Final Report

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Abstract

The trade war between the United States and China has shocked global trade flows. This paper explores the effects of retaliatory tariffs between 2018 and 2019 on the U.S. apple market. This analysis uses data sets with the volume and unit price of fresh, dried and juice apple products released by the USDA, on both export and import sections, at a monthly frequency and a simple regression discontinuity approach to measure the level of changes of retaliatory tariffs on the apple market. Comparison between change in the market and rate of tariffs suggests that retaliatory tariffs have large impact on export and import of the U.S. apple market, but the relationship is not always positive. This implies that although tariffs mostly impact negatively, they increase the export volume of dried products, the remaining effect of tariffs increase juice's import volume and its export unit price. Tariffs decrease the import unit price of all three products. This result suggests that tariffs have positive impacts on particular sections of apple products but most of the effects remain negative.

Introduction

The trade war between China and the United States since 2018 has been one of the largest disruptors of the world economy. In early 2018, the U.S. introduced tariffs on steel and aluminum products, which started the U.S. trade disputes with China. Shortly after it, China responded with retaliatory tariffs on U.S. imports (P.Bown & Kolb, 2020). In 2018 and 2019 both countries hiked up tariffs, more than 90% of products are affected. As of early 2020, the phase one trade deal slowed down the elasticity of both countries increasing tariffs on specific products by removing some of the previous tariffs and suspending the implement of announced tariffs (P.Bown & Kolb, 2020; Li, Balistreri, & Zhang, 2019). Needless to say, both China and the U.S. have been hurt by this trade war. The U.S. agricultural section has been adversely affected by Chinese retaliatory tariffs and as the major exporter, China suffered economic losses as well.

There is an emerging literature that employs a variety of models to study the impact of the trade war. They draw similar estimation that the trade war does not benefit international trade nor the U.S. For the early stage of trade war, Benedikt & Gabriel (2018) estimated the U.S. benefits from it by transferring most of economic costs to Chinese firms who pay approximately 75% of the tariff burden. In another hand, Americans do not gain from the tariffs. Liu & Woo (2018) predicted the trade war leading to a zero-sum game. Similar conclusions are drawn by Waugh (2019), suggesting that Chinese retaliation is leading to concentrated welfare losses in the U.S. Guo, Lu, Sheng, & Yu (2018) evaluated the impact of trade war in global economy and suggested it will lead to a collapse in U.S.- China bilateral trade and benefit some small open economies in global scale; the trade war will have great adverse impact on global supply chains and most of the third countries that are exposed under indirect tariff impacts (Mao & Gorg, 2020). The remaining tariffs after the phase one trade deal signed by the two countries continue to impact the U.S. export and import sections. In this paper, we assess the impacts of trade war focusing on the U.S. apple market using a simple Regression Discontinuity model with a timeline and detailed tariff rates.

Regression Discontinuity (RD) analysis was firstly introduced by Campbell in 1960 as a way to estimate the casual effect of a treatment that is potentially heterogeneous under a nonexperimental situation across units. However, until the late 1990s only few studies in economics had applied and extended the model (Lemieux & Imbens, 2008). The RD models are used to estimate effects of policies or programs in a wide variety of economic context. We adopt Michael Bailey's (2019) varying slopes RD model so that we are able to examine the changes in the apple market in responses to tariffs levied by China and other countries to their imports from the U.S. The research design is simple: we record the timeline of retaliatory tariff events on the U.S. apple products between 2018 and 2019 and correlate the tariff rates with changes in three selected apple products: fresh, dried and juice apple products. The focus on changes involves both the volumes and unit price of selected apples, for each tariff. The export and import, rather than the volume and unit price of production, probably better reflect the responses of domestic and foreign firms to the tariff shocks. Moreover, the volume and unit price response assist in revealing the transition of apple markets under tariffs' impact. For instance, firms could change their fresh products to juice if heavy tariffs are imposed on fresh apples. To measure the volume and price, we use the export and import volume and unit price datasets released from the USDA at monthly frequency, over the period 2016-2019.

We examine the change of apple products in responses to (a) the "instant" effect after the date that tariffs were imposed and (b) the remaining effect of tariffs to the selected apple products. Results show that through 2018 and 2019, changes in retaliatory tariffs had large effects in export and import of apples. The precise impact is unclear because our datasets provide mixed results with other factors. But after specifying dates, a sizeable effect of retaliatory tariffs emerges. Simple comparisons of means of regression analysis show that the tariffs raised export volume of dried products by averagely 21.7 thousand pounds per tariff; after the initial data tariffs were implied, the remaining impact increased averagely 3.8 thousand pounds of export volume of dried product per tariff. At the same time, juice and fresh apple lost approximately 0.1 million and 51 million pounds per tariff, remaining effects increase fresh apple's export volume but not juice's. The juice raises its export unit price for averagely $0.152 per tariff and $0.016

with the remaining impact. The other two products experience decreases on their unit price in both responses.

Using comparison between tariff rates and products' response to the "instant" effect, we connect the retaliatory tariff rates with change on export volume and unit price and find that the rate of retaliatory tariff does not always have a positive relationship to its effect on the market. In particular, exports of fresh and dried apple responded less negatively to the tariffs in June, July and August 2018 than in April 2018, though the latter had lower rates than them. This suggests that the apple products' responses to retaliatory tariffs varies, some products actually benefit from tariffs, at least for a short amount of time.

The consequence of a trade war that impairs bilateral trade will be shifting trade flows, Li, Balistreri, & Zhang (2019) find that the significant trade diversion results in 49.3% reduction of Chinese imports from the United States, a long-term distortion of the U.S. – China trade relation relocates export and import sectors to the markets in the EU, Canada, Mexico and some Asian countries such as South Korea (Guo, Lu, Sheng, & Yu , 2018). The effect of tariffs on the U.S. apple market likely to lead to a change of importers of the U.S. apple products, which explains the responses of export section to the remaining effect of tariffs that not all apple products experience a decline on their export volume.

