Do China's Plywood Exports Depend on Trade Partners? Evidence from the Gravity Model

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Abstract

A gravity model was formulated to identify the factors related to China's plywood exports and examine whether the impact of factors depended on trade partners using panel data from 2005 to 2015. The data set was divided into three groups based on the income of trade partners. The findings reveal that the factors performed differently in the three groups. For the high income group, gross domestic product (GDP), per capita gross national income (GNI), the ratio of per capita forest area, and Open were related to China's plywood exports. GDP, the ratio of per capita forest area, exchange rate, and Open were correlated to China's plywood export for the middle income group. In the low income group, per capita GNI, the ratio of per capita forest area, Open and Free Trade Agreements were significantly related to China's plywood exports.

With a rapidly expanding economy and membership in the World Trade Organization, China's export activities have increased substantially in the 21st century, including plywood. China became the largest plywood producer in the world in 2003, surpassing the United States (Wan et al. 2010). China became the largest plywood exporting country in 2005, surpassing Malaysia and Indonesia (UN Comtrade 2017), and has continued to increase its export levels. Plywood played an important role among Chinese wood product[1] exports. The export value of China's plywood increased by an annual rate of approximately 21 percent between 2001 and 2017. Additionally, export volume rose from 1.27 to 11.46 million m^3 during the period 2001 to 2016, an annual rate of 16 percent. China's plywood export value accounted for 80 percent of China's wood-based panels and 37 percent of China's wood products in 2017, taking up 35 percent of the global plywood export trade in 2017.

Also, technical achievements are making plywood competitive with other panel products such as oriented strand board, which requires less labor costs during manufacture. Phenol formaldehyde resins that are tailored for plywood manufacturing parameters can be made with phenols derived from plants and trees through pyrolysis (Mao et al. 2018). Others are using liquefaction to make similar phenolic oils from waste lignin and plants to increase sustainability while meeting local plywood strength and dimensional stability standards (Lee et al. 2012).

As shown in Figure 1, export value rose very quickly between 2005 and 2007, with the value of plywood exports in 2007 almost doubling that of 2005. The Global Financial Crisis caused export value to decrease by almost 30 percent between 2007 and 2009. Since 2009, however, plywood export value has increased annually until 2014, reaching a high value of US$5.81 billion (UN Comtrade 2017). From 2015 to 2017, plywood export value decreased slightly.

The top 10 destinations of China's plywood exports accounted for 69 percent of China's total plywood export

[1] In this study, wood products refer to wood and articles of wood; wood charcoal, with Harmonized System code HS44.

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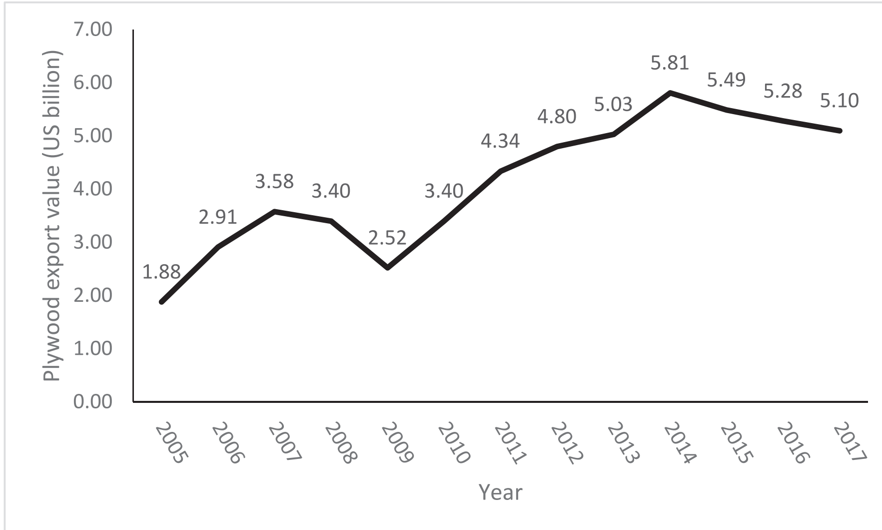

