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economics

Tariff and US Paper Products Trade

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In this article, we used the gravity model to study the effects of tariffs on US exports and imports of paper products that include paper, paperboard, and wood pulp. The results show that an increase in tariffs would have a small, significant, and asymmetric impact on US exports and imports of paper products. Furthermore, exchange rates, economic sizes of the United States and its trade partners, and internet use rates are found to be significant factors influencing US paper products trade. These results show that the United States has some leverage in promoting free trade in paper products.

Keywords: paper and paperboard, tariff, exchange rate, gravity model, panel data, trade

The United States is the largest producer of paper products in the world (World Growth 2011). Between 1990 and 2014, US production of paper products accounted for 27% of global paper production, and its imports and exports accounted for 21% and 17% of the global total imports and exports, respectively (FAOSTAT 2016). In the same period, the share of US imports and exports to domestic consumption was 13.5% and 11.5%, respectively (FAOSTAT 2016). Although US trade in paper products grew steadily over the last 25 years, the country has changed from a net importer to a net exporter since 2010 (Figure 1).

The purpose of this paper is to study the effects of tariffs on the import and export of US paper products. Since its peak in 1933 that resulted from the infamous Smoot-Hawley Act, the US general tariff rate, measured as the share of tariffs collected on all dutiable goods, has declined steadily (Figure 2). In addition, the share of duty-free imports to the United States has been increasing in the last few decades. As a result, the weighted average rate of US duties on all imported goods has remained around 1.5% in the last 30 years (Figure 2). US tariff rates on imported paper products have been reduced even further to an average of 0.8% between 1990 and 2014 (World Bank 2016). Similarly, tariff rates on exports of US paper products to other countries have declined sharply, albeit not to the level of the US tariff rate on paper product imports (Figure 3). Yet, it is unclear if and to what extent the reduction in tariff rates in the United States and by its trading partners has enhanced US paper product trade in the last few decades. In this paper, we intend to fill this gap by investigating the effect of tariffs on controlling trade flows of paper products between the United States and its trading partners.

A few scholars (e.g., Buongiorno 1978, Baudin and Lundberg 1987, Li and Zhang 2008, Hujala et al. 2013) have studied the demand and trade flows of paper products without considering tariffs. There have been many studies on the effect of tariff and other trade measures on forest product trade besides paper products, notably softwood lumber related to the softwood lumber war between the United States and Canada (e.g., Zhang 2007, Nagubadi and Zhang 2013, Parajuli and Zhang 2016) and wood furniture associated with antidumping activities in the United States (e.g., Luo et al. 2015). Studies on tariffs have also been conducted on agricultural and other commodities such as apples (Yue et al. 2006), wheat (Koo and Uhm 2007), meat (Koo et al. 1994), salmon (Asche 2001, Kinnucan and Myrland 2005), tobacco (Pompelli and Pick 1990), Portland cement (Cohen-Meidan 2013), and chemical products (Krupp 1994). Irwin (2010) compares the deadweight losses from US tariffs among various industries. Most of these studies indicate that tariff has a negative impact on US trade, but the magnitude of its impact is asymmetric, with the tariff on US imports being greater than the tariff on US exports. The next section describes our study method and models, followed by data and empirical results. The final section concludes with some discussion on trade policy.

Methods and Models

To determine the major factors that may influence US paper products trade, we used the gravity model, which provides consistent results and relatively compact specification (Grant and Anders 2010) in this study. Known as a "workhorse" for empirical studies in international economics, the gravity model has performed

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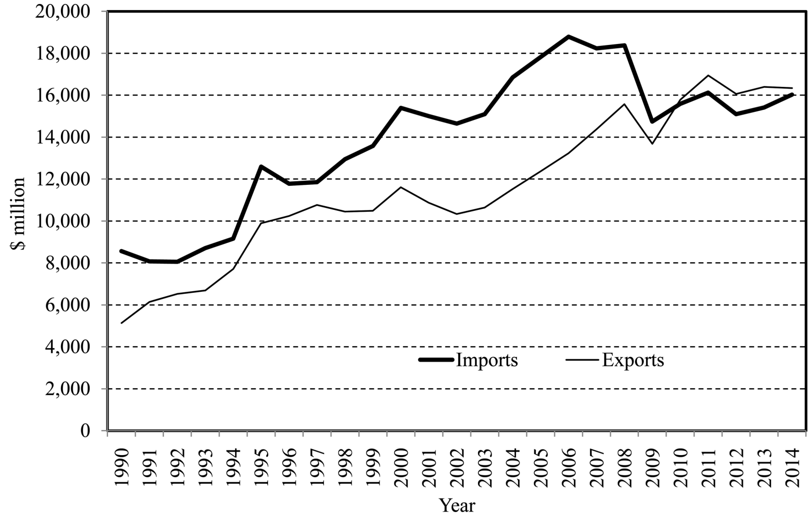

Figure 1. Trade flows of US paper products: 1990–2014. Source: FAOSTAT (2016).