Our study examines the effect of retaliatory tariffs on the United States apple market. From a theoretical perspective, we should expect the tariffs to affect the market through two hardships. The first hardship is that retaliatory tariffs to the U.S. will impose hardship on all apple consumers through higher price and a reduction in variety of apple products from the United States. This prediction is becoming apparent as Waugh (2019) find that Chinese retaliatory tariffs reduced the total exports of the U.S. and consumption and that the effects of trade war are “spilling over” into economic activity not exposed directly to retaliatory tariffs.

The second motivation of this paper is to highlight the important role of the retaliatory tariffs in a particular market as one of the consequences of China-U.S. trade war. Given the current U.S.-China trade imbalance, if the trade war leads to a trade balance, the United States must export more and import less to move from a trade deficit to balanced trade (Guo, Lu, Sheng, & Yu , 2018). In the apple market, we expected to see a reduction of import of the three apple products and more export. From the regression results, the export volume of juice and dried apple products falls through 2018 to 2019 as responses to the tariffs’ remaining effects since the first retaliatory tariff went into effect. Our analysis implies that the result of trade war might not be desirable for the U.S. if it launches a trade war against China while planning to minimize its trade deficit in apple market.

The rest of this paper is organized as the followings, section 2 reviews the current trade conflicts between the United States and China; section 3 presents our model and data; section 4 shows the analysis results; section 5 presents the concluding remarks with a discussion on policies.

Literature Review

The US-China Trade War began two years ago when the Trump administration announced the first tariff to steel and aluminum products. China retaliated by imposing tariffs on U.S. imports to China. After an investigation on national security and intelligence property in 2017, in March 2018 the Trump administration announced an increase of tariffs on 25% of steel and 10% of aluminum products as a result of the investigation. As the dominator of the global steel industry market, China imposed retaliatory tariffs on various US products worth $2.4

billion in export value in 2017 a month later (P.Bown & Kolb, 2020; Waugh, 2019). The trade war looks very likely to escalate. In late 2018 and 2019, both US and China increased different amounts of tariffs on a list of multiple imports from each other. (Liu & Woo, 2018; P.Bown & Kolb, 2020). In February 2020, the sign of phase one trade deal alleviated the heat of struggle between these two countries, both China and Trump stepped back, and removed or canceled some tariffs (P.Bown & Kolb, 2020). However, most tariffs remain in effect.

China is not the only country that imposes additional tariffs on US imports. In 2018 President Trump announced an increase of tariffs from 25% to 50% on Turkey steel imports that supplied 4.2% of US steel imports and 0.3% of US aluminum imports in 2017 (P. Bown & Kolb, 2020). In response, Turkey announced new tariffs on imports from US products such as automobiles, tobacco, and alcohol. Similarly, the European Union (EU), Canada, and Mexico stroke back with tariffs on iconic American goods including agricultural and food products, and other consumer goods after the US imposed tariffs on their steel and aluminum imports (P. Bown & Kolb, 2020).

The ongoing trade war between the US and China where both countries hike up tariffs targeting specified imports has post direct and indirect impact on the third countries (Mao & Gorg, 2020). Needless to say, China and the US are hurt and become the two largest losers from the trade war (Guo, Lu, Sheng, & Yu, 2018). In a global aspect, the effect of this war remains and is pervasive, countries having close trade relationship to the US and China suffer lighter or heavier damage from it. Among them, the EU, Canada, and Mexico are hit hardest in absolute terms by tariffs on Chinese exports to the US: tariffs impose an estimated burden of between 500 million to 1 billion US dollars on them (Mao & Gorg, 2020). Guo & Lu's paper predicts that the trade war will lead to a collapse in bilateral US-China trade which is already under deficit after

2006 (Guo, Lu, Sheng, & Yu, 2018; Liu & Woo, 2018). Significant trade diversion results into a shifting pattern of trade: China has incentives to seek products from US competitors and export its goods to them, and long-term disruption of the US-China trade relationship could lead to relocations of the exporter to the US from China to other Asian countries, such as South Korea (Li, Balistreri, & Zhang, 2019).

The Impact of Trade War

The impact of the trade war can be considered to start in 2018 when both the US and China start increasing tariffs on each other's specific products. with the trade war ongoing, different scholars start using various techniques to assess the effects of trade shocks on exports, imports, output, and real wages, including consumption. Rather than labor market outcomes, it reflects "how economic welfare is allocated across those who are differentially impacted by trade" well (Waugh, 2019). A summary of Waugh's paper finds that counties highly exposed to trade with China experience a harder decline in automobile consumption relative to counties with little trade with China, its growth rate dropped at least by 3.8 percentage rate of points and could be as high as 5.5%relative to counties with low impact (Belsie, 2020; Waugh, 2019). New auto sales fell 2.7% in high-impact counties and 0.5% in low-impact counties. Statistical analysis suggests that 1 percentage rate of exposure to Chinese retaliatory tariffs results in 1 percentage rate of decrease in new auto sale growth (Belsie, 2020).

In his paper, Waugh uses data set with new auto sales at the US county level and approach with a simple difference–in–differences model to measure the effect of trade policy on county-level consumption. Connecting decline in consumption with exports and employment growth, he finds that Chinese retaliatory tariffs negatively affected a county's total exports and the labor market, the percentage of impact differs from counties to counties based on their exposure level to Chinese tariffs (Waugh, 2019; Belsie, 2020). Waugh also estimates a 0.75 % decline in employment growth for counties exposed to high tariffs relative to low tariff counties. The estimation doubles for good-producing employment, suggesting that decline in consumption is relatable to negative labor market growth (Waugh, 2019).

