2023

Balancing Trade and Security during the US-China Trade War: A Gravity Model Approach to South Korea's Relations with the United States and China

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submitted to

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by

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For

Senior Thesis

Fall 2022

December 5, 2022

ABSTRACT

In analyzing monthly trade and gross domestic product (GDP) data for South Korea, China, and the United States from January 2016 to December 2019, this paper attempts to quantify the effects of the US-China Trade War on Korea's security and economic considerations. By using a three-country gravity model with both monthly and HS Code (harmonized system) fixed effects, it finds the following. First, increases in both real GDP for the United States and China, as well as real GDP for Korea, are positively associated with increases in Korean exports at statistically significant levels. Thus, the general predictions of the gravity model are true even given the four-year timeframe. Second, the use of fixed effects provides insight on months and HS codes that experienced statistically significant changes in exports, allowing one to better contextualize the data within the general trade war timeline. Finally, using South Korea as the country to analyze this question is particularly insightful due to the country's geographic location and historic background. While its largest trading partner is also its neighbor (China), South Korea's military and economic ties to the United States date back to the Korean War and the subsequent decades of reconstruction and development. Thus, while Korea has already had to carefully balance these ties for years, should tensions between the two world powers continue to rise, more countries may find themselves in a similar predicament.

ACKNOWLEDGEMENTS

This thesis is not just the outcome of one semester's work, but the slow buildup of knowledge and support received throughout the years from a variety of people. For that, I want to thank my family for being patient with me and for giving me the strength to continue putting effort into my studies, especially during the pandemic, when days and problem sets blurred with each other quite easily. I want to also thank the dining hall and custodial staff across the 5Cs, whose warm meals and smiles constantly remind me of home. Finally, a big thank you to my thesis and academic advisor, Professor Lincoln, whose support since Econ101 has given me the confidence to truly immerse myself in the field of international economics. I'm excited to see where this curiosity will continue taking me.

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Introduction and Background

A. General Introduction

The main research question of this thesis concerns the way in which South Korea (ROK) balanced its relationship with the United States and China during the general period of the US-China Trade War by employing a gravity model and looking at how trade flows were impacted. Although this paper relies on quantitative analysis, it is heavily influenced by the field of international relations (IR). Therefore, the literature review will be conducted in two parts. The first being a more standard IR literature review looking at previous work on economic interdependence and conflict.

For the economics portion, the paper will review the literature on the gravity model to develop the theoretical foundation for the paper. This section of the literature review will also focus specifically on how previous scholars have employed the gravity model to study South Korea's trade behavior. Given past research, South Korea's trade flows can be studied using a gravity model; however, due to the relative recency of the US-China Trade War, there is a gap in employing the model to study trade behavior during this time.

The rest of the paper is as follows: the first section consists of the literature review, broken up into a general background, a focus on economic interdependence theory, and then an introduction to the gravity model. The second section consists of the data methods, in which the type of data obtained is discussed as well as how it was prepared for regressions. Afterward, the results and data analysis section will provide summary statistics, general descriptive graphs, and will give context to regression results. The final section, conclusion, will put the regression will wrap up the study, discuss limitations, and suggestions for future directions similar work could take.

Literature Review

A. Background: South Korea's Bilateral Relations with the United States and China

There is growing literature attempting to understand South Korea's unique position between the United States and China. While the Korean peninsula's ties with China date back centuries, the normalization of diplomatic ties in 1992 after the Korean War (1950-1953), prompted a sharp increase in bilateral trade and political relations with South Korea. However, the quality of these interactions and the level of economic interdependence, or rather dependence on China, is matter of scrutiny for many scholars. Despite bilateral trade going from $6 billion in 1992 to $243 billion in 2019, it has "amounted to 23% of South Korea's trade and 6% of China's" a point that highlights Korea's increasing vulnerability to China.[1] In fact, by 2005 China had overtaken the spot of the United States as its largest trading partner.[2] During this time, the US portion of trade in South Korea decreased from 23% in 1992 to 13% in 2019.[3] Yet, despite its increasing involvement with China and decreasing in relative trade with the US, the United States-Korea Free Trade Agreement (KORUS FTA) was signed in 2007. At the same time, Korea's eventual FTA with China (CKFTA), which was signed in 2014, despite pressure from Washington to join the Transpacific Partnership and continued to highlight Korea's awkward, yet strategically significant, position.

Despite Korea signing of FTAs with both nations, the period since 1992 has also witnessed many episodes of high tensions between combinations of all three players. Some relate to historical claims, such as the 2003 clash over the borders of the ancient kingdom Koguryo that encompasses the region of modern-day China and Korea. Other conflicts relate to the issue of North Korea and

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[1] Byun, "Interdependence, Identity, and China–South Korea Political Relations: Asia's Paradox," 481.
[2] Sohn, "South Korea under the United States–China Rivalry: Dynamics of the Economic-Security Nexus in Trade Policymaking," 1025.
[3] Byun, "Interdependence, Identity, and China–South Korea Political Relations: Asia's Paradox," 481.

joint ROK-US precautionary efforts, such as the deployment of the anti-ballistic missile defense system known as the Terminal High Altitude Area Defense (THAAD) in 2016. THAAD's presence on the Korean peninsula did not please China, which "claimed that the powerful radar used by THAAD to detect missiles would penetrate parts of China and undermine its nuclear deterrence,"[4] and promptly cut down on cultural exchanges and tourism of Chinese citizens to Korea.[5] More recently, scholars have also been interested in the possible effects of the US-China Trade War on Korea's trade patterns and general security strategy. However, work on this is very preliminary. Studies such as Lee and Song (2018), and more recently, Suh (2019) have begun looking at the effects of the US-China Trade War. Suh (2019) takes advantage of being published later and directly points to Lee and Song (2018)'s predictions not being close to reality. Contrary to Lee and Song (2018)'s prediction that a 25% tariff in Chinese imports would cause a decline in Korean exports from "US$ 10,334 million to US$ 13, 259 million,"[6] Suh (2019) reports a much higher actual figure. Suh (2019) finds that "Korea's exports declined by 9.5 percent year-on-year to US$ 45.9 billion in May 2019."[7] Furthermore, "Korea's exports fell for six consecutive months (from November 2018 to May 2019), the first time since January 2009."[8] A possible reason, as witnessed later, could lay in the fact that "more than 80 percent of South Korea's exports to China are intermediate …Therefore, Trump's tariffs [could] result in falling Chinese exports to the United States…[leading to] knock-on effects for Korea's exports to China."[9] Both Lee and Song (2018) and Suh (2019) do

[4] Sohn, "South Korea under the United States–China Rivalry: Dynamics of the Economic-Security Nexus in Trade Policymaking," 1030.
[5] More information on the repercussions felt as a result of the THAAD conflict can be seen in Sohn (2019).
[6] Song and Lee, "Korea's Contents in China's Exports to the US and Its Implications to Korean Exports: The Effects of Trump's Tariffs on China," 14.
[7] Suh, "U.S.–China Trade Conflict and the Changing Multilateral Trading System: Korea's Perspective*," 152.
[8] Suh, 159.
[9] Suh, 146.

not employ a gravity model to further analyze how, or why, trading trends might have shifted during this time. In general, there does not appear to be a gravity model approach focusing specifically on the period of the US-China Trade War on South Korea's trading behavior, and therefore this would be an innovative way to approach this question. Another reason for why to focus on this specific period, as noted in Fajgelbaum et al. (2020) is the US's strong departure from its decades-long stance on free trade. The extent to which the US-China Trade War impacted economies at a large continues to be studied,[10] but for the US specifically, its protectionary measures had negative consequences with "large declines in imports when the tariffs were implemented" by the US.[11] Given these effects on one of the countries waging the trade war, it would be worthwhile to further analyze impacts outside the home economy.

B. An International Relations Approach: Economic Interdependence and Conflict Theory

In Copeland (1996), the author develops the trade expectations theory, which essentially combines both realist and liberalist thought on economic interdependence and conflict. Back in the 19th century, Richard Cobden's pioneered liberal thought on this issue by stating that free trade "[makes] each [state] equally anxious for the prosperity and happiness of both."[12] Even earlier in the 17th century, French political writer Émeric Crucé, attributed wars to "international misunderstandings…[that] could be reduced by expanding commerce."[13] Indeed, liberalist thought focuses primarily on the idea that states have more to gain through trade than they do through war, and as such, increased trade increases these costs and benefits even more. A major gap in this school of thought, however, is liberalism's failure to account for the costs associated with severing these

[10] Fajgelbaum et al. (2020) being an excellent resource for seeing the impacts of the trade war specifically in the United States.
[11] Fajgelbaum et al., "The Return to Protectionism," 3.
[12] Copeland, "Economic Interdependence and War," 8.
[13] Oneal and Russet, "The Classical Liberals Were Right: Democracy, Interdependence, and Conflict, 1950–1985," 268.

ties. This is where realism comes in. Realist thought, which is more concerned with security holds that "states dependent on others for vital goods have an increased incentive to go to war to assure themselves of continued access of supply."[14] Copeland even points to the old economic system of mercantilism as an early manifestation of this realist thought. Under this system, imperial powers such as the United Kingdom and Spain behaved as if in a zero-sum game in which their goal was to acquire as much gold through exports while becoming internally self-sufficient via newly acquired colonies. Nevertheless, despite having these two theories in mind, Copeland found that while they both served to explain certain aspects of Germany's actions in WWI and WWII,[15] they could be developed further to provide a more thorough understanding of the calculations trading partners have in war. In short, Copeland believed that an important factor in these calculations was that of future trade expectations. According to Copeland, high interdependence combined with high expected future trade reduces the incentive for war. On the other hand, high interdependence combined with low future trade expectations increases the incentive for war.[16]

Released around the same time as Copeland (1996), Oneal and Russet (1997) find similar results on the pacifying effects of trade on conflict while centering their research on how it differs for democracies and autocracies. The consideration that regime type might influence the way a state approaches conflict and general comportment is not new, either. Immanuel Kant's *Perpetual Peace* sets a foundation for which the state of peace can be achieved (as opposed to the natural state of war) if the following conditions are present: "republican institutions…international law and

