An Empirical Analysis of China's Wood Pulp and Recovered Paper Imports Using an Augmented Gravity Model Approach

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Abstract

Production and consumption trends of China's pulp and paper products are discussed as well as imports of two principal raw materials: wood pulp and recovered paper. We developed an augmented gravity model to understand trade behavior between China and its trading partners using panel data from 1995 to 2012. The results show that China's economic growth is an important driver for wood pulp and recovered paper imports. Exporters' economic size has positive impacts on wood pulp exports and is also a significant factor in determining recovered paper exports. Distance has a significant negative impact on China's wood pulp and recovered paper imports. Finally, China's accession to the World Trade Organization increased both its wood pulp and recovered paper imports.

China has become an important producer and consumer of paper and paperboard in the world (RISI 2013). However, China's forest coverage and per capita forest inventory are only 20 percent of the land area and 10 m^3 per person, representing 67 and 14 percent of the world average, respectively (State Forestry Administration 2010). Although planted forests have contributed somewhat to higher levels of forest products production, China is still far from being self-sufficient in terms of raw materials for its paper-making industry. Consequently, China relies heavily on imported wood pulp and increasing amounts of imported recovered paper. For instance, China has recently become the largest importer of recovered paper in the world. While studies have lent insight into some of China's forest products trade activity (Cheng et al. 2010, Yang et al. 2012), little research has been carried out regarding China's wood pulp and recovered paper trade.

This article aims to discuss China's wood pulp and recovered paper imports during the past two decades. In the context of international trade, the gravity model has been extensively used to explain bilateral trade flows. The model was first introduced by Tinbergen (1962) and Pöyhönen (1963), assuming that the trade volume is positively related to the economic sizes of bilateral countries and negatively related to the geographic distance between them. Some other factors, such as common language, shared borders, and bilateral trade agreements have also been added to the model in recent research (Bergstrand 1985, De Grauwe 1988, Polak 1996, Kangas and Niskanen 2003). The gravity model has achieved great success in empirical analysis of bilateral trade flows between countries for many goods and services (Polak 1996, Eichengreen and Irwin 1998). With regard to forest products trade, Zhang and Li (2009) modeled China's forest products trade, but time-invariant variable distance and unobserved individual heterogeneity were ignored in the model. Hujala et al. (2013) explained changes in the international paper market. However, no special attention was paid to China's paper trade. We

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Forest Prod. J. 65(7/8):381–386.
doi:10.13073/FPJ-D-14-00080

expand the existing literature by studying wood pulp and recovered paper imports to China, and by using the Hausman-Taylor (HT) estimator that allows for time-invariant factors such as distance and individual-specific effects to be analyzed in the gravity model.

Developing Trends in China's Pulp and Paper Markets

Figure 1 shows the increase in China's paper and paperboard consumption from less than 26 million tonnes in 1995 to over 100 million tonnes in 2012, an annual growth rate of over 6 percent (Food and Agriculture Organization of the United Nations [FAO] 2013). In 2009, China became the largest consumer of paper in the world. Production of paper and paperboard showed the same growth trend throughout this period. Interestingly, the production and consumption of paper products have overlapped since 2006, indicating that the demand and supply of paper products in China are identical.

Figure 2 shows the production and consumption trends of China's wood pulp and recovered paper. The consumption of wood pulp rose to 25 million tonnes in 2012, almost eight times the level seen in 1995 (FAO 2013). This is a result of China's growing demand for paper as well as the increased use of wood fiber in place of straw fiber as the main raw material in China's biggest paper mills (Sun et al. 2004). Production of wood pulp increased slowly to 8 million tonnes in 2012, accounting for only one-third of China's total wood pulp consumption. There are two potential reasons for the gap between production and consumption. The main reason is China's lack of forest resources. Second, in 1998, a devastating flood in the upper and middle reaches of the Yangtze River resulted in the implementation of the Natural Forest Protection Program in China that restricts logging activities in natural forests, which in turn decreased China's wood pulp production.

Recovered paper has become an important raw material in the paper industry. Figure 2 also shows the consumption of recovered paper, which surpassed that of wood pulp during the period from 1995 to 2012. Consumption rose rapidly from 9 million tonnes in 1995 to around 75 million tonnes in 2012, an annual growth rate of 12 percent. Waste paper recovery in China is still far from self-sufficient. In 2012, recovered paper production accounted for only 60 percent of total consumption. Several reasons may account for the gap between recovered paper production and consumption. One is the technical progress of recovered paper usage in China's paper-making industry over the past two decades that causes the substitution of recovered paper for other materials in paper manufacturing. In addition, China's paper recycling is much lower compared with its fast increasing consumption of recovered paper.