It is intuitive to conclude that the US consumers bear more burdens from the trade shocks. Historically the bilateral US-China trade deficit has grown to 46% in 2016 to 2017; China's exports of goods to the US was $505 billion in 2017, the U.S. had a trade deficit with China with roughly $375 billion. Th U.S. trade imbalance in goods has been 4.17% of GDP in 2017 (the trade balance is -4.17 percent), where 1.94% from it is China component (Liu & Woo, 2018; Benedikt & Gabriel, 2018). With that being said, the US tariffs on Chinese imports will lead to an increase in consumer prices and limit a variety of goods and U.S. consumers are the first ones to bear the burden. However, on November 2018, after calibrating a simple economic model and evaluating tariff revenues and welfare effects, Benedikt and Gabriel find that the US government transferred most of the tariff burden to Chinese firms—the producer price of them reduced by 20.5%, and US consumer prices on all affected Chinese products only rose by 4.5% on average, $522 million losses are sustained by the Chinese firms. From this trade war, the US gains tariff revenue that could be used to compensate the losses of US consumer, which implied a net welfare gain of $18.4 billion for them, though the trade war impacts on the overall welfare of the US modestly (Benedikt & Gabriel, 2018; Li, Balistreri, & Zhang, 2019).

Trade war shocks countries' social welfare level, leading to a significant decline in social welfare. The two largest global economies, China and the U.S., suffer the most welfare losses (Liu & Woo, 2018; Guo, Lu, Sheng, & Yu, 2018). The relocation of exporters and importers gives other countries the opportunity to gain social welfare from trade war. Li & Balistreri assess the impact of trade war using the GTAPinGAMS model, a Computational General Equilibrium (CGE) model provided by Lanz and Rutherford in 2016 with detailed tariff information under three scenarios from different phases of the trade war. In the full tariffs scenario that the phase one deal is not signed and both countries implement threatened tariffs, China and the US experience further social welfare decline, 2.4% and 0.4%, respectively (Li, Balistreri, & Zhang, 2019). Under the scenario with remaining tariffs after phase one deal, China's welfare falls by 1.7% while the US falls by 0.2% and the welfare of major export regions of manufactured goods to the US such as Mexico, Malaysia, and Taiwan earn the most benefits from the disputes, gaining welfare by 0.9%, 0.8%and 0.7%. The persistence of trade war leads to welfare losses for the two biggest competitors, and both countries relocate their exporters and importers (Li, Balistreri, & Zhang, 2019).

Given the scale of the trade distortion, the estimated welfare impact is modest, the aggregate welfare loss on China and the US on 2018 are around 1.6 billion, and two of the third of this loss falls to Chinese exporting firms (Benedikt & Gabriel, 2018; Li, Balistreri, & Zhang, 2019). The trade war could change the global economy, tariffs open a new market, generate beneficial impacts that help to offset the welfare losses (Benedikt & Gabriel, 2018; Li, Balistreri, & Zhang, 2019; P.Bown & Kolb, 2020). However, if we take account of the future debt payment of the US, welfare loss would be smaller for China and larger for the US (Liu & Woo, 2018).

Large import tariffs lead to a slump in output, damaging national production sectors. Guo & Lu use Eaton and Kortum's 2002 multi-sector and multi-country general equilibrium model to evaluate and forecast how outputs, imports, exports, and real wages will change in the case of Chinese retaliatory tariff and the US maintains trade deficits and China remains trade surplus as before the trade war began. They use real wage to measure social welfare in each country, by this measure, the real wage of China and the US decreases by 0.37% and 0.32% respectively if US and China both increase their import tariffs against each other to 45% (Guo, Lu, Sheng, & Yu, 2018). A trade war significantly reduces the outputs of sectors that are targeted by tariffs, including agriculture, electronic components, mining, petroleum products, in addition to steel and aluminum products, and other countries' retaliatory tariffs worsen the situation (Guo, Lu, Sheng, & Yu, 2018; P.Bown & Kolb, 2020). The consequence of this war is, while some other countries in Asia may gain slightly from the diversion, other advanced economies may experience collateral damage, even with balanced trade. China's output in textile and computer products is expected to decline by 6.29% and 14.26%, the output of US agricultural and food industries will fall in an amount to 1.14% and 4.18% respectively (Guo, Lu, Sheng, & Yu, 2018). Auto sales growth rate across counties experience a similar result. From July 2018 to January 2019, auto sales growth experiences a fall in both light-tariff counties and heavy-tariff counties, from 0.52% to 2.69%, while auto sales grew in both county types prior to the trade war (Waugh, 2019).

In the scenario of trade imbalance and Chinese retaliatory tariff, the US needs to boost its exports to restore trade balance. Although the US experienced output decline on multiple sectors, its average output is positive (1.79%), while Chinese average output declines. One of the reasons for this is that the greatest share of the tariff burden falls on Chinese exporters to the US, paying approximately 75% of the burden. (Guo, Lu, Sheng, & Yu, 2018; Benedikt & Gabriel, 2018).

In the case closer to reality, given retaliatory tariffs of 45% to imports from each other, China needs to maintain its trade surplus as before to trade shock, and the US can increase its consumptions and imports by running a trade deficit and receive a net income transfer from other countries. China experiences much higher losses on output and exports while simultaneously maintaining the trade surplus and losing its biggest market (US), and the output of China and US falls by 1.36% and 0.11% respectively (Guo, Lu, Sheng, & Yu, 2018). In another hand, China has a strong incentive to diverge away from the US and seek new trade partners and products, including agricultural products such as soybeans and meat products that are "hallmark" products of US exports to China from competitors of US and non-US countries to mitigate potential losses tied to this trade war, in fact, on March 2020 after the phase one deal, though exports from China to US fall by 52.3%, Chinese exports are estimated to fall by only 4.9%, with major market penetration to the EU (+8.0%), Mexico (+10.8%) and Canada (10.2%) (Li, Balistreri, & Zhang, 2019; Guo, Lu, Sheng, & Yu, 2018).

While China and the US are imposing direct tariffs on each other, their trade partners and other countries experience an impact from the trade war. Other advanced economies may experience collateral damage due to "spillover effects transmitted through input-output linkages and the general equilibrium effects" from the trade war between the two largest global economies (Guo, Lu, Sheng, & Yu, 2018). There are indirect effects to these economies, China and the US increase the tariffs to each other and then transfer part of the burden to other countries by increasing price to importers, imposing indirect tariffs on intermediate goods to their trade partners, or both. For instance, the US can increase its price to countries who imports as a result of the tariff, trade partners of the US are hit hardest by US tariff on Chinese goods as they use imported intermediate goods which are subjects of the tariff hikes (Mao & Gorg, 2020). One example of indirect tariff is US tariffs imposed on the steel and aluminum products from the EU, Mexico, Turkey, and Canada after Trumps' steel and aluminum tariffs went on effect on March 2018 and China retaliatory tariff (P.Bown & Kolb, 2020).