[14] Copeland, "Economic Interdependence and War," 10.
[15] Copeland (1996) includes two separate case studies explaining Germany's decisions to go to war both times, emphasizing, that despite involvement in world trade in the time prior to WWI, it was the pessimistic future trade expectations and need for economic self-sufficiency that fueled its actions--heightened even more for WWII once those trade ties broke down following WWI.
[16] Copeland, 17.

organization, and 'cosmopolitan law,'"[17] the last to which Oneal and Russet interpret as economic interdependence. Indeed, the authors of this paper include a detailed literature review that focuses on the questions of whether democracies are more peaceful than non-democracies. Two studies they mention in detail are Maoz and Russett (1992, 1993) which found that even when controlling for "contiguity, alliance ties…economic development, and the dyadic balance of power" democracies were more peaceful after WWII, in specific during the years 1946-1986.[18] Looking at a similar time frame (1950-1985), Oneal and Russet (1997) use regression analysis to quantify the pacifying benefits of trade by regime type. They find that "higher levels of …trade…are associated with lower incidence of…war, even controlling for…contiguity, the balance of power, [alliances]."[19] They also find that "the likelihood of conflict is also influenced by the political distance that separates states" given that the likelihood of conflict between two autocracies is higher than between democracies.[20]

In another relevant study, Mansfield and Milner (2002) look into what influences democracies to join trade agreements more than autocracies and use trade agreements as a measure of international economic cooperation. Given that "such agreements offer a more credible means for leaders to signal to voters about their policy choices than do unilateral policy declarations" (Mansfield and Milner 479),[21] leaders in democracies, who must please both regular voters and interest groups, also see trade agreements as a way to distance themselves from economic downturns come time for reelection. As expected, the main results of this study are that "pairs of democracies are roughly four times as likely to [form a preferential trade area, or PTA] as autocratic

[17] Oneal and Russet, "The Classical Liberals Were Right: Democracy, Interdependence, and Conflict, 1950–1985," 268.
[18] Oneal and Russet, 269.
[19] Oneal and Russet, 288.
[20] Oneal and Russet, 288.
[21] Mansfield, Milner, and Rosendorff, "Why Democracies Cooperate More," 479.

pairs."[22] In other words, democracies are more likely to cooperate on commercial terms when compared to autocracies. Given related literature, these effects could be very useful should conflict arise. While the regression model for this thesis does not intend to account for regime type given that there are only three states being observed, the intellectual thought put in by aforementioned scholars, is an important consideration to keep in mind given that this thesis will work with two different regime types given China's authoritarian regime structure compared to the more democratic nature of the United States and South Korea.

Literature in the theme of economic interdependence has tended to focus on bilateral trade relations, and while this paper also intends to focus on such, Martin et al. (2008) sheds new light on the considerations to go to war by focusing on multilateral trade relations instead. Since this paper will look at how South Korea's trade ties with the United States and China vary during the period of the US-China Trade War, it is reasonable to, at the very least, be familiar beyond the typical bilateral trade approach when determining issues of economic interdependence and conflict. Martin et al. (2008) not only looks at the probability for conflict between two countries who share bilateral trade ties, but also how general global trade openness and relative distance from each other further impacts the likelihood of conflict between this dyad and a third country. The general idea here is to go beyond the general calculus of determining the costs to go to war in a two-country model and allow countries to simultaneously weigh their trade ties with other nations as a way to offset the costs of either going to war or severing those existing trade ties. As such, Martin et al. (2008) uses a large-scale dataset of bilateral conflicts from 1950-2000 obtained from the Correlates of War (COW) project, in which they implement a gravity model to determine the aforementioned effects. Through their regressions, which include country-pair and time fixed effects, and also an instrumental variable

[22] Mansfield, Milner, and Rosendorff, 481.

(IV) strategy, they find the following outcome: globalization has "[increased] the probability of a bilateral conflict by around 20% for proximate countries" while not for distant countries.[23] While the paper finds that conflict has become more local in the period of the study, another main finding was that "bilateral trade…deters bilateral war" while "multilateral trade openness…weakens the incentive to make concessions…[and] increases the probability of war between any given pair of country," and more notably, with a third and local country.[24]

C. An Economics Approach: The Gravity Model and its Applications in South Korea

While the original law of gravity was pioneered by Isaac Newton in the 17th century, the field of international economics has similarly developed its own version of the gravity model. Beginning with Tinbergen (1962) and the paper titled *Shaping the world economy: suggestions for an international economic policy*, the field of economics has assessed the levels of trade between countries given their size in gross domestic product (GDP) and distance from each other and has found a strong inverse relationship between these two factors. At the same time, this model has helped shed light on other factors, like distance and GDP, that similarly affect exports between countries. Shepherd (2016) elaborates more on the traditional implications of the model, stating that the model "[expects] larger country pairs to trade more…[but] countries that are further apart to trade less."[25] As shown in Rasoulinezhad and Kang (2016), the Tinberg's 1962 original econometric form of this model took the following form:

$$lnExport_{ij} = \beta_0 + B_1 lnY_i + \beta_2 lnY_j + \beta_3 lnDIS_{ij} + \varepsilon_{ij}$$

[23] Martin, Mayer, and Thoenig, "Make Trade Not War?," 867.
[24] Martin, Mayer, and Thoenig, 894.
[25] Shepherd, "The Gravity Model of International Trade : A User Guide.," 3.

where *i* and *j* are two different countries and DIS serves as a proxy for transportation cost.[26] As with Martin et al. (2008)'s considerations of looking at multilateral, instead of simply bilateral ties, Shepherd brings to the attention common issues with the model's intuition. One such being that changes in trade cost such as through a preferential agreement between one country pair might impact the trade costs a third country experiences with that same country pair despite being outside of the agreement. Nevertheless, since the mid-20th century, the model has expanded to account for common issues and has developed to "include variables far beyond tariffs…[such as] Regulatory policies, as well as deep political and institutional characteristics of countries."[27] Sohn (2005) goes further in depth on the theoretical development of the model over the years, with mentions of the work done by Anderson (1979) and Deardorff (1998) to list a few. As mentioned in Sohn (2005)'s literature review, he points out specifically to Deardorff (1998)'s finding that the "the gravity equation is consistent with the Heckscher–Ohlin trade model in homogeneous goods with perfect competition" but Sohn individually points out that the differentiated product model would work better in cases on monopolistic competition.[28]

These considerations are important since Sohn's paper is one of the first to look closely at South Korea via a gravity model, with one main consideration being whether or not Korea's trade patterns can be accurately assessed through the use of such a model. After looking at data from 30 major trading partners for the year 1995, Sohn (2005) determines that South Korea's trade patterns do fit the gravity model, specifically the Heckscher-Olin pattern in which its "trade flows depend more on factors such as comparative advantage, income difference and different development stages

[26] Rasoulinezhad and Kang, "A Panel Data Analysis of South Korea's Trade with OPEC Member Countries: The Gravity Model Approach," 7.
[27] Shepherd, "The Gravity Model of International Trade : A User Guide.," 1.
[28] Sohn, "Does the Gravity Model Explain South Korea's Trade Flows?," 218.

than on economies of scale or product varieties."[29] In a similar paper, Rasoulinezhad and Kang (2016) use panel data spanning from 1980-2014 on to assess the trading relationship between South Korea and 13 OPEC countries. As with Sohn (2015), they again find that South Korea's trading patters can be accurately estimated using a gravity approach, especially the Heckscher-Ohlin model. With both the work done by Soh (2005) and Rasoulinezhad and Kang (2016), in addition to other scholars, using the gravity model should once again be suited to analyze Korea's bilateral trade with both China and the US.

Data Methods

A. Working with Monthly GDP Approximators

IHS Markit (part of S&P Global) has a Monthly GDP Index for the United States which "is an indicator of the real aggregate output that is conceptually consistent with real [GDP] in the National Income and Products Accounts (NIPA)."[30] When comparing the index with FRED's *Real Gross Domestic Product, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate* data,[31] they match up quite well. For instance, Q4 2015 as reported on FRED was 17565.465. For the IHS database, it was 17548.124 in January 2016. For the end of the observed period, Q4 2019 FRED data shows the GDP as 18989.877. For December 2019, IHS Markit gives a figure of 19263.589.

For Korea, the only semi-monthly GDP growth rate approximator available was through the website kr.investing.com where data is obtained from the Korea National Statistical Office and has both actual and predicted growth rates.[32] Data is not obtained at a consistent frequency, but publication dates are available and are often enough to approximate for monthly estimates. For

[29] Sohn, 428.
[30] "US Monthly GDP (MGDP) Index."
[31] "Real Gross Domestic Product [GDPC1]."
[32] "한국 국내총생산(GDP) <전년 대비> (Korea GDP <Year-on-Year>)."

instance, the first few observations in 2018 were obtained on 01/25, 03/28, 04/26, and so on. This paper uses the actual, not predicted, growth rates. Because some data points (monthly observations) are missing, the data is further extrapolated by taking the midpoint between the observed datapoints before and after the missing timeframe. For example, 01/2016 has a percent change of 3% and 03/2016 has one of 3.10%, so the datapoint given to 02/2016 is 3.05%. This process is continued for the remaining gaps until December 2019.

Converting the data into monthly GDP figures was not as simple as was the case for USA GDP. Given that the monthly GDP growth rate estimates appeared to be annualized, the growth rates had to be compounded to get more accurate monthly GDP growth figures. Upon doing this process, the figure obtained for December 2019 GDP was 467390907 compared to FRED's Q4 2019 figure of 463733000.[33] Again, a relatively close estimate.

Finally, IHS Markit has another dataset, created by Dr Paul Smith, director of Economic Indices, which tracks monthly Chinese economic performance in order to create an "alternative GDP growth indicator."[34] The data was obtained from Dr. Smith directly.

The way monthly GDP growth was approximated was the following: first, the data provided by China's National Bureau of Statistics that had GDP at constant prices in 100 million yuan was obtained.[35] Specifically, Q4 2015 was used, as it was for both Korea and the US, to serve as the January 2016 figure. Afterward, a process similar to the one done for Korea was followed in which annualized monthly rates were compounded to get a more accurate monthly GDP figure. In doing so, a figure of 217863.2277 was obtained for December 2019 monthly GDP. When compared to the National Bureau of Statistics, the figure they report is 247627.8. Compared to the GDP

[33] "Real Gross Domestic Product for Republic of Korea [NGDPRSAXDCKRQ]."
[34] Smith, "Tracking Monthly Chinese Economic Performance."
[35] "Gross Domestic Product, Current Quarter(100 Million Yuan)."

approximators used for both Korea and the US, the estimates figure is not as close to the actual reported figure. Nevertheless, it is still a good estimator.