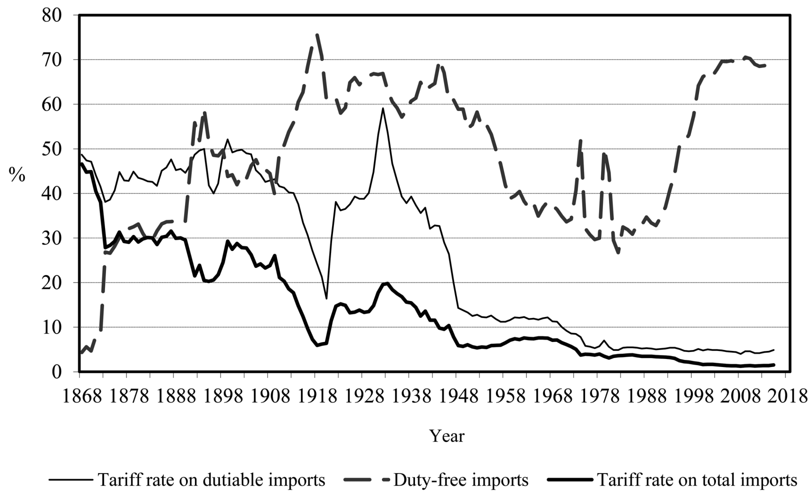

Figure 2. Tariff rates on dutiable and total imports and share of duty-free imports in the United States, 1868–2015. Sources: Zhang (2007); USITC (2016).

remarkably well in explaining bilateral trade flows (Eichengreen and Irwin 1998). Pioneered by Tinbergen (1962) and Pöyhönen (1963), the gravity model states in its most rudimentary form that bilateral trade increases with economic mass and decreases with commercial distance, just as the Newton's gravity equation in physics demonstrates. Anderson and van Wincoop (2003) expand this model to cover multilateral trade resistance indexes such as importer- and exporter-fixed effects. Empirically, the gravity model has been used to explain bilateral trade flows (e.g., Summary 1989, Sohn 2005), to investigate determinants and impacts of trading blocs (e.g., Krugman 1991, Roberts 2004), to predict trade potential (e.g., Frankel and Romer 1999), to differentiate alternative trade theories (Feenstra et al. 2001), and to study the impacts of international borders (e.g., McCallum 1995, Evans 2003), language (Hutchinson 2002), and currency unions (e.g., Rose 2000, Frankel and Rose 2002, Buongiorno 2015). Nonetheless, the gravity model is used only to describe the behavior of trade flows, not economic welfare (Shepherd 2013). Furthermore, it has presented discrepancies in defining the parameters involved, giving rise to the "ad hoc" nature of hypotheses on the international mobility of goods (Mele and Baistrocchi 2012). These issues do not directly impact this paper because we do not analyze economic welfare here, and parameters can only be refined by additional empirical studies.

Most studies that use the gravity model are based on aggregated trade flows, although studies using disaggregated, industry-level trade data are increasing. As for forest products trade, Kangas (2001) uses the gravity model to study the development of round wood trade in Europe, and Kangas and Niskanen (2003) use it to investigate forest products trade patterns between European

Management and Policy Implications

We find that a tariff has a significantly negative impact on US paper products trade, but the magnitude of its impact is asymmetric with respect to imports and exports. In particular, US imports of paper products are more sensitive to US tariff than US exports of paper products to the tariff imposed on US paper products. Given the fact that the US average tariff rate on paper products is much lower than that of its trading partners, the United States has some leverage in negotiating tariff reductions with its trading partners and promoting free trade in paper products.

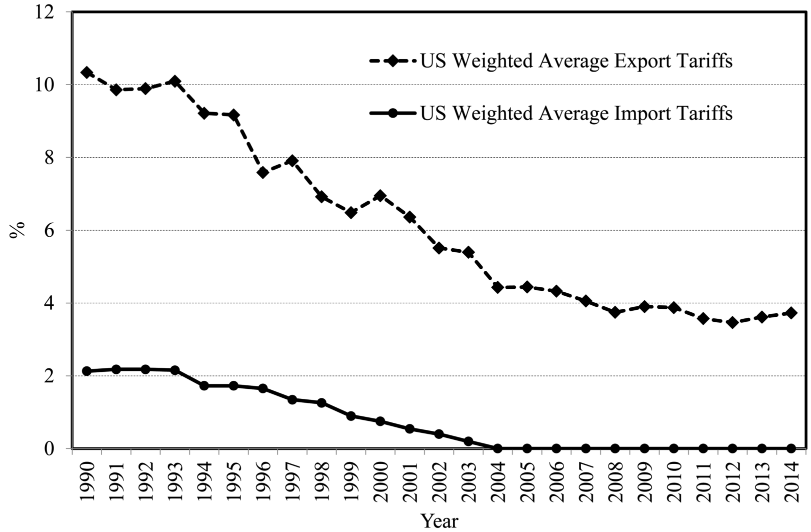

Figure 3. Tariff rates in the United States and its trading partners: 1990–2014. Source: TRAINS, the World Bank.

Union countries and Central and Eastern European countries. Kang (2003) uses it to investigate US wood product trade, while Li and Zhang (2008) and Zhang and Li (2009) analyze factors affecting China's wood products and paper products trade, respectively. Again, none of these studies has a tariff variable.

This study applies an augmented gravity model separately to examine US paper products imports and exports using panel data. The trade flow of US paper products is modeled as

$$T_{it} = e^{\alpha_i} \prod_m X_{imt}^{\beta_m} \prod_k e^{\gamma_k P_{ikt}} \varepsilon_{it} \tag{1}$$

or in its log-linear form

$$lnT_{it} = \alpha_i + \sum_m \beta_m lnX_{imt} + \sum_k \gamma_k P_{ikt} + ln\varepsilon_{it} \tag{2}$$

where T_{it} is the value of paper products exports or imports between the United States and its trading partner ($i \in M$, where M is the total number of US paper products trading partners) in year t (t = 1, 2, …25); X_{imt} is the mth explanatory variable for country i in year t, and P_{ikt} is the kth dummy variable; β and γ are parameters to be estimated, and ε_{it} is the error term. Equation (2) is called a fixed-effects (random-effects) panel data model if the intercept α_i is assumed to be fixed (random).