Mao and Gorg use the method developed by Rouzet and Miroudot to find a cumulative tariff that is the total cost of all tariffs incurred in a production process along the global value chain to estimate extra tariff burden on the third countries. They considered an increase in US tariffs on Chinese imports by 100%, the cumulative tariff increase differs across countries as well as industries affected, the countries hit hardest by a tariff are US main trade partners such as Canada and Mexico, particularly in the chemical, electrical components and automobile manufacturing industries (Mao & Gorg, 2020; Waugh, 2019). These are industries that heavily rely on intermediate imports, also subjects of the trade war, increasing tariffs on such from China lead to a significant increase in the cumulative tariffs: the cumulative tariff imposed by the US on Mexican imports adds up to 1.39%, where 98.81% of which are indirect tariffs; similarly, Canada receives 0.3% cumulative tariff on its imports to the US, 69.46% of it is indirect tariffs (Mao & Gorg, 2020; Li, Balistreri, & Zhang, 2019). Mao and Gorg estimate the indirect tariff burden caused by "trade war" by multiplying import from the US or the world of 2018 with the total indirect tariff rate in 2014, and find that the burden caused by the US adding tariff on China ranges from $53.58 million to $766.64 million for imports from the US, the impact of China's trade protection is much less in the opposite scenario, respectively. The calculated changes in indirect tariff are economically significant, for imports from the US, the growth rate achieved nearly 150% for every country, which is "substantial", the third countries are not unaffected by the trade war between the two largest global economies (Mao & Gorg, 2020).

Consequences of Trade War

The trade war will lead to the collapse of the US-China trade, the trade partners of the US and China are less or more affected by it. However, this war also positively impacts the welfare of some countries. Relocation of the market allows some Asian countries earn positive welfare change, Malaysia, Taiwan, Thailand, and the rest of Southeast Asia are estimated to increase their welfare for approximately 0.5%, and countries like Cambodia, Costa Rica, and Mexico experience the increase of their real wages for 0.22%, 0.11%, and 0.06%, respectively (Guo, Lu, Sheng, & Yu, 2018; Li, Balistreri, & Zhang, 2019). The reason for such welfare increase is that both China and the US are looking for new exporters and importers, change in trade flows for major Asian trading partners of the US or China has shown that Asian countries in general experience increases in exports. South Korea saw significant increases in exports to the US, with South Korean exports to the US rising over 17.5% after the sign of the phase one trade deal, mainly benefit from the electronic equipment sector (Li, Balistreri, & Zhang, 2019). In contrast, Li and Balistreri find that the Southeast Asian countries and Japan increase their exports to China for 7.9% and 4.7%, while Chinese exports to all Asian countries increases roughly by 3-4%, reflecting the diversion of exports originally to the US. China also diverges away from the US and seeks agricultural products such as soybeans and meat products including from Brazil and Europe, while export of agriculture and food sectors from the US to China has experienced a significant decline (Guo, Lu, Sheng, & Yu, 2018; Li, Balistreri, & Zhang, 2019).

The trade war started in 2018 between China and the U.S., the two largest global economies. If the US policy goal is to protect domestic industries such as electronic components and constrain the growth of similar industries in China, then the overall effect of the trade war is consistent with this goal (Li, Balistreri, & Zhang, 2019). However, if the US intends to increase its trade surplus through tariffs, the trade war has the opposite effect, with total export decreasing more than total imports (Li, Balistreri, & Zhang, 2019). Exports from China and the US to each other decreased hard, the third countries and trade partners of them are affected by it, both negatively and positively. While the trade war leads to the collapse to US-China trade, to China, trade diversity will tend to mitigate the negative trade war impacts, it will increase imports from non-US countries to reduce the potential losses tied to trade war (Li, Balistreri, & Zhang, 2019; Guo, Lu, Sheng, & Yu, 2018). Although both countries experience social welfare losses and become two biggest losers, the US will experience fewer losses because it can still increase its consumption by running a trade deficit, on 2018 most of the tariff burden is also transferred to Chinese export industries, but as the tariff hikes, US welfare might decrease as more burden fall to US consumers, as well as US exporters (Belsie, 2020; Guo, Lu, Sheng, & Yu, 2018; Li, Balistreri, & Zhang, 2019).

Although the impact of the trade war has drawn lots of scholars' attention, I find few papers focusing on the apple market or any specific agricultural or food product. As the largest apple exporter, the US has experienced a decline in the export volume of various apple products. Prior to the first trade tariff announcement, other factors have impacted the apple market, for instance, the export volume of dried apple market starts declining on 2016/17; similarly, the unit price of fresh apple falls dramatically between 2016 and 2015, but the export volume doesn't experience the same drop (Data by Commodity-Imports and Exports, 2020). More research is needed to understand the impact of trade war individually on both domestic and international US apple product markets.

Method

Like other markets, the apple market in U.S. experienced similar damage from the U.S. – China trade war. Retaliatory Chinese tariff on U.S. imports can impact labor production and should lead to an economic wellbeing and consumption reduction (Waugh, 2019). Based on export & import volume and per pound price, the effect of tariffs can be estimated. This tariff burden can show how much the apple market gets hurt by the trade war between China and U.S.

The Regression Discontinuity (RD) model designs were first introduced in (Campbell & Thistlethwaite, 1960) as a way to estimate the causal effect of a treatment under a nonexperimental situation, where the effect of the treatment is potentially heterogeneous across units (Lemieux & Imbens, 2008). The basic RD design is consist of a cutoff point, an assignment variable determining how much above and below the dependent variable is to designated cutoff point, and a dummy variable to indicate whether the dependent variable gets the treatment (Lee & Lemieux, 2010; Bailey, 2019). The RD models did not attract many economists' attention until the late 1990s, since then there has been a large number of studies in economics contributing to the extension and application of RD models.

