US Foreign Trade Zones: Working as Cushions for Trade War

Xincheng HUANG*

November 2, 2023

Abstract

Enabling deferral or elimination of duty payments, the US Foreign Trade Zones (FTZs) displayed significant "Cushion Effects" for producers within the zones during the US-China trade war. The first source of "Cushion Effects" resulted from the over 28% increase in the zones' export volume during the tariff war, measured by the extra duties directly exempted. The effect amounted to about 883 million dollars in 2019. In addition, the FTZ demand for sanctioned components used in the production of domestically sold products was less affected due to the deferral and efficiency of duty payments, providing the second source of "Cushion Effects". I apply the rarely quantitatively analyzed FTZ import data from USITC and compiled trade volumes from zones' annual reports. The empirical identification results at the intensive margin show that tariff shocks triggered more sales of FTZ firms to both foreign and domestic markets. This phenomenon is especially pronounced among the 120 new firms whose entrance was positively correlated with extra tariffs, providing the evidence of the existence of "Cushion Effects" at the extensive margin. The supplementary duties that were exempted, temporarily deferred, and non-paid by the year's end quantify "Cushion Effects". Under the protection, FTZ firms' tendency to pre-storage when anticipating new tariffs or substitute the domestic and non-affected foreign sources of inputs for their sanctioned Chinese counterparts is less pronounced, as the FD and DID models estimate. For the cutting-edge technology inputs of List 2 issued in Section 301 Act, which were also included in the "Made in China 2025" program, the imposed tariff shocks generated positive impacts on FTZ producers' import volumes. Lastly, the empirical observations are mapped theoretically to a two-tier Melitz-type model, and the counterfactual comparative statistics derived provide a constructive suggestion that the government can enhance the protection by relaxing the criteria of entry into the zones.

Keywords: foreign trade zone; US-China trade war; cushion effect; Melitz-type model

1 Introduction

Foreign Trade Zones (FTZs), the US version of free trade zones or special economic zones, are secure areas under the supervision of US Customs and Border Protection (CBP) and outside the customs territory of the US for duty payments.[1] In the US, nearly one-eighth of total imports and over 28% of total taxable imports entered the US through FTZs in 2018 and 2019. CBP does not collect tariffs on products admitted into FTZs until they cross custom boundaries for domestic consumption, and the duties are charged through "bundling" of entries,[2] this deferral and efficiency of payment improve the

*School of Economics, Singapore Management University, Singapore (e-mail: xchuang.2019@phdecons.smu.edu.sg).

[1] There are two foreign trade zone types. A "general-purpose zone", which can be used by more than one business, is the area (e.g., an industrial park or sea/airport) within 60 statute miles or a 90-minute drive from the outer limits of a customs port of entry. A "subzone" is a location operated by only one business. A subzone can be located outside the statute mile/driving time limit for the general purpose zone as long as CBP can adequately oversee its activities.

[2] Entries are reports of individual shipments of goods entering or leaving zones. In addition to time and paperwork savings, "bundling" allows an importer to file one entry for an entire week and pay a single merchandise processing fee (up to $485) instead of a separate entry and merchandise processing fee for each shipment.

cash flow liquidity of firms. FTZs also seek to promote re-exporting and processing trade: firms that transfer their imports abroad directly and sell their commodities produced by processing or assembling foreign intermediate goods to the foreign market are exempted from the import tariffs imposed on their foreign components (Koopman, Wang and Wei (2008)). Foreign and domestic merchandise is imported into zones for operations including warehouse and production, a firm in a zone can choose the tariff rate it pays according to products' "status": (1) "Privileged Foreign" status: goods are effectively "locked in" to the rate imposed on the date when they physically enter an FTZ; (2) "Nonprivileged Foreign" status: importers pay duty at the rate of finished product; (3) "Domestic Status": goods are sourced domestically or have all duties paid prior to entering an FTZ. As the tariff inversion phenomenon (the tariff rates on inputs are higher than the tariff rates on the finished products) is very significant in the composition of imports to FTZ firms and about 91.2% of FTZ users that conduct production activities have higher import tariff rates on components than products,[3] they usually replace inputs' tariff rates with those imposed on finished products to pay duties for their products with "Nonprivileged Foreign" status. According to the findings reported in Wong (2019), a Volkswagen production plant in Chattanooga, TN, which was granted FTZ status in 2011, projected potential savings of approximately $1.9 million. This translated to an estimated inverted tariff savings of $13 per car, considering the plant's annual production volume of 150,000 cars. Within the oil industry, the majority of inverted tariff benefits are concentrated in a relatively narrow sector, namely the petrochemical industry, which represents approximately 15% to 17% of the overall refinery yield. This cross-importer tariff discrimination over FTZ and non-FTZ producers is demonstrated to maximize the social welfare defined in Grossman and Helpman (1994) (Grant (2020)). In summary, in the absence of tariff shocks, firms situated in the FTZs can derive duty-related benefits through three principal channels: deferral, exemption, and reduction.

As the principal trading partner of the US, China contributed about 23% and 21% of total imports into FTZs and domestic respectively in 2017. In order to mitigate the impact of international import competition, the Trump administration implemented a set of additional tariffs in 2018, primarily targeting intermediate goods (Bown (2019)), as a means to restrict trade with China. Despite its partial intention to stimulate US manufacturing activities, Flaaen and Pierce (2019) find that the intended positive effects of import protection measures were counteracted by the amplified adverse consequences stemming from escalating input costs and retaliatory tariffs. Rather than conducting a general analysis of all firms and the aggregate impacts received, this paper focuses on discerning the specific influence of the US-China trade war on producers within US FTZs, given their significant role as importers into the US. Before tariff war, foreign goods entering the US via FTZs amounted to over 10% of the nation's total imports, and this figure is 12% for Chinese products. In light of this fact, in the context of the US-China trade war, the zones' benefits of duty reduction applied to imports with "Nonprivileged Foreign" status in inverted tariff situations were deprived, and Chinese products listed in Section 301 must be admitted in the "Privileged Foreign" status.[4] This restrictive policy implies that the further levies would be imposed on the sanctioned Chinese products once they physically entered an FTZ, and importers were supposed to pay whenever imports leave the zones for US distribution. Despite the reduction in the magnitude of "Cushion Effects," the two remaining channels of protection conferred by the FTZs continued to play a crucial role for firms operating within their boundaries throughout the tariff war. By 2020, the percentage of Chinese products imported through FTZs increased to 17%.[5]

Inspecting the importing pattern of US producers, a discernible decline of 4% was observed in the share of Chinese merchandise within the overall imports of non-FTZ firms. Conversely, FTZ enterprises

[3]The report of Congressional Research Service document the estimated data made by FTZ board: of all FTZ benefits, "duty reduction on inverted tariff situations" is generally the one most heavily used by businesses. It likely accounts for more than 50% of the total money saved from zone use (link).

[4]From Federal Register Documents published by the Office of US Trade Representative (link).

[5]According to the zones' import data provided by International Trade Commission (USITC).

exhibited a consistent rise in procurement of Chinese goods, as exemplified in Figure 1. This import behavior of FTZ firms, which appeared counter-intuitive, suggests that the cash-flow reliefs derived from the deferral and exemption of duty payments served as significant "Cushion Effects" against tariff shocks. Upon examining the inventories and domestic market sales at the zone level through econometric models, it is identified that both measures exhibited an increase in response to the tariff shocks. Hence, this cash-flow "Cushion Effects" were observed through two distinct dimensions: firstly, the levied duties on inventories remained unpaid and were kept deferred until the end of the reporting year, and secondly, the duties were temporarily deferred on domestically sold products. The Annual Report of Foreign Trade Zones[6] also indicates a significant rise of approximately 25% in the export volume of firms within the zones between 2017 and 2019, with 57% of this increase being attributed to production activities taking place within the zones. The empirical analysis reveals a positive correlation between tariff shocks and the observed expansion in export volume which provides evidence that FTZ firms leveraged their user privileges to eliminate tariff costs by engaging in export activities, leading to positive impacts on cost structure which are referred to as expense-saving "Cushion Effects". The finding is also a supplement analysis of the exporting behaviors of US producers that were exposed to import tariff shocks during the US-China trade war. Handley, Kamal and Monarch (2020) reveals that the imposed additional duties had a negative impact on exports of firms operating in the affected industries. However, these spillover frictions did not affect firms operating in FTZs, as their imported inputs used in the production of exported goods were not subject to tariff shocks.

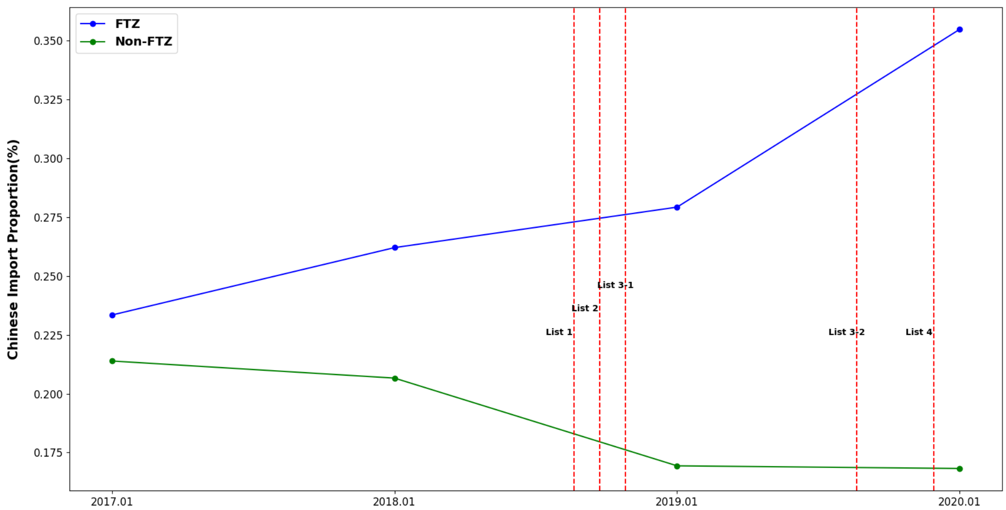

Figure 1: FTZs and non-FTZs Chinese Imports Proportion, 2017-2020

Drawing on a wealth of empirical evidence supporting the presence of "Cushion Effects" to mitigate tariff-related risks, this paper quantifies the protective effects of deferral and exemption channels by dissecting the additional duties levied on Chinese goods subject to sanctions into three segments based on sales in two distinct markets and inventory levels. Specifically, the additional duties associated with the sanctioned inputs employed in export production serve as cost-saving "Cushion Effects," while the extent of cash-flow protection is gauged by the supplementary tariffs levied on domestically sold products and stored inventory. Empirical results reveal that the bulk of additional tariffs were deferred for a brief period, followed by the amount being exempted. Manufacturing firms operating in FTZs exhibited a

[6]Annual Reports of FTZs can be downloaded from (link).

proclivity for stockpiling goods for future manufacture, and the deferred duty payments bolstered their cash-flow liquidity.

