environmental impact of global forest certification is unknown. *GAIA: Ecol. Persp. Sci. Soc.* 22(1):25–28. doi:10.14512/gaia.22.1.8.

WEAR, D.N., J.P. PRESTEMON, AND M.O. FOSTER. 2016. U.S. forest products in the global economy. *J. For.* 114(4):483–493. doi:10.5849/jof.15-091.

WOOLRIDGE, J.M. 2009. *Introductory econometrics—A modern approach*, 4th ed. Cengage Learning, Boston, MA. 865 p.

WORLD BANK. 2014. *World Bank development indicators.* World Bank Group, Washington, DC. Available online at http://data.worldbank.org/data-catalog/world-development-indicators.

ZHANG, Y., AND J. BUONGIORNO. 1997. Communication media and demand for printing and publishing paper in the United States. *For. Sci.* 43(3):362–377. http://www.ingentaconnect.com/contentone/saf/fs/1997/00000043/00000003/art00008.

ZHU, S., AND J. BUONGIORNO. 2002. International impact of national environmental policies: The case of paper recycling in the United States. *Int. For. Rev.* 4(2):133–142. http://www.ingentaconnect.com/content/cfa/ifr/2002/00000004/00000002/art00005.