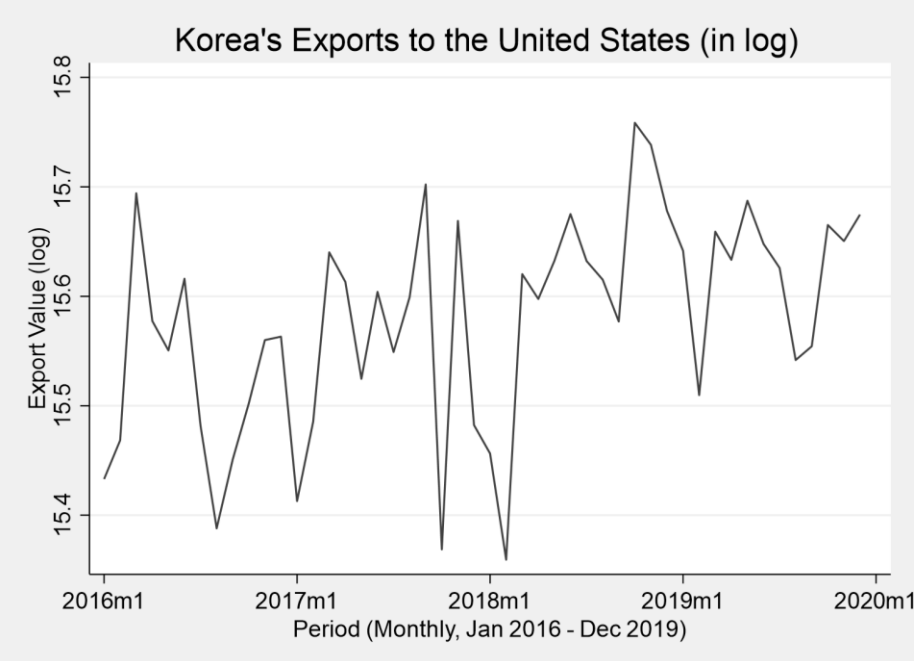
B. Summary and Descriptive Statistics

Table 1: General Summary Statistics of Key Variables in Log

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Export Value (log)	8,878	8.39	2.93	0.00	16.51
Real GDP for Korea (log)	9,353	19.91	0.03	19.86	19.96
Real GDP for US (log)	4,632	9.82	0.03	9.77	9.87
Real GDP for China (log)	4,673	12.17	0.08	12.04	12.29

Note: The variable for export value has less observations than that of Korea's real GDP since export value is reported for monthly aggregate trade as well as for HS codes. Certain HS codes will not have an export value attached to them if they are not traded during a certain month. A similar reasoning follows for the US and China's unequal number of observations. There are months in which either country will not trade products pertaining to a specific HS code. When this happens the real GDP value associated with that specific month will not be attached.

Graph 1: Korea's Exports to the United States (in log)



Graph 2: Korea's Exports to China (in log)

Graph 3: Korea's Exports to China and the United States (in log)

The three graphs above show the log values of Korea's exports to the United States and China, respectively, then together. In presenting the information in this way, as opposed to real values in respective currency, it becomes easier compare between countries as it standardizes figures.[36] However, similar graphs shown in absolute values can also be seen in the appendix. Before going further into discussing the observable trends, information on Korea's exports was obtained by country (China and United States), on a monthly basis, in aggregate terms[37][38] and by HS Codes[39][40] (Harmonized System Codes). Appendix 2 at the end shows a detailed list of the approximately 100 different HS codes that were included over the period of 2016-2019. The information was obtained from the Korea Customs Service.

From a pure observation standpoint, there appears to be a sharp dip in late 2017 and early 2018 in exports to the United States. During this time, the same trend does not appear to take place with China. However, a sharp dip does appear in late 2018 with Korean exports to China; a similar occurrence can be seen in the United States. Upon looking at both these graphs together in Graph 3, several facts become evident. The first being that export values to China are higher than to the United States. The second thing one can observe is that the United States appears to have felt a stronger shock in the period of late 2017 compared to China, but that the reverse was true in the later late-2018 shock.

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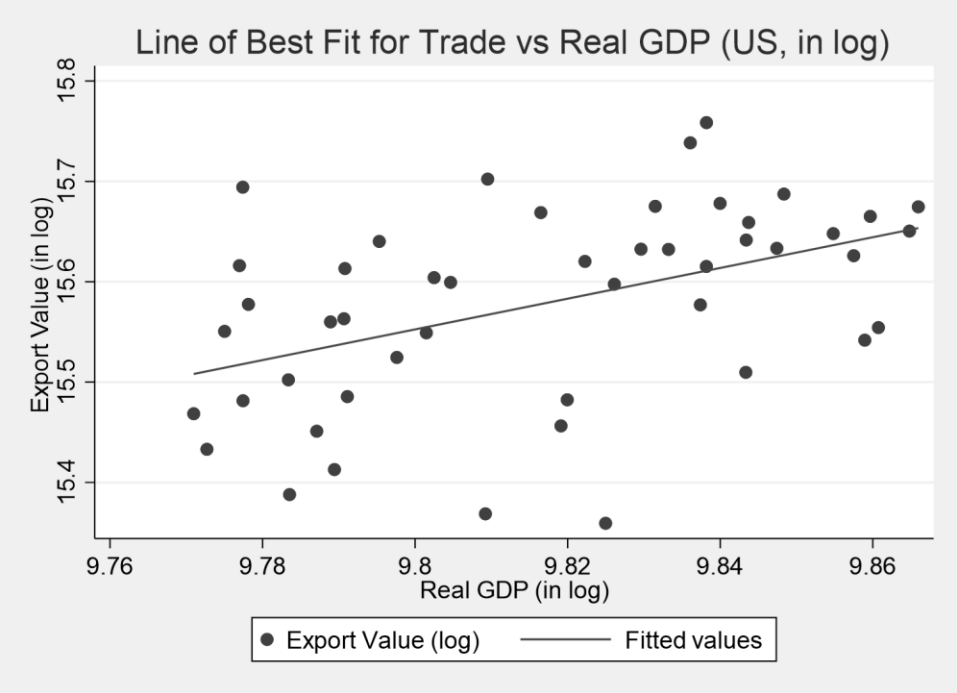
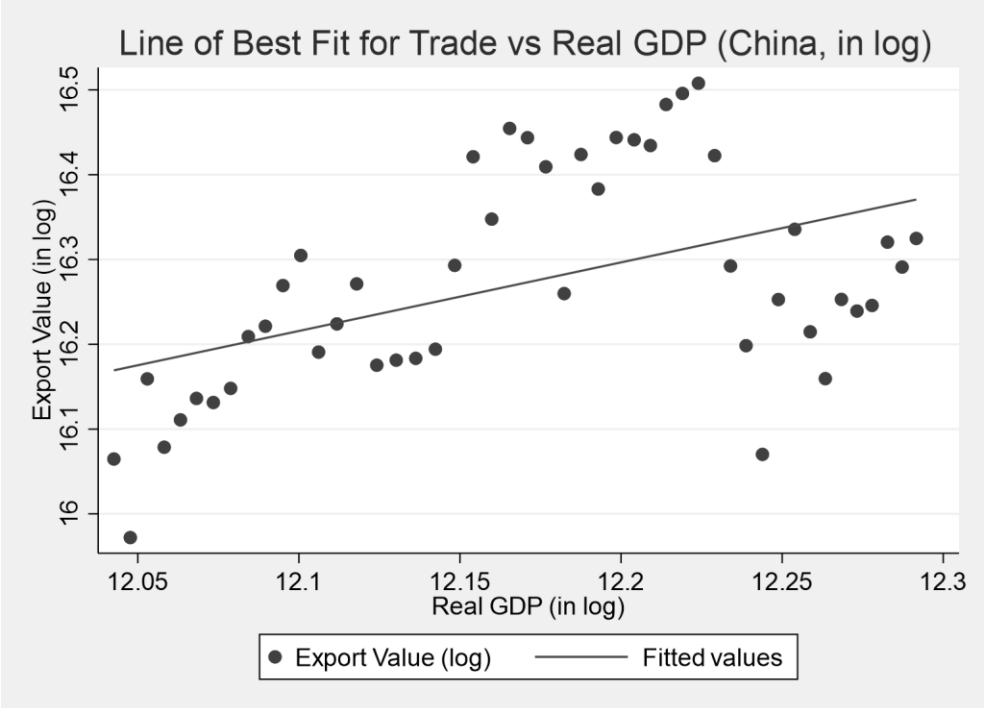
[36] As an important side note, the paper by Silva and Tenreyro, "The Log of Gravity." details that although the practice of log-linearizing equations in quite common in trade literature, the same is not always the case with the gravity equation and, thus, advises against the practice of doing so while suggesting to use the "poisson pseudo-maximum-likelihood estimator." Nevertheless, given the time and scope limitations of this paper, I will be taking the general log-linearizing approach as I believe the overall results will still be informative and, overall, not entirely inapplicable.
[37] "Trade Statistics for Export/Import (for Korea-China, 01/2016-12/2019)."
[38] "Trade Statistics for Export/Import (Korea-United States, 01/2016-12/2019)."
[39] "HS Code by Country (Korea-China, 01/2016-12/2019)."
[40] "HS Code by Country (Korea-United States, 01/2016-12/2019)."

Graph 4: Line of Best Fit for Trade vs Real GDP (US, in log)



Graph 5: Line of Best Fit for Trade vs Real GDP (China, in log)



Graphs 4 and 5 show the line of best fit for trade versus real GDP for the United States and China, respectively. Graph 3 in the appendix combines these two graphs, but given their difference in export value, it is not as straightforward. Regardless, these graphs support the gravity model (albeit not including the distance variable). One can see that both the US and China display a trend showing that a higher real GDP (for itself) will experience a higher export value for Korean goods.