Furthermore, the benefits of duty payments deferral and exemption resulting from production in FTZs were heightened when confronting tariff disruptions, leading to the attraction of new producers. As evidenced by the 2019 Annual Report of FTZs, the number of firms starting operations in the zones increased by a net of 120. Furthermore, there was a 25% rise in the number of new subzone/site designations, with 250 designations in 2019 compared to 200 in 2018. The first-difference empirical model enables the quantitative estimation of the impact of tariff shocks on the firm count. Results indicate that a one-point increase in tariff rates leads to an additional 1.013 and 2.496 log points increase in production-side and warehousing firms, respectively. Notably, incumbent (firms that entered the zones prior to the trade war) faced significantly less pronounced tariff shock effects, as their entry was predominantly driven by the tariff rate reduction channel accessible before 2018.

Following the extensive and intensive empirical evidence supporting the "Cushion Effects" of FTZs, Section 4 examines the differential impacts of the tariff war on FTZ and non-FTZ producers by their monthly import data and applying First Difference(FD) and Difference-in-Differences(DID) models. The impact of tariff shocks is examined by considering two factors: firstly, the proposed tariffs that are yet to be implemented by the end of a month, which are referred to as predicted tariff shocks; secondly, the implemented tariffs, which are referred to as effective tariff shocks. Contrary to the pronounced impact of predicted and effective tariff shocks on domestic firms, FTZ producers' import behavior appears relatively insensitive to these tariff-related factors. This observation holds when controlling for retaliation tariffs or US tariff implementations targeted at other countries. To explore the data in a more granular manner, this paper estimates the impact of tariff disruptions on imported products classified as intermediate or final goods respectively. The findings suggest that, compared to final goods, non-FTZ importers tend to warehouse more intermediate goods in response to anticipated new tariffs and their consumption of sanctioned components also decreases by a smaller magnitude. Finally, I decompose the effects across distinct sets of sanctioned goods observed during the four successive rounds of tariff escalation. The findings demonstrate that FTZ firms exhibited heightened import activity solely in response to the imposition of supplementary duties on goods categorized under List 2, which encompasses high-tech products of the "Made in China 2025" program. This aligns with the positive outcomes of tariff shocks on trade dynamics unveiled in the empirical results at the intensive margin outlined in Section 3.

Diverging from the framework expounded in Grant (2020) which justifies that the US government's two-tier tariff policy implemented in FTZs is welfare-maximized, this paper proposes a Melitz-type model with intermediate goods sourced as Eaton and Kortum (2002) to characterize FTZ firms from a micro-perspective, the propositions inferred capture the extensive and intensive evidence established through the empirical exercises. The "Cushion Effects" can be captured by a discount rate function that mitigates the original tariff rate, implying that FTZ firms benefited from reduced input costs attributed to the comparatively lesser magnitude of tariff shocks they encountered. Driven by compelling empirical evidence showcasing that firms in the production sector experienced heightened levels of "Cushion Effects" amidst substantial tariff shocks, I propose a fundamental attribute of the discount rate function: a diminishing value in response to escalating import tariff rates. The magnitude of the first-order derivative of the discount rate function serves as an indicator of the FTZ protection's sensitivity. Given the observation that the establishment of FTZs has attracted new participants, it is assumed that the discount rate function exhibits a degree of sensitivity that surpasses a lower threshold. This assumption ensures that the aggregate cost of inputs is comparatively lower for FTZ firms in comparison to domestic producers during the tariff war. As a result, firms in the zones appear to have greater profitability, as the adverse effects are countered by the "Cushion Effects", and the burden of extra duties is borne by consumers. With the further increase in sensitivity, the decision to relocate operations to FTZs offers firms increasingly pronounced advantages by substantially reducing duty payments. Therefore, in this context, the low barriers to entry within the zones amplify these reductions, ultimately resulting in total duties paid that are lower than pre-war levels. Consequently, consumers enjoy the benefits of reduced prices for final products, leading to significant welfare gains. While there is evidence in the prior literature suggesting that social welfare was negatively impacted, this paper argues that the government can utilize FTZs as a tool to alleviate the detrimental consequences of the trade war.

There are three main contributions of this paper. Firstly, I compile data regarding firms operating within the FTZs of the US, including comprehensive details on their production sets consisting of components and products classified by the six-digit Harmonized Tariff Schedule(HTS) code, annual trade volumes, and additional pertinent economic indicators. As crucial import channels for US businesses to acquire foreign intermediate goods, the utilization of micro-level data provides an additional tool to analyze the factors influencing the importation decisions of FTZ participants. The quantitative results discussed in this paper add to the small body of work on US FTZs. Bobonis and Shatz (2007), Seyoum and Ramirez (2012), Bell (2016), Ghosh, Reynolds and Rohlin (2016), Seyoum (2017), Lane (2020), Lane and Liu (2022) are studies conduct case study about the spillover effects of the establishment of the zones. Lane (2020) find that US counties with FTZs in the Southeast have significantly higher economic output than counties without access to FTZs while exacerbating spatial inequality. Because the detailed trading data of zones incorporate business-proprietary information and lack transparency, previous work of the World Bank, International Labour Organization, and United Nations Conference on Trade and Development (Farole, Akinci et al. (2011), Akinci and Crittle (2008), Boyenge et al. (2007), UNCTAD (2019)) focuses on case studies and high-level summary statistics of the worldwide free trade zones. Siroën, Yücer et al. (2014) quantitatively proves that worldwide zone users are importers of components and raw materials, thus they raise the rest of the world's exports. The dataset with regard to Chinese firms and administration is richer, Wang (2013), Brooks, Kaboski and Li (2016), Alder, Shao and Zilibotti (2016), Zheng et al. (2016), Yao and Whalley (2016), Lu, Wang and Zhu (2019), Jiang, Wang and Liu (2021) examine the effects of Chinese FTZs on economic indicators including markups, wages, and trade flows.

Secondly, it is worth noting that the existing literature on US FTZs has largely focused on aggregate-level statistics, with limited attention paid to the firm-level trading behaviors of FTZ participants. Through empirical analysis of both intensive and extensive aspects, FTZs mitigated the impact of tariff shocks on firms by deferring and exempting additional duties during the two-year tariff war, resulting in significant "Cushion Effects". It is suggested that the protective effects of FTZs can have spillover effects on the stability of social consumption by reducing production costs. Therefore, the losses incurred due to tariff shocks as quantified in other studies can be amplified. Amiti, Redding and Weinstein (2019*a*), Fajgelbaum et al. (2020), Cavallo, Ghezzi and Balocco (2019), Flaaen, Hortaçsu and Tintelnot (2020), and Bown et al. (2021*a*) show that the negative effects of the trade war on social welfare are reflected in the increasing producer prices, which is due to the rising input costs as Flaaen and Pierce (2019) discussed.

Finally, building upon the empirical results, this paper develops an innovative model that incorporates FTZs into the classic Melitz framework (Melitz (2003)) and captures the tariff-related benefits of FTZ participation through a discount rate function embedded in the prices of EK-traded intermediate goods (Eaton and Kortum (2002)). The technique of constructing this two-tier trade model originates from Caliendo and Parro (2015). Thus this paper extends the old literature(Hamada (1974), Hamilton and Svensson (1982), Miyagiwa (1986), Young (1987), Young (1991), Young and Miyagiwa (1987), Din (1994)) about the model of FTZs in small developing countries, which suggest that this policy cannot be the optimal policy. The following case study include Jayanthakumaran (2003), Zeng (2015), Moberg (2015), Newman and Page (2017).

The subsequent sections are arranged as follows. Section 2 elucidates the data comprehensively. Section 3 outlines the identification approaches of "Cushion Effects" and the results of the estimates, followed by the quantification part. Section 4 evaluates the differential effects of tariff shocks on import activity for firms within and outside the purview of FTZs. Section 5 presents the theoretical model and its associated implications. The last section offers concluding remarks.

2 Data

The compiled data used in the empirical analysis mainly includes trade volumes and lists of additional tariff rates implemented during the trade war period. Firstly, I extract the yearly zone-level trade data from the annual reports of FTZs and apply econometrics models to identify the intensive and extensive evidence of the existence of the "Cushion Effects". This officially sourced data was rarely quantitatively analyzed in other literature about the US FTZs, which is one of the innovative works of this paper. In addition, I employ the monthly import data tabbed with HTS10 code from the DataWeb of the United States International Trade Commission(USITC) to identify the import behavior differences between producers inside and outside the zones. The data applied to construct the tariff-shock variables is the supplementary tariff rates imposed on the Chinese products in the four lists issued by the Office of the United States Trade Representative in Section 301 Action. Firms were given the right to apply for the exclusion of specific products, and the used dataset captures those exemptions. In the robustness checks, the other anti-dumping tariff waves implemented by the US government on several targeted countries are taken into account, e.g. the solar panel tariffs issued in Section 201 of the US trade act.

2.1 Trade Volumes of FTZ Firms

From the annual reports submitted by the Foreign Trade Zones Board to the United States Congress, the trade volumes of FTZ firms with active operations within the zones from 2017 to 2019 are obtained. Segmenting firms based on their manufacturing operations, those that function as distribution centers are referred to as warehousing firms, while those engaged in production activities are designated as manufacturing firms, their trade volumes are observed at the zone-level and firm-level respectively. FTZ firms have three options for managing the transportation of their products that contain imported components: domestic shipping, exportation, and inventory holding. The trade volumes are reported in terms of intermediate goods value rather than final outputs, implying that value-added contributions from FTZ firms are excluded. This reporting structure facilitates the determination of additional duty expenses paid, exempted, or temporarily deferred by year-end through the shipment volumes to domestic and foreign markets, as well as inventories.

For the manufacturing firms, the annual reports also provide information on their identities, and thus their production sets can be searched from the FTZ Production Database[7]. This public database provides approvals released by the FTZ Board for the production authority of firms, in which the goods are documented in the HTS6 code and distinguished as final products or components.

2.2 Imports of FTZ Firms and Non-FTZ Firms

The DataWeb of the United States International Trade Commission(USITC) provides the monthly Chinese import volumes with the HTS10 code and port of entry information. Each product is labeled with the Rate Provision Code defined by the US Census and represents whether the imported product is free or dutiable. "00" denotes the goods imported into FTZs and bonded warehouses, the imports with other

[7] `https://ofis.trade.gov/ManufacturingDB`

codes clear their duty immediately and are consumed by the non-FTZ firms. Quoting the calculation of MatthewGrant (2020), 98% of the imports with rate provision code "00" is distributed to the FTZ firms. To control the within-industry variations, I apply the commodity concordance table from the HTS10 code to the six-digit North American Industry Classification System(NAICS) code and identify the industries of imported inputs.