We need to build a statistic model to observe the pretreatment and posttreatment effects. The necessary elements are the assignment variable that determines whether and how the dependent variable is affected by a treatment, indicating how much above or below the cutoff point an observation is, and a dummy variable indicates whether the observed assignment variable exceeds a known cutoff point, where the difference of receiving treatment or not is made. Subjects with values of the assignment variable above the cutoff receive the treatment; subjects with values of the assignment variable below the cutoff do not receive the treatment. In the analysis, experimental treatment should provide an elevation to the regression of a dependent variable on the subjects exposed to treatment, providing a "steplike discontinuity at the cutting score (referred as "cutoff point" or "cutoff line" in this literature)" (Campbell & Thistlethwaite, 1960; Trochim, n.d.). As long as the only difference at cutoff is that the market receives treatment, any change in the dependent variable at the cutoff will reflect the causal effect of the treatment (Bailey, 2019).

In its most basic form, a typical RD model looks like (Bailey, 2019):

$$Y_i = \beta_0 + \beta_1 T_i + \beta_2 (X_{1i} - C) + \epsilon_i$$

Where

$$T_i = 0 \; if \; X_{1i} - C < 0$$

$$T_i = 1 \; if \; X_{1i} - C \geq 0$$

Where T_i is the dummy variable, and $X_{1i} - C$ is the assignment variable. Those with X_1 above C receive the treatment; those with X_1 below C do not receive the treatment, $X_1 = 0$ at the cutoff point (Bailey, 2019). Any gap at the cutoff point is the estimated casual effect of the treatment. The most important parameter in this model is β_1, which is the effect of receiving treatment: this is the jump or fall in the RD analysis. β_2 is the slope parameter, this slope is the same on the left and right in the basic model. β_0 represents the pretreatment value where the left slope intersects with cutoff line.

In this paper, we use a varying slopes RD model from *(Bailey, 2019)*. It is similar to the basic model but allows the slope to vary below and above the cutoff point:

$$Y_i = \beta_0 + \beta_1 T_i + \beta_2 (X_{1i} - C) + \beta_3 (X_{1i} - C) T_i + \epsilon_i$$

Where

$$T_i = 0 \; if \; X_{1i} - C < 0$$

$$T_i = 1 \; if \; X_{1i} - C \geq 0$$

The coefficient on the interaction between T_i and $X_{1i} - C$, β_3 captures how different the slope is for observations where $X_{1i} - C > 0$. The slope for untreated observations will be β_2 to the left of cutoff line; on the right side, slope for the treated observations will be $\beta_2 + \beta_3$. In the new model, we use $X_{1i} - C$ for assignment variable to ensure that $\beta_0 + \beta_1$will indicate the difference between treated and untreated groups when the assignment variable is zero (Bailey, 2019).

The trade war continued for approximately two years, where China and the U.S. have imposed many tariffs on various kinds of each other's imports. To determine the casual effect of these tariffs, the dates that the tariffs were announced or went into effect are important in our analysis. For the cutoff point, C, we use a typical date that U.S. and China impose tariffs since 2018 (P.Bown & Kolb, 2020). The rest of monthly market data is then X_{1i}. Our dependent variables are export/import volume or price per pound of three apple commodities: fresh, dried or juice product. In a specified case, U.S. announced a tariff on China in August 2018. The export volumes and prices for these three apple products will be affected after August, by setting August 2018 as the cutoff point. For the subjects before this month, the slope will be on the left side of the cutoff point; for those after this month, the slope will be on the right side. If there is a significant impact on the above data after this tariff, a gap will appear between these two slopes, and the posttreatment slope will be different.

Data

Along with recorded different countries' tariff rates on the U.S. apple exports from Hopkinson (2018) and Regmi (2019), we use both a timeline of the U.S.- China trade war provided by P.Bown & Kolb (2020) and apple market data from United States Department of Agriculture Economic Research Service (USDA ERS) to estimate the effect of the trade war between U.S. and China (Data by Commodity-Imports and Exports, 2020).

Timeline

By using important events such as countries imposing tariffs as key dates with a combination of the model, it is possible to estimate the effect. In the end, we obtain nine tariffs that have effects on apple products, their rates range from 10% to 25% from USDA (2020); The State of Council of The People's Republic China (2018, 2019); Jingjinnews (2019); Hopkinson (2018); Regmi (2019); Milkovich (2019); and Hua (2018), as below:

Events	Date	Tariff Rate on Apple
China Imposes Retaliatory Tariffs	15%	4/2/2018
Mexico Imposed retaliatory tariffs on US agricultural products	20%	6/5/2018
EU Retaliates on Iconic American Goods	25%	6/22/2018
Canada Retaliates on US products	10%	7/1/2018
US and China Impose First Phase of June 15 Tariff Lists	25%	7/6/2018
US and China Impose Second Phase of $50 Billion Tariffs	20%	8/23/2018
Announced Tariffs Go into Effect	25%	9/24/2018
China Raises Retaliatory Tariffs	20%	6/1/2019
India Retaliates against US exports After losing Special Trade Status	20%	7/15/2019

Table 1: Timeline of Tariff Imposed on US Apple Products

Although there are other countries like Canada and Mexico imposing retaliatory tariffs on the U.S., we focus on U.S. and Chinese tariffs on each other and the after effect when the tariffs were announced or went into effect. In particular, we drop most of other countries' tariffs on the U.S., because these tariffs were not imposed on the food and fruit export sectors of U.S. We also exclude irrelevant events such as tariff exemptions and investigations by the U.S. In the end, we obtain 8 events potentially affecting the apple market. They include retaliatory tariffs on U.S. from China, EU and Canada, the phase one and two tariffs and the signing of phase one trade deal.