Figure 1.—China's plywood export value, 2005 to 2017.

value in 2005 (see Fig. 2; UN Comtrade 2017). The three primary destinations were the United States, Japan, and the United Kingdom, which accounted for 33 to 47 percent of the total between 2005 and 2017. The United States has been the largest export destination, comprising >20 percent of the total during the study period. Japan and the United Kingdom accounted for approximately 5 percent each. The Republic of Korea, Belgium, and the rest of Asia followed, with a stable 7 to 12 percent of export value during the 13-year period. The United Arab Emirates, Germany, Spain, and Israel played an important but less substantial role over the same period.

Why did China's plywood exports grow so fast? What factors accelerated China's plywood exports? Do the influencing factors perform the same with different trade partners? Most published work addresses more general categories of exports, such as wood products. For instance, Zhang et al. (1998), Sun et al. (2004), and Zhang and Li (2009) analyzed the wood products trade of China. Few researchers have focused specifically on China's plywood export trade. Wan et al. (2010) analyzed China's plywood demand, supply, and exports, but only included the United States as China's plywood export destination. The aim of this article is to examine whether the impact of factors related to China's plywood exports depends on trade partners. To achieve that, the data set was divided into three groups according to the income of trade partners, and the gravity model[2] was used for the three groups.

The rest of the article is structured as follows: first, a literature review, focusing on the gravity models; second, the methods, including panel-data regression models and estimation methods, which explain the data and variables used in the gravity model; third, the results for, and discussion of, the three groups; and finally, a conclusion section that summarizes the significant results.

Literature Review

The gravity model, first used by Tinbergen (1962), is one of most frequently used and effective methods to explain bilateral trade flows. The gravity model describes the relationship between a response variable and explanatory variables. The basic model is

$$E_{ij} = a_0 N_i^{a_1} N_j^{a_2} D_{ij}^{a_3} \tag{1}$$

where E_{ij} = volume of trade flow between country i and country j; N_i = gross national product (GNP) of import country i (proxy for economic size of country i); N_j = gross

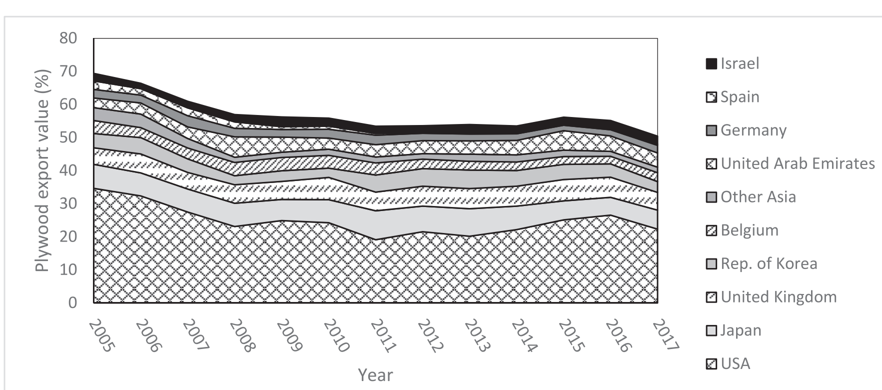

Figure 2.—Distribution of China's plywood exports, 2005 to 2017.

national product (GNP) of export country j (proxy for economic size of country j); D_{ij} = distance between country i and country j (proxy for transportation cost); a_1, a_2, and a_3 are trade elasticities for the corresponding explanatory variables; and a_0 is the gravitational constant.

Pöyhönen (1963) used a country's gross national income (GNI) rather than GNP as the proxy of economic size (I_i, I_j). He analyzed data for 10 European countries in 1958 to test the model. The model is defined by

$$E_{ij} = cc_i c_j \frac{I_i^{\alpha} I_j^{\beta}}{(1 + D_{ij})^{\xi}} \tag{2}$$

where, I_i = GNI of import country i (proxy for economic size of country i), I_j = GNI of export country j (proxy for economic size of country j), α and β are trade elasticities, ξ is isolation parameter, c_i is parameter of import country i, c_j is parameter of export country j, and c is constant.