2.3 Tariff Exposures

The additional ad-valorem tariff waves with the HTS10 code imposed by the US government on listed Chinese products during the US-China trade war from 2018-2019 are shown in Table 1. There are five rounds of implementations in total which include four lists of sanctioned products.

Table 1: US-China trade war Actions: Section 301

	Proposed Date	Proposed Rate	Effective Date	Effective Rate
$ 34 Billion List 1	$April6, 2018$	25%	$July6, 2018$	25%
$ 16 Billion List 2	$June20, 2018$	25%	$August23, 2018$	25%
$ 200 Billion List 3 - 1_{st}	$July17, 2018$	10%	$September24, 2018$	10%
$ 200 Billion List 3 - 2_{nd}	$August1, 2018$	25%	$June1, 2019$	15%
$ 300 Billion List 4	$May17, 2019$	25%	$September1, 2019$	15%

On April 6th, 2018, the US government proposed the first round of tariff war against a list of Chinese goods worth 34 billion in total, and this tariff implementation took effect after three months. Before this first round of tariff waves being effective, there was another list initiated that included products worth 16 billion. The goods sanctioned in the two aforementioned lists primarily belonged to manufacturing sectors. Notably, List 2 contained products of the "Made in China 2025" program, which are intermediates of high-tech sectors, such as the production of solar panels and computers. Following the first two rounds of sanctions, the third list covered products with a much wider range and worth 200 billion in total, involving the resources industry and extra manufacturing industries. The third list of products underwent two rounds of tariff rate increases, the first round of extra tariffs proposed in July 2018 was 10%, before this proposed rate was in effect, the board raised the rate to 25% in the following month and was enforced in 2019. In May 2019, the fourth List was published and experienced the last round of tariff increment during the trade war. A 25% additional import tariff rate covering products worth 300 billion was proposed, while the actual effective rate decreased to 15%.

The sanctioned lists of products with the HTS8 codes are downloaded from the notices published by US Trade Representative about implementing modifications to Section 301 Action on the official website of the Federal Register[8]. Applying the concordance table, the tariff increment data with the HTS8 code is translated to the HTS10 code. There are rare cases that the Trade Representative Office approved exempting specific products with the HTS10 code within the HTS8 categories which are captured in the compiled dataset.

Each round of US tariff increases provoked retaliatory tariffs from China, and thus there were four rounds of actions taken by the Chinese government, the lists were also described with the HTS8 code, and the levels of the additional tariffs were published on the official website of the Ministry of Finance of China. To ensure consistency with the US import data, the HTS8 codes of products are also converted to the HTS10 codes. Out of the scope of the US-China trade war, there were other rounds of tariff waves initiated by the US on a wider range of trading partners, mainly targeting the Solar Panel Tariffs, Steel Tariffs, and Aluminum Tariffs. These tariff implementations of the US and the triggered retaliatory tariffs from other countries were collected in Li (2018).

[8] https://www.federalregister.gov/agencies/trade-representative-office-of-united-states.

3 Existence of "Cushion Effects"

This section analyzes the basic statistics of FTZ firms and identifies evidence of the existence of "Cushion Effects" during the tariff war. There are two main channels of protection against tariff shocks by operating in the zones, including deferral and exemption of duties which are defined as the cash-flow "Cushion Effects" and the expense-save "Cushion Effects" respectively. For the FTZ products serving the domestic market, the attached import duties are non-paid until the date products cross the customs territory of the US. Therefore, FTZ firms have a higher level of cash-flow liquidity compared to their non-FTZ counterparts, reflecting the protection from cash-flow "Cushion Effects". For the dutiable foreign components used in the manufacture of FTZ exports, rather than paying duties in advance and withdrawing on the date when products are sold abroad, firms in the zone can get tariff exemptions directly. As a consequence, the negative effects from trade shocks were avoided in the volume of exports, referred to as the expense-save "Cushion Effects".

Foreign commodities took about 36% among the overall merchandise received in the zones. Amidst the US-China trade conflict, FTZ firms witnessed a significant augmentation in the share of imported Chinese products, constituting an average level of 30% and denoting a more than 6% increase compared to the corresponding figure in 2017, as Figure 1 displays. Accompanying these rising imports, the shipment volumes of Chinese products to foreign and domestic markets also increased by around 9% and 16% respectively. In the absence of tariff reductions applied to Chinese products during the tariff war, the contrasting patterns of FTZ firms, characterized by an expanding share of Chinese imports and growing trade volumes, as opposed to the declining imports observed among non-FTZ firms, underscore the significance of both cash-flow "Cushion Effects" and expense-saving "Cushion Effects". In addition, during 2018 and 2019, there were additional 120 firms that started their manufacturing activities in the FTZs, with 83% of them involved in warehouse activity and the rest of them conducting productions. Hence, the subsequent sections present empirical findings that substantiate the presence of the "Cushion Effects" on both the intensive and extensive dimensions, offering quantitative evidence of their existence.

3.1 Intensive and Extensive Evidence

Considering the intensive evidence, I investigate the effects of zone-level tariff shocks on the trade volumes of Chinese goods in both warehousing and manufacturing firms through the following econometric models,

$$\Delta ln(S_{zt}^{f,d}+1) = \gamma_1^{f,d} \Delta USTariff_{zt}^{f} + FE_t$$
$$\Delta ln(I_{zt}^{f}+1) = \gamma_1^{f} \Delta USTariff_{zt}^{f} + FE_t$$

where superscript $f \in \{w, p\}$ and $p \in \{pc, pn\}$ labels different types of firms. w and p represent the warehousing and manufacturing firms respectively, the producers in the zones can be further classified into the incumbent (entered before the trade war) labeled as pc, and new firms (entered during the trade war) labeled as pn. Superscript $d \in \{FM, DM\}$ is the destination of shipments, including foreign market FM and domestic market DM. Zone-level import volumes of Chinese components used in the production of final goods sold by FTZ firms to market d or reserved as inventories for future processing in year t are represented by $S_{zt}^{f,d}$ and I_{zt}^{f} respectively. Adopting the shift-share construction method for the zone-level tariff shocks and taking the import volume of each Chinese product as weight, the weighted tariff-exposure variable $\Delta USTariff_{zt}^{f}$ is calculated from the product-level extra tariff rates. Δ operator takes the differences of the zone-level variables over the year, and our investigated time horizon is from 2018 to 2019. Time-fixed effects FE_t control the time variations in the data over the years. The intensive-side effects of tariff shocks are displayed in Table 2 and Table 3.

Table 2: Trade Volume and Tariff Shocks - China

	(1) $\Delta S_{zt}^{w,DM}$	(2) $\Delta S_{zt}^{w,FM}$	(3) ΔI_{zt}^{w}	(4) $\Delta S_{zt}^{p,DM}$	(5) $\Delta S_{zt}^{p,FM}$	(6) ΔI_{zt}^{p}
$\Delta USTariff_{zt}^{w}$	3.217***	3.157***	1.639			
	(1.208)	(0.956)	(1.067)			
$\Delta USTariff_{zt}^{pa}$				0.653***	0.583***	0.736***
				(0.220)	(0.157)	(0.177)
Constant	-0.013	0.054*	0.038	0.013	0.023	0.100**
	(0.041)	(0.032)	(0.035)	(0.062)	(0.044)	(0.050)
Time FE	Y	Y	Y	Y	Y	Y
F-stat	3.687	6.454	1.297	4.621	7.039	8.658
Observations	522	522	506	522	522	489

Notes: In this table, we investigate the changes in the trade volume of Chinese products in warehouse-side firms w and production-side firms p, and quantify the effects of tariff shocks. With DM and FM representing domestic and foreign markets respectively, $\Delta S_{zt}^{w,DM}$ and $\Delta S_{zt}^{w,FM}$ are the differences in the zone level shipment volumes of warehouse side firms w to these two markets, ΔI_{zt}^{w} is their inventory volume. In column (1)-(3), we investigate the effects of tariff shocks $\Delta USTariff_{zt}^{w}$ to the trade volume of firms w, and in column (4)-(6), we investigate all production firms pa that conduct production activities. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3: Trade Volume and Tariff Shocks - China

	(1) $\Delta S_{zt}^{pc,DM}$	(2) $\Delta S_{zt}^{pc,FM}$	(3) ΔI_{zt}^{pc}	(4) $\Delta S_{zt}^{pn,DM}$	(5) $\Delta S_{zt}^{pn,FM}$	(6) ΔI_{zt}^{pn}
$\Delta USTariff_{zt}^{pc}$	0.557**	0.396**	0.262			
	(0.249)	(0.178)	(0.165)			
$\Delta USTariff_{zt}^{pn}$				4.450***	3.185***	2.927***
				(0.243)	(0.162)	(0.173)
Constant	-0.026	0.017	0.102**	0.047	-0.002	-0.019
	(0.065)	(0.046)	(0.042)	(0.031)	(0.021)	(0.022)
Time FE	Y	Y	Y	Y	Y	Y
F-stat	2.551	3.428	2.180	168.928	196.383	148.605
Observations	522	522	492	522	522	521

Notes: In this table we divide FTZ firms into two groups, including incumbent pc (joined before the Trade War) and new firms pn (join during the Trade War), and regress their trade volume of Chinese products to the tariff shocks. With DM and FM represent the domestic and foreign markets respectively, $\Delta S_{zt}^{pc,DM}$ and $\Delta S_{zt}^{pc,FM}$ are the shipment volume of incumbent pc to these two markets, ΔI_{zt}^{pc} is their inventory volume. In column (1)-(3), we investigate incumbent pc and the effects from tariff shocks $\Delta USTariff_{zt}^{pc}$, and in column (4)-(6), we investigate the new firms pn. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

During the trade war, both categories of firms engaged in active operations within the zones exhibited an expanded market penetration. Columns (1) and (2) of Table 2 highlight the analysis of warehousing firms, revealing that tariff shocks exhibit pronounced positive influences on shipment volumes to both markets. Specifically, a one-point increase in $\Delta USTariff_{zt}^{w}$ leads to 3.217 and 3.157 logarithmic points increases in warehouses' domestic sales and exports respectively. In contrast, the sales of manufacturing firms experienced five times smaller positive effects as Columns (4) and (5) present. Their subdued reactions stem from the inherent characteristic of production-oriented goods, which exhibit relatively limited mobility when contrasted with warehousing entities that serve as distribution centers. For the same reason, the imposition of additional tariffs did not prompt warehouse-side firms to accumulate inventory. However, it had a pronounced positive impact on producers' inventories, surpassing the effects observed in their other two sub-flows of import volumes. Therefore, despite the absence of reduced duties on Chinese products, FTZ firms were granted exemptions for the duties imposed on sanctioned imports utilized in the production of exported outputs and were able to temporarily defer all additional duties prior to shipping for domestic consumption. These "Cushion Effects" served as a mitigating force against tariff shocks, leading to an increased demand for Chinese goods within the zones during the tariff war and a surge in export volumes.