Results and Data Analysis

A. General Regressions

Table 2: Change in Korea's Export Value in Log Using 'areg'

VARIABLES	(1) General	(2) By Combined HS Code	(3) By Agg. Trade for China and US
Real GDP (log)	0.201***	0.201***	0.298
	(0.0102)	(0.0102)	(0.450)
Real GDP for Korea (log)	1.140***	1.138***	1.202
	(0.376)	(0.380)	(0.817)
Constant	-16.53**	-16.56**	-11.29
	(7.478)	(7.559)	(11.92)
Observations	8,878	8,782	96
Adjusted R-squared	0.856	0.845	0.922

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The first regression is done using the 'areg' command on STATA. Because there are multiple observations for the same entity (country-HS code) over time, it seemed reasonable to use this feature in STATA to account for this type of data. By using *areg*, each observation has its own intercept and effects are grouped by categories. To be specific, the effects are grouped by HS code using the *absorb* specification. In terms of results, only column 1 and 2 showed any statistically significant coefficients (column 3 not being statistically significant). Nevertheless, both columns 1

and 2 show statistically significant results at the 1% significance level. Beginning with the real GDP variable in columns 1 and 2, they effectively show that a 1% increase in RGDP is associated with a .201% change in export value if we look at both aggregate trade values and HS code trade values together with both nations. In addition, the real GDP variable for Korea is statistically significant Table 2. Looking at the general regression (column 1), one can see that a 1% increase in the real GDP for Korea is associated with a 1.14% increase in its export value. This value becomes a 1.138% increase in export value if one looks only at combined HS code-only observations. The results of these regressions (columns 1-3) follow the typical expectations of the gravity model. Specifically, that increases in GDP for both the exporting nation and the receiving nation (Korea and then the US and China, respectively in this paper), will have a positive effect on the exports to the receiving nations by the exporting country. Indeed, seeing the positive coefficients in the RGDP and Korea's RGDP variables at highly statistically significant levels once again conclude that the gravity model is adequately able to analyze trade behaviors during the time period of January 2016 – December 2019.

B. With Time Dummies

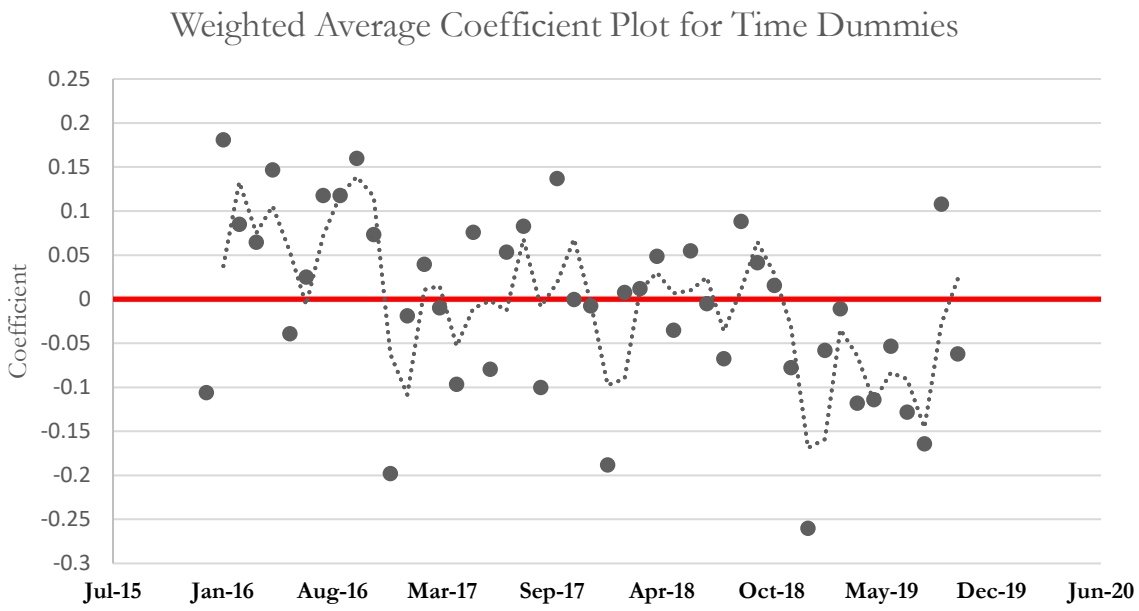
Table 3 in the appendix shows the outputs for the following regression

$$lnExport_{ij} = \beta_0 + B_1 lnRealKGDP_i + \beta_2 lnRealGDP_j + \beta_m MonthDummy + \varepsilon_{ijm}$$

with specifications for whether the observations include both values given by HS code and aggregate trade (column 1), by HS code-only (column 2), and then by aggregate trade-only observations (column 3). There are also indications for levels of significance at 1%, 5%, and 10%. In creating month dummies, it allows one to see if any month presented any significant changes for the variable export value. While there is a statistically significant date during 2016, this paper will look more closely at dates after April 2017, which is when Chinese President Xi Jinping visited former

President Trump to "set up a 100 Day Action Plan to resolve trade differences."[41] After April 2017, then, months with statistically significant coefficients include the following: August 2017, October 2017, January 2018, May 2018, September 2018, October 2018, and January 2019. While most of the aforementioned months were statistically significant in all two regression specifications, others were so in one or three of them. Because this model does not incorporate other variables that could potentially play a role in trade trends, these results should be interpreted rather conservatively. Nevertheless, it would be useful to contextualize what was occurring in the context of the US-China Trade War during these periods.

Graph 6: Weighted Average Coefficient Plot for Time Dummies Using 'areg'



Beginning with the months of August and October 2017, the coefficients for these months are positive and statistically significant in column 3. Back in May 2017, both countries agreed to a deal that would "give US firms in certain industries increased access to the Chinese

[41] Wong and Chipman Koty, "The US-China Trade War."

market….[benefiting] beef producers, credit rating services…among others."[42] While on August 18, 2017, the US Trade Representative began an investigation on issues relating to intellectual property.[43] Although not statistically significant, the month after, in September 2017, the month coefficients were negative, compared to being positive in August.

January 2018 was another month that had statistically significant negative coefficients for two of the regression specifications (columns 1 and 2). The only significant event from that time was the imposition of tariffs on solar panels and washing machines in mid-January.[44] The next month with a statistically significant date is May 2018; however, that is only the case with one of the regressions (aggregate trade-only observations, column 3). Furthermore, only this regression specification gives the coefficient a positive sign, while the other two carry negative signs. In the month prior, the USTR "[released] an initial list of 1,334 proposed products (worth US$50 billion) subject to a potential 25 percent tariff" while China similarly put in place "antidumping duties of 178.6 percent on imports of sorghum from the US."[45] However, early May did see some, although unproductive, trade talks between both nations which might help explain the mixed signs on the coefficients.[46]

The next two periods with statistically significant signs are September and October 2018. However, both of these signs are once again for the third regression specification which only looks at aggregate trade flows and, thus, has much fewer observations. The coefficient for the September 2018 month dummy is significant at the 5% level, and the October 2018 is so at the 10% level.

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[42] Chipman Koty, "China-US Trade Deal Opens Access for US Beef, Financial Services."
[43] "USTR Announces Initiation of Section 301 Investigation of China."
[44] Lynch, "Trump Imposes Tariffs on Solar Panels and Washing Machines in First Major Trade Action of 2018."
[45] Wong and Chipman Koty, "The US-China Trade War."
[46] Wearden, Fletcher, and Wearden, "Markets Slide as US-China Trade Talks Begin with Trump Call for 'level Playing Field' - as It Happened."

During these two months, the coefficient sign is positive. This was around the time the trade war began in earnest. Since July 6, 2018 was the day the United States began "collecting a 25 percent tariff on 818 imported Chinese products"[47] among other specifications and is generally accepted as the beginning of the trade war. During the month of August, both China and the US continued revising and announcing more tariffs on each other.[48] And while China also filed a World Trade Organization (WTO) lawsuit for the duties on solar panels in August of 2018, this time was also filled with multiple failed US-China dialogues. Because only one regression was statistically significant, the period dummies do not appear to be very well suited to explaining trends around here.

In the last year of observations, January 2019 appears statistically significant for all three specifications and carries a negative sign. Interesting about this timeframe is that in the month before, there had been a truce after productive talks in Argentina during a G20 summit.[49] In addition, early January saw a three-day trade talk in Beijing.[50] The negative signs on most month coefficients continue for the following months. In general, the rest of the observations for 2019 (save September 2019) carry a negative sign for the month dummies. In 2019, there were a variety of trade talks held both in Beijing and in Washington, including some held February, March, April, etc.[51] However, at the same time, tariffs continued to increase, and both the US and China continued to announce, threaten, or increase tariffs in May-September. The period of 2019 experienced plenty of other tension-causing events. Although not an exhaustive list, other notable events that took place include China publishing a white paper on June 2nd "denouncing US unilateral and

[47] Wong and Chipman Koty, "The US-China Trade War."
[48] For an exhaustive list of tariffs set around this time, Wong and Chipman Koty provide a very detailed timeline of the trade war.
[49] Rampton and Martina, "U.S., China Agree on Trade War Ceasefire after Trump, Xi Summit."
[50] Wong and Chipman Koty, "The US-China Trade War."
[51] Once again, Wong and Chipman Koty list in more detail the tariffs that were set during this time.

protectionist measures, [and] criticizing its backtracking on Sino-US trade talks,"[52] the August 6th statement that several Chinese companies will cease purchasing US agricultural goods, and the US "implementing tariffs on more than US$125 billion worth of Chinese imports" in September.[53] In general, however, given the high tensions of the trade war then, the negative coefficient appearing for most month dummies is indicative to how Korean exports also suffered during this time period.

C. With HS Code Dummies

Appendix 2 at the end of the paper includes an exhaustive list of all of the HS codes included in this study. As mentioned earlier, there were about 100 different HS codes for which data was obtained using the Korea Customs Service. Because of the long list of variables, Table 4 in the appendix also includes a table in which regressions using HS code dummies were run. The appendix also includes two different HS code coefficient plots separated by country for a more visual representation of the data. In general, however, the following regressions take the form of:

$$lnExport_{ij} = \beta_0 + B_1 lnRealKGDP_i + \beta_2 lnRealGDP_j + \beta_h HSCodeDummy + \varepsilon_{ijh}$$

Given that most, if not all, HS code dummies were statistically significant among the three regression specifications, it will be more informative to focus on those for which the coefficient signs between China and the United States are opposite. The modified version of the table is shown below as Table 3. The remaining observations can be divided into two groups, the first being those for which the HS code for China has a positive sign and the US one has a negative sign (group 1). The second being the inverse, those for which the HS code relating to China has a negative sign while the one relating to the US has a positive sign (group 2).