Linnemann (1967) proposed that gross domestic product (GDP) could be a proxy of economic size (Y_i, Y_j). He added population (P_i, P_j) and a preferential factor (F_{ij}) as explanatory variables in the model (Eq. 3):

$$E_{ij} = \sigma_0 Y_i^{\alpha_1} Y_j^{\alpha_2} D_{ij}^{\alpha_3} P_i^{\alpha_4} P_j^{5} F_{ij}^{\alpha_6} \tag{3}$$

Since the initial studies of Tinbergen, Pöyhönen, and Linnemann, gravity models have been utilized extensively in international trade research. Anderson (1979) provided a theoretical grounding, deriving the gravity equation from the properties of an expenditure system. It was hypothesized that trade partners had identical homothetic preference, which was the structure of traded goods. Later studies by Bergstrand (1989, 1990), Harrigan (2001), Evenett and Keller (2002), and Hanson and Xiang (2004) enhanced the theoretical constructs.

The traditional gravity model included few explanatory variables: the proxy for economic size and transportation cost. Over time, additional variables have been added. Frankel (1992) incorporated per capita GNP as a proxy for a country's development level[3]. The results showed that per capita GNP had a positive effect, indicating richer countries traded more as the hypothesis suggests. Nguyen (2010) augmented the exchange rate to examine Vietnam's export trade. Guan and Gong (2015) used the ratio of per capita forestland area between trade partners and China as a proxy for the relative abundance of the forest resource endowment between them. The results revealed that the ratio of per capita forestland area had a significant impact on China's trade flow of forest products. Narayan and Nguyen (2016) introduced openness[4] as an explanatory variable to denote the openness level of Vietnam and its trading partners, and concluded that the influence of determinants was dependent on trading partners.

However, distance was not the only factor blocking bilateral trade between countries. McCallum (1995) analyzed the combined data of international trade between the individual states in the United States and provinces in Canada and interprovincial trade in Canada in 1988. He reported that the US–Canadian border had significant influences, resulting in province-to-province trade in Canada being much larger than Canadian province-to-US state trade. Based on this work, Anderson and Wincoop (2003) added multilateral resistance variables for trade (unions, currency exchange, languages, and adjacency). They noted that borders reduced bilateral trade, especially in small countries.

As gravity models evolved, dummy variables (binary variables for which the value equals 1 or 0 [Berger and Nitsch 2008]) were introduced. The influence of trade organization and regional trade agreements such as World Trade Organization and free trade agreements (FTAs) were assessed. Aitken (1973) analyzed the effects of European Economic Community (EEC) and European Free Trade Association (EFTA), finding that gross trade increased with EEC more than with EFTA. Brada and Mendez (1985) analyzed trade activities with FTAs among developing countries belonging to the Central American Common Market (CACM) or the Latin America Free Trade Agreement (LAFTA) and developed countries (who were members of EFTA or EEC). They found that trade in CACM countries was similar to that in EFTA and EEC countries, but LAFTA resulted in no positive effect.

Gravity models have been used to explain international trade for many different kinds of products or trades as well, including aquatic (Natale et al. 2015), agricultural (Esmaeili and Pourebrahim 2011), and forest products (Kangas and Niskanen 2003, Zhang and Li 2009, Akyüz 2010). Kangas and Niskanen (2003) studied forest products trade between the European Union (EU) and Central and Eastern European (CEE) candidates and reported that gravity models explained about 66 percent of the trade between EU and CEE, with EU countries focusing on high value-added products and CEE nations concentrating on lower value-added products. Zhang and Li (2009) used data from 1995 to 2004 to analyze determinants of Chinese wood products trade. The results revealed that the forest resource endowment of the trade partners and logging restrictions in China affected both wood product imports and exports in China. Akyüz (2010) used panel data from 2000 to 2006 to study trade between Turkey and the EU, concluding that Turkey and the EU had a strong relationship, but the trade volume in forest products between Turkey and EU countries was less than its potential.