Considering firms operating in 2017 as a baseline, I classify those active in 2018 and 2019 as two distinct groups: incumbent *pc* (joined before the trade war) and new firms *pa* (joined after the trade war). Examining the effects of tariff shocks on these two groups separately, the findings are presented in Table 3. Significant disparities emerge in the impact of tariff shocks on the two cohorts, with substantially greater positive effects observed in terms of trade volumes and inventories for *pn* compared to *pc*. This disparity implies that the newly established firms exhibited heightened sensitivity to tariff shocks, evincing a stronger inclination to engage in production and market penetration via FTZs. The accrued profits from their operations in these new branches within the zones evidently surpassed the fixed costs associated with the entry. Notably, the observed positive impacts of tariff shocks on manufacturing firms' inventories, as depicted in Table 2, can be attributed to the influence of *pn* rather than *pc*. The newly established firms exhibited a propensity for inventory accumulation, strategically storing products for subsequent processing. The non-payment of attached extra tariffs on inventories, remaining outstanding until the end of the reporting year, contributed to a heightened cash flow level relative to their pre-FTZ status. In contrast, *pc* opted to replace Chinese inputs with those sourced from unaffected countries or domestic suppliers. Consequently, these firms lacked the motivation to stockpile unaffected products, resulting in negligible impacts of tariff shocks on their inventory levels.

In addition to examining the intensive effects resulting from tariff shocks, this paper also investigates the extensive effects by analyzing the number of firms engaged in operations within the designated zones. Applying the following regression models, extensive effects are identified,

$$\Delta ln(n^w_{zt}+1) = \gamma^w_2 \Delta USTariff^w_{zt} + FE_t$$
$$\Delta ln(n^p_{zt}+1) = \gamma^p_2 \Delta USTariff^p_{zt} + \gamma^p_3 \Delta DUSTariff^p_{zt} + FE_t$$

where n^w_{zt} and n^p_{zt} are the number of firms involved in the warehouse and production activities in each zone, with $p \in \{pc, pn\}$ represents the different group of manufacturing firms. When engaging in imports from countries other than China and subsequently delivering the outputs to the domestic market, manufacturing firms have the opportunity to utilize the lower import tariff rates applicable to components and final products. However, warehousing firms continue to be subject to the original baseline tariff rates. Thus in addition to the tariff shocks $\Delta USTariff^w_{zt}$ and $\Delta USTariff^p_{zt}$ encountered by warehousing and manufacturing firms, the variable $\Delta DUSTariff^p_{zt}$ captures the difference in tariff rates between components and the corresponding actual payments of production-side firms. Taking into account the advantages arising from the duty reduction in unaffected imports and their potential impact on the count of operational manufacturing firms within FTZs, I incorporate controls for tariff rate differentials in the regression models for the extensive side analysis. Similarly, time variations are controlled by FE_t and the operator Δ takes the differences of variables over years. The regression results are presented in Table 4.

Column 1 of Table 4 shows the extensive margin of tariff shocks $\Delta USTariff^w_{zt}$ on the warehousing firms w, the significant positive effects explain the great increase of firms working as distribution centers triggered by the trade war.

Considering the two groups of manufacturing firms, the number of incumbent decreased from 331 in 2017 to 292 in 2019. The decline observed can be attributed to the withdrawal of duty reduction benefits, leading to diminished profitability for a subset of FTZ firms. Consequently, a limited number of these firms opted to exit the zones when the benefits from the remaining two channels failed to sufficiently

Table 4: Number of Firms and Tariff Rates

	(1) Δn_{zt}^{w}	(2) Δn_{zt}^{p}	(3) Δn_{zt}^{pc}	(4) Δn_{zt}^{pn}
$\Delta USTariff_{zt}^{w}$	2.496**			
	(1.032)			
$\Delta USTariff_{zt}^{p}$		0.253***		
		(0.076)		
$\Delta DUSTariff_{zt}^{p}$		0.008		
		(0.060)		
$\Delta USTariff_{zt}^{pc}$			0.117*	
			(0.070)	
$\Delta DUSTariff_{zt}^{pc}$			0.160***	
			(0.048)	
$\Delta USTariff_{zt}^{pn}$				1.013***
				(0.185)
$\Delta DUSTariff_{zt}^{pn}$				3.581***
				(0.718)
Constant	0.043	0.014	-0.018	0.056***
	(0.022)	(0.014)	(0.011)	(0.014)
Time FE	Y	Y	Y	Y
F-stat	3.303	3.916	5.828	34.080
Observations	522	522	522	522

Notes: In this table, we investigate the effects of tariff shocks on the number of firms operating in the FTZ. In column (1), we quantify the effects of tariff shocks $\Delta USTariff_{zt}^{w}$ to the changes in the number of warehouse-side firms. In addition to the tariff shocks, we control the changes of the reduction in tariff rates $\Delta DUSTariff_{zt}^{p}$ in the regressions of production side firms $p \in \{pc, pn\}$. In columns (2)-(4), we investigate the effects of tariff shocks and changes in tariff rate reductions over entire production firms p, incumbent pc, and new production firms pn. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

offset the fixed costs associated with ongoing operations. However, companies that held a substantial market share in foreign markets were able to offset their profit losses in the domestic market by leveraging duty exemptions as a compensatory avenue of benefits. As a result, tariff shocks yielded positive effects on the count of export-oriented incumbent. Aligning with the intensive analysis, the actively operating incumbent during the trade war exported more products triggered by the tariff shocks. Considering the confluence of these divergent influences from extra tariffs, the effects stemming from $\Delta USTariff_{zt}^{pc}$ are almost insignificant as Column (3) displays. In contrast, the reduction benefits $\Delta DUSTariff_{zt}^{pc}$ have significant positive effects on the number of pc, one point reduction in the tariff rate attracts 0.16 log point producers. The explanation is that incumbent entered into the zones before trade war when the reduction benefits were still accessible to Chinese imports, thus their entrances are mainly driven by this channel. Taking into account pn, there were additional 59 manufacturing firms starting manufacture in FTZs. Tariff shocks are identified to produce significant positive effects, one point increase in tariff shocks induces an additional 1.013 log points of new manufacturing firms entering. Combining the intensive analysis of pn, they utilized FTZs to serve both the domestic and foreign markets. Besides effects from tariff shocks, their decisions to enter FTZs can also be well explained by the reduction of tariff rates as firms could take this advantage over the unaffected imports or when trade war ends.

When examining the overall impact of tariff shocks on manufacturing firms p, it is observed that only tariff shocks targeting Chinese products yield statistically significant positive effects, as opposed to reduction benefits. There were pc firms exited while pn firms entered within FTZs during the trade war. Considering these contrasting dynamics in the number of manufacturing firms, there was a net increase of 20 firms commencing operations. These entrances can be attributed to tariff shocks, as evidenced by the positive relationship between tariff shocks and the log point increase of new manufacturing firms, which amounts to 0.253 per one-point tariff shock increment.

3.2 Quantifying the "Cushion Effects"

The trade barriers implemented with the aim of decreasing the demand for Chinese products produced unintended consequences in the FTZ firms as Section 3.1 identified. Due to the rates of extra tariffs being different across the four waves of sanctions, the additional duties incurred depended on both the import volumes and the levels of tariff rates. I quantify the "Cushion Effects" in three channels by decomposing the additional duties on Chinese imports into three parts according to the shipment volumes in the two markets and inventory levels. Specifically, the additional duties over products consumed in the domestic or foreign market are defined as temporarily deferred duties $Duty(P)^f_{zt}$ and exempted duties $Duty(E)^f_{zt}$ respectively. For the inventories of FTZ firms, the additional duties attached were still deferring by the end of year t and defined as unpaid costs $Duty(I)^f_{zt}$. From the classification of "Cushion Effects", $Duty(P)^f_{zt}$ and $Duty(I)^f_{zt}$ are cash-flow savings, firms didn't pay those expenses until outputs were consumed domestically. And $Duty(E)^f_{zt}$ represents the expense-save "Cushion Effects", as the re-exported outputs of the firms were exempted from tariff payments. The intensive and extensive evidence shows that tariff shocks have induced firms to trade through FTZs and attracted new manufacturers, the effects of tariff shocks on these benefits measured by the extra duties are displayed in Table 5 and Table 6.

Table 5: Duty and Tariff Shocks - China

	(1) $Duty(P)^w_{zt}$	(2) $Duty(E)^w_{zt}$	(3) $Duty(I)^w_{zt}$	(4) $Duty(P)^p_{zt}$	(5) $Duty(E)^p_{zt}$	(6) $Duty(I)^p_{zt}$
$\Delta USTariff^w_{zt}$	10.435***	3.163***	0.145			
	(1.390)	(0.710)	(0.361)			
$\Delta USTariff^p_{zt}$				1.521***	0.502***	0.371***
				(0.168)	(0.077)	(0.054)
Constant	0.191***	0.057**	0.007	0.194***	0.042**	0.012
	(0.044)	(0.023)	(0.011)	(0.046)	(0.021)	(0.015)
Time FE	Y	Y	Y	Y	Y	Y
F-stat	30.569	11.657	1.105	43.983	25.329	25.271
Observations	522	522	522	522	522	522

Notes: In this table, I regress the additional duties on Chinese products in the trade volumes and inventories of outputs on the tariff shocks. In column (1)-(3), we investigate the effects of tariff shocks $\Delta USTariff^w_{zt}$ received by the warehouse-side firms, the extra duties related include the paid duties $Duty(P)^w_{zt}$ over products shipped to domestic markets, the exempted duties $Duty(E)^w_{zt}$ over products re-exported to foreign markets, and the unpaid duties $Duty(I)^w_{zt}$ at the end of year t. In columns (4)-(6), we investigate the production-side firms p. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Consistent with the intensive evidence, warehousing firms' "Cushion Effects" measured by the duties on the distributed volumes in both domestic and foreign markets were induced by $\Delta USTariff^w_{zt}$ significantly, one point increase in tariff shocks brought about six times larger "Cushion Effects" manifested in $Duty(P)^w_{zt}$ and $Duty(E)^w_{zt}$, compared to the manufacturing firms. The products of w require high liquidity as indicated in Column (3) of Table 2, thus their unpaid expenses were also not obvious. The tariff shocks $\Delta USTariff^p_{zt}$ produce significant positive effects on all manufacturing firms p, one point increase in tariff shock induces 1.892 (1.521+0.371) log points cash-flow "Cushion Effects" and 0.502 log points expense-save "Cushion Effects". Taken overall, the cash-flow "Cushion Effects" over domestically consumed products are the major sources of benefits and are three times larger than the expense-save "Cushion Effects" for both w and p, resulting from the fact that 80% FTZ firms' outputs serve the domestic market.

