Governing Illegal Logging and the Comparative Advantage of Forest Product International Trade

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Abstract

Illegal logging has become a global issue because of its effects on biodiversity and climate change. In order to reduce illegal logging, many countries around the world have introduced regulations of international trade of forest products. This paper examines the effects of efforts aimed at reducing illegal logging on the comparative advantage of seven types of forest products by using the HOV model. The results show that measures against illegal logging have affected the comparative advantage of international trade in different directions. The number of regulations a country enforced to combat illegal logging has negative effects on its net export of charcoal and wood residues, but has positive effects on the net export of other forest products. The effects are statistically significant for all types of forest products except paper and wood pulp.

Key words: illegal logging; international trade; forest products; comparative advantage

Introduction

Illegal harvesting has existed for a long time. It has influenced forest ecological environment and the forest carbon storage significantly. Illegal logging is perceived to pose significant obstacles to the achievement of sustainable management of forests. It leads to the destruction of forest resources, biodiversity and other environmental services associated with forests (Kishor and Damania 2006; Tacconi 2007). In addition, and equally importantly, it gives rise to or supports other undesirable outcomes, such as networks of corruption, generating significant volumes of "black" money and crime (Smith et al. 2003; Tacconi 2007). In addition to this, illegal harvesting has reduced national financial revenues drastically.

Although illegal logging occurs mainly in some developing countries, it has become a global issue because of the increasing worldwide concerns about biodiversity and climate change. Many countries around the world have made serious efforts in attempt to reduce illegal logging. The Group of Eight (G8 countries) proposed an Action Program on Forests in 1998. Thereafter, USA, European Union and some other countries adopted a series of rules, laws and regulations to combat illegal logging. The UK first proposed the green procurement movement, EU has put forward the Forest Law Enforcement, Governance and Trade (FLEGT) action plan to reduce illegal logging through carrying out the VIP voluntary partnership agreement plan with some timber production countries, , and EU started to implement new Wood Regulations across European Union to combat illegal logging in 2013. USA implemented Lacey Act Amendment in 2008, where a clear definition of illegal timber is provided. According to FAO forest resource assessment report (FAO, 2010), some conventions like Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora

(CITES), and the International Tropical Timber Organization (ITTO) process, also have helped in preventing illegal logging.

Efforts to combat illegal logging have shown many effects. Bosello et al. (2013) used an Intertemporal Computable Equilibrium System to evaluate demand and import condition after implementing illegal logging ban in global timber market. Their result shows that EU ban eliminates illegal timber from the market, but it forms illegally produced secondary products accompanying exported products in some illegal logging countries or states, which reduces the role of the EU ban. Li et al. (2008) suggested that, although illegal timber will be substituted to some extent by legal wood, the global timber supply will decrease and its world price will rise, which increases the cost of processed wood products. All these create effects on production, processing and consumption countries at different level. Putz et al. (2008) analyzed the opportunities and challenges of reducing harvesting. But until now theeffects on the comparative advantage of forest products in international trade have not been investigated.

Some scholars have applied HOV model in studying forest products trade. Liu and Tian (2007) tested the applicability of HOV model to analyze international trade of forest products using data of 54 countries in 1995, 1998, 2001 and 2004. They concluded that international trade flows of total forest products, logs, other wood, sawnwood, wood-based panel, wood pulp and recycled paper are in line with the trade theory of comparative advantage. They also added environmental variables to test their effects on forest products trade flow. Although their result shows that the environmental variables did not have any significant effect, the conclusion does not rule out the impact of a government's environmental policy on forest products trade flow. Uusivuori and Tervo (2002), using 18 OECD countries for the period 1977–1998, analyzed how forest endowment and economic activity affected net trade of industrial roundwood and forest products. They found limited support for the Heckscher–Ohlin model and concluded that while historical differences in forest industries and resources still exist, the role of forest resources is becoming less important in shaping the development of forest industries. However, they fail to include the increasingly more important energy sector where forest resources are used as fuel. Bonnefoi and Buongiorno (1990) empirically tested the model and concluded that for all examined commodities (roundwood, sawnwood, panels, pulp and paper) forest endowment has a positive effect on net trade. Furthermore, they found that domestic demand, measured by income, has a negative effect on net trade. Both results are coherent with theoretical predictions.