Methods

Data

Our data set includes China's top 84 plywood export countries between 2005 and 2015[5], and is divided into three groups according to the income level of the country[6]. The

[2] The gravity model is one of most frequently used and effective methods to explain trade flows.

[3] The hypothesis is that if trade partners are more developed, they tend to trade more.

[4] Openness variable is constructed as total trade of goods divided by GDP.

[5] Value of plywood exports to these destinations comprises >90% of China's total plywood export value during 2005 to 2015. No zero trade flow showed in trade partners.

[6] Our data set was divided into three income groups, in order to examine whether the impact of factors on China's plywood export depended on trade partners. Also, it could avoid the endogeneity in the gravity model (Baier and Bergstrand 2007). Narayan and Nguyen (2016) divided the data set according the income and location, estimating the trade between Vietnam and its top 54 trade partners.

groups are based on 2016 per capita gross national income (GNI), using the World Bank Atlas method (World Bank 2018). The high income (HI) group includes trade partners with per capita GNI >US$12,236; the low income (LI) group includes those with per capita GNI <US$1,005, including lower middle income and low income countries; and the middle income (MI) group includes those with per capita GNI between US$1,005 and US$12,236 (Table 1). Plywood in this study was classified by the Harmonized System (HS), which is a multipurpose international product nomenclature developed by the World Customs Organization (2018). The Harmonized System code of plywood is HS4412: Plywood, veneered panels and similar laminated wood. The article will use the term ''plywood'' to represent all components of H4412. The study period begins in 2005 because that marks the point at which China became the largest plywood exporter.

In Table 2, we summarize the trade value (US dollar) contribution of each group to China's plywood export trade. For the average contribution, HI countries were the major contributors to China's plywood exports. In 2005, they contributed 89 percent of the total export flow, followed by MI countries with 5.8 percent and LI countries with 5.2 percent. During the study period, the percentage of HI decreased, while MI, and especially LI, increased.

Model specification

We used the gravity model to assess how China's plywood export levels were related to trade partners. To do this, we added more variables to the traditional gravity model. In the study, the response variable was China's plywood export value to trade partners. Explanatory variables included GDP, per capita GNI, the ratio of per capita forest area, exchange rate, and open index, as well as a dummy variable related to FTAs (Guan and Gong 2015, Wang et al. 2017, Das et al. 2018). Distance was not included in our gravity model, because Frankel (1992) pointed out that a simple geographical variable could result in bias toward intraregional trade. We utilized the natural log of the response and explanatory variables, except for the FTA dummy variable. The specific gravity equation used in our analysis was

$$lnE_{ij} = \alpha_0 + \alpha_1(lnGDP_j) + \alpha_2(lnPGNI_j) + \alpha_3(lnRFA_j) + \alpha_4(lnER_j) + \alpha_5(lnOpen_j) + \alpha_6 FTA_j + \varepsilon_j \tag{4}$$

where E_{ij}, the response variable, represents the export trade value of plywood from China to the destination countries j. Plywood export value data were obtained from the UN Comtrade (2017) and reported in US dollars.

GDP_j denotes the gross domestic product (GDP) of the export trade partner j, which is the proxy of their economic size. It is hypothesized that destination countries with more income will import more plywood. Therefore, GDP coefficient is expected to be positively related to trade. Data for GDP were obtained from the World Bank (2017) and reported in US dollars.

$PGNI_j$ is per capita gross national income (GNI) of trade partner j, which reflects the development level of trade partners. $PGNI_j$ increasing in the destination countries should encourage the China's plywood export trade. The coefficient is expected to be positive. Per capita GNI data were obtained from the World Bank (2017) and reported in US dollars.

RFA_{ij} is the ratio of per capita forest area between China and trade partners, which is a proxy of forest resource endowment. $RFA_{ij} = \frac{FA_j/P_j}{FA_i/P_i}$; FA_i and FA_j are the forest areas of China and trade partners, and P_i and P_j are the total populations of China and trade partners, respectively.