China imports most of its wood pulp from countries rich in forest resources (Fig. 3). Canada is the most important wood pulp trading partner, accounting for a quarter of China's total import volume. Wood pulp imports from the United States and Indonesia increased from 0.19 to 2.13 million tonnes and from 0.10 to 1.75 million tonnes, respectively. Chile, Russia, and Finland together contributed over 20 percent of China's total import volume in 2012. Brazil has become the second largest importing source of wood pulp since 2008. Brazil's planted forests are an important raw material input for the chemical pulp-making industry (Hujala et al. 2013).

Figure 4 shows China's major source countries for recovered paper. Among these, the United States has been the largest source for imports, contributing about half of China's total import volume. The United States is followed by Japan and the United Kingdom, each accounting for over 10 percent of China's recovered paper imports in 2012. Recovered paper imports from The Netherlands, Canada, Hong Kong, and Australia increased during the period from 1995 to 2012, and together they accounted for more than 20 percent of China's import volume in 2012.

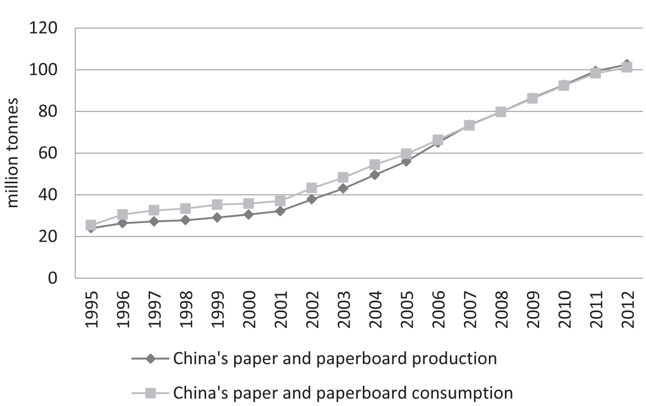

Figure 1.—China's paper and paperboard production and consumption from 1995 to 2012. Source: Food and Agriculture Organization Forestry databases.

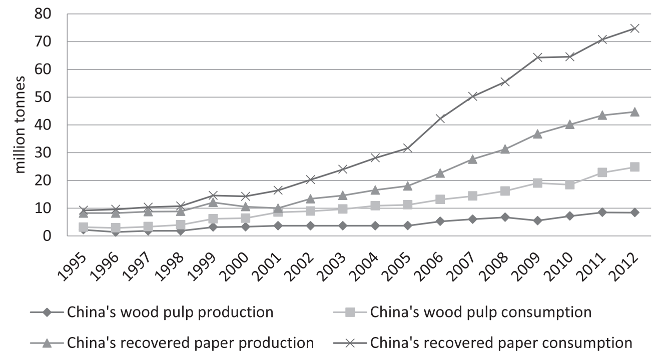

Figure 2.—China's wood pulp and recovered paper production and consumption from 1995 to 2012. Source: Food and Agriculture Organization Forestry databases.

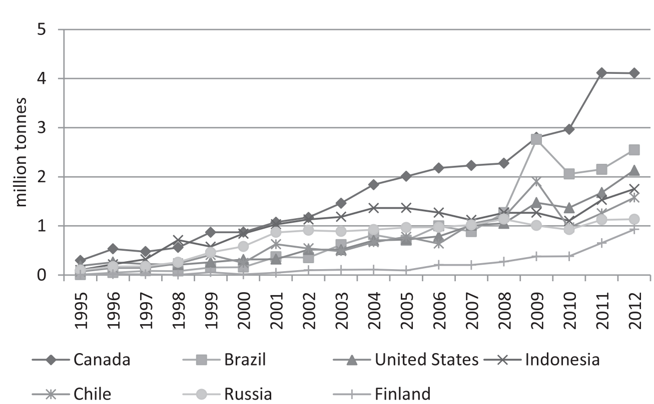

Figure 3.—Sources of China's wood pulp imports from 1995 to 2012. Source: Global Trade Atlas.