[52] "China Releases White Paper on Its Position on Economic and Trade Consultations with US."
[53] Wong and Chipman Koty, "The US-China Trade War."

Table 3: HS Code Coefficients

VARIABLES	(1) Combined	(2) China	(3) United States
HS Code = 5	0.431**	2.910***	-1.462***
	(0.188)	(0.247)	(0.147)
HS Code = 7	0.867***	-0.118	2.864***
	(0.183)	(0.247)	(0.135)
HS Code = 10	-0.610***	-1.297***	0.238*
	(0.192)	(0.265)	(0.135)
HS Code = 18	0.710***	3.054***	-0.623***
	(0.183)	(0.247)	(0.135)
HS Code = 23	0.807***	3.072***	-0.446***
	(0.183)	(0.247)	(0.135)
HS Code = 26	2.790***	5.143***	-0.384**
	(0.199)	(0.247)	(0.188)
HS Code = 31	0.187	1.981***	-0.680***
	(0.185)	(0.247)	(0.141)
HS Code = 36	1.593***	-2.985***	1.382***
	(0.214)	(0.799)	(0.135)
HS Code = 43	-0.712***	1.457***	-2.018***
	(0.186)	(0.247)	(0.142)
HS Code = 47	2.197***	5.103***	-3.494***
	(0.201)	(0.247)	(0.202)
HS Code = 51	1.220***	4.356***	-0.905***
	(0.183)	(0.247)	(0.135)
HS Code = 93	3.864***	-1.765***	4.110***
	(0.210)	(0.442)	(0.135)
Observations	8,878	4,420	4,410
Adjusted R-squared	0.856	0.935	0.941

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: Specific HS Code descriptions can be found in Appendix 2.

According to the data, the following items had positive effects on Korean export values for China but negative effects when looking at the US: HS Code 5, 18, 23, 26, 31, 43, 47, and 51. HS code 5 pertains to "products of animal origin," 18 to cocoa products, 23 to waste from food industries, 26 to "ores, slag and ash." For the remaining products, 31 refers to fertilizers, 43 to furskins, 47 to pulp of wood and other recovered papers, and finally 51 refers to wool. Similarly, the following items has positive coefficients when looking at Korea's exports to the US but negative when looking at China: HS Code 7, 10, 36, and 93. As for what these HS codes refer to, HS code 7

encompasses "edible vegetables and certain roots and tubers," while 10 is for cereals, 36 is for explosives, and finally HS code 93 refers to arms and ammunition.

In looking purely at the categorization of these products, it is interesting to see the types of products that were included. Specifically, that explosives and ammunition carried a positive sign for the US and a negative sign for China. While on the other hand, products like furskins and wool fared positively for China and not for the US during this time period. While more research is certainly needed to analyze and contextualize these trends, given arms culture in the United States, this revelation is not entirely unexpected. For China, as well, its wool market also appears to be relatively strong, but might have weakened as a result to COVID-19.[54]

D. With Both Time and HS Code Dummies

Additional regressions include one which looked at both time and HS code dummies together. However, only relevant results were included in the table below due to space limitations. Beginning with the coefficients on the variable for real GDP, compared to previous regressions, it has taken a negative coefficient. Important to note, however, is that it is not statistically significant. As for the variable for Korea's real GDP, this one continues to have a positive coefficient and is statistically significant at the 5% level. As for the time dummies, there are fewer months that are statistically significant compared to previous tables. This time, the months that were of importance included: December 2016, and January 2018 and 2019. All of which were also significant in previous regressions. Finally, as mentioned in the previous section for HS code dummies, most of the coefficients continue to be statistically significant. Due to issues of collinearity, regressions looking specifically time-hscode dummies were not included.

[54] C, "China's Dominance on the Global Wool Market Shows Signs of Weakening."

Table 4: Effects on Log Export Values
Using Period and HS Code Dummies

VARIABLES	(1) Export Value (log)
Real GDP (log)	-0.481
	(0.510)
Real GDP for Korea (log)	3.488**
	(1.395)
December 2016	-0.203**
	(0.104)
January 2018	-0.189*
	(0.101)
January 2019	-0.263**
	(0.107)
HS Code = 5	0.427**
	(0.188)
HS Code = 7	0.865***
	(0.183)
HS Code = 10	-0.613***
	(0.192)
HS Code = 18	0.707***
	(0.183)
HS Code = 23	0.805***
	(0.183)
HS Code = 26	2.787***
	(0.199)
HS Code = 31	0.183
	(0.185)
HS Code = 36	1.591***
	(0.214)
HS Code = 43	-0.714***
	(0.186)
HS Code = 47	2.193***
	(0.201)
HS Code = 51	1.218***
	(0.183)
HS Code = 93	3.862***
	(0.210)
Observations	8,878
Adjusted R-squared	0.856

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Only statistically significant months included. Most, if not all, HS code dummies were statistically significant, therefore only the ones that were discussed in previous regressions were included for space. Entire coefficient outputs are not included in the appendix due to space limitations.

E. Specifying Smaller Timeframes

Table 5: Regressions Within a Smaller Timeframe

VARIABLES	(1) July 2018 - Oct 2019	(2) April 2017 - Oct 2019
Real GDP (log)	0.201***	0.186***
	(0.0163)	(0.0120)
Real GDP for Korea (log)	-0.144	1.302*
	(1.964)	(0.670)
Constant	9.081	-19.58
	(39.17)	(13.35)
Observations	3,343	6,113
Adjusted R-squared	0.858	0.861

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The final way in which the data was analyzed was looking at it in even smaller timeframes. What is good to note, is that even when looking at a smaller timeframe, the adjusted R^2 continues to be very high. In essence, meaning that approximately 85% of the variance in Korea's exports between July 2018 – October 2019 can still be explained by the model. This figure becomes 86% when the time period is a big longer (April 2017 – October 2019). Two additional points to note, however. When looking at the slightly shorter time period (column 1), the coefficient for Korea's real GDP becomes statistically insignificant while also being negative. However, the coefficient for real GDP is positive and significant at the 1% level. Using both time and HS code dummies within this time period continues to produce statistically insignificant results for Korea's real GDP variable; however, the coefficient becomes positive.[55] Due to the inconsistent outcomes, Korea's real GDP showing a negative coefficient in the table below is not a cause for much concern.

[55] Regression outputs not included in the appendix in order to conserve space and due to lack of relevance.

If one looks at the slightly longer time period (column 2), then both coefficients are positive and statistically significant. Furthermore, comparing these coefficients with previous results, such as those found on Table 2, they are quite similar. For instance, comparing it to column 1 of Table 2 where we look at the time period of January 2016 – October 2019, we can see that an increase a 1% increase in RGDP (KRGDP) is associated with a .20% (1.14%) change in export value. These values then become that a 1% increase in RGDP (KRGDP) is associated with a .186% (1.30%) change in Korea's export value. Because of the similarity in main variable coefficients and to avoid redundancy, it did not seem necessary to include further regressions using both time and HS code dummies. As it appears, most of the results and analysis included in earlier sections of this paper will continue to apply to even more granular time frames.

Conclusion

While the gravity model has long been a staple of analysis in the field of international relations, it had not yet been used within the context of the US-China Trade War to specifically look at how Korea's trade behavior changed during this time. This paper continues to prove that the gravity model is adequate at explaining trade flows, effectively showing that increases in GDP are associated with increases in trade. Table 2, column 1 specifically shows that a 1% increase in RGDP is associated with a .201% change in export value. While a 1% increase in the real GDP for Korea is similarly associated with a 1.14% increase in its export value. This paper further employed time fixed effects to take a more granular look at these changes, essentially finding specific months with statistically significant changes (August 2017, October 2017, January 2018, May 2018, September 2018, October 2018, and January 2019) and contextualized them within the events of the trade war. Finally, by comparing the effects by HS code per country, it pointed out about 12 different categories of exports that had opposite effects for China and the United States. Most notably, it was

found that ammunition fared better for the US (as opposed to China) and wool fare better for China (as opposed to the US) among other results.

While I believe the results of this paper offer a useful contribution to the literature on trade wars and gravity models in general, there were several limitations that must be noted. First, and perhaps most importantly, the data on GDP had to be approximated with three different approximators. Since GDP data is released either at the yearly or quarterly interval, it would have been difficult to obtain statistically significant results given the timeframe of interest. Future studies might benefit from finding different measures to use instead of GDP. Another limitation was the exclusion of the distance variable. Given that the typical gravity model looks at the relationship between GDP and distance, by employing only a three-country model, the use of distance would not have been very intuitive, and, indeed, faced issues with collinearity in preliminary regressions. Finally, due to time limitations, this paper could not make full use of the richness in data offered by the HS codes. Future work would benefit in looking more closely at the classifications of these goods, separating them into broader categories like simple versus complex goods or even intermediate versus final goods, and analyzing general trends from that. Given that most of Korea's exports to China comprise of intermediary goods,[56] this could have been an insightful direction to take the research.

As mentioned previously, the gravity model has not yet been used to study the effects of the US-China Trade War in South Korea. Given the recency of it, efforts by other scholars are also quite new. Having done this exercise, I hope it opens doors to further studies using (or improving upon) the approach taken. Indeed, it might become even more imperative in the next few years.

[56] Suh, "U.S.–China Trade Conflict and the Changing Multilateral Trading System: Korea's Perspective*," 146.