The independent variables included in this study are distance, exchange rate, US Gross Domestic Production (GDP), GDP of US trading partners, tariff rate, World Trade Organization (WTO) membership, US economic recessions, US internet use rate, the US trading partner internet use rate, and the lagged dependent variable for controlling possible autocorrelation. Since we used panel data, which may bring potential issues of fixed effects/random effects, heteroscedasticity, and endogeneity, we applied the Passion Pseudo Maximum Likelihood (PPML) estimation including fixed effects of country and time (year) then compared the results with those of the Ordinary Least Square (OLS) regression, and Generalized Methods of Moment (GMM) estimation. The latter treats the tariff variable as endogenous.

The final models expressing the effects of the gravity variables on the exports or imports of paper products in the United States are presented in Equation (2), which becomes

$$\begin{aligned} \ln(import_{it}) / \ln(export_{it}) = {} & \alpha + \alpha_i + \alpha_t + \beta_1 \ln\left(import_{i(t-1)}\right) \\ & / \ln\left(export_{i(t-1)}\right) + \beta_2 \ln(distance_i) \\ & + \beta_3 \ln(ex_{it}) + \beta_4 \ln(PNGDP_{it}) \\ & + \beta_5 \ln(USGDP_t) + \beta_6 tariff_{it} \\ & + \beta_7 recession_t + \beta_8 WTO_{it} \\ & + \beta_9 usinteru_t + \beta_{10} partnerinter_{it} + \varepsilon_{it}, \end{aligned} \tag{3}$$

where ln(import$_{it}$) or ln(export$_{it}$) is the logarithm of the real value of the US imports or exports with a partner country i in year t; and α_i and α_t are dummy variables representing fixed effects caused by a country i and year t, respectively. In addition to the lag value of imports or exports, (ln(import$_{i(t-1)}$)/ ln(export$_{i(t-1)}$)), the independent variables included in Equation (3) are geographical distance between countries (ln(distance$_{it}$)); exchange rate (ln(ex$_{it}$)); the economic sizes of the exporting and importing countries captured by their respective gross domestic product (ln(PNGDP$_{it}$); ln(USGDP$_{it}$)); the tariff rate (tariff$_{it}$) applied by the United States for imported paper products from a county i; dummy variables for US economic recessions; a dummy variable indicating whether a partner country is a member of the WHO (WTO$_{it}$); the US internet use rate (usinter$_t$); and the partner countries' internet use rate per total population calculated as individuals using the internet (partnerinter$_t$).

The last two variables are included because a literature review reveals that technology development is one of the major driving forces to shift the demand of newsprint, printing, and writing paper (Hetemaki 2005). Recently, Hujala (2011), Latta et al. (2016), and Johnston (2016) showed that internet adaptation in a population is a key variable in estimating the current consumption or predicting the future demand of paper products. Both Latta et al. (2016) and Johnston (2016) demonstrate that internet usage reduces the demand of newsprint, printing, and writing paper because internet and printing and writing paper are substitutes. In addition, the growth of the internet influences investment in paper production (Latta et al. 2016). Therefore, we assume internet use rate has a negative effect on the export supply and import demand of US paper products. As domestic consumption is influenced by price, income, and other variables (Latta et al. 2016), adding the internet-use rate variable in the model could also serve as a proxy and exogenous variable for domestic consumption.

By including US GDP in the model, we assume that the size of the US economy correlates with the import demand and export supply of paper products. The logic for a positive relationship between US imports of paper products and US GDP is that when US GDP increases, personal income and domestic consumption in the United States grow, which promotes imports. On the other hand, it is expected that US GDP should have a negative relationship with US export of paper products. The sign of the US GDP variable could become positive because strong domestic demand is a prerequisite to the development of an export industry (Basevi 1970), which has been proved to be true with nondurable consumer goods (Clarida 1994).

The real GDP of US trading partners also affects both US exports and imports. A country with a high GDP means that it demands more imports of paper products from the United States and elsewhere. Yet the sign of this variable on exports of US paper products may vary depending on whether paper products in the country are normal or necessary products.

We expect that a long distance between two countries limits their trade. The exchange rate is the ratio of the local currency per US dollar. An increase in exchange rate implies an appreciation of US dollars, which works as an export tax and import subsidy. Thus, an increase in exchange rate often leads to an increase in imports and a decrease in exports. Similarly, a decrease in exchange rate means depreciation of US dollars and serves as an export subsidy and import tariff, which increases US exports and decreases US imports. This effect is found to be true for China's wood products trade (Zhang and Li 2009) and softwood lumber trade in the United States (Bolkesjo and Buongiorno 2006, Parajuli and Zhang 2016). On the other hand, Buongiorno et al. (1988) and Nagubadi et al. (2009) show that there is no significant effect of exchange rate on softwood lumber imports to the United States from Canada, and Uusivuori and Buongiorno (1990) find that exchange rate has a small effect on Swedish and Finnish exports of forest products to the United States that disappears within a year. Overall, these studies only cover certain forest products and one or a few US trade partners and therefore may not present the whole picture of US forest products trade with many countries.