Table 6: Duty and Tariff Shocks - China

	(1) $Duty(P)^{pc}_{zt}$	(2) $Duty(E)^{pc}_{zt}$	(3) $Duty(I)^{pc}_{zt}$	(4) $Duty(P)^{pn}_{zt}$	(5) $Duty(E)^{pn}_{zt}$	(6) $Duty(I)^{pn}_{zt}$
$\Delta USTariff^{pc}_{zt}$	1.564***	0.424***	0.325***			
	(0.172)	(0.073)	(0.055)			
$\Delta USTariff^{pn}_{zt}$				1.592***	0.993***	0.669***
				(0.151)	(0.085)	(0.042)
Constant	0.187***	0.042**	0.014	0.015	0.001	-0.001
	(0.043)	(0.019)	(0.014)	(0.018)	(0.010)	(0.005)
Time FE	Y	Y	Y	Y	Y	Y
F-stat	43.042	19.284	18.074	58.241	70.107	131.459
Observations	522	522	522	522	522	522

Notes: In this table, we classify FTZ firms into two groups, including incumbent *pc* (joined before the Trade War) and new firms *pa* (joined during the Trade War) respectively, and regress the additional duties over affected Chinese products used in the trade volumes and inventories of outputs on tariff shocks. In column (1)-(3), we investigate the effects of tariff shocks $\Delta USTariff^{pc}_{zt}$ received by the incumbent *pc*, the extra duties related include the paid duties $Duty(P)^{pc}_{zt}$ over products shipped to domestic markets, the exempted duties $Duty(E)^{pc}_{zt}$ over products re-exported to foreign markets, and the unpaid duties $Duty(I)^{pc}_{zt}$ by the end of year *t*. In columns (4)-(6), we investigate the new firms *pn*. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Investigating manufacturing firms in two categories *pc* and *pn*, the levels of effects from tariff shocks on the "Cushion Effects" are similar to the overall effects on *p*. In general, newcomers were more sensitive to tariff shocks, one point increase in tariff rate leads to 2.261 (1.592+0.669) and 0.993 log points increases in the cash-flow "Cushion Effects" and the expense-save "Cushion Effects" respectively, about two times larger than the effects from tariff shocks on the incumbent. Recalling the intensive analysis results in Table 3, *pn* also had a much larger scale of trading triggered by the extra tariffs and thus they obtained greater protection in terms of the improvements in the cash-flow liquidity and a larger amount of exempted duties.

4 Tariff Shocks and Import Behavior Differences

In Section 3, the intensive and extensive evidence of the existence of "Cushion Effects" is identified and measured by the extra duties in the effects quantification subsection. Both manufacturing and warehousing companies responded to the imposition of tariffs by increasing their sales of affected products through the zone, particularly those that commenced operations during the trade war. Although the tariff war impaired incumbent and they were less profitable due to the loss of duty reduction benefits, they turned to export and obtained the expense-save "Cushion Effects" for compensations. While firms that relied heavily on Chinese inputs and primarily catered to the domestic market exhibited a tendency to withdraw from the zones. Overall, the trade war saw a net influx of 120 new firms into FTZs, which responded more robustly to additional tariffs by generating both cash-flow and expense-saving "Cushion Effects" compared to incumbents.

In contrast to FTZ firms that received protection, non-FTZ firms faced challenges due to the rise in import tariffs on Chinese products, as they were required to pay duty promptly upon arrival at the port of entry. The elevated anti-dumping tariffs resulted in an increase in their production costs. Revisiting Figure 1 presented in the Introduction Section, FTZ firms have exhibited consistent growth in the usage of Chinese products in their consumption bundle, while non-FTZ entities have witnessed a substantial decline. The investigation of protected firms in Section 3 regarding the impact of tariff shocks constitutes one aspect of the analysis, while another is to compare the import behaviors of firms located within and outside the zones, which further sheds light on the significance of the "Cushion Effects." Therefore in this section, I examine the impact of the US-China trade war on the monthly import volumes of Chinese products, covering nearly 15,700 varieties that are represented by HTS10 codes, for both domestic and FTZ firms. In the subsequent empirical strategies section, the results of this analysis, along with a set of rigorous robustness checks are presented.

Encountering several rounds of tariff waves with regard to the imports from China to the US during the trade war, the US producers adjusted their usual plan of importing to alleviate the possible losses resulting from the increasing trade barriers. The Office of the United States Trade Representative usually proposed tariff actions two months earlier, with several rounds of the public hearing by the 301 Committee. Therefore, anticipating the large additional tariffs to be imposed on Chinese goods, firms responded by bringing forward the timing of importing process and increasing the import volumes before new tariffs came into effect. With the onset of the tariff war, they showed a tendency to substitute the domestic and non-affected foreign sources of inputs for their Chinese counterparts. The import behaviors of non-FTZ firms would be more strongly impacted by negative shocks due to tariffs compared to FTZ firms, given that the latter enjoyed "Cushion Effects" provided by the zones.

Given the monthly data on imports and tariff rates, two key factors are identified to examine the impact of the trade war on import activities, namely, (1) the announced but not implemented additional tariff rates, which are considered as predicted rates of importers, and (2) the effective additional tariff rates. These factors are used to model the tariff shocks and their effects on import behavior. In the empirical experiments, I have taken two steps to identify the mitigating effects of the "Cushion Effects" by conducting a comparative analysis between the two types of firms. To estimate the effects of tariff shocks on trade patterns, I employ a first difference estimator on monthly-level import data spanning from 2017 to 2019. This approach mitigates potential biases caused by unobserved, time-invariant variables, allowing for a more accurate measurement of the impact of tariff-related factors. The results of the FD estimations reveal notable differences in the effects of tariff shocks between firms located within and outside of FTZs. To further explore the disparity in imported goods between the two producer types, this section employs the difference-in-difference technique at last.

4.1 Empirical Strategy

First Difference Regression: There were four rounds of tariff waves with various rates during the US-China trade war, with three rounds taking place in 2018 and the fourth one in 2019. Firstly, I regress the changes in import values of the US firms on the increments of tariff-shock factors in the following FD empirical model,

$$\begin{aligned}\Delta ln(m_{it}+1) = \alpha_1 \Delta USTariff^P_{it} + \alpha_2(\Delta USTariff^P_{it} \times D_{FTZ}) + \beta_1 \Delta USTariff^E_{it} \\ + \beta_2(\Delta UStariff^E_{it} \times D_{FTZ}) + D_{FTZ} + FE_s + \Delta Controls + u_{it} \qquad (1)\end{aligned}$$

where $m_{it} \in \{m_{it}(d), m_{it}(f)\}$ are the volumes of Chinese imports of product i in month t, by non-FTZ or FTZ firms. Two tariff-shock factors $\Delta USTariff^P_{it}$ and $\Delta USTariff^E_{it}$ capture the exposures of product i to the additional tariff rate in month t, with superscripts P and E represent the predicted or effective tariff shocks respectively. The dummy variable D_{FTZ} is equal to one when the imports were consumed by FTZ firms. With the identification of coefficients, the effects of tariff shocks are identified for the two different destinations. The estimated coefficients α_1 and β_1 indicate the adverse impact of tariff shocks on non-FTZ firms, adding to α_2 and β_2 respectively the tariff-shock effects on FTZ firms are quantified. The "Cushion Effects" manifest as opposite signs of the coefficients α_2 and β_2 in comparison to α_1 and β_1, which suggests that the FTZ firms experienced a mitigation of the adverse impact of tariff shocks. Δ operator denotes the differences in variables between two years in one specific month t.

The fixed effects FE_s are comprised of (1) Time-fixed effects FE_t, which absorb the seasonal variations in imports, e.g. there is usually an obvious decline in the volumes of Chinese imports in February due to the public holiday of exporters during the Lunar New Year; (2) Product-fixed effects FE_i account for the characteristics of products; (3) Industry-by-time fixed effects FE_{nt} is the interaction term of dummy variables represent sectors and months respectively, where industries of products are classified according to the six-digit NAICS code. Through the identification of sectors, the biases which result from the tendency that additional tariffs are often targeted at intermediate inputs are well controlled[9].

The control variables are represented by $\Delta Controls$, which indicate the first difference of other predictors of tariff shocks. Specifically, when each round of US tariff hikes took effect, China responded with retaliatory measures, and to address the potential impact of these counter-actions, the retaliatory tariff rates imposed by China on US exports are included as additional control variables in the further robustness checks. The other rounds of anti-dumping tariffs out of the scope of the US-China trade war are also taken into account. For example, Section 201 of the US Trade Act provided the safeguard actions directed at solar panels and washing machines and was implemented in February 2018 in almost all countries. Further robustness checks and analyses are presented in the subsequent sections, which demonstrate the consistent effects of the tariff-related shocks and offer explanations for the observed differences in import volumes between firms operating in FTZs and those outside the zones.

Difference-in-Difference Regression: In addition to the identification of "Cushion Effects" embedded in coefficients α_2 and β_2 of the FD model (1), I take the differences of imports between FTZ and non-FTZ firms and use DID empirical model (2) for further verification,

$$\Delta D[ln(m_{it}+1)] = \alpha_3 \Delta USTariff_{it}^P + \beta_3 \Delta USTariff_{it}^E + FE_s + \Delta Controls + u_{it} \tag{2}$$

where $\Delta D[ln(m_{it}+1)] = \Delta[ln(m_{it}(d)+1) - ln(m_{it}(f)+1)]$, $m_{it}(d)$ and $m_{it}(f)$ are the import volumes of Chinese product i in month t by non-FTZ firms d and FTZ firms f respectively. The fixed effects and control variables are the same as FD Model (1). Coefficients α_3 and β_3 are difference-in-difference estimates of the effects of tariff-shock factors on $\Delta D[ln(m_{it}+1)]$.

Both types of firms would increase their imports in month t when anticipating $\Delta USTariff_{it}^P$ and reduce their reliance upon Chinese products with $\Delta USTariff_{it}^E$. Without the protection of "Cushion Effects", domestic firms were more sensitive to tariff shocks than FTZ firms, and thus in DID model (2) the coefficients $\alpha_3 > 0$ and $\alpha_4 < 0$ are dominated by the effects of tariff shocks on non-FTZ firms. For instance, if a new round of additional tariffs is announced in month t and the proposed list includes product i, domestic firms will import a larger volume of product i than last year before this new tariff comes into effect, and $\Delta ln(m_{it}(D)+1) > \Delta ln(m_{it}(F)+1)$ lead positive α_3.