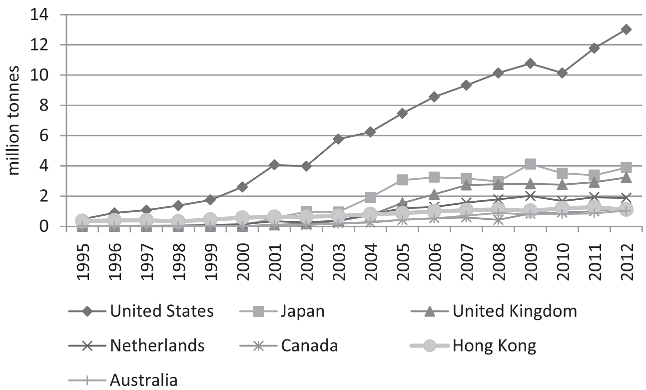

Figure 4.—Sources of China's recovered paper imports from 1995 to 2012. Source: Global Trade Atlas.

Model Specifications

In the context of wood pulp and recovered paper trade analysis, the gravity model has been widely used. For example, Kangas and Niskanen (2003) estimated a gravity model using an ordinary least square (OLS) estimator to analyze forest products trade between the European Union and the Central and Eastern European countries and indicated that income and distance have impacts on trade between the European Union and Central and Eastern European countries. Zhang and Li (2009) applied the gravity model using several estimation methodologies to estimate China's forest products trade and revealed that trade partners' forest resource endowments and China's forest logging restrictions have impacts on China's forest products imports and exports. Polyakov and Teeter (2007) used different specifications of a gravity model to explain pulpwood trade in the southern region of the United States and showed that the fixed coefficient gravity model exhibited the best results. Hujala et al. (2013) applied the gravity model to analyze changes in the international pulp and paper industry and found that import demand plays a more important role in determining chemical pulp and recovered paper trade.

The focus of this study was forest products trade. In particular, the study examined two raw materials imports for China's paper industry: wood pulp and recovered paper. The basic gravity model of international trade takes the form of:

$$F_{ij} = G\frac{M_i^{\alpha} M_j^{\beta}}{D_{ij}^{\gamma}} \tag{1}$$

where F_{ij} is the trade flows between two countries, M_i and M_j are the economic sizes of bilateral countries, D_{ij} is the distance between them, and G is the constant.

In this study, the gravity model was expanded by adding some other explanatory variables, which may have trade-adding or trade-resisting effects on China's wood pulp and recovered paper imports. The determinants of the trade activities of these two products are not the same, because wood pulp and recovered paper are sourced from different regions. Therefore, two gravity models were estimated. The gravity models are specified as follows for wood pulp imports (Eq. 2) and recovered paper imports (Eq. 3).

$$\begin{aligned}\ln T_{wit} = {} & \beta_1 \ln \mathrm{PGDP}_{ct} + \beta_2 \ln \mathrm{PGDP}_{it} + \beta_3 \ln D_{ci} + \beta_4 \ln \mathrm{RER}_{cit} \\ & + \beta_5 \ln \mathrm{PW}_{it} + \beta_6 \mathrm{APEC}_{it} + \beta_7 \mathrm{WTO}_{it} + \alpha_i + \varepsilon_{it}\end{aligned} \tag{2}$$

$$\begin{aligned}\ln T_{rit} = {} & \beta_1 \ln \mathrm{PGDP}_{ct} + \beta_2 \ln \mathrm{PGDP}_{it} + \beta_3 \ln D_{ci} + \beta_4 \ln \mathrm{RER}_{cit} \\ & + \beta_5 \mathrm{APEC}_{it} + \beta_6 \mathrm{WTO}_{it} + \alpha_i + \varepsilon_{it}\end{aligned} \tag{3}$$

The dependent variables T_{wit} and T_{rit} are China's imports of wood pulp (Eq. 2) and recovered paper (Eq. 3) from country i in year t. The independent variables in both models include the economic development level of China (PGDP_{ct}) and country i (PGDP_{it}), distance (D_{ci}), and bilateral real exchange rate (RER_{cit}). In Equation 2, we include exporters' pulpwood production per capita (PW_{it}). In addition, dummy variables for Asia-Pacific Economic Cooperation (APEC_{it}) and the World Trade Organization (WTO_{it}) are included in the two models. α_i is the constant and ε_{it} is the error term.

Gross domestic product per capita (PGDP) is treated as a proxy for the level of economic development, which will affect import demand and export supply. Economically developed countries tend to import and export more pulp and paper products as economic activity expands. Therefore, we expect the coefficients of PGDP in both China and the exporting countries to be positive.