The dummy variable for WTO membership (WTO_{it}) takes the value of 1 if a partner country is a WTO member at year t, and zero otherwise. This variable is expected to be positive because a country that is open to world trade promotes exports and imports. Another dummy variable, $recession_t$, takes the value of 1 when the United States had economic recessions in 1990, 2001, and 2008, and zero otherwise. A recession is defined as a negative growth in GDP for a specific year, and this dummy variable determines whether negative shocks in US economic growth affect the exports and imports of paper products. Ince and McKeever (2011) and Zhang et al. (2017) find that the economic recessions had a negative impact on US paper demand and imports of US forest products, respectively. Therefore, we assume the recessions caused a decrease in imports and exports of paper products in these three years as well as for the following years (1991, 2002, and 2009). The effect of a dummy variable on US exports or imports of paper products is measured by a $((\exp(\beta_n) - 1)*100)$ percentage, where β_n is the estimated coefficient of the dummy variable.

The key coefficient of interest in this research is β_6, which measures the effect of average annual tariff rate on US imports and exports of paper products. In theory, tariffs impede bilateral trade. Therefore, we test the hypothesis that the effects of tariffs on exports and imports of paper products are significantly negative. Tariff elasticities are of interest to many researchers because they demonstrate the effectiveness of a trade policy (Kinnucan and Myrland 2005). Asche (2001) finds that an antidumping duty on salmon always decreases the trade with duty-levied countries. Prusa (1997) shows that tariffs have caused US imports to decrease from tariff-levied countries and to increase from not-subject countries. Adams (2003), Devadoss et al. (2005), Devadoss (2006), and Song et al. (2011) evaluated the effects of the US countervailing duties and antidumping tariffs on Canadian softwood lumber imports and found these tariffs are effective. However, since a country chooses tariffs as a tool to control the trade balance and protects the domestic production, this variable may not be an exogenous variable in the model. Some studies have suggested the potential of endogeneity of the trade barriers in trade models (Trefler 1993, Essaji 2008, Baylis et al. 2009). Therefore, we will test the endogeneity of this variable to determine appropriate model for this study.

Data

Our data cover trade flows between the United States and its major trade partners of paper products from 1990 to 2014. The exporting and importing partners are not necessarily the same. In this research, we include 38 major US trade partners that accounted for about 95% of total US exports of paper products and 18 major trade partners that accounted for more than 95% of US paper products imports in 1990, 2000, and 2014, respectively. Tables 1 and 2 list these countries and their accumulative share of US exports and imports of paper products, respectively.

Annual trade data of paper products were collected from FAOSTAT. These data contain nominal values of US exports and imports of paper products to/from various countries. All these values were converted into the real values by using US GDP deflator with the base year of chained 2010 dollars. Overall, we had 950 observations of panel data for the US export model and 475 observations for the US import model. The historical GDP and exchange rate data were collected from the USDA Economic Research Service. Data for geographic distance between the United States and a trade partner country were collected from the geodistance dataset of the Centre d'Etudes Prospectives et d'Informations Internationales. Information on the year that a country became a member of WTO was from the WTO website. The tariff rate data for all paper products by the US and the other countries were collected from the World Integrated Trade Solution TRAINS database maintained by the World Bank. This indicator is a simple, unweighted average tariff rate effectively applied on all products and calculated based on the total values of all traded paper products. In a case where tariff data were not available for particular years from a country to which the US exported paper products, we filled in with the tariff rate of the next closest year (t + 1). When the tariff rate by an individual EU country was not available, it was replaced by the EU average tariff rate for Belgium, France, Germany, Italy, Netherlands, Spain, and United Kingdom. Tables 3 and 4 present the definition,

Table 1. The value and accumulative share of US paper products exports to selected countries in 1990, 2000, and 2014.