The subsequent section presents the findings of the baseline and sensitivity analyses of the two econometric models. The first-difference estimates, which pertain to the interaction terms, directly capture the impact of the "Cushion Effects". The difference-in-differences estimates are primarily driven by the effects on non-FTZ firms, thus providing further evidence of the differences in import behavior between FTZ and non-FTZ firms.

4.2 Empirical Results

The coefficient estimates of the first-difference model (1) are the quantitative identifications of "Cushion Effects" and the results are shown in Table 7.

The robustness of the regression results is confirmed by controlling various combinations of the fixed

[9] Bown (2018) documents this pattern by looking at the tariff policies applied by the United States against other countries, as well as the tariff policies applied by other advanced economies. In the US-China trade war, US tariffs were also skewed toward intermediate inputs, such as primary metals and electrical equipment (Fajgelbaum et al. (2019)).

Table 7: Tariff Shocks and Import Behavior Difference - FD1

	(1)	(2)	(3)	(4)	(5)	(6)
	Δm_{it}	Δm_{it}	Δm_{it}	Δm_{it}	Δm_{it}	Δm_{it}
$\Delta USTariff_{it}^{E}$	-0.203***	-0.249***	-0.201***	-0.213***	-0.167***	-0.167***
	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)	(0.005)
$\Delta USTariff_{it}^{E} \times D_{FTZ}$	0.184***	0.184***	0.184***	0.184***	0.147***	0.147***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\Delta USTariff_{it}^{P}$	0.130***	0.135***	0.150***	0.149***	0.160***	0.163***
	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
$\Delta USTariff_{it}^{P} \times D_{FTZ}$	-0.170***	-0.170***	-0.170***	-0.170***	-0.185***	-0.190***
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Constant	0.015***	-0.012	0.014***	0.004***	0.010***	0.011***
	(0.001)	(0.016)	(0.001)	(0.001)	(0.001)	(0.001)
Time FE	Y	Y	Y	Y	Y	Y
Product FE	N	N	Y	Y	Y	Y
Industry FE	N	Y	N	Y	Y	Y
$CHN\_Re\_USTariff$	N	N	N	N	Y	Y
$US\_Other\_USTariff$	N	N	N	N	N	Y
F-stat	375.312	10.765	396.796	7.650	8.566	8.771
Observations	687,792	687,792	687,792	687,792	687,792	687,792

Notes: In this table, we regress the over-year changes in the monthly import volume of products with HS10 code of US firms on the tariff shock factors and their interaction terms. Columns (1)-(3) control different combinations of fixed effects and we take column (4) as our baseline results which control fixed effects over time, product and industry. The effective and predicted tariff shock factors are $\Delta USTariff_{it}^{E}$ and $\Delta USTariff_{it}^{P}$ respectively, dummy variable $D_{FTZ} = 1$ indicate the import volume is of FTZ firms and we control their interaction terms in this FD1 Model. In columns (5) and (6), we conduct robustness tests by taking Chinese retaliation tariffs and other rounds of antidumping tariffs imposed by the US as additional controls. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

effects in Columns (1)-(4) and the full set of fixed effects is controlled in the baseline results (Column (4)). Considering the retaliation tariffs from China and other anti-dumping tariffs imposed by the US on a wider range of countries, the results of robustness checks in Column (5) and Column (6) show that the baseline results are consistent.

Upon investigating the baseline outcomes, it was revealed that firms not situated within FTZs augmented their imports of goods subject to sanctions in the months leading up to the implementation of supplementary tariffs. A one-unit increment in the forecasted tariff shocks ($\Delta USTariff_{it}^{P}$) relative to the previous year resulted in a 0.149 log point escalation in import quantities. After the implementation of proposed tariffs, a one-point increase in effective tariff shocks, denoted by $\Delta USTariff_{it}^{E}$, caused a reduction of 0.213 log points in the import volumes of domestic producers. Despite domestic firms responding to the anticipated high tariff shocks by accelerating their import schedules, the overall consumption of Chinese inputs still decreased due to the greater negative impact of effective tariff shocks. Therefore, the portion of Chinese products consumed by domestic firms exhibited a declining trend, as illustrated in Figure 1.

The impact of tariff shocks on FTZ firms was mitigated by the presence of the "Cushion Effects," as indicated by the coefficients on the interaction terms. Specifically, the coefficient α_2 associated with the term $\Delta USTariff_{it}^{E} \times D_{FTZ}$ demonstrates the "Cushion Effects" on the imports of products subject to additional effective tariff rates. Likewise, the coefficient β_2 for the term $\Delta USTariff_{it}^{P} \times D_{FTZ}$ illustrates the "Cushion Effects" over the imports of goods that were predicted to be subject to additional tariffs. The coefficients α_2 and β_2 exhibit opposite signs in comparison to α_1 and β_1, which correspond to the impacts experienced by non-FTZ firms. By combining these coefficients correspondingly, the impacts on FTZ firms can be derived, which are relatively smaller in absolute magnitude compared to those on non-FTZ firms. In anticipation of the proposed additional tariff rates, FTZ firms did not exhibit any inclination to import goods in advance. Conversely, the coefficient estimate of the proposed tariff rates ($\alpha_1 + \alpha_2 < 0$) suggests that FTZ firms reduced their import volume when faced with positive proposed tariff rates. This finding is consistent with the observation that FTZ firms relied more on domestic inputs during the US-China trade war, as evidenced by the increase in the domestic input ratio of manufacturing firms from 72% in 2017 to 76% in 2019. Meanwhile, the FTZ firms expressed a willingness to curtail their consumption of goods subjected to additional tariff rates as indicated by the negative coefficient $\beta_1 + \beta_2 < 0$. Nevertheless, their reaction was considerably less pronounced than that of their domestic counterparts. Specifically, a one-point increase in effective tariff shocks resulted in a mere 0.029-point reduction in import volumes, which was 7 times smaller than that observed among non-FTZ firms. The estimates presented in Table 7 combine the effects from all four lists. However, the impacts of the tariff shock factors are analyzed in detail in the Robustness Checks Section, revealing that the augmented increasing import volumes of sanctioned goods stem primarily from the additional duties imposed on products classified under List 1 and List 2.

4.3 DID Verification

In the empirical model (2) of the difference-in-differences approach, I employ the difference of imports to provide a more intuitive confirmation of the tendency for non-FTZ firms to exhibit a more pronounced response. Specifically, non-FTZ firms would stockpile more inventories in anticipation of higher duty expenses and also cut back their consumption more sharply when faced with such expenses. The empirical results, which are presented in Table 8, confirm these expectations.

Table 8: Tariff Shocks and Import Behavior Difference - DID

	(1) Δd_m_{it}	(2) Δd_m_{it}	(3) Δd_m_{it}	(4) Δd_m_{it}	(5) Δd_m_{it}	(6) Δd_m_{it}
$\Delta USTariff^E_{it}$	-0.255***	-0.256***	-0.198***	-0.224***	-0.178***	-0.178***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$\Delta USTariff^P_{it}$	0.074***	0.083***	0.108***	0.103***	0.109***	0.109***
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Constant	0.024***	-0.018	0.021***	0.000	0.011***	0.012***
	(0.002)	(0.030)	(0.002)	(0.002)	(0.002)	(0.002)
Time FE	Y	Y	Y	Y	Y	Y
Product FE	N	N	Y	Y	Y	Y
Industry FE	N	Y	N	Y	Y	Y
$CHN\_Re\_USTariff$	N	N	N	N	Y	Y
$US\_Other\_USTariff$	N	N	N	N	N	Y
F-stat	197.127	9.738	227.364	5.067	5.665	5.646
Observations	343,896	343,896	343,896	343,896	343,896	343,896

Notes: In this table, we regress the over-year changes in the monthly import volume difference between FTZ and non-FTZ firms of products with HS10 code on the tariff shock factors. Columns (1)-(3) control different combinations of fixed effects and we take column (4) as our baseline results which control fixed effects over time, product and industry. The effective and predicted tariff shock factors are $\Delta USTariff^E_{it}$ and $\Delta USTariff^P_{it}$ respectively, and in Columns (5) and (6) we conduct robustness tests by taking Chinese retaliation tariff and other rounds of antidumping tariffs imposed by the US as additional controls. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

With different combinations of fixed effects, the effects from $\Delta USTariff^E_{it}$ and $\Delta USTariff^P_{it}$ are robust, the results in Column 4 are the baseline results of DID Model (2). The negative impact of effective tariff rates on the import differences of Chinese products between non-FTZ and FTZ firms is statistically significant. When compared to other Chinese goods not subject to additional duties during the trade war, an increase of one point in a product's exposure to effective tariff shocks results in a greater reduction of 0.224 log points in the import volume for non-FTZ firms compared to FTZ firms.

This observation suggests that domestic firms exhibited a greater propensity to reduce their expenditures on these costlier goods procured from China compared to the firms sheltered by FTZs. In the same vein, the variations in the anticipated tariff rate manifest a marked positive impact. A one-point surge in the predicted tariff rate leads to an increase of 0.103 log points in imports by domestic firms relative to those by FTZ firms. The estimated coefficients of α_1 and β_1 are proximate to α_3 and β_3 correspondingly, suggesting that the impact of tariff shocks on the domestic firms is more pronounced and dominates the estimates, in contrast to FTZ firms who experience less significant effects. Controlling the impacts from other tariff actions imposed or targeted at the U.S. in Columns (5) and (6), the baseline results are robust regarding the other tariff shocks.

4.4 More Robustness Checks

In this section, utilizing the first-difference model (1) and accounting for the complete set of fixed effects, I commence by examining the robustness of our findings through the disaggregation of the effects of tariff-shock variables based on product classification. Subsequently, taking into account the chronology of the four rounds of tariff shocks, I evaluate the impact of each of these lists.