The aim of this paper is to examine the impact of regulations against illegal logging on trade flow within the traditional comparative advantage theory, based on HOV model. In order to do this we extend the traditional HOV model by introducing an environmental variable related to the efforts of combating illegal logging and study how it affects trade comparative advantage. The paper extends Liu and Tian's (2007) analysis in number of ways. 1. The selection of forest products follows strictly the definition of FAO. Furniture is also considered because of the close relationship between the export of furniture and illegal logging; 2. The samples are expanded to 91 countries, and their trade amount represents about 95% of world imports and exports. 3. The time period of the analysis is extended to 2005 - 2011; 4. The number of regulations aimed at combating illegal logging and per capita income are included as explanatory variables. Per capita income influences the market demand for forest products. It also reflects people's environmental attention due to the strong correlation between per capita income and environmental attention (Dasgupta et al., 2001).

The remainder of the paper is organized as follows: Section 2 introduces the research methods and data. Section 3 presents the model estimation result. Section 4 concludes.

Research methods and data

In general, the magnitude and direction of forest product trade flows are determined by geography, size of economies, character of forest endowments and government policies. Classical trade theory prescribes that trade occurs because there are differences among trading partners in their relative costs of production. The link between net trade, prices and resource endowments is provided by the Heckscher–Ohlin model (Heckscher, 1919; Ohlin, 1933), which has had mixed success in empirical analyses. The Heckscher–Ohlin model predicts that a country's net exports of a given good are a positive function of its resource endowments and a negative function of its income. There are a number of assumptions underlying the Heckscher–Ohlin model (Prestemon and Buongiorno, 1997): (i) there exists factors that are immobile between countries; (ii) markets are competitive, with no barriers to trade; (iii) the same technology is universally available and; and (iv) consumption is homothetic with respect to income.

In this paper we use econometrics method to examine the effects of resource endowments on the comparative advantage of forest products international trade. Following Tobey (1990), who suggested the basic idea, we add an environmental variable in the model to examine its effect on 7 types of products: roundwood, sawnwood, other wood, wood-based panels, wood pulp and recycled paper, paper and paperboard, furniture, and their sum. The dependent variable is net export value of the respective forest product, whereas independent variables include a country's capital stock, three types of labor force according to education level, forestland area, per capita income, and the number of regulations adopted to combat illegal logging. The model is expressed as follows:

$$NET_{ik}=C_k+\beta_0 LAB_{1i}+\beta_1 LAB_{2i}+\beta_2 LAB_{3i}+\beta LAND_i+\beta_4 KS_i+\beta_5 EN_i+\beta_6 PCI_i+\varepsilon_{ik}$$

where NET_{ik} means net export value of country i and product k; C_k is a constant for product k; KS_i is capital stock of country i; LAB_{1i}, LAB_{2i}, LAB_{3i} refer to workforce with high, medium, and low quality respectively, $LAND_i$ represents forestland area of country i; EN_i is the number of regulations adopted by county i to combat illegal logging, PCI_i means per capita income,ε_{ik} represents the random error term.

Our classification of forest products differs from that in Liu and Tian (2007). In addition to the traditional products defined by FAO, we also examined the trade of furniture (including office furniture, kitchen furniture, bedroom furniture, and other wood furniture) Therefor, in the paper the effects of efforts to reduce illegal logging on the trade of roundwood, other wood (charcoal, wood, scrap and residues), sawnwood, wood-based panels, wood pulp and recycled paper (hereafter referred to as wood pulp), paper and paperboard (hereafter referred to as paper), furniture, as well as the sum of all these forest products are studied.

Forest products data come from International Trade Centre Trade Statistics. Forestland area, per capita income and capital stock data come from World Bank (WDI). High quality workforce means high education and technic worker (data come from WDI), law quality means illiterate (data comes from UNESCO), and medium quality is the remaining part of the total economic population. Efforts in combating illegal logging are represented by the environmental variable EN, which is measured by the number of relevant regulations enforced by each country. Combining the report of Brack and Hayman (2001) and FAO forest resources assessment report (FAO, 2010), we identified 3 environment regulations: CBD, ITTO, CITES, which all contribute to reduceing illegal logging. Each country's domestic laws and regulations aimed at combating illegal logging, like green procurement policy, America Lacey Act Amendment and European wood regulations, are also recognized. Moreover, according to the illegal logging port website, the EU Member of FLEGT (Forest Law Enforcement, Governance and Trade) action

plan as well as voluntary partnership agreements (VIP) with the European Union's member countries are also regarded as combating illegal logging regulations. Descriptive statistics of the data are presented in Table 1.