No.	Year	1990		2000		2014	
	Country	Value (in 2010$)	Accumulative %	Value (in 2010$)	Accumulative %	Value (in 2010$)	Accumulative %
1	Canada	1,362,618,800	26.53	3,793,811,873	32.68	5,092,097,109	31.17
2	Mexico	659,168,792	39.36	2,474,043,813	54.00	3,858,931,000	54.79
3	Japan	515,583,489	49.40	807,551,734	60.96	799,691,939	59.68
4	China	84,175,888	51.04	399,214,110	64.39	660,632,646	63.73
5	UK	245,718,270	55.82	319,390,284	67.15	355,786,253	65.91
6	Hong,Kong	180,199,636	59.33	248,921,124	69.29	275,665,601	67.59
7	Netherlands	124,036,222	61.74	229,149,025	71.27	258,073,553	69.17
8	Germany	155,389,398	64.77	222,024,611	73.18	250,398,631	70.70
9	Australia	136,498,876	67.43	191,340,993	74.83	248,732,763	72.23
10	Taiwan	95,426,454	69.28	165,083,548	76.25	239,883,767	73.70
11	Korea,South	127,923,329	71.77	159,626,121	77.62	234,925,825	75.13
12	Costa,Rica	68,726,018	73.11	145,699,014	78.88	222,204,363	76.49
13	Italy	91,534,717	74.89	133,392,952	80.03	197,349,717	77.70
14	Dominican,Rp.	28,360,097	75.45	130,878,840	81.16	189,553,690	78.86
15	Ecuador	86,996,252	77.14	128,455,262	82.26	189,166,686	80.02
16	Brazil	36,818,787	77.86	124,525,433	83.34	188,211,325	81.17
17	Belgium	58,124,546	78.99	112,996,388	84.31	183,596,490	82.30
18	France	64,745,828	80.25	103,278,293	85.20	168,177,674	83.32
19	Guatemala	33,616,573	80.90	102,977,691	86.09	157,248,904	84.29
20	Spain	40,639,682	81.70	97,905,468	86.93	151,681,624	85.22
21	Singapore	60,522,668	82.87	95,095,014	87.75	148,215,561	86.12
22	Malaysia	70,096,115	84.24	90,588,448	88.53	141,711,723	86.99
23	Colombia	43,691,481	85.09	80,913,873	89.23	128,782,606	87.78
24	Venezuela	36,469,996	85.80	78,414,452	89.90	118,666,121	88.51
25	Israel	45,793,170	86.69	76,416,644	90.56	114,946,684	89.21
26	Philippines	53,448,681	87.73	75,173,051	91.21	114,727,652	89.91
27	Saudi Arabia	54,428,555	88.79	73,225,185	91.84	98,413,424	90.51
28	Indonesia	17,412,436	89.13	72,860,924	92.47	85,297,080	91.04
29	El Salvador	16,588,078	89.45	65,510,942	93.03	82,796,332	91.54
30	Argentina	6,591,035	89.58	62,108,315	93.57	80,225,021	92.03
31	Honduras	39,483,759	90.35	60,366,096	94.09	78,445,756	92.51
32	Panama	55,953,443	91.44	57,111,198	94.58	65,480,819	92.91
33	Thailand	13,779,128	91.71	53,234,991	95.04	64,160,036	93.31
34	Chile	22,112,385	92.14	44,983,166	95.42	63,011,259	93.69
35	South Africa	73,427,277	93.57	39,962,603	95.77	62,205,292	94.07
36	Peru	3,026,447	93.63	36,629,165	96.08	57,924,230	94.43
37	Jamaica	26,086,304	94.13	34,628,916	96.38	55,615,878	94.77
38	Turkey	5,487,107	**94.24**	32,543,391	**96.66**	54,466,977	**95.10**
	World	5,136,528,878	100.00	11,607,480,545	100.00	16,337,334,253	100.00

Table 2. The value and accumulative share of US paper products imports from selected countries in 1990, 2000, and 2014.

No.	Country	1990		2000		2014	
		Value (in 2010$)	Accumulative %	Value (in 2010$)	Accumulative %	Value (in 2010$)	Accumulative %
1	Canada	6,324,188,125	73.9	10,133,404,676	65.8	6,832,719,096	42.6
2	China	53,866,925	74.5	618,246,038	69.9	2,765,067,270	59.9
3	Mexico	193,167,612	76.8	510,141,384	73.2	972,438,528	66.0
4	Finland	382,186,436	81.2	690,508,805	77.7	793,268,280	70.9
5	Germany	298,154,160	84.7	585,968,513	81.5	721,371,449	75.4
6	South Korea	74,108,319	85.6	319,400,839	83.5	523,256,438	78.7
7	Indonesia	4,363,750	85.6	191,021,019	84.8	442,140,523	81.4
8	Japan	243,000,642	88.5	521,543,536	88.2	373,832,026	83.8
9	Brazil	9,537,115	88.6	99,754,072	88.8	285,400,198	85.6
10	France	123,739,237	90.0	201,422,733	90.1	263,517,704	87.2
11	UK	158,962,249	91.9	365,044,330	92.5	243,792,581	88.7
12	Italy	71,646,503	92.7	162,508,594	93.6	181,509,675	89.9
13	Portugal	146,763	92.7	448,130	93.6	168,731,246	90.9
14	Australia	2,761,204	92.7	19,385,220	93.7	147,601,489	91.8
15	Taiwan	62,739,331	93.5	49,703,442	94.0	143,553,633	92.7
16	Spain	21,565,285	93.7	64,447,591	94.4	122,003,144	93.5
17	Vietnam	0	93.7	139,565	94.4	115,375,548	94.2
18	Sweden	128,227,472	95.2	133,404,679	95.3	105,788,312	94.9
19	Hong Kong	24,150,500	**95.5**	56,641,690	**95.7**	94,211,458	**95.5**
	World	8,561,820,362	100.0	15,389,880,242	100.0	16,023,036,541	100.0

descriptive statistics, and data sources of the variables used in this study. The United States and other countries' internet use rate as number of individual per total population was collected from the US Census Bureau and the World Bank database.

Empirical Results

Serial Correlation and Unit Root Tests

The OLS regression model shows a Durbin-Watson statistical value of 0.06, implying that there is possibility of positive serial

Table 3. Definitions and descriptive statistics of variables in the export model.