Table 9: Tariff Shocks and Import Behavior Difference - FD1, Robustness Checks

	(1) Baseline	(2) IG	(3) FG	(4) L-1	(5) L-2	(6) L-3	(7) L-4
$\Delta USTariff^E_{it}$	-0.213***	-0.171***	-0.392***	-0.054***	-0.165***	-0.203***	-0.274***
	(0.004)	(0.005)	(0.008)	(0.008)	(0.015)	(0.007)	(0.012)
$\Delta USTariff^E_{it} \times D_F$	0.184***	0.165***	0.267***	0.0159***	0.277***	0.135***	0.216***
	(0.005)	(0.005)	(0.009)	(0.009)	(0.018)	(0.007)	(0.015)
$\Delta USTariff^P_{it}$	0.149***	0.169***	0.109***	0.300***	0.564***	0.111***	0.116***
	(0.005)	(0.006)	(0.008)	(0.010)	(0.025)	(0.008)	(0.009)
$\Delta USTariff^P_{it} \times D_F$	-0.170***	-0.170***	-0.176***	-0.248***	-0.475***	-0.143***	-0.170***
	(0.007)	(0.009)	(0.010)	(0.014)	(0.035)	(0.011)	(0.011)
Constant	0.004***	-0.000	0.014***	-0.008***	-0.008***	-0.003**	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Time FE	Y	Y	Y	Y	Y	Y	Y
Product FE	Y	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y	Y
F-stat	7.650	5.153	6.466	4.385	3.954	4.827	3.794
Observations	687,792	447,552	237,024	687,792	687,792	687,792	687,792

Notes: In this table, we conduct robustness check tests by decomposing the effects of tariff shock factors according to the industries of imports or the different lists of products that were imposed additional tariff rates. In Columns (2) and (3), we regress the over-year changes in the monthly import volume of intermediates (IG) and final products (FG) classified according to the BEC code on their related tariff shock factors. In Column (4)-(5), we distinguish the tariff shocks over four lists: L1-L4, and regress the over-year changes in the monthly import volume on each list's regulated rates. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Drawing on the classification scheme of the Broad Economic Categories (BEC), I divide the data into two distinct subsets. The first subset is composed of intermediate inputs and capital goods, while the second subset is composed of consumption goods. Columns (2) and (3) of Table 9 show the estimation of effects for these two subsets in the FD model (1). Upon comparing the estimates of these two columns and examining non-FTZ firms, it can be observed that the negative effects of $\Delta USTariff^E_{it}$ on intermediate inputs exhibit an absolute value 2.3 times smaller than that on final goods, whereas the positive effects of $\Delta USTariff^P_{it}$ on intermediate inputs display an absolute value 1.6 times larger than that on final goods. This observation implies that Chinese intermediate inputs are relatively indispensable to domestic producers compared to the final products, as producers tended to stockpile more intermediate inputs in advance and their consumption also suffered less adverse effects. Also, the majority of final goods were intended for domestic consumption in the U.S. without any plans for further re-export, thus leading firms to substitute them to minimize the associated duty expenses.

Additionally, through the decomposition of the aggregate effects based on distinct product lists, it was discovered that the unfavorable effects of the effective tariff shock factor on both non-FTZ and FTZ firms were largely attributed to products listed under List 1, 3 and 4. Conversely, the effects of this factor on products listed under List 2 are positive. This disparity across the product lists stemmed from varying levels of product significance in the manufacturing process. Upon examining the product classifications under HTS8 codes for the four lists, it becomes evident that List 2 include products incorporating industrially significant technology, such as solar panels, which are also included in China's "Made in China 2025" program. In contrast, other lists encompass goods from industries that are more diverse but tend to be more substitutable, such as those related to agriculture and food production. Hence, when anticipating extra tariffs on these essential intermediates, non-FTZ firms warehoused more than the ordinary intermediates in other lists. And aided by the "Cushion Effects" of duty deferral and exemption, FTZ firms consistently increased their imports of essential intermediate goods during the trade war, which accounted for their significant rise in Chinese imports. Consequently, the overall adverse impact of tariff shocks on FTZ firms in the baseline analysis primarily stems from the decline in imports of goods listed in Lists 1, 3 and 4, and they resorted to domestic substitutes.

5 Theoretical Model

This section is motivated by empirical findings that unilateral tariff increases on Chinese imports led to the entry of US firms into FTZs, raising the share of sanctioned intermediates used in production and the proportion of domestically consumed final goods produced in FTZs, compared to the domestic market. In light of these observations, this section puts forward comparable propositions, utilizing a two-tier Melitz-type model.

5.1 Set Up

Consider N countries indexed by $i = 1, 2, ..., N$ and populated by L_i identical households, each supplies one unit of labor inelastically and earns wage w_i. Let the first country be the only site that has FTZs and is equipped with the technology to produce final goods, labeling it as the home country and applying subscript $r \in \{d, ftz\}$ to represent the firms located outside or inside the FTZs respectively. The other $N-1$ foreign countries are symmetric. Household in the home country consumes both homogeneous good and non-traded differentiated final goods from the local producers. The preference of consumers is Dixit-Stiglitz in each location with the elasticity of substitution $\sigma > 1$. Wages in each location are pinned down by the productivity of the numeraire good.

Home country has an endogenous measure M_1^e of monopolistically competitive firms entering the market, each paying an entry cost F_1 and drawing productivity. The overhead costs structure of final producers is two-tier, after observing productivity, firms choose to pay f_d or a higher level cost f_{ftz} to produce in domestic or FTZs respectively, and both entry costs and overhead costs are measured in the units of the numeraire good. The productivity is drawn from the cumulative distribution function $G(\varphi)$. Given φ, a final producer faces a cost c_d/φ (c_{ftz}/φ) to produce in domestic (FTZs), where c_d and c_{ftz} are the prices of the input bundles. Thus, the prices of the final goods are $p_d = \frac{c_d}{\rho\varphi}$ and $p_{ftz} = \frac{c_{ftz}}{\rho\varphi}$ respectively.

Profits are monotonically increasing in productivity φ, only the relatively productive firms can cover the fixed cost f_{ftz} of entering into FTZs and enjoy the discounted trade costs, thus there are two productivity cutoffs φ_d^* and φ_{ftz}^*. Let $\rho = 1 - 1/\sigma$, the cut-off of entering FTZs is defined implicitly by the fact that the firm on the margin is indifferent to paying for an additional fixed cost to enter FTZs and staying as a domestic producer while facing higher trade costs. Thus, the cutoffs of productivity are derived from

$$(1-s_0)Y_1P_1^{\sigma-1}\left(c_{ftz}/\rho\varphi_{ftz}^*\right)^{1-\sigma}-(1-s_0)Y_1P_1^{\sigma-1}\left(c_d/\rho\varphi_{ftz}^*\right)^{1-\sigma}=\sigma\left(f_{ftz}-f_d\right)$$

$$(1-s_0)Y_1P_1^{\sigma-1}\left(c_d/\rho\varphi_d^*\right)^{1-\sigma}=\sigma f_d$$

where $1-s_0$ is the expenditure share of final goods in the home country and s_0 is the share of the numeraire good. P_1 is the price index of final goods in the home country and is defined as

$$P_1^{1-\sigma}=M_1^e\int_{\varphi_d^*}^{\varphi_{ftz}^*}\left(\frac{c_d}{\rho\varphi}\right)^{1-\sigma}dG(\varphi)+M_1^e\int_{\varphi_{ftz}^*}^{\infty}\left(\frac{c_{ftz}}{\rho\varphi}\right)^{1-\sigma}dG(\varphi)$$

The intermediate goods production follows closely Eaton and Kortum(2002), with one unit of labor per unit of output. The productivity follows the Frechet distribution $F_i(z)=e^{T_iz^{-\theta}}$, $\theta>1$. For simplicity, I assume the elasticity of substitution of intermediate goods is the same as final goods, and the composite of intermediate goods has a CES form $\left(\int_0^1 m_i(\nu)^{\frac{\sigma-1}{\sigma}}d\nu\right)^{\frac{\sigma}{\sigma-1}}$, where $m_i(\nu)$ is the quantity consumed of the variety ν. Thus, the prices of the intermediate composite faced by the domestic and FTZ producers are given by

$$P_d^M=\gamma\left(\sum_i T_i(d_{i1}\tau_{i1}w_i)^{-\theta}\right)^{-1/\theta}\triangleq\gamma\Phi_d^{-1/\theta}$$

$$P_{ftz}^M=\gamma\left(\sum_i T_i(d_{i1}\tau_{i1(ftz)}w_i)^{-\theta}\right)^{-1/\theta}\triangleq\gamma\Phi_{ftz}^{-1/\theta}$$

where the bilateral transportation cost d_{i1} is in an ice-berg manner, d_{i1} equal to 1 when $i=1$. The import tariff rates of intermediates are discounted by $\delta_{i1}=\delta(\Delta\tau_{i1})$ if the production of final goods conducted in FTZs, where $\Delta\tau_{i1}=\tau_{i1}-1$ and thus

$$\tau_{i1(ftz)}=\begin{cases}\delta_{i1}\tau_{i1} & \text{if } i\neq j\\ 1 & \text{if } i=1\end{cases}$$

The discount rate δ_{i1} is a decreasing function of tariff rate $\Delta\tau_{i1}$, τ_{i1} and δ_{i1} equal to 1 if $i=1$, indicating that the benefits with regard to the FTZs are amplified when facing an increasing tariff rate[10]. Denoting the share of intermediates sourced from country $i\neq 1$ of domestic and FTZ final producers as

$$\pi_{i1}=\frac{T_i(d_{i1}\tau_{i1}w_i)^{-\theta}}{\Phi_d}$$

$$\pi_{i1(ftz)}=\frac{T_i(d_{i1}\tau_{i1(ftz)}w_i)^{-\theta}}{\Phi_{ftz}}$$

The prices of the final goods input bundle are given by $c_d=(w_1)^{\alpha}\left(P_d^M\right)^{1-\alpha}$ and $c_{ftz}=(w_1)^{\alpha}\left(P_{ftz}^M\right)^{1-\alpha}$

[10]Based on the empirical identification sections, it was observed that FTZ firms were shielded from tariff shocks by the provision of cash-flow relief through temporary deferral of extra tariffs levied on domestically sold products. FTZ firms' Chinese inventories also increased in response to the tariff shocks and the non-paid duties contributed to the cash-flow "Cushion Effects". In addition, the volume of exports rose because the duties were exempted when transferring products abroad, referred to as expense-save "Cushion Effects". Therefore, the benefits of locating in the Zone are magnified during the trade war. Although the model does not account for the "Cushion Effects" resulting from both channels, it aligns with the observation that roughly 80% of the outputs are intended for domestic consumption.

for firms produce in domestic and FTZs respectively.