A large RFA means that trade partners have abundant forest resources compared with China. Trade partners have a comparative advantage in opportunity cost of plywood production (Das et al. 2018), which could reduce plywood imports from China. The coefficient is expected to be negative. Population data were collected from the World Bank (2017). Forest area data were obtained from the Global Forest Resources Assessment (FAOSTAT 2017a,b), but were available only for 2005, 2010, and 2015. Annual change rates from 2000 to 2010 and from 2010 to 2015 were given in the Global Forest Resources Assessment. The other years' data were calculated according to the original data and annual change rates.

ER_j refers to China's currency relative to that of trade partners j. An increase in exchange rate results in an appreciation of the Chinese Yuan against trading partner currency, which decreases China's plywood export trade flow because the exporting price to trade partners increases. The coefficient of exchange rate is expected to be negative. Exchange rates were calculated from the World Bank (2017).

$Open_j$ is an index, representing the trade openness and activity of trade partner j. We hypothesized a positive relation between openness and export trade flow. Open data were drawn from the Economic Freedom Website (Fraser Institute 2017).

FTA_j is the dummy variable of whether China signed FTAs with trade partner j. If they are involved in FTAs, the variable equals 1; otherwise 0. FTAs decrease the tariffs of China's product exports, including plywood (China FTA Network 2017). This process promotes China's plywood exports, and the coefficient of FTA is expected to be positive. FTA data were obtained from the China FTA Network (2017).

Table 1.—Trading partner groups divided by income.

Group[a]	Definition[b]
High income (HI)	GNI per capita ≥&12,236
Middle income (MI)	GNI per capita between \$1,005 and \$12,236
Low income (LI)	GNI per capita ≤&1,005

[a] Income groups follow World Bank Data, World Bank Country, and Lending Groups (for detailed classification see, https://datahelpdesk.worldbank.org/knowledgebase/articles/906519).

[b] GNI per capita = per capita gross national income. Reported in US dollars.

Table 2.—China's plywood export share by income (%).

Group	2005	2010	2015	Average
High income (HI)	89.0	80.5	77.3	80.3
Middle income (MI)	5.8	8.3	8.7	8.4
Low income (LI)	5.2	11.2	14.1	11.2

Empirical methods

To avoid multicollinearity of Equation 4, we evaluated variance inflation factors (VIFs)[7]. VIF values of all explanatory variables in all groups were <10 (Table 3), indicating that multicollinearity was not significant (Allison 1999).

The panel data of international trade flows would follow a dynamic data-generating process (Kabir et al. 2017). To avoid spurious regression, it was necessary to test the stationarity of panel data before proceeding with estimation. The common method is a unit root test. Three panel-data unit-root tests were employed—LLC (Levin et al. 2002), ADF-Fisher (Maddala and Wu 1999), and IPS (Im et al. 2003). The LLC test assumes a common root process, whereas the ADF test and IPS test assume an individual root process. Different tests improve the accuracy of the results. Three unit-root tests have the same null hypothesis that the panels contain a unit root. If the results reject the null hypothesis, the panel data is stationary.

Then, if the unit root results show that variables are integrated in the single level (no unit root), the co-integration test is conducted to examine whether data has a long-term relationship. We conducted Kao's (1999) co-integration test, which allowed for the endogeneity of the regressors in homogenous panel data. The null hypothesis of the Kao test is that no co-integration exists between variables. If the co-integration test rejects the null hypothesis, it suggests a long-term relationship existing between the Equation 4, after which we could conduct gravity estimations.