No.	Variable	Unit	Mean	Max	Min	Standard Deviation
1	Export	US$ in 2010 value	326,000,000.0	5,480,000,000.0	4,532,373.0	782,000,000.0
2	Distance	Km	7936.3	16,374.6	734.3	4502.3
3	Exchange rate	Local currency unit/US$	1184.3	44,167.0	0.5	4955.2
4	PNGDP	Billions of 2010 US$	812.2	8230.5	7.6	1194.3
5	Tariffs	Percentage	7.4	38.2	0.0	6.7
6	USGDP	Billions of 2010 US$	12,838.7	16,282.0	9057.7	2313.4
7	US internet use rate	Internet users per 100 persons	46.0	87.4	0.8	29.9
8	Partner internet use rate	% of population	23.4	93.9	0	27.0

Data sources: US GDP Deflator: https://research.stlouisfed.org/fred2/series/GDPDEF#.
WTO member: https://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm.
Free trade agreement with the US: https://ustr.gov/trade-agreements/free-trade-agreements.
Real GDP https://www.ers.usda.gov/data-products/international-macroeconomic-data-set.aspx.
Exchange rate: http://www.ers.usda.gov/data-products/agricultural-exchange-rate-data-set.aspx.
The US export and import share to total domestic production and consumption: http://faostat3.fao.org/download/F/FO/E.
Distance: http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8.
Tariffs database TRAINS from World Bank: http://databank.worldbank.org/data/reports.aspx?source=UNCTAD-~-Trade-Analysis-Information-System-(TRAINS)#.
Internet use rate: https://data.worldbank.org/indicator/IT.NET.USER.ZS.

Table 4. Definition and descriptive statistics of variables in the import model.

No.	Variable	Unit	Mean	Max	Min	Standard Deviation
1	Import	US$ in 2010 value	738,000,000.0	10,400,000,000.0	146,763.0	1,900,000,000.0
2	Distance	Km	8515.5	16,374.6	733.7	4131.6
3	Exchange rate	Local currency unit/US$	687.5	21,770.4	0.5	2652.4
4	PNGDP	Billions of 2010 US$	1501.2	8230.5	104.1	1437.6
5	Tariff rate	Percentage	0.8	4.2	0.0	1.1
6	USGDP	Billions of 2010 US$	12,838.7	16,282.0	9057.7	2314.8
7	US internet use rate	Internet users per 100 persons	46.0	87.4	0.8	29.9
8	Partner internet use rate	% of population	32.8	94.8	0	31.8

correlation in the models. We used Breusch-Godfrey LM to test serial correlation of the first and second lag values of the dependent variable. The results show that there is statistically significant correlation in the first lag model. Therefore, the model with one lag of the dependent variable is presented in this study. We also apply two unit root test methods—the Augmented Dickey-Fuller (ADF) and Phillips-Perron tests (Maddala and Wu 1999) with a hypothesis that our panel data have unit root. These tests are used by Levin et al. (2002), Breitung (2000), and Im et al. (2003). All test results reject the hypothesis, implying that the variables in the model have heteroscedasticity.

In addition, we used the Durbin-Wu-Hausman test for the endogeneity of the tariff variable in the simple gravity model. The Durbin-Wu-Hausman test assumes that the error term is white noise. We found no evidence of an endogenous variable in the model. This result is reasonable because the value of paper products exports and imports is relatively small in comparison to the US total import and import values. Therefore, we treat tariff as an exogenous variable in the import and export models.

Equation (3) is estimated using several techniques. As a first try, it is estimated by using pooled OLS assuming intercepts are the same for all countries and all years. We then run a least squares dummy variable regression that includes control of fixed effects for both countries and years. The first and second columns under the heading of OLS in Tables 5 and 6 present the results of these models for US exports and imports, respectively. Most of the results are similar.

Since our second model for both imports and exports had less standard error and higher power of explanation, the least squares dummy variable regression with control for the fixed effects of countries was preferable to the OLS model. Additionally, the dummy variable of economic recessions was collinear to the annual dummy variable, so we dropped the annual fixed effects variable in the model to eliminate this collinearity. Thirdly, with the time control of fixed effects, the variable without time invariance such as distance and without partner invariance such as US GDP had to be removed from the model.

However, because of the presence of heteroscedasticity and lagged dependent variable, estimates of the log-linear form of the gravity equation were biased and inconsistent. We thus chose to rely on the PPML specification of the trade gravity model. Using the PPML model allowed us to overcome for both fixed effects and presence of heteroscedasticity for a dynamic panel dataset (Santos Silva and Tenreyro 2006, 2011). Moreover, the PPML model can allow zero values in the dependent variable. Interpretation of the coefficients from the PPML estimator is similar to the OLS estimator. The coefficient is elasticity if an independent variable is taken logarithm values and semi-elasticity if the independent variable is formed in level (Shepherd 2013). In the latter case, the elasticity of the dependent variable with respect to a continuous independent is $\beta/100$, where β is the estimated coefficient for the independent variable.

Although the tariff variable is not endogenous in this study, we present the results of the GMM model, which treats tariff as an endogenous variable to compare with those of PPML. As shown in Tables 5 and 6, there is no significant difference between these results whether tariff is treated as either endogenous or exogenous variable in the models. Hence, we used the results from the PPML estimation to explain our research findings.