Table1. Descriptive statistics of the data

Variable implication	Variable	Mean	Maximum	Minium	standard deviation
High quality labor force (thousand)	LAB_1	20,600.11	534,090	11.79	59,832.33
Middle quality labor force (thousand)	LAB_2	13,078.75	759,788.2	10.67	52,805.97
Low quality labor force (thousand)	LAB_3	6,604.79	287,355.5	0	31,361.78
forestland area (square kilometer)	LAND	350,424.30	8,091,500	23	1,102,780
Capital stock (billion USD)	KS	73,253.58	1,860,000	66,687.73	214,000
Illegal logging regulations	EN	2.68	5	0	1.13
Per capita income (USD)	PCI	15,020.42	99,697.76	146.07	18,446.17
Net export of roundwood (thousand USD)	ROUND	-48,376.14	4,136,007	-8,267,412	713,788
Net export of sawnwood (thousand USD)	SAWN	-1,413.84	8,183,556	-704,502	1,070,136
Charcoal, wood, scrap and residues net export (thousand USD)	OTHER	-51,418.4	956,749	-3,038,581	331,399.4
Wood-based panels net export (thousand USD)	PANEL	35,941.86	5,637,603	-5,743,315	755,686.1
Wood pulp and recycled paper net export (thousand USD)	WOODPULP	-106,461.8	7,236,411	-18,676,452	1,654,300
Paper and paperboard net export (thousand USD)	PAPER	46,407.57	10,477,538	-5,835,378	1,772,898
Furniture net export (thousand USD)	FURNITURE	21,352.34	10,915,734	-11,411,831	1,448,686
Total forest products net export (thousand USD)	TOTAL	-103,968.4	25,804,489	-27,048,409	4,139,098

Result and discussion

Before estimating the model, we examined the correlations between different variables. The correlation matrix between the variables is presented in Table 2. The dotted lines form three regions. The first region shows the correlation coefficients among the independent variables. The second region shows the correlation coefficient between dependent and independent variables, indicating the influence of resource endowments on the value of forest products net exports. The third region shows the relationship among the dependent variables, indicating how and to what extent the net export of one product will affect the next export of another product. Based on the results in Table 2, we can draw the following conclusions.

1. There are significant correlations between the independent variables. High interdependency among independent variables may create multiple collinearity, which influence the real result of the model. Examination of the VIF value reveals that the model can be estimated without paying attention to multicollinearity (the VIF values for LAB_1, LAB_2, LAB_3, LAND, KS, EN and PCI are 6.3, 3, 2, 1.2, 2.5, 1.8, 2 respectively, all lower than the critical value of 10).

2. Factor endowments have different effects on net exports of forest products. The result suggests that rich human resource is still a main driver of the net export of processed products like furniture, paper and paperboard in some developing countries, which caters to the countries development character. Also the result shows that larger forestland area in a country will

increase its net export of raw material products, and reduce the net export of processed forest products. Furthermore, the result also suggests that the abundance of capital in a country will reduce its net export of all types of forest products.

3. Negative or positive correlations have been found between net exports of different types of forest products. A negative correlation between two products means that the products are substitutes, such as roundwood and paper, roundwood and furniture, wood pulp and furniture. A positive correlation exposes that the products are complementary, such as sawnwood and all other kinds of forest products.

Table 2. Correlation matrix of the variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.LAB_1	1														
2.LAB_2	.786**	1													
3.LAB_3	.622**	.562**	1												
4.LAND	.356**	.225**	.079*	1											
5.KS	.616**	.311**	.106**	.358**	1										
6.EN	.122**	0.037	-0.003	0.016	.272**	1									
7.PCI	-0.005	-.120**	-.150**	0.045	.305**	.656**	1								
8.ROUND	-.591**	-.685**	-.339**	.242**	-.147**	-0.071	0.016	1							
9.SAWN	-.305**	-.208**	-0.056	.251**	-.456**	-0.04	-0.013	.302**	1						
10.OTHER	-.136**	-.085*	-0.002	-0.016	-.243**	-.143**	-.108**	.307**	.247**	1					
11.PANEL	.282**	.445**	.118**	.130**	-.236**	0	-.150**	-.381**	.429**	.214**	1				
12.WOODPULP	-.516**	-.597**	-.202**	.203**	-.084*	0.014	.149**	.708**	.455**	.126**	-.380**	1			
13.PAPER	-.092*	-0.057	-0.077	0.057	-.112**	.128**	.217**	-.095*	.643**	-0.042	.346**	.197**	1		
14.FURNITURE	.220**	.463**	.141**	-.092*	-.396**	-0.043	-.237**	-.586**	.184**	-0.039	.730**	-.602**	.177**	1	
15.TOTAL	-.309**	-.198**	-.116**	.203**	-.426**	0.012	0.033	.242**	.930**	.255**	.497**	.454**	.779**	.262**	1