Four estimation methods—pooled OLS, fixed-effects (one-way), random-effects, and Poisson Pseudo Maximum Likelihood (PPML)—were used to analyze the data. The pooled OLS hypothesizes that the residuals are uncorrelated with the explanatory variables, with a 0 mean and constant variance (Buongiorno 2016). The fixed-effects approach hypothesizes that $\varepsilon_j = \Psi + \omega_j$, where Ψ is a constant term and ω_j is uncorrelated with the explanatory variables, with a 0 mean and constant variance (Buongiorno 2016). The random-effects estimation hypothesizes that $\varepsilon_j = \varphi + \omega_j$, where φ is a random variable uncorrelated with the explanatory variables. ω_j is defined as in the fixed-effects approach (Buongiorno 2016). Silva and Tenreyro (2006) argued the estimated parameters of log-linearized could be biased in the gravity model. However, it can be corrected by PPML. Therefore, we also used PPML for comparison.

Results and Discussion

Unit root tests and co-integration tests

We utilized three panel-data unit-root tests—LLC test, ADF-Fisher test, and IPS test, respectively—for all three groups, although we provide results only for the HI group (Table 4). Panel data are stationary (no unit root) if the results reject the null hypothesis. In the HI group (Table 4), the Open variable is stationary at level 1, whereas other

Table 3.—Variance inflation factors.[a]

Group	Ln(GDP)	Ln(PGNI)	Ln(RFA)	Ln(ER)	Open	FTA
High income (HI)	1.470	1.731	1.062	1.210	1.583	1.446
Middle income (MI)	1.407	1.253	1.212	1.197	1.304	1.081
Low income (LI)	2.306	2.041	1.445	1.589	1.809	1.399

[a] GDP = gross domestic product; PGNI = per capita gross national income; RFA = the ratio of per capita forest area between China and trade partners, which is a proxy of forest resource endowment; ER = China's currency relative to that of trade partners; Open = an index representing the trade openness and activity of trade partners; FTA = a dummy variable indicating whether China signed free trade agreements with trade partner.

variables were stationary at zero level. However, all variables were stationary in level 1. Variables are stationary in level 2 in the MI group, and stationary in level 1 in the LI group. For brevity, we only report the results for the HI group.

In three groups, all variables were integrated in the single level. Next, we conducted the Kao co-integration test in all groups. The results indicated that the Kao test rejected the null hypothesis for all groups (Table 5), suggesting a long-term relationship between Equation 4 in all groups. We then ran the gravity model.

Group gravity model results and discussion

Four estimation methods were used in this study—pooled OLS model, fixed-effects model (one way), random-effects model, and Poisson Pseudo Maximum Likelihood model (PPML). We used a Likelihood Ratio test to compare pooled OLS model and fixed-effects model[8]. The Hausman test was used to compare fixed-effects and random-effects model[9]. The results showed that the fixed-effects model was preferred in the HI group, compared with the pooled OLS and random-effects models. Also, PPML was used for comparison because it can eliminate the problem of zero trade flow (Westerlund and Wilhelmsson 2009). However, 94.8 percent of the response variables were explained by the explanatory variables in the fixed-effects model, >77.9 percent of that in PPML model (Table 6). Among the four models, the fixed-effects model was preferred for the all three income groups. For brevity, we only report fixed-effects model results for the MI and LI groups (Table 7).

GDP was positively and significantly related to China's plywood exports for the HI and MI groups (Tables 6 and 7), as reported by Turner and Buongiorno (2004) and Zhang and Li (2009). A 1 percent increase in GDP led to China's plywood exports increasing by 0.436 percent in HI countries and 1.614 percent in MI countries. PGNI was positively related to China's plywood exports to HI and LI countries.

[7] Multicollinearity refers to the existence of a high-correlation relationship between explanatory variables in a multiple-regression model. Before the regression model, multicollinearity should be tested to avoid distortion of the model. Variance inflation factor (VIF) is the ratio of variance with multiple terms divided by variance with one term in the model (James et al. 2017). It measures the multicollinearity of the regression model.

[8] Likelihood ratio test is a hypothesis test of goodness of fit between models. In panel data, it is used to differentiate the pooled OLS model and fixed-effects model. The null hypothesis is that pooled OLS is better than fixed effects. In our model, the results rejected the null hypothesis. Fixed-effects model was preferred.