Distance (D) indicates transportation costs, which may reduce the trade volume between China and other countries. Therefore, we expect it will have a negative coefficient. Typically, distance is calculated by the distance between capitals of bilateral trading partners. However, most of China's wood pulp and recovered paper imports are transported by ship. Thus, distance between capitals was not an appropriate measure in this study. As a result, we used the maritime distance between the main ports of China and its trading partners.

Real exchange rate (RER) suggests the relative price between bilateral trading countries. In this study, RER is defined by the ratio of trading partners' currency per Chinese Yuan. An appreciation of the Chinese Yuan will increase China's imports, while a depreciation of the Chinese Yuan will hinder China's imports. Thus, the coefficient of RER is expected to be positive.

We add each trading partner's pulpwood production per capita (PW) into Equation 2 because it has an impact on the export supply. Countries with larger pulpwood production tend to produce and export more wood pulp. Thus, the coefficient is expected to be positive. In Equation 3, however, we drop this variable, because recovered paper production is not determined by pulpwood production but by paper consumption and waste paper recycling efficiency.

According to Carrère (2006) and Jayasinghe and Sarker (2008), regional trading agreements are a beneficial factor that boost trade flows among members and reduce them between nonmembers. We include a dummy variable (APEC) in both models because China's membership to the Asia-Pacific Economic Cooperation since 1991 is expected to have a positive effect on China's imports of wood pulp and recovered paper from other members. The APEC dummy equals 1 if the exporter is also a member of APEC and 0 otherwise. Another factor considered is China's accession to the World Trade Organization in 2001. A dummy variable (WTO) is used to capture the impacts of this event. The WTO dummy variable is equal to 1 when the exporting country is a member of the WTO after 2001 and 0 otherwise. It is assumed to have a positive effect on China's wood pulp and recovered paper imports.

Estimation Method and Data

Estimation method

Early gravity models were estimated with cross-sectional data using OLS methods. However, this approach does not allow time effects to be included and may lead to biased estimates owing to neglected heterogeneity (Serlenga and Shin 2007). Panel data are used to solve the problem. A fixed-effects (FE) estimator and a random-effects (RE) estimator are applied to panel data models. However, the FE estimator drops time-invariant variables, such as distance, which is an important factor in bilateral trade analysis, while assuming an RE estimator would not account for any significant individual effects among different countries.

Hausman and Taylor (1981) put forward a new method that is used to resolve the limitations of using panel data to estimate gravity models. It treats time-varying variables as instruments for endogenous independent variables that are correlated with country-specific heterogeneity, which can provide consistent parameter estimates. Another advantage of the HT estimator is that time-invariant variables such as distance can now be included in the model. In this study, we assumed that only GDP per capita is correlated with individual-specific effects, and this assumption can be tested by the over-identification test according to Hausman and Taylor (1981). Egger (2005) compared different estimation techniques for the gravity model and found that the HT estimator provides consistent estimates, while the traditional FE estimator and the RE estimator do not work very well. Serlenga and Shin (2007) showed that the empirical results of the HT estimator are more sensible than the FE and RE estimators. In this article, the HT estimator for both China's wood pulp imports and recovered paper imports will be estimated.

Data description

The time period of this study is from 1995 to 2012. The data on China's wood pulp and recovered paper imports are from the Global Trade Atlas (2013). The data on paper and paperboard, wood pulp, recovered paper, and pulpwood production and consumption came from the FAOSTAT Forestry database by the FAO (2013). The GDP per capita is from the World Development Indicators database published by The World Bank (2013). The real exchange rate is taken from the Agricultural Exchange Rate data set provided by the US Department of Agriculture (2013). The distance between China and its trading partners originates from the online Web site SeaRates.com (2013). Summary statistics for the variables are presented in Table 1.

As can be seen from Table 1, each variable except pulpwood production per capita has 360 observations. The mean of China's recovered paper imports is almost double that of China's wood pulp imports. China's GDP per capita increased from a low of $778 to a high of $3,348. The standard deviation of exporters' GDP per capita in the wood pulp model is much larger than that of the recovered paper model, and the mean of this variable is smaller in the wood pulp model. The real exchange rate differs greatly between these two models given the sets of country-specific observations are different. Distance and dummy variables are similar. In the empirical analysis, all the variables except dummy variables are expressed in natural log units.