Volume and Unit Price Data

Trade flow data are important to examine the channels through which tariffs would affect consumption and production opportunities (Waugh, 2019). Our sample also includes trade data on apple volume (1000 pounds) and price per pound provided by USDA ERS. We collected export and import volume of three apple products: juice, fresh and dried, as well as their price per pound. The list of data includes monthly and quarterly trade data on the above categories from 2016/17 to 2019/20, the sample size of individual products' volume or unit price is 47. The impact to each individual category of apple products is measured separately based on their monthly data from 2016 to 2019. Given these values, we can simulate the model and calculate the changes in their output, volume of trade and unit price, given tariff changes.

After obtaining the change, we then use given tariff rates on the apple exports from different countries in 2018-2019 to compare and estimate the impact of tariffs to the U.S. apple market on a monthly basis. For months that multiple tariffs were imposed, we accumulate the tariff rates together.

Result

The previous section provides a regression discontinuity model to estimate tariffs' impact to the U.S. apple market categorically. This section explores the impact of retaliatory tariffs on the U.S. The analysis involves simple visualizations, tabular representations and regression analysis. Since we estimated the impact of tariffs individually, the effect varies across different tariffs. Combined with linear graphs of volume and unit price chronologically through 2016 to 2019, we analysis these effects by using minimum, maximum and mean value of regression results. As discussed in Method and Data, three categories of apple products are considered: fresh, dried, and juice. When the retaliatory tariffs were posted, they decreased the export volume of fresh and juice apple products, with dried apple products as an exception: although its volume is decreasing from 2016 to 2019, the tariffs increased most of the volume of dried products when they were posted. We examined tariffs' effect on unit price, the results show that tariffs have various of impact on the apple products. We also look at regression results of volume before and after tariffs and found that tariffs have various of long-run impacts on different products. These effects distinct from gaps at cutoff point. A positive post- tariff rate (*rate** as shown in the tables) does not represent a growth of volume above zero, it only means that the slope is steeper than pre-tariff slope.

The following tables display summarized results. We take the average value of our regression results. In the tables, we use volume of 1000 pounds.

Export Volume	$\overline{Gap}$	$\overline{Rate}$	$\overline{Rate^*}$
Fresh	-51849.295	-754.493	13244.120
Dried	21.761	-11.177	3.831
Juice	-147.373	5.467	-9.503

Table 1: Export Volume Regression Result

Import Volume	$\overline{Gap}$	$\overline{Rate}$	$\overline{Rate^*}$
Fresh	-2495.881	-108.770	-1755.084
Dried	282.544	-3.992	-32.972
Juice	-5741.399214	-214.2017543	1989.977701

Table 2: Import Volume Regression Result

Export Unit Price	$\overline{Gap}$	$\overline{Rate}$	$\overline{Rate^*}$
Fresh	-0.020	0.00051	-0.00189
Dried	-0.101	0.048	-0.116
Juice	0.152	-0.014	0.016

Table 3: Regression Result of Export Unit Price

Import Unit Price	$\overline{Gap}$	$\overline{Rate}$	$\overline{Rate^*}$
Fresh	0.028	0.001	-0.029
Dried	0.037	0.0085	-0.024
Juice	0.085	0.0048	-0.031

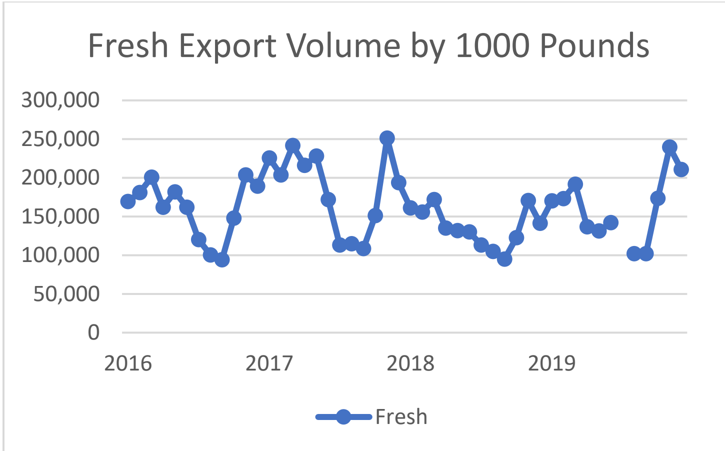
Table 4: Regression Result of Import Unit Price

Volume

Export Volume

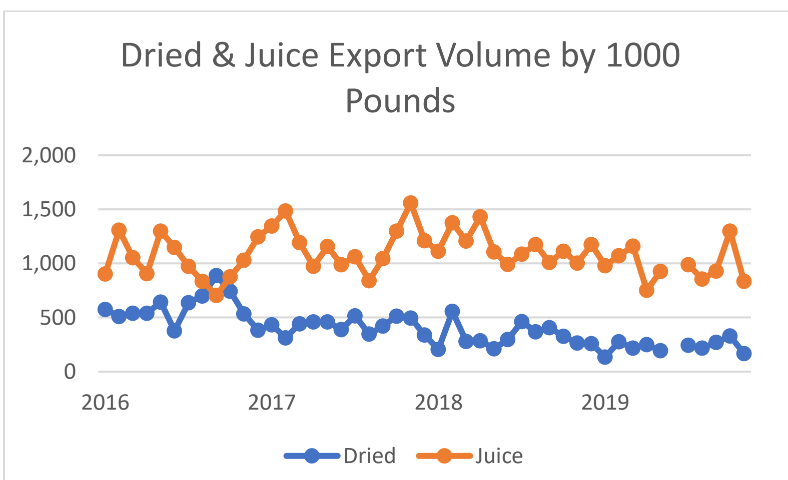
Table 1 summarizes the result of regression analysis on export volume, each of the first three column represents the minimum, maximum and average impact of tariffs on individual products. The fourth to sixth columns of Table 1 display regression results of volume before tariffs, in the order of minimum and maximum rate and the average rate. The seventh to ninth columns represent results of remaining effect after tariffs in the same order. In the table, positive numbers represent an increase on volume or price for each tariff imposed to the U.S. apple market, negative numbers stand for the opposite.