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Appendices

Appendix 1: Main Variable Names and Descriptions

1. period
    a. monthly from 01/2016 – 12/2019
2. country
    a. usa for the United States
    b. chn for China
3. hscode
    a. refers to Harmonized System (HS) Codes, standard method of classifying traded goods
    b. made "999" represent KOR-USA aggregate trade data, "888" represents KOR-CHN data
        i. see 'aggtrade' variable for more explanation
4. aggtrade
    a. binary variable, 0 for if hs code observation includes the aggregate trade for that specific month-country and 1 if it is an observation of aggregate trade for that particular month-country
    b. in hs code, "999" represent KOR-USA aggregate trade data, "888" represents KOR-CHN data
    c. has the following observations: numexp, numimp, expv, impv, tradebal
        i. Unit: USD 1,000
5. expv
    a. export value in USD 1,000
        i. exports from kor
        ii. also in log
6. rgdp
    a. Real gross domestic product (approximates using monthly estimators), in national currency, also in log
        i. United States → usd
            1. Billions of Chained 2012 Dollars, Seasonally Adjusted Annual Rate
        ii. China → yuan
            1. Current Quarter (100 million yuan), 2016-2020 data calculated at 2015 constant prices
    b. also in log
7. krgdp
    a. Real gross domestic product for South Korea (approximates using monthly estimators), in national currency (won), seasonally adjusted
    b. also in log

Appendix 2: HS Code Specifications (from Korea Customs Service)

H.S Code	Items
1	Live animals
2	Meat and edible meat offal
3	Fish and crustaceans, mollusks and other aquatic invertebrates
4	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included
5	Products of animal origin, not elsewhere specified or included
6	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage
7	Edible vegetables and certain roots and tubers
8	Edible fruit and nuts; peel of citrus fruit or melons
9	Coffee, tea, mate and spices
10	Cereals
11	Products of the milling industry; malt; starches; inulin; wheat gluten
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder
13	Lac; gums, resins and other vegetable saps and extracts
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included
15	Animal, vegetable or microbial fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes
16	Preparations of meat, of fish, of crustaceans, mollusks or other aquatic invertebrates, or of insects
17	Sugars and sugar confectionery
18	Cocoa and cocoa preparations
19	Preparations of cereals, flour, starch or milk; pastrycooks' products
20	Preparations of vegetables, fruit, nuts or other parts of plants
21	Miscellaneous edible preparations
22	Beverages, spirits and vinegar
23	Residues and waste from the food industries; prepared animal fodder
24	Tobacco and manufactured tobacco substitutes; products, whether or not containing nicotine, intended for inhalation without combustion; other nicotine containing products intended for the intake of nicotine into the human body
25	Salt; sulphur; earths and stone; plastering materials, lime and cement
26	Ores, slag and ash
27	Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes
28	Inorganic chemicals; organic or inorganic compounds of precious metals, of rare-earth metals, of radioactive elements or of isotopes
29	Organic chemicals

30	Pharmaceutical products
31	Fertilizers
32	Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other coloring matter; paints and varnishes; putty and other mastics; inks
33	Essential oils and resinoids; perfumery, cosmetic or toilet preparations
34	Soap, organic surface-active agents, washing preparations, lubricating preparations, artificial waxes, prepared waxes, polishing or scouring preparations, candles and similar articles, modelling pastes, "dental waxes" and dental preparation with a basis of plaster
35	Albuminoidal substances; modified starches; glues; enzymes
36	Explosives; pyrotechnic products; matches; pyrophoric alloys; certain combustible preparations
37	Photographic or cinematographic goods
38	Miscellaneous chemical products
39	Plastics and articles thereof
40	Rubber and articles thereof
41	Raw hides and skins (other than furskins) and leather
42	Articles of leather; saddlery and harness; travel goods, handbags and similar containers; articles of animal gut (other than silk-worm gut)
43	Furskins and artificial fur; manufactures thereof
44	Wood and articles of wood; wood charcoal
45	Cork and articles of cork
46	Manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork
47	Pulp of wood or of other fibrous cellulosic materials; recovered (waste and scrap) paper or paperboard
48	Paper and paperboard; articles of paper pulp, of paper or of paperboard
49	Printed books, newspapers, pictures and other products of the printing industry; manuscripts, typescripts and plans
50	Silk
51	Wool, fine or coarse animal hair; horsehair yarn and woven fabric
52	Cotton
53	Other vegetable textile fibers; paper yarn and woven fabrics of paper yarn
54	Man-made filaments; strip and the like of man-made textile materials
55	Man-made staple fibers
56	Wadding, felt and nonwovens; special yarns; twine, cordage, ropes and cables and articles thereof
57	Carpets and other textile floor coverings
58	Special woven fabrics; tufted textile fabrics; lace; tapestries; trimmings; embroidery

59	Impregnated, coated, covered or laminated textile fabrics; textile articles of a kind suitable for industrial use
60	Knitted or crocheted fabrics
61	Articles of apparel and clothing accessories, knitted or crocheted
62	Articles of apparel and clothing accessories, not knitted or crocheted
63	Other made up textile articles; sets; worn clothing and worn textile articles; rags
64	Footwear, gaiters and the like; parts of such articles
65	Headgear and parts thereof
66	Umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts thereof
67	Prepared feathers and down and articles made of feathers or of down; artificial flowers; articles of human hair
68	Articles of stone, plaster, cement, asbestos, mica or similar materials
69	Ceramic products
70	Glass and glassware
71	Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal, and articles thereof; imitation jewelry; coin
72	Iron and steel
73	Articles of iron or steel
74	Copper and articles thereof
75	Nickel and articles thereof
76	Aluminum and articles thereof
78	Lead and articles thereof
79	Zinc and articles thereof
80	Tin and articles thereof
81	Other base metals; cermets; articles thereof
82	Tools, implements, cutlery, spoons and forks, of base metal; parts thereof of base metal
83	Miscellaneous articles of base metal
84	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof
85	Chapter 85 Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles
86	Chapter 86 Railway or tramway locomotives, rolling-stock and parts thereof; railway or tramway track fixtures and fittings and parts thereof; mechanical (including electro-mechanical) traffic signaling equipment of all kinds
87	Vehicles other than railway or tramway rolling-stock, and parts and accessories thereof
88	Aircraft, spacecraft, and parts thereof

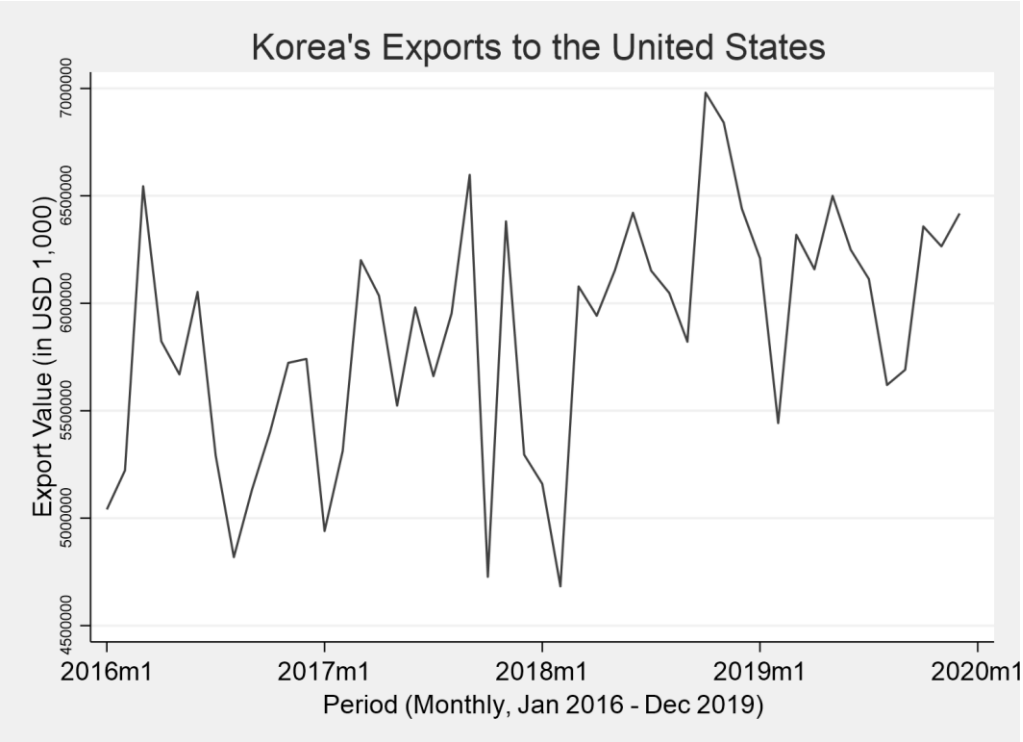
89	Ships, boats and floating structures
90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; parts and accessories thereof
91	Clocks and watches and parts thereof
92	Musical instruments; parts and accessories of such articles
93	Arms and ammunition; parts and accessories thereof
94	Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; luminaires and lighting fittings, not elsewhere specified or included; illuminated signs, illuminated name-plates and the like; prefabricated buildings
95	Toys, games and sports requisites; parts and accessories thereof
96	Miscellaneous manufactured articles
97	Works of art, collectors' pieces and antiques
99	TEMPORARY LEGISLATION; TEMPORARY MODIFICATIONS ESTABLISHED PURSUANT TO TRADE LEGISLATION; ADDITIONAL IMPORT RESTRICTIONS ESTABLISHED PURSUANT TO SECTION 22 OF THE AGRICULTURAL ADJUSTMENT ACT, AS AMENDED