Empirical Results

The gravity models are estimated using an HT estimator. Estimation results for the FE estimator and the RE estimator are also reported. To test the superiority of the HT estimator, we first run a Hausman test to decide between the FE and the RE estimators. Results show that an RE estimator is preferred over an FE estimator for both China's wood pulp and recovered paper imports. Then, an over-identification test is applied, and the results suggest GDP per capita as an instrument for endogenous independent variables is correlated with country-specific heterogeneity. Therefore, the RE estimator may produce biased estimates. The HT estimator is more efficient. Empirical results for China's wood pulp and recovered paper imports are presented in Table 2.

The estimation results of the HT estimator for China's wood pulp imports show that most coefficients of explanatory variables have the expected signs and are statistically significant. The positive and significant coefficient of China's GDP per capita suggests China's economic growth and increasing demand for paper products have raised wood pulp imports. A 1 percent increase of China's GDP per capita resulted in a 1.7 percent increase of China's wood pulp imports. The coefficient of exporters' GDP per capita is also positive and significant, indicating that exporters' supply capability is important in determining wood pulp exports. A 1 percent increase of exporters' GDP per capita led to a 3.2 percent increase in China's wood pulp imports. A negative and significant coefficient of distance clearly shows transportation costs have negative impacts on China's wood pulp imports. A 1 percent increase in distance led to 4.2 percent less wood pulp imports.

The coefficient of exporters' pulpwood production per capita has the expected positive sign and is significant at the 1 percent level, which means exporters' forest resource

Table 1.—Summary statistics.

Variable[a]	Wood pulp Mean	SD	Min.	Max.	Obs.	Recovered paper Mean	SD	Min.	Max.	Obs.
China's wood pulp imports (million tonnes)	0.34	0.61	0.00	4.12	360					
China's recovered paper imports (million tonnes)						0.66	1.69	0.00	13.02	360
China's GDP per capita (USD)	1,746	806	778	3,348	360	1,746	806	778	3,348	360
Exporters' GDP per capita (USD)	22,808	16,612	1,050	67,805	360	29,543	12,851	3,300	67,805	360
Distance (km)	15,163	6,882	1,407	21,663	360	14,256	7,072	804	21,611	360
Pulpwood production per capita (m^3)	0.77	1.11	0.02	4.91	355					
Real exchange rate	66.75	277.94	0.08	2,318.72	360	8.72	33.33	0.06	197.31	360
APEC	0.44	0.50	0.00	1.00	360	0.49	0.50	0.00	1.00	360
WTO	0.58	0.49	0.00	1.00	360	0.58	0.49	0.00	1.00	360

[a] GDP = gross domestic product; APEC = Asia-Pacific Economic Cooperation; WTO = World Trade Organization.

Table 2.—Estimation results for China's wood pulp and recovered paper imports.[a]

Explanatory variable	Model 1 (wood pulp)			Model 2 (recovered paper)		
	FE estimator	RE estimator	HT estimator	FE estimator	RE estimator	HT estimator
China's GDP per capita	1.593*** (2.86)	2.342*** (5.61)	1.705*** (3.15)	4.346*** (7.87)	3.984*** (8.48)	4.184*** (8.55)
Exporters' GDP per capita	4.007** (2.17)	0.077 (0.10)	3.229* (1.85)	2.535 (1.51)	3.137*** (3.84)	2.107* (1.83)
Distance		−2.540** (−2.43)	−4.238** (−2.34)		−3.896*** (−3.68)	−3.941*** (−3.28)
Exporters' pulpwood production per capita	1.427*** (4.32)	1.371*** (4.56)	1.357*** (4.24)			
Real exchange rate	0.500 (0.73)	0.132 (0.38)	0.735 (1.31)	−2.097*** (−2.39)	−1.182*** (−2.58)	−1.326*** (−2.58)
APEC	−2.356** (−1.98)	0.046 (0.05)	−1.539 (−1.39)	−2.670* (−1.91)	−1.028 (−1.13)	−1.217 (−1.23)
WTO	0.521 (1.42)	0.584* (1.62)	0.582* (1.61)	1.656*** (3.60)	1.889*** (4.34)	1.905*** (4.36)
Constant	−38.074** (−2.55)	17.067 (1.41)	8.159 (0.43)	−49.684*** (−3.34)	−16.984 (−1.52)	−7.630 (−0.57)
Hausman test	11.60 χ^2 (6)			1.21 χ^2 (5)		
Over-identification Test			3.86 χ^2 (6)			3.56 χ^2 (5)
No. of observations	355	355	355	360	360	360
No. of groups	20	20	20	20	20	20