The fresh apple export section experienced the most negative impact as it is the most exported product (Workman, 2020). Each tariff is estimated to reduce 51 million pounds fresh apple export volume on average. However, each tariff remains in increasing export volume averagely 13 million pounds. Our model did not exclude seasonal effect, which is one of the other direct factors to the export and import change. Graph 1 represents monthly curve of fresh apple export volume; it has a repeating pattern which consumption increases following the growth pattern of fresh apples. Besides the impact of tariffs, apple market is directly exposed to the change of seasonal effect. Although tariffs reduce the export volume of fresh apple, the seasonal effect and other factors offset most of the remaining negative impact. The graph shows its volume experienced a significant drop after our first tariff in 2018. Dried section is the only one experiencing positive impact from tariffs. Although experience losses, most tariffs give dried product volumes a jump at the cutoff point, result in a gap of averagely 0.2 million pounds increase. One possible explanation is that export companies changed their products that are targeted by tariffs, leading to an increase on export volume of dried products that are less targeted.



Graph 1: Fresh Export Volume

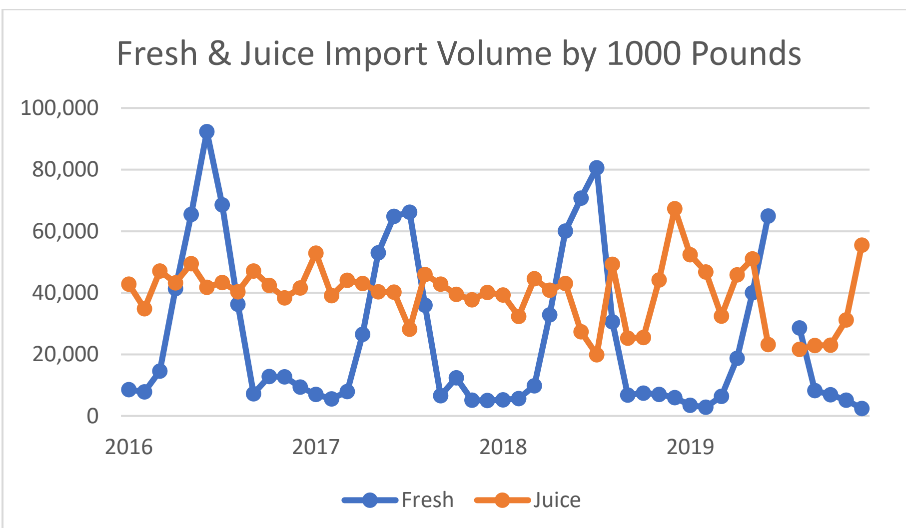
Tariffs hit the long-term export volume of juice section hardest. The average rates after tariff suggest that export volume of dried products continues to grow negatively after tariffs were imposed. Tariff is not the only reason of this negative growth. Dried export volume curve below shows that the export volume of dried products is constantly falling since 2016. It suggests that other than tariffs from the trade war, there are external factors such as policy change, market competition or taste of consumers impact its annual export volume. Regression results show that tariffs imposed negative effect on juice products. Each tariff decreased 0.14 million pounds of juice products and 9.5 thousand pounds after they were imposed.



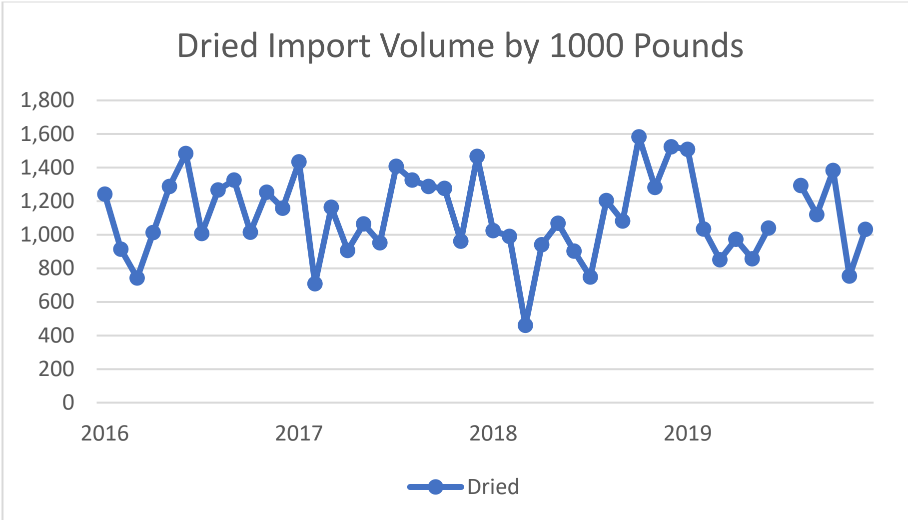
Graph 2: Dried & Juice Export Volume

Import Volume

The Table 2 represents regression analysis of the import volumes. The results show that tariffs had greater negative effect on fresh and juice than on dried sections because of their volume size. From the table, each tariff reduced on average 2.4 million pounds of import volumes of fresh apple and 1.7 million pounds as the remaining impact. The results show that dried products did not experience similar impact. However, three apple products' import volume curves show that its monthly import volumes through 2016 to 2019 were 0.4 to 1.6 million, as the volume of fresh products in the same time period were 10 to 90 million. Even though tariffs did not affect dried volume as they did to the other products, dried products experienced similar levels of damage from them. Import volume of fresh products reacts to the seasonal effect, although tariffs had negative effect on its cutoff point and after they were imposed. Fresh import volume curve suggests that seasonal peaks remain high and the effect is strong. Tariffs reduced import volume of juice product; imports lost on average 5 million pounds of volume per tariff, the remaining effect of tariff is estimated to reduce 2 million pounds of juice imports.