**. significant at 1% (2-tailed).*. significant at 5% (2-tailed).

In this paper, we use the least squares method to estimate the model. With consideration of the possible presence of heteroscedasticity in the cross-section variables, we use White test to check and correct through Heteroscedasticity Consistent Coefficient Covariance in regression process. In order to analyze the influence of regulations related to illegal logging, we first estimated the model without including the EN variable. Thereafter, we included the EN variable and reestimated model. The results are presented in Tables 3 and 4.

Table 3. Regression result without EN variable

Variable	C	LAB_1	LAB_2	LAB_3	LAND	KS	PCI	Adjusted R-squared
FURNITURE	84062.03***	19.628***	11.532***	-22.36***	-0.129***	-6.435***	3.092	0.68
	(3.771)	(5.705)	(5.345)	(-7.71)	(-3.448)	(-9.814)	(1.521)	
OTHER	20948.43 **	0.134	-0.417	0.384	0.025	-0.402	-0.63	0.06
	(-2.098)	(0.196)	(-0.87)	(0.916)	(1.32)	(-1.553)	(-1.103)	
PAPER	-286551.8***	1.572	1.078	-3.595**	0.198**	-2.328***	28.048***	0.09
	(-6.396)	(0.521)	(0.386)	(-2.211)	(2.519)	(-3.37)	(4.161)	
SAWN	-47125.09**	-2.214**	-1.79***	3.973***	0.497***	-2.97***	8.793***	0.44
	(-2.131)	(-1.988)	(-3.65)	4.141	7.586	-4.947	3.095	
WOODPULP	-106109.4***	-26.849***	-10.821***	27.699***	0.663***	3.049***	3.706	0.66
	(-2.83)	(-8.004	(-11.988)	(8.07)	(7.206)	(5.387)	(1.526)	
ROUND	56563.05***	-9.555***	-6.267***	7.522***	0.323***	1.036***	-4.32***	0.75
	(5.779)	(-5.819)	(-6.767)	(5.155)	(6.809)	(4.162)	(-5.764)	
PANEL	-11838.26***	9.948***	4.754***	-11.257***	0.074**	-2.948***	3**	0.51
	(-0.713)	(5.865)	(3.703)	(-8.813)	(2.424)	(-6.969)	(2.292)	
TOTAL	-341947.7	-7.33***	-1.93	2.37	1.64***	-11***	41.69**	0.37
	(-3.563)	(-1.272)	(-0.387)	(0.739)	(6.087)	(-4.638)	(3.502)	

*Significant at 10%, **significant at 5%, ***significant at 1%, t value in parentheses.

Looking at the effect of resource endowments in the models, we can see that the labor factor has exposed a significant effect on the net export of all kinds of products except paper, other wood and the total net export of all forest products. However, low quality labor has a significant effect on paper and high quality labor has a significant effect on total forest product. Capital stock as well as forestland area has significant effects on the net exports of all kinds of products with the exception of other wood. Per capita income has significant effects on net exports of paper, roundwood, wood-based panels, sawnwood and the sum of all forest products.