[a] The numbers in parentheses are *t* statistics. In the Hausman-Taylor (HT) estimator, gross domestic product (GDP) per capita is a time-varying endogenous variable and distance is a time-invariant exogenous variable. All other variables are time-varying exogenous variables. FE = fixed effects; RE = random effects; APEC = Asia-Pacific Economic Cooperation; WTO = World Trade Organization; *** = significant at the 1 percent level; ** = significant at the 5 percent level; * = significant at the 10 percent level.

endowments have positive impacts on wood pulp exports. A positive and insignificant coefficient of real exchange rate means that an appreciation of the Chinese currency against exporters' currency does not increase China's wood pulp imports. Contrary to expectation, the coefficient of APEC is negative and insignificant, indicating China's decision to join the APEC may not help wood pulp imports. A positive and significant coefficient of WTO suggests China's accession to the WTO increases wood pulp imports.

Results observed from the HT estimator for recovered paper imports are presented next. The coefficient of China's GDP per capita is positive and significant at the 1 percent level, indicating that China's demand for raw materials has increased recovered paper imports during the past two decades. A 1 percent increase of China's GDP per capita resulted in a 4.2 percent increase of China's recovered paper imports. The coefficient of exporters' GDP per capita is positive and significant at the 10 percent level, implying that exporters' economic development level is still an important factor in determining recovered paper exports. A 1 percent increase of exporters' GDP per capita led to a 2.1 percent increase in recovered paper imports. Distance has a negative and significant coefficient, indicating transportation costs will reduce China's recovered paper imports. A 1 percent increase in distance led to 3.9 percent less recovered paper imports.

Unexpectedly, the coefficient of real exchange rate is negative and significant, suggesting an appreciation of the Chinese currency may decrease China's recovered paper imports. A positive and significant coefficient of WTO suggests China's entrance to the WTO increases recovered paper imports. Additionally, the coefficient of APEC is negative and insignificant, which means there is no close relationship between an APEC membership and China's recovered paper imports.

Discussion and Conclusions

This study aimed to discuss China's wood pulp and recovered paper imports. We expanded the traditional gravity model by adding some proper explanatory variables that have impacts on China's wood pulp and recovered paper imports and compared different estimation methodologies. The HT estimator was chosen over the FE and RE estimators to estimate panel data. Most of the explanatory variables have the expected signs and are statistically significant, indicating that the gravity model is successful in explaining China's wood pulp and recovered paper imports.

According to the results, China's growing demand was an important driver of wood pulp and recovered paper imports over the past two decades. However, the effects are different. This may be caused by the substitution between recovered paper and wood pulp as raw materials in China's paper-making industry. Imported recovered paper has become a main raw material for the paper-making industry in China. The results also show that exporters' economic growth has impacted raw material supplies to China, but it is less significant than China's own economic development. It is clear that China's quickly increasing demand is a more important driver of wood pulp and recovered paper imports. Besides, exporters' pulpwood production had significant positive effects on wood pulp exports. This is because wood pulp industry is resource intensive. Thus, countries with rich pulpwood resources have bigger supply capabilities in wood pulp exports.

Contrary to the previous research, an increase in the value of Chinese currency did not significantly increase China's imports of wood pulp. However, it did decrease China's recovered paper imports. Two factors to consider when evaluating this result are (1) China is the biggest importer of recovered paper and (2) over 40 percent of the total volume comes from the United States. The real exchange rate between Renminbi (RMB) and the US dollar has been rising since 2005, but recovered paper production in the United States is almost even with the 2008 level. Another reason is that recovered paper is price inelastic because of the rigid demand. In addition, being a member of the APEC did not increase China's wood pulp and recovered paper imports. Possible reasons could be the inclusion of the distance variable in the HT estimator given that APEC membership consists of Asian-Pacific countries with possible correlation between distances.

Several factors not studied may have future impacts on China's imports of wood pulp and recovered paper. With the widespread usage of information technology, consumption of printed paper products decreased in economically developed countries. This may impact China's paper products exports, as well as the imports of wood pulp and recovered paper. China's own waste paper recycling rate, although relatively low, continues to grow steadily. In addition, the fast-growing and high-yielding planted forests in China, such as eucalyptus, will be an important raw material for the paper-making industry. All of these changes may have significant impacts on China's paper industry in the future. Future studies using the gravity model on China's paper products trade may provide more insights on these factors.

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