The Export Model of US Paper Products

The results estimated by OLS fixed effects, GMM, and PPML are presented in Table 5. The high R^2 value (0.96) of the simple

Table 5. Results of US paper products export model

Variable	OLS (LNEXPORT)		GMM (LNEXPORT)	PPML (EXPORT)
	1	2	3	4
LNEXPORT(-1)	0.932***	0.672***	0.928***	0.003***
	(0.010)	(0.020)	(0.014)	(0.000)
LNDISTANCE	-0.069***	0.022	-0.072***	-1.024***
	(0.013)	(0.042)	(0.013)	(0.041)
LNEX	0.004	-0.439***	0.004	-0.557***
	(0.003)	(0.043)	(0.003)	(0.075)
LNPNGDP	0.030***	0.091*	0.032***	0.315***
	(0.006)	(0.049)	(0.007)	(0.057)
LNUSGDP	0.498	0.621**	0.208***	1.306**
	(0.319	(0.307)	(0.037)	(0.543)
TARIFFS	-0.001	-0.005**	-0.002	-0.011***
	(0.002)	(0.002)	(0.002)	(0.003)
RECESSION	-0.042	-0.003	-0.043*	0.003
	(0.025)	(0.022)	(0.025)	(0.026)
WTO	-0.033	0.076***	-0.028	0.205***
	(0.027)	(0.027)	(0.029)	(0.035)
USinter	-0.004**	-0.006***	-0.003***	-0.010***
	(0.002)	(0.002)	(0.001)	(0.003)
partnerinter	0.0002	-0.0006	0.0002	-0.0041***
	(0.0004)	(0.0005)	(0.0004)	(0.0010)
Country fixed effects	No	Yes	Yes	Yes
Tariff endogenous	No	No	Yes	No
R^2	0.962	0.981		0.988
SE of Regression	0.208	0.251		
Durbin-Watson Stat	1.920	2.170		

*Country fixed effects refer to dummy variables for each exporter, number in parenthesis is standard error, and ***, **, and * indicate the estimated parameter is significantly different from zero at the 1%, 5%, and 10% levels, respectively.

Table 6. Results of US paper products import model.

Variable	OLS (LNIMPORT)		GMM (LNIMPORT)	PPML (IMPORT)
	1	2	3	4
LNIMPORT(-1)	0.946***	0.904***	0.941***	0.764**
	(0.010)	(0.019)	(0.018)	(0.043)
LNDISTANCE	-0.034	-0.543**	-0.052*	-0.676***
	(0.026)	(0.253)	(0.031)	(0.227)
LNEX	0.005	0.139	0.007	0.148*
	(0.005)	(0.091)	(0.006)	(0.083)
LNPARTNERGDP	0.011	-0.087	0.011	0.149**
	(0.014)	(0.091)	(0.010)	(0.062)
LNUSGDP	0.592	0.854	0.176***	0.938***
	(0.561)	(0.566)	(0.062)	(0.333)
TARIFFS	-0.072***	-0.111***	-0.042	-0.069***
	(0.021)	(0.025)	(0.036)	(0.027)
RECESSION	-0.053	-0.066	-0.056	-0.005
	(0.045)	(0.044)	(0.042)	(0.024)
WTO	0.005	-0.013	0.029	0.078
	(0.048)	(0.053)	(0.052)	(0.068)
USinter	-0.423	-0.465	-0.001	-0.551***
	(0.342)	(0.343)	(0.001)	(0.200)
Partnerinter	-0.132**	-0.199*	-0.001***	-0.178*
	(0.067)	(0.117)	(0.000)	(0.105)
Country fixed effects	No	Yes	Yes	Yes
Tariff endogenous	No	No	Yes	No
R^2	0.979	0.981		0.992
SE of Regression	0.223	0.251		
Durbin-Watson Stat	1.918	2.170		
Log likelihood	23.01	-0.648		

*Country fixed effects refer to dummy variables for each exporter, number in parenthesis is standard error, and ***, **, and * indicate the estimated parameter is significantly different from zero at the 1%, 5%, and 10% levels, respectively.

OLS model indicates a good fit. The sign and magnitude of all coefficients are largely consistent among OLS, GMM, and PPML models. With the PPML estimation, all explanatory variables are statistically significant except the economic recession variable. The coefficient of the lagged dependent variable indicates that US exports of paper products to a trading partner country are correlated with past trend. As expected, the GDP of importing countries has a positive effect on US exports of paper products. US GDP has a positive effect on the export revenue of paper products, indicating that a large US domestic economy enhances the development and exports of US paper products.

The exchange rate variable is found to have a negative and statistically significant effect on US exports of paper products. A 1% appreciation in the US dollar causes export revenue of US paper products to decrease by 0.56%. The coefficient of the WTO membership variable is found to be positive and statistically significant, implying that being a member of WTO causes US exports of paper products to that country to increase by 0.2%. This is because WTO member countries promote international trade in their policy, standards, and actions.

As expected, the tariff variable is found to have a negative effect on US exports of paper products. If a country increases its tariff rate on US paper products by 1%, the exports of paper products from the US to this country decrease by 0.00011%. A 1% increase in the tariff on US exports is 0.074% (7.4*1% = 0.074) in the study period. Thus, increasing tariff on US exports from 7.4% to 7.474% by an "average" country of the top 38 destinations of US paper products (which imported $326 million US paper products annually in the study period) would reduce annual US paper products exports to that country by only $0.036 million in the study period. This implies that US exports of paper products are not very sensitive to tariffs. One possible explanation of this result is that the export destinations of US paper products are diverse: if the tariff rate in one country increases, US exporters could switch to another country. On the other hand, as the gravity model is a partial equilibrium model, this result needs to be taken with caution. For example, if the US could simultaneously and successfully negotiate with multiple countries for tariff reduction, the total US exports of paper products could increase more than this coefficient indicates.