[9] Huasman test is a statistical hypothesis test, which evaluates the consistency of two estimators (Wu 1974, Greene 2012). In panel data, it is used to distinguish between fixed-effects model and random-effects model. The null hypothesis is that random-effects model is better than fixed-effects model. In our model, the results rejected the null hypothesis. Fixed-effects model was preferred.

Table 4.—Unit root tests for the high income group.[a]

Variables[b]	LLC test	IPS test	ADF-Fisher test	Conclusion
Ln(E)	−10.204 (0.000)	−3.778 (0.000)	126.378 (0.000)	Stationary
Ln(GDP)	−8.638 (0.000)	−4.581 (0.000)	131.660 (0.000)	Stationary
Ln(PGNI)	−11.102 (0.000)	−5.617 (0.000)	155.661 (0.000)	Stationary
Ln(RFA)	−2.216 (0.013)	1.411 (0.921)	103.851 (0.003)	Stationary
Ln(ER)	−27.200 (0.000)	−3.070 (0.001)	52.979 (0.955)	Stationary
Ln(Open)	−4.195 (0.000)	−1.248 (0.106)	88.453 (0.091)	Nonstationary
DLn(Open)	−15.154 (0.000)	−8.743 (0.000)	212.726 (0.000)	Stationary

[a] Three unit-root tests were carried with an intercept. Probabilities are in parentheses. D refers to level 1.

[b] E = the export trade value of plywood from China to the destination countries; GDP = gross domestic product; PGNI = per capita gross national income; RFA = the ratio of per capita forest area between China and trade partners, which is a proxy of forest resource endowment; ER = China's currency relative to that of trade partners; Open = an index representing the trade openness and activity of trade partners.

Table 5.—Cointegration test.

Kao cointegration test	Statistic	Probability
High income	−4.553	0.000
Middle income	−6.529	0.000
Low income	−1.799	0.036

With a 1 percent increase in PGNI, China's plywood exports increased by 1.851 percent in HI countries and 1.889 percent in LI countries. As the proxy for trade partners' economic size, GDP and PGNI provided similar results, which are more sensitive to lower income countries.

RFA was negatively correlated with China's plywood exports in all groups, which was similar to results obtained by Guan and Gong (2015). A 1 percent increase in RFA resulted in 0.139, 3.574, and 2.059 percent declines in HI, MI, and LI countries, respectively. Trade partners have relatively abundant per capita forest area, so China's plywood exports decreased because of the comparative advantage conferred by the timber reserves of trade partners.

ER was found to be significantly and negatively related to China's plywood exports to MI countries, whereas no influence on HI and LI countries was identified. An increase in exchange rate, which is an appreciation of Chinese Yuan against trading partner currency, decreased China's plywood exports in MI countries. Exchange rate is considered the most crucial macroeconomic variable that affects international trade of forest products (Bolkesj and Buongiorno 2006). The effect of exchange rate on trade flow of forest products was debated in earlier studies. Commonly, exchange rate has negative effects on export trade of forest products (Jee and Yu 2001, Wisdom and Granskog 2003). However, some studies show that no relationship exists between exchange rate and forest products export trade (Buongiorno et al. 1988, Uusivuori and Buongiorno 1990). Our results with MI countries were consistent with Jee and Yu (2001) and Wisdom and Granskog (2003), whereas the results with HI and LI countries were in agreement with Buongiorno et al. (1988) and Uusivuori and Buongiorno (1990).

Open was positively correlated with China's plywood exports in HI and LI countries, and negatively associated in MI countries. A 1 percent rise in Open resulted in 3.516 and 3.416 percent increases in HI and LI countries, respectively, and a 3.762 percent decrease in MI countries. Open has important links to China's plywood exports. The result of MI countries was counter to the hypothesized relationship, possibly as a result of a number of factors. First, the data set was divided based on income level, whereas most previous research did not separate the data. Narayan and Nguyen's research (2016) also divided the data set according to the income of trade partners, and reported similar results. Moreover, other variables in the model could produce complex influence, resulting in the negative impact of Open on the MI group.