Table 4. Regression result with EN variable

Variable	C	LAB_1	LAB_2	LAB_3	LAND	KS	PCI	EN	Adjusted R-squared
FURNITURE	-274927***	19.354***	11.362***	-22.501***	-0.117***	-6.46***	-4.05**	176127.2***	0.69
	(-3.701)	(5.584)	(5.27)	(-7.681)	(-3.136)	(-10.191)	(-2.531)	(4.521)	
OTHER	34335**	0.176	-0.391	0.405	0.023	-0.398	0.470	-27123***	0.06
	(2.242)	(0.257)	(-0.813)	(0.957)	(1.225)	(-1.549)	(0.621)	(-2.798)	
PAPER	-318366**	1.556	1.067	-3.604**	0.199**	-2.33***	27.614***	10702	0.09
	(-2.364)	(0.514)	(0.383)	(-2.208)	(2.525)	(-3.371)	(4.061)	(0.162)	
SAWN-WOOD	-162425**	-2.302**	-1.849***	3.927***	0.5***	-2.98***	6.499**	56568.58*	0.44
	(-2.405)	(-2.073)	(-3.858)	(4.076)	(7.606)	(-4.965)	(2.519)	(1.838)	
WOOD PULP	-134326.1*	-26.87***	-10.834***	27.688***	0.664***	3.05***	3.145	13843.67	0.66
	(-1.785)	- (7.968)	(-12.031)	(8.08)	(7.193)	(5.373)	(1.396)	(0.426)	
ROUND-WOOD	-2326.869	-9.6***	-6.295***	7.498***	0.325***	1.03***	-5.491***	28892.6***	0.75
	(-0.12)	(-5.842)	(-6.794)	(5.165)	(6.844)	(4.102)	(-6.348)	(2.68)	
PANEL	-179278***	9.82***	4.675***	-11.323***	0.079***	-2.96***	-0.327	82149***	0.52
	(-3.697)	(5.748)	(3.648)	(-8.769)	(2.608)	(-7.052)	(-0.271)	(3.314)	
TOTAL	-1037314	-7.867***	-2.265	2.091	1.673***	-11.05***	27.86**	341161 **	0.37
	(-3.638)	(-1.362)	(-0.455)	(0.645)	(7.083)	(-4.673)	(2.496)	(2.533)	

*Significant at 10%, **significant at 5%, ***significant at 1%, t value in parentheses

Regarding the effect of the environmental variable, firstly we notice that the R-squared values of the models remain unchanged after adding the environmental variable, meaning that the variable does not change the explanatory power of the models. Secondly, we find that the environmental variable have significant effects on the net export of all types of forest products except wood pulp and paper. The effect is significantly positive on the net exports of furniture,

roundwood, wood-made panels, sawnwood, and the total net export of all products, and significantly negative on the net export of other wood.

It should be noted that the R-squared value of the models for other wood and paper is very low, implying that the models are inadequate for explaining the net export of these two types of forest products.

Conclusions

In this paper, 91 countries' data from 2005 to 2011 are used to test the impact of regulations against illegal logging on the comparative advantage of international trade of different categories of forest products based on the HOV model. The main conclusions are as follows:

1. Different factor endowments have different effects on the net export of forest products. Capital stock affects all kinds of forest products including their sum significantly. It affects the net export of roundwood and wood pulp positively, but affects the other kinds of products negatively. It means that a larger capital stock is advantageous for the net export of forest products of raw materials, but is disadvantageous for net the export of processed forest products. Forestland area has significant effects on the net export of all types of forest products except other wood, and its effects are positive for all kinds of forest products except furniture. Naturally we can derive that forestland area is still an important determinant of the comparative advantage of the forest products international trade. The effect of high and medium quality labors on the comparative advantage is negative for primary forest products like roundwood and sawnwood, but positive for processed forest products like furniture and wood-based panel. Low quality workforce has brought the opposite effects, its effects for the processed forest products are negative, while the effect for primary forest products are positive.

2. In the models that do not include trade regulations as an explanatory variable, per capita income affects all types of forest products' export positively except roundwood and other wood. This result is inconsistent with the theory of international trade. Although the effect of income on the net export of roundwood and other wood is negative, these two types of products are not consumption goods for which the demand would automatically increase when income increases. The result seems suggest that income has structural effects on the forest sector such that richer countries have better developed wood processing industry. This would explain the observed effects of income on the net export of different types of forest products.

3. Introducing trade regulations into the HOV model does not change the overall explanatory power of the model. The estimated model for other wood and paper has very low R-squared value. For some products like furniture, other wood and wood-based panel, in the new model PCI has exposed the opposite effect compare with the former one, as well PCI affects the net export of furniture significantly, while affects the net export of wood-based panel insignificantly.

4. Trade regulation aimed at reducing illegal logging have significant effects on the net export of different types of products except paper and wood pulp. The effect is positive on all kinds of forest products except for other wood. The result shows that the efforts against illegal logging have promoted the net export of major forest products, and their effects on the comparative advantage are mostly positive..

Acknowledgment

The paper is supported by the National Social Science Foundation of China (Grant No. 13BGL101). The first author would also like to thank the financial support from Jiangsu Education Administration Bureau.

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