Not surprisingly, the internet use rate variables have a negative effect on US export values. In the United States, a 1% increase of people using the internet causes US paper products export value to decrease by 0.0001%, and a 1% increase in the internet use rate of the partner country leads US paper products export to that partner country to decrease by 0.00004%. The former is perplexing, as an increase in internet use in the US should not have a direct impact on exports, which is foreign demand. Perhaps as domestic producers adjust their production volume and products types for domestic consumption, their exports also suffer. Although the effect of US internet use rate on paper export value is much greater than those effect of partner country internet use rate, these effects are relatively small in comparison to the effects of other variables in the model.

Overall, the model for export revenue supports trade theory and explains the effects of tariffs on the export revenues of US paper products. Specifically, if a partner country increases its tariff on US paper products, US export revenue falls because the tariff raises the prices of these products. Our finding is consistent with tariff studies in forest and agricultural products such as US softwood lumber (Devadoss et al. 2005), Mexico apple (Devadoss and Ridley 2014), and US salmon (Kinnucan and Myrland, 2005). The variables that have the largest coefficients on US exports are the US GDP and the distance between US and a partner country. The least influential variables are tariff and internet use rates.

The Import Model of US Paper Products

The import model also fits well (Table 6). The results show that the economic recessions and WTO memberships have no significant effect on US imports of paper products. All other variables show statistically significant effects on US imports of paper products. The distance variable is found to have a significant negative impact on US imports of paper products from a partner country. US GDP and the partner economic mass are found to have positive and significant impacts on US imports. So does the exchange rate. Specifically, a 1% increase in the exchange rate causes US imports to increase by 0.15%. A statistically significant US and partner country internet use rate variable indicates that, as domestic demand for paper products decreases, US import demand for paper products falls. And as the partner country internet use rate increases, their investment in the paper industry decreases, causing a reduction in their production as well as exports to the United States. Specifically, a 1% growth of the internet use rate in the United States and a partner country causes US imports of paper products to fall by 0.0055% and 0.0018%, respectively. Compared to the export model result, the effect of internet use rate on the import values is 55 times greater than their effect on the export values. On the other hand, the US economy size and distance between the United States and a partner country have the greatest effects in both export and import models.

The tariff variable has a negative and significant effect on US imports. If the US tariff on imports of paper products from a country increases by 1%, the exports from that country to the United States decrease by 0.0007%. This value is nearly 7 times that of the tariff elasticity in the export model. A 1% increase in the US tariff on paper products is 0.008% (0.8*1% = 0.008%) in the study period. Thus, increasing the US tariff on paper products from 0.8% to 0.8008% on an "average" country of its top 19 exporters (which exported $738 million of paper products to the US annually in the study period) would only reduce annual US paper products import from that country by $0.509 million in the study period. However, if and when the US paper industry petitions the US government for actions against imports of certain paper products, the alleged dumping and subsidy margins could be much higher (and thus tariff) than the existing import duty (which is near zero). For example, in a petition by North Pacific Paper Company on August 9, 2017 for the imposition of antidumping and countervailing duties on imports of Certain Uncoated Groundwood Paper from Canada, the North Pacific Paper Company alleged that Canada's dumping margin alone was 23.45% to 54.97% (Neely 2017). Thus, the United States could "threaten" other countries and bring them to the negotiation table for reciprocal trade agreements in paper products.

In sum, exports of paper products from other countries to the United States are more sensitive to US tariffs than US exports to a tariff placed by a trading partner. This finding confirms the results of many previous studies that tariff has a smaller impact on US exports than on US imports (Prusa 1997, Devadoss and Ridley 2014).

Conclusions and Discussion

This study uses the gravity model to investigate determinants of US trade in paper products between 1990 and 2014, including the effects of tariffs. US exports and imports of paper products are modeled separately, using different methodologies. Overall, the results show that the gravity model fits well, and results are relatively consistent among these models in which the PPML is "best fit" to deal with the zero value of dependent variable and heteroscedasticity.

Results from the export model suggest that an importing country's GDP, distance between the United States and a partner country, tariff rate, US GDP, exchange rate, WTO membership, US internet use rate, and the partner country's internet use rate all significantly affect exports of US paper products. Importing country's GDP, US GDP, and WTO membership have positive effects, and all other variables have negative effects on US exports of paper products. Results of the import model show that imports of US paper products are affected by US GDP, partner economic size, tariff rate, distance, exchange rate, partner country's internet use rate, and US internet use rate. Both export and import models show lagged values contribute significant effect on the current export or import values.

We find that tariffs have a small but significant effect on both US exports and imports of paper products and that the tariff elasticity on US exports of paper products is much lower than that on US imports. In other words, foreign exporters of paper products to the US are more sensitive to changes in US tariff rate, which is already very low compared to that of its trade partners. This result may be because US export destinations of paper products are more diverse than its import sources. On the other hand, this result may explain why there has been an increase in petitions for antidumping and countervailing duties from US paper producers on imports of US paper products in recent years. For example, we find in a search of the Federal Register that, in 2017 alone, there are US industry petitions (and follow-up investigations and actions by the US government) on lined paper from China and India, uncoated groundwood paper from Canada, and uncoated paper from Australia, Brazil, China, Indonesia, and Portugal.

Our results also mean that the United States could have some leverage in negotiating reciprocal free trade agreements with other countries in trading paper products. Although paper products may only be a small issue in the current renegotiation of the North America Free Trade Agreement, the United States could use the result of this paper and the threat of tariffs as a bargaining chip to achieve its overall goals. The United States could also use the result of this study in its negotiation of bilateral trade deals that include paper products.

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