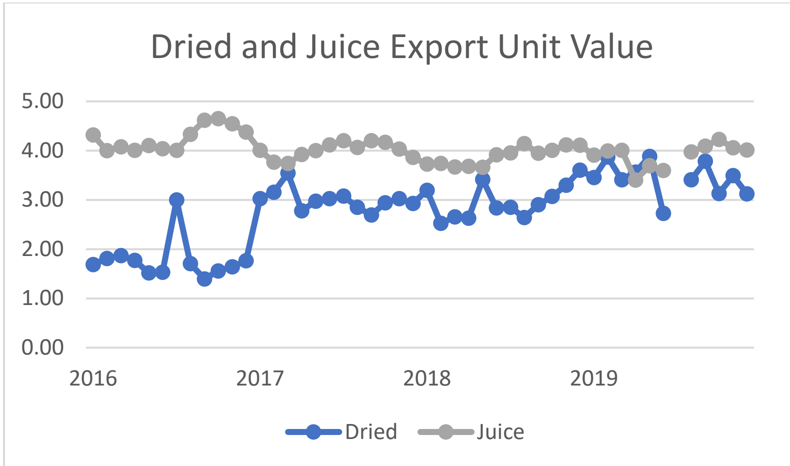
Graph 3: Fresh and Juice Import Volume



Graph 4: Dried Import Volume

Unit Price

From the regression results on table 3 and 4, fresh and dried products reduced their unit price at the cutoff point. The remaining tariff effect will reduce averagely $0.001- and $0.1-unit price of fresh and dried products, respectively. It is worth noting that unit price of dried products did not fall with tariffs. The dried export price curve shows a raising curve on dried price which moves oppositely to its export volume. It is understandable that firms will increase their price to offset the losses brought from tariffs. Under this context, tariffs could impact a little on export unit price. Juice is the only section that experience a raise of its unit price both at and after the cutoff point. On the import side, each tariff raises the price of all three products but decreases them as a remaining impact. Import unit price of juice experienced the most raise and reduction both at the gap and rate*, as Table 4 shows. From the post-tariff effect, tariffs damaged unit price of almost all three products expect for juice on export side. Their effect at the cutoff point created jumps on import side but fall on the export section.



Graph 5: Dried and Juice Export Unit Value

The results of our model are against our hypothesis that states tariffs will decrease volume in export and import section and decrease unit price in export but increase them in import section. Tariffs could have various of effects on the three products that we test and have the opposite impact after a time period they were imposed. This result is similar compared to the findings to previous research. The trade war is likely to reduce the dependent relationship between China and the U.S. Retaliatory tariffs have a negative effect on total U.S. exports but not suggest a positive effect (Waugh, 2019). However, because of the redirection of tariff burden and new importers, the U.S. exporters can transfer their losses to other main trading partners of the U.S. (Mao & Gorg, 2020).

Hypothesis 2 Test

Another hypothesis that states tariff rates raise the impact of tariff is proved not true as well. The tariff rates do not always have a positive connection to the corresponding impact. The effect of tariffs on export volume of fresh and dried products in April 2018 is stronger than the ones on June, July and August 2018 though tariff rates in April was less than them. We find the same happening on import volume of dried and juice. Table 2 compares the rate of tariffs from

April to August 2018. On fresh products, a 15% tariff reduce more volume than a 45% tariff, as well as on dried. On dried, tariffs have a surprising positive effect on the export volume: dried products actually receive benefit from high tariff rate. Table 3 shows the result of tariff rates on import volume. We find the effect of tariff rate varies on apple products; and they do not have a strong positive correlation to the expect damage as hypothesized.

Date	*Tariff Rate*	*Fresh*	*Dried*	*Juice*
April 2018	15%	-56886.61	-20.81	-66.41
June 2018	45%	-47382.39	48.43	-173.31
July 2018	35%	-36460.09	65.16	-132.953
August 2018	20%	-21645.91	15.64	-128.85

Table 2: The Relation of Tariff Rate to Export Volume Change in 1000 pounds

Date	*Tariff Rate*	*Fresh*	*Dried*	*Juice*
April 2018	15%	28639.5	90.71544	-307.0395
June 2018	45%	1738.402	186.5551	2224.018
July 2018	35%	-19369.82	335.0875	9460.463
August 2018	20%	-23555.29	324.6663	5984.634

Table 3: The Relation of Tariff Rate and Import Volume Change in 1000 pounds

Conclusion

This paper investigates the potential effects of tariffs in the United States-China trade war on the U.S. apple market. Through the use of vary slopes Regression Discontinuity analysis we estimate the effects of retaliatory tariff on export and import sections of the U.S. apple market, which take into account the “instant” effects and long-term effects. We then compare the responses of three apple products to tariff rates, find that the effects of tariffs do not always adversely affect the market. This implies that although tariffs mostly impact negatively, few products respond by increase their volume or unit price. However, there are limits. Given its multicollinearity with effects of other factors, the results imply that to precisely measure the effect of tariffs, excluding the endogeneity is essential. For instance, in response of retaliatory tariffs, firms have intentions to change their products. Inclusion of seasonal effect has disrupted our result as well. Another limitation is that compare to tariffs in 2018, we have less recorded data to assess the impact of tariffs in 2019 precisely, further analysis is required. Since we use the dates that the US apple market was imposed tariffs on, import section needs more analyze by using dates that US imposed tariffs on other countries apple market.

Contribution

From the papers we have collected so far, few scholars focus on the impact of trade war on an agricultural market. Thus, our findings contribute to this topic. On one hand, our results suggest that the trade war leading to a collapse in bilateral relationship of U.S.-China trade does not reduce the United States’ preexisting trade deficit-retaliatory tariffs reduce the exports of apple market. On the other hand, trade war’s spill-over effect has impacted economic activities that are not directly exposed to it, these effects will adversely impact consumption through higher price and lack of variety.

These results have policy implications. In the context of current trade imbalance of the U.S., these results have policy implications for the appropriate response to the retaliatory tariffs. The conventional wisdom is that trade wars lead to a zero-sum game, the declines in export volume that we find suggest that there are important demand-side effects from the trade war for consideration in the next step of trade war in the U.S. (Liu & Woo, 2018; Waugh, 2019)

There is a broader context which the U.S.-China trade war fits into. This paper concentrates in export section of the U.S. market, which raise the question on the impact of import section. The second question concerns a more precise estimation. A better economic model is needed that takes into account the nature of market preference, can explore the relationship between changes in consumption of apple products, and seasonal effect and can examine the effects that announcements of future tariff have on the market.

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