5.2 Model Implications

Based on the Pareto Distribution of productivity with shape parameter μ, $G(\varphi) = 1 - \varphi^{-\mu}$, the productivity cutoffs of production in domestic and FTZs can be written as

$$\varphi_d^* = \left[\frac{\sigma f_d}{(1-s_0)Y_1}\right]^{\frac{1}{\sigma-1}} \frac{c_d}{P_1\rho}$$
$$\varphi_{ftz}^* = \left[\frac{\sigma(f_{ftz} - f_d)}{(1-s_0)Y_1}\right]^{\frac{1}{\sigma-1}} \frac{1}{P_1\rho}\left(c_{ftz}^{1-\sigma} - c_d^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$$

Expressing the price indexes of intermediate goods as $P_{ftz}^M = \bar{\delta} P_d^M$, where $\bar{\delta} = \bar{\delta}(\{\delta_{i1}\}_{i\neq 1})$ is a function of all discount rates and can be expressed as

$$\bar{\delta} = \frac{P_{ftz}^M}{P_d^M} = (\frac{\Phi_{ftz}}{\Phi_d})^{-1/\theta} = \left(\frac{\sum_i(\delta_{i1})^{-\theta}T_i(d_{i1}\tau_{i1}w_i)^{-\theta}}{\sum_i T_i(d_{i1}\tau_{i1}w_i)^{-\theta}}\right)^{-1/\theta}$$

Then the relative value of the share of intermediates sourced from country $i \neq 1$ to domestic and FTZ final producers can be denoted as

$$\pi_R = \frac{\pi_{i1(ftz)}}{\pi_{i1}} = (\frac{\delta_{i1}}{\bar{\delta}})^{-\theta}$$

There are three critical lemmas of function $\bar{\delta}$[11], which lead to the main propositions corresponding to the empirical findings,

Lemma 1 *For each $i \neq 1$, $\bar{\delta} > \delta_{i1}$ and thus $\pi_R > 1$.*

Lemma 2 *For each $i \neq 1$, there is a lower bound $\underline{\delta}_{i1}^{'} = \frac{\pi_R - 1}{\pi_R/\delta_{i1}}\tau_{i1}^{-1}$, if $|\delta_{i1}^{'}| > \underline{\delta}_{i1}^{'}$, we have $\partial\bar{\delta}/\partial\tau_{i1} < 0$; otherwise, $\partial\bar{\delta}/\partial\tau_{i1} > 0$.*

Lemma 3 *For each $i \neq 1$ and $|\delta_{i1}^{'}| > \underline{\delta}_{i1}^{'}$, if $\pi_{i1} < \pi_{i1}^* = (\frac{\delta_{i1}}{\bar{\delta}})^{\theta+1}$ or $N > N^* = \pi_{i1}^{-\frac{1}{\theta+1}} + 1$, we have $|\partial\bar{\delta}/\partial\tau_{i1}| < |\delta_{i1}^{'}|$; if $\pi_{i1} > \pi_{i1}^*$ or $N < N^*$, there is an upper bound $\bar{\delta}_{i1}^{'} = \frac{\pi_{i1}\bar{\delta}(\pi_R - 1)}{\pi_{i1}\bar{\delta}(\pi_R/\delta_{i1}) - 1}\tau_{i1}^{-1}$ such that if $|\delta_{i1}^{'}| \in (\underline{\delta}_{i1}^{'}, \bar{\delta}_{i1}^{'})$, we have $|\partial\bar{\delta}/\partial\tau_{i1}| < |\delta_{i1}^{'}|$.*

Lemma 1 indicates that the aggregate discount rate $\bar{\delta}$ that FTZ firms obtain compared to their domestic counterparts is larger than the specific discount rate δ_{i1} on the intermediate good imported from country i because the local input is free from tariff and thus no discount applied to. Lemma 2 indicates that although the specific discount rate δ_{i1} decreases with increasing τ_{i1}, it does not necessarily produce a higher level of aggregate benefits for FTZ firms compared to domestic firms. This phenomenon can be attributed to the relatively greater use of goods subject to trade sanctions in the production processes of FTZ firms, and hence the more pronounced adverse effects suffered by these firms during the tariff war. Thus, the overall "Cushion Effects" measured by $\bar{\delta}$ depend on the level of sensitivity of the specific discount rate to the increments of tariff rate measured by $|\delta_{i1}^{'}|$. If it exceeds the lower bound $\underline{\delta}_{i1}^{'}$, we have the aggregate discount rate $\bar{\delta}$ decreases when facing a higher level of tariff rate τ_{i1}. The aggregate effects resulting from the increased tariff rate are determined by the relative size of negative effects from higher input costs and amplified "Cushion Effects". When the sensitivity of the specific discount rate function δ_{i1} is higher than an upper bound $\bar{\delta}_{i1}^{'}$, and FTZ firms use imports from country i intensively or the number of foreign exporters of intermediate goods is small, e.g. $\pi_{i1(ftz)} = \pi_R\pi_{i1} > \pi_R\pi_{i1}^*$ or $N < N^*$,

[11]Detailed proofs are in the Appendix.

the aggregate level of discount rate $\bar{\delta}$ is more sensitive than the good i's discount rate δ_{i1}. Otherwise, the aggregate level benefits are less sensitive than the specific benefits received when importing good i, as stated in Lemma 3.

In the sections of empirical findings, the extensive evidence shows that there was a net increase in the number of FTZ firms triggered by the additional shocks, indicating that the aggregate benefits of entering FTZs compared to operating as domestic producers increased during the trade war. In the model, these increased aggregate level benefits that alleviated tariff shocks are measured by variable $\bar{\delta}$. Considering Lemma 2, the extensive evidence infers that the sensitivity of discount rate function δ_{i1} to tariff rate τ_{i1} should be higher than the lower bound and thus $\partial\bar{\delta}/\partial\tau_{i1} < 0$. Further investigating the conditions of Lemma 3, the Chinese products imported by the US domestic firms accounted for 21.39% of the total imports in 2017, and using this number to approximate π_{i1} before the trade war, we have $N^* = \pi_{i1}^{-\frac{1}{\theta+1}} + 1 < \pi_{i1}^{-1} + 1 \approx 5.68$. The number of countries that exported to the US was obviously larger than 5.68 and thus $N > N^*$ leads $|\partial\bar{\delta}/\partial\tau_{i1}| < |\delta_{i1}^{'}|$, according to Lemma 3.

Given stylized facts in the data, we have the first-order derivations of aggregate-level and specific-level discount rate functions satisfying $\partial\bar{\delta}/\partial\tau_{i1} < 0$ and $|\partial\bar{\delta}/\partial\tau_{i1}| < |\delta_{i1}^{'}|$ under the assumption that $|\delta_{i1}^{'}| > \underline{\delta}_{i1}^{'}$, the main empirical evidence identified is derived based on this two-tier Melitz-type model,

Proposition 1 *If the import tariff imposed on the intermediate good from country i increases,* $|\delta_{i1}^{'}| > \underline{\delta}_{i1}^{'}$ *and* $N > N^*$*, the productivity cutoff of FTZ producers decreases, that is*

$$\frac{\partial\varphi_{ftz}^*}{\partial\tau_{i1}} < 0$$

Proposition 2 *If the import tariff imposed on the intermediate good from country i increases,* $|\delta_{i1}^{'}| > \underline{\delta}_{i1}^{'}$ *and* $N > N^*$*, the share of intermediate good sourced from i in FTZ firms increases relative to domestic firms, that is*

$$\partial\pi_R/\partial\tau_{i1} > 0$$

Proposition 3 *If the import tariff imposed on the intermediate good from country i increases,* $|\delta_{i1}^{'}| > \underline{\delta}_{i1}^{'}$ *and* $N > N^*$*, there will be a larger share of final goods consumed that are produced from FTZ producers compared to the domestic producers, that is*

$$\partial\left(\frac{\bar{r}_d}{\bar{r}_{ftz}}\right)/\partial\tau_{i1} < 0$$

Propositions 1 to Proposition 3 connect the intensive and extensive empirical evidence of "Cushion Effects" through the model. Given the assumption that the sensitivity level of discount rate function δ_{i1} be larger than a lower bound, the negative effects resulting from the increased duties on the sanctioned intermediate products are offset by the amplified "Cushion Effects" received by FTZ firms, and thus the extensive evidence that more firms entered into zones for protection is verified in Proposition 1. The increased share of Chinese products imported by the FTZ firms compared to the shrinking portion of sanctioned intermediate goods used by domestic firms during the trade war, as Figure 1 displays, is the results stated in Proposition 2. Lastly, Bown et al. (2021*b*) documented the stylized facts that tariffs have large negative effects, decreasing sales in the US industries to the domestic market. On contrary, recalling the intensive evidence identified in the zone-level empirical model, the shipment volumes of Chinese products to the home market of FTZ firms respond positively to the tariff shocks, especially the newly entered firms. Proposition 3 exactly interprets the opposite effects of extra duties on firms' sales inside or outside the FTZs to the home country.

5.3 Discount Rate Function and Comparative Statistics

In the Model Implications Section, given the amplification rate of FTZ benefits be larger than a lower bound, applying to manufacture in the FTZs is a duty-saving choice for the firm with a high level of productivity. The existence of such discount rate function and more implications of the comparative statistics about the critical variables in the model are discussed in this section[12].

5.3.1 Existence of Discount Rate Function

The discount rate function $\delta_{i1} = \delta(\Delta\tau_{i1}) \in (0, 1]$ satisfies: (i)decreasing in tariff rate increment $\Delta\tau_{i1} = \tau_{i1} - 1$, and $\delta_{i1}(0) = 1$, $\delta_{i1}(\infty) \to 0$; (ii) $\delta^{'}_{i1}|_{\Delta\tau_{i1}} = \delta^{'}_{i1}|_{\tau_{i1}} > \underline{\delta}^{'}_{i1}$ and $\underline{\delta}^{'}_{i1} = \frac{\pi_R - 1}{\pi_R/\delta_{i1}}\tau_{i1}^{-1} < 1$. The example function is

$$
\begin{aligned}
\delta_{i1} &= \frac{2/a}{\sqrt{a\Delta\tau_{i1}} + 1} + (1 - 2/a) \\
\delta^{'}_{i1} &= (a\Delta\tau_{i1})^{-1/2}(\sqrt{a\Delta\tau_{i1}} + 1)^{-2}
\end{aligned}
$$

For example, if $a = 3$, the tariff rate $\Delta\tau^{*}_{i1} = 0.072$ satisfies $|\delta^{'}_{i1}(\Delta\tau^{*}_{i1})| = 1$, and τ^{*}_{i1} decreases in a. Thus, given the initial tariff rate level $\Delta\tau_{i1}$, the properties of the discount rate function can be satisfied by adjusting the value of parameter a. Based on this specific form of the discount rate function, the general equilibrium of the model can be solved.

5.3.2 Comparative Statistics

Proposition 4 investigates the effects of the sensitivity of the discount rate on the costs of firms' final good production, the higher costs paid by producers will finally pass on to the consumers.

Proposition 4 *If $|\delta^{'}_{i1}| > \underline{\delta}^{'}_{i1}$ and $N > N^{*}$, when τ_{i1} increases, there are cutoffs $\delta