Appendix 3: Table 2, General Summary Statistics

General Summary Statistics of Key Variables

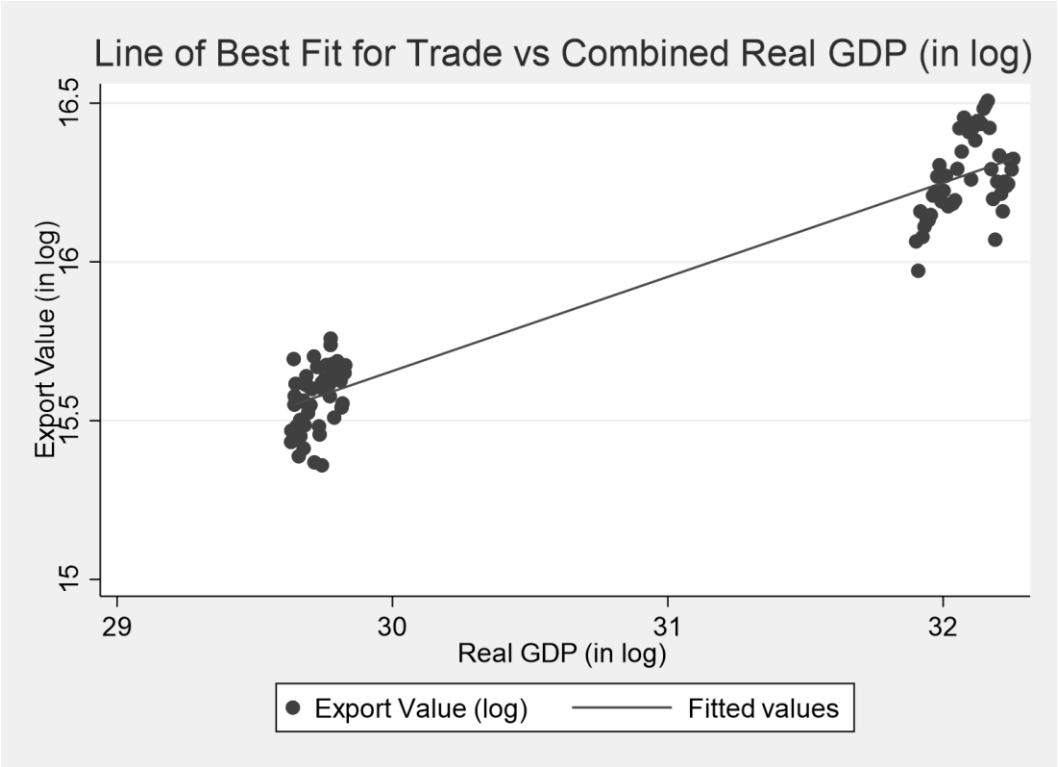
VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Export Value (in USD 1,000)	9,353	180,844	1,020,297	0	14,767,041
Real GDP for Korea (in won)	9,353	445,295,679	13,954,330	421,371,392	467,390,912
Real GDP for US (in USD)	4,632	18,353	534	17,518	19,264
Real GDP for China (in yuan)	4,673	193,599	14,482	169,833	217,863

Appendix 4: Graph 1, Korea's Exports to the United States (in absolute terms)



Appendix 5: Graph 2, Korea's Exports to China (in absolute terms)

Appendix 6: Graph 3, Line of Best Fit for Trade vs Combined Real GDP (in log)



Appendix 7: Table 3, Regression with Period Dummies

Effects on Log Export Values Using Period Dummies

VARIABLES	(1) HS Code and Agg. Trade Observations	(2) HS Code-only Observations	(3) Agg. Trade-only Observations
Real GDP (log)	0.201***	0.201***	0.321
	(0.0102)	(0.0102)	(0.402)
Real GDP for Korea (log)	2.364**	2.367**	1.891*
	(1.114)	(1.126)	(1.099)
periodm = 673	-0.106	-0.107	-0.0338
	(0.114)	(0.116)	(0.0898)
periodm = 674	0.181	0.181	0.166*
	(0.113)	(0.114)	(0.0888)
periodm = 675	0.0852	0.0854	0.0616
	(0.112)	(0.113)	(0.0877)
periodm = 676	0.0649	0.0650	0.0598
	(0.111)	(0.112)	(0.0869)
periodm = 677	0.147	0.147	0.0998
	(0.109)	(0.111)	(0.0861)
periodm = 678	-0.0390	-0.0397	0.0248
	(0.108)	(0.110)	(0.0853)
periodm = 679	0.0251	0.0256	-0.0204
	(0.108)	(0.109)	(0.0844)
periodm = 680	0.118	0.119	0.0352
	(0.106)	(0.108)	(0.0836)
periodm = 681	0.118	0.119	0.0615
	(0.105)	(0.107)	(0.0829)
periodm = 682	0.160	0.161	0.108
	(0.104)	(0.106)	(0.0823)
periodm = 683	0.0735	0.0730	0.122
	(0.104)	(0.105)	(0.0817)
periodm = 684	-0.198*	-0.200*	-0.0144
	(0.104)	(0.105)	(0.0813)
periodm = 685	-0.0189	-0.0194	0.0338
	(0.103)	(0.104)	(0.0809)
periodm = 686	0.0399	0.0389	0.129
	(0.102)	(0.103)	(0.0805)
periodm = 687	-0.00979	-0.0106	0.0639
	(0.102)	(0.103)	(0.0802)
periodm = 688	-0.0967	-0.0980	0.0163
	(0.101)	(0.102)	(0.0798)
periodm = 689	0.0760	0.0763	0.0510
	(0.101)	(0.102)	(0.0795)
periodm = 690	-0.0793	-0.0805	0.0236

	(0.101)	(0.102)	(0.0792)
periodm = 691	0.0536	0.0532	0.0925
	(0.101)	(0.102)	(0.0790)
periodm = 692	0.0830	0.0817	0.202**
	(0.1000)	(0.101)	(0.0788)
periodm = 693	-0.100	-0.101	-0.00649
	(0.100)	(0.101)	(0.0788)
periodm = 694	0.137	0.136	0.189**
	(0.100)	(0.101)	(0.0787)
periodm = 695	-7.80e-05	-0.000990	0.0835
	(0.0999)	(0.101)	(0.0787)
periodm = 696	-0.00753	-0.00811	0.0467
	(0.100)	(0.101)	(0.0788)
periodm = 697	-0.188*	-0.189*	-0.0831
	(0.101)	(0.102)	(0.0790)
periodm = 698	0.00759	0.00631	0.125
	(0.101)	(0.102)	(0.0792)
periodm = 699	0.0122	0.0114	0.0870
	(0.101)	(0.102)	(0.0795)
periodm = 700	0.0487	0.0479	0.129
	(0.101)	(0.102)	(0.0798)
periodm = 701	-0.0352	-0.0372	0.143*
	(0.102)	(0.103)	(0.0801)
periodm = 702	0.0550	0.0543	0.113
	(0.102)	(0.103)	(0.0805)
periodm = 703	-0.00500	-0.00640	0.123
	(0.103)	(0.104)	(0.0810)
periodm = 704	-0.0675	-0.0694	0.105
	(0.103)	(0.104)	(0.0815)
periodm = 705	0.0885	0.0873	0.197**
	(0.104)	(0.105)	(0.0821)
periodm = 706	0.0417	0.0407	0.140*
	(0.105)	(0.106)	(0.0825)
periodm = 707	0.0156	0.0154	0.0405
	(0.105)	(0.106)	(0.0829)
periodm = 708	-0.0777	-0.0783	-0.0292
	(0.106)	(0.107)	(0.0834)
periodm = 709	-0.260**	-0.261**	-0.165*
	(0.107)	(0.108)	(0.0842)
periodm = 710	-0.0579	-0.0585	-0.00452
	(0.108)	(0.109)	(0.0850)
periodm = 711	-0.0107	-0.0110	0.0178
	(0.108)	(0.110)	(0.0859)
periodm = 712	-0.118	-0.119	-0.0194
	(0.109)	(0.110)	(0.0864)
periodm = 713	-0.114	-0.114	-0.0712

	(0.110)	(0.111)	(0.0869)
periodm = 714	-0.0532	-0.0534	-0.0394
	(0.111)	(0.112)	(0.0874)
periodm = 715	-0.128	-0.128	-0.0926
	(0.112)	(0.113)	(0.0881)
periodm = 716	-0.164	-0.165	-0.0873
	(0.112)	(0.113)	(0.0888)
periodm = 717	0.108	0.110	0.00177
	(0.113)	(0.115)	(0.0894)
periodm = 718	-0.0620	-0.0625	-0.0250
	(0.114)	(0.115)	(0.0901)
periodm = 719, omitted	-	-	-
Constant	-40.90*	-41.04*	-25.30
	(22.18)	(22.43)	(19.54)
Observations	8,878	8,782	96
Adjusted R-squared	0.856	0.845	0.939

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Period 673 corresponds to January 2016. Each period is monthly, no gaps. The data ends in October 2019 since November 2019 is omitted due to collinearity.

Appendix 8: Table 4, Regression with HS Code Dummies

	HS Code Coefficients		
VARIABLES	(1) Combined	(2) China	(3) United States
HS Code = 2	-1.816***	-0.858***	-0.287
	(0.225)	(0.257)	(0.269)
HS Code = 3	5.268***	6.738***	4.810***
	(0.183)	(0.247)	(0.135)
HS Code = 4	2.428***	4.176***	1.692***
	(0.183)	(0.247)	(0.135)
HS Code = 5	0.431**	2.910***	-1.462***
	(0.188)	(0.247)	(0.147)
HS Code = 6	0.772***	1.832***	0.711***
	(0.183)	(0.249)	(0.135)
HS Code = 7	0.867***	-0.118	2.864***
	(0.183)	(0.247)	(0.135)
HS Code = 8	1.670***	1.563***	2.727***
	(0.183)	(0.249)	(0.135)
HS Code = 9	1.317***	1.899***	1.746***
	(0.183)	(0.247)	(0.135)
HS Code = 10	-0.610***	-1.297***	0.238*
	(0.192)	(0.265)	(0.135)
HS Code = 11	1.475***	2.220***	1.741***
	(0.183)	(0.247)	(0.135)
HS Code = 12	3.750***	5.372***	3.140***
	(0.183)	(0.247)	(0.135)
HS Code = 13	2.861***	3.920***	2.813***
	(0.183)	(0.247)	(0.135)
HS Code = 14	-2.913***	-1.328***	-3.910***
	(0.203)	(0.250)	(0.192)
HS Code = 15	1.649***	3.209***	1.099***
	(0.183)	(0.247)	(0.135)
HS Code = 16	3.931***	5.094***	3.780***
	(0.183)	(0.247)	(0.135)
HS Code = 17	3.328***	5.846***	1.822***
	(0.183)	(0.247)	(0.135)
HS Code = 18	0.710***	3.054***	-0.623***
	(0.183)	(0.247)	(0.135)
HS Code = 19	5.472***	6.712***	5.243***
	(0.183)	(0.247)	(0.135)
HS Code = 20	3.953***	5.547***	3.370***
	(0.183)	(0.247)	(0.135)
HS Code = 21	5.363***	6.496***	5.241***
	(0.183)	(0.247)	(0.135)
HS Code = 22	4.887***	6.188***	4.597***
	(0.183)	(0.247)	(0.135)

HS Code = 23	0.807***	3.072***	-0.446***
	(0.183)	(0.247)	(0.135)
HS Code = 24	3.535***	3.674***	4.407***
	(0.183)	(0.247)	(0.135)
HS Code = 25	4.267***	5.938***	3.608***
	(0.183)	(0.247)	(0.135)
HS Code = 26	2.790***	5.143***	-0.384**
	(0.199)	(0.247)	(0.188)
HS Code = 27	8.564***	10.09***	8.048***
	(0.183)	(0.247)	(0.135)
HS Code = 28	6.393***	8.783***	5.014***
	(0.183)	(0.247)	(0.135)
HS Code = 29	8.287***	10.57***	7.013***
	(0.183)	(0.247)	(0.135)
HS Code = 30	5.462***	6.534***	5.402***
	(0.183)	(0.247)	(0.135)
HS Code = 31	0.187	1.981***	-0.680***
	(0.185)	(0.247)	(0.141)
HS Code = 32	5.827***	7.899***	4.768***
	(0.183)	(0.247)	(0.135)
HS Code = 33	7.000***	8.903***	6.108***
	(0.183)	(0.247)	(0.135)
HS Code = 34	5.147***	6.862***	4.444***
	(0.183)	(0.247)	(0.135)
HS Code = 35	4.552***	6.285***	3.829***
	(0.183)	(0.247)	(0.135)
HS Code = 36	1.593***	-2.985***	1.382***
	(0.214)	(0.799)	(0.135)
HS Code = 37	5.474***	7.514***	4.445***
	(0.183)	(0.247)	(0.135)
HS Code = 38	6.568***	8.216***	5.932***
	(0.183)	(0.247)	(0.135)
HS Code = 39	8.624***	10.41***	7.855***
	(0.183)	(0.247)	(0.135)
HS Code = 40	7.194***	7.938***	7.462***
	(0.183)	(0.247)	(0.135)
HS Code = 41	3.152***	6.056***	1.260***
	(0.183)	(0.247)	(0.135)
HS Code = 42	3.958***	5.046***	3.880***
	(0.183)	(0.247)	(0.135)
HS Code = 43	-0.712***	1.457***	-2.018***
	(0.186)	(0.247)	(0.142)
HS Code = 44	2.175***	3.420***	1.941***
	(0.183)	(0.247)	(0.135)
HS Code = 45	-2.920***	-1.932***	-2.993***
	(0.227)	(0.290)	(0.168)
HS Code = 46	-0.692***	-1.986***	-0.0890
	(0.199)	(0.289)	(0.135)

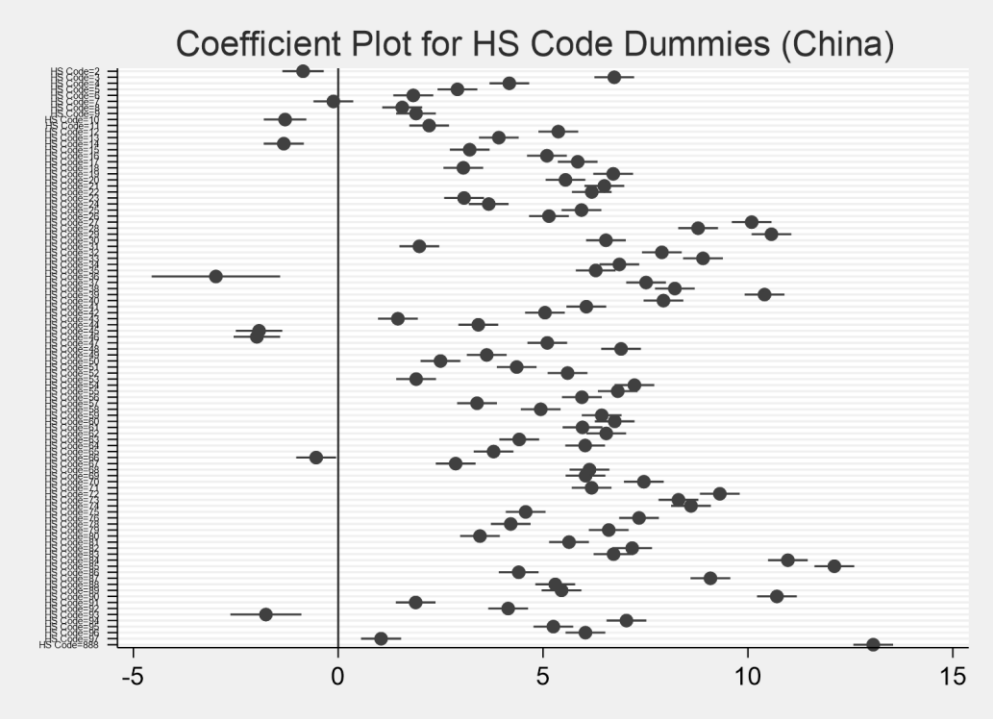
HS Code = 47	2.197***	5.103***	-3.494***
	(0.201)	(0.247)	(0.202)
HS Code = 48	6.047***	6.903***	6.202***
	(0.183)	(0.247)	(0.135)
HS Code = 49	3.417***	3.625***	4.220***
	(0.183)	(0.247)	(0.135)
HS Code = 50	2.198***	2.497***	2.910***
	(0.183)	(0.247)	(0.135)
HS Code = 51	1.220***	4.356***	-0.905***
	(0.183)	(0.247)	(0.135)
HS Code = 52	4.739***	5.598***	4.892***
	(0.183)	(0.247)	(0.135)
HS Code = 53	0.847***	1.902***	0.804***
	(0.183)	(0.247)	(0.135)
HS Code = 54	5.776***	7.230***	5.334***
	(0.183)	(0.247)	(0.135)
HS Code = 55	5.519***	6.822***	5.228***
	(0.183)	(0.247)	(0.135)
HS Code = 56	4.573***	5.948***	4.209***
	(0.183)	(0.247)	(0.135)
HS Code = 57	2.145***	3.388***	1.914***
	(0.183)	(0.247)	(0.135)
HS Code = 58	3.653***	4.942***	3.376***
	(0.183)	(0.247)	(0.135)
HS Code = 59	5.237***	6.431***	5.055***
	(0.183)	(0.247)	(0.135)
HS Code = 60	5.467***	6.748***	5.197***
	(0.183)	(0.247)	(0.135)
HS Code = 61	5.115***	5.962***	5.278***
	(0.183)	(0.247)	(0.135)
HS Code = 62	4.514***	6.542***	3.497***
	(0.183)	(0.247)	(0.135)
HS Code = 63	3.446***	4.418***	3.484***
	(0.183)	(0.247)	(0.135)
HS Code = 64	4.381***	6.027***	3.746***
	(0.183)	(0.247)	(0.135)
HS Code = 65	3.210***	3.792***	3.640***
	(0.183)	(0.247)	(0.135)
HS Code = 66	-1.618***	-0.538**	-1.680***
	(0.184)	(0.248)	(0.137)
HS Code = 67	1.650***	2.867***	1.446***
	(0.183)	(0.247)	(0.135)
HS Code = 68	5.191***	6.132***	5.262***
	(0.183)	(0.247)	(0.135)
HS Code = 69	4.351***	6.036***	3.678***
	(0.183)	(0.247)	(0.135)
HS Code = 70	5.652***	7.460***	4.856***
	(0.183)	(0.247)	(0.135)

HS Code = 71	5.192***	6.185***	5.210***
	(0.183)	(0.247)	(0.135)
HS Code = 72	7.803***	9.314***	7.304***
	(0.183)	(0.247)	(0.135)
HS Code = 73	7.459***	8.304***	7.625***
	(0.183)	(0.247)	(0.135)
HS Code = 74	6.491***	8.610***	5.383***
	(0.183)	(0.247)	(0.135)
HS Code = 75	2.922***	4.575***	2.280***
	(0.183)	(0.247)	(0.135)
HS Code = 76	5.992***	7.342***	5.654***
	(0.183)	(0.247)	(0.135)
HS Code = 78	3.861***	4.211***	4.587***
	(0.184)	(0.247)	(0.138)
HS Code = 79	2.925***	6.603***	0.259*
	(0.183)	(0.247)	(0.135)
HS Code = 80	1.327***	3.460***	0.188
	(0.183)	(0.247)	(0.136)
HS Code = 81	4.125***	5.633***	3.629***
	(0.183)	(0.247)	(0.135)
HS Code = 82	6.020***	7.175***	5.876***
	(0.183)	(0.247)	(0.135)
HS Code = 83	5.806***	6.719***	5.905***
	(0.183)	(0.247)	(0.135)
HS Code = 84	9.753***	10.97***	9.542***
	(0.183)	(0.247)	(0.135)
HS Code = 85	10.28***	12.11***	9.465***
	(0.183)	(0.247)	(0.135)
HS Code = 86	3.429***	4.405***	3.465***
	(0.183)	(0.247)	(0.135)
HS Code = 87	8.997***	9.084***	9.921***
	(0.183)	(0.247)	(0.135)
HS Code = 88	5.562***	5.298***	6.838***
	(0.183)	(0.247)	(0.135)
HS Code = 89	2.603***	5.450***	0.737***
	(0.183)	(0.247)	(0.136)
HS Code = 90	8.468***	10.71***	7.240***
	(0.183)	(0.247)	(0.135)
HS Code = 91	1.113***	1.890***	1.348***
	(0.183)	(0.247)	(0.135)
HS Code = 92	3.416***	4.149***	3.695***
	(0.183)	(0.247)	(0.135)
HS Code = 93	3.864***	-1.765***	4.110***
	(0.210)	(0.442)	(0.135)
HS Code = 94	5.865***	7.035***	5.706***
	(0.183)	(0.247)	(0.135)
HS Code = 95	4.492***	5.251***	4.745***
	(0.183)	(0.247)	(0.135)

HS Code = 96	4.800***	6.033***	4.578***
	(0.183)	(0.247)	(0.135)
HS Code = 97	1.562***	1.047***	2.926***
	(0.184)	(0.250)	(0.135)
Observations	8,878	4,420	4,410
Adjusted R-squared	0.856	0.935	0.941

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 9: Graph 4, HS Code Coefficient Plot (China)



Appendix 10: Graph 5, HS Code Coefficient Plot (US)