The dummy variable FTA was positively associated with China's plywood exports in LI countries. FTA between

Table 6.—Gravity model results[a] for the high income group.

Variable[b]	Pooled OLS	Fixed-effects	Random-effects	PPML
C		−21.041*** (−5.415)	−17.662*** (−6.438)	1.112*** (12.67)
Ln(GDP)	0.734*** (23.749)	0.436*** (2.847)	0.623*** (8.277)	0.045*** (27.35)
Ln(PGNI)	0.375*** (3.173)	1.851*** (7.502)	1.262*** (7.033)	0.029*** (5.04)
Ln(RFA)	−0.284*** (−11.562)	−0.139*** (−2.592)	−0.189*** (−4.433)	−0.018*** (−17.44)
Ln(ER)	0.154*** (5.448)	−0.068 (−1.116)	0.048 (0.995)	0.010*** (8.58)
Ln(Open)	−3.016*** (−5.588)	3.516*** (2.909)	2.502** (2.294)	0.120** (2.46)
FTA	0.117 (0.527)	−0.196 (−0.956)	−0.069 (−0.356)	−0.018** (−2.17)
R^2	0.747	0.948	0.442	0.779
Likelihood Ratio test		34.162 (0.000)		
Hausman test			27.960 (0.000)	

[a] Numbers in brackets correspond to t-statistic. PPML = Poisson Pseudo Maximum Likelihood model; ***, **, and * = statistical significance level of 1, 5, and 10 percent, respectively.

[b] C = constant; GDP = gross domestic product; PGNI = per capita gross national income; RFA = the ratio of per capita forest area between China and trade partners, which is a proxy of forest resource endowment; ER = China's currency relative to that of trade partners; Open = an index representing the trade openness and activity of trade partners; FTA = free trade agreement.

Table 7.—Fixed-effects model in middle income group (MI) and low income group (LI).[a]

Variable[b]	Middle income	Low income
C	−19.482* (−1.752)	−4.360 (−1.366)
Ln(GDP)	1.614** (2.690)	−0.014 (−0.202)
Ln(PGNI)	0.855 (1.301)	1.889*** (7.743)
Ln(RFA)	−3.574** (−3.157)	−2.059** (−3.555)
Ln(ER)	−0.603* (−0.603)	−0.218 (−0.873)
Ln(Open)	−3.762** (−3.078)	3.416** (2.188)
FTA	0.067 (0.319)	0.390* (1.723)
R^2	0.867	0.875
Likelihood Ratio test	45.458 (0.000)	23.604 (0.000)
Hausman test	39.116 (0.000)	38.275 (0.000)

[a] Numbers in brackets correspond to t-statistic; ***, **, and * = statistical significance level of 1, 5, and 10 percent, respectively.

[b] C = constant; GDP = gross domestic product; PGNI = per capita gross national income; RFA = the ratio of per capita forest area between China and trade partners, which is a proxy of forest resource endowment; ER = China's currency relative to that of trade partners; Open = an index representing the trade openness and activity of trade partners; FTA = free trade agreement.

China and trade partners eliminates or reduces trade barriers (tariffs of destination countries importing), improving China's plywood exports.

Conclusions

Focusing on 84 countries from 2005 to 2015, we used the gravity model to examine whether factors related to China's plywood exports depended on trade partners. The panel data set was divided into three groups, according to the income of trade partners. The results revealed that the impact of factors related to China's plywood exports do depend on trade partners. Variables performed differently in the three groups. For the high income group, GDP, PGNI, RFA and Open were related to China's plywood exports. GDP, RFA, ER, and Open were correlated with China's plywood exports for the middle income group. In the low income group, PGNI, RFA, Open, and FTA were significantly related to China's plywood exports. The variables proxy for economic size (GDP and PGNI) were more sensitive to lower income countries. Except for the Open variable in the middle income group, all variables were consistent with a priori expectations. A puzzling finding of the study is that Open does not improve China's plywood exports for middle income countries. Future research should examine whether this is a result of the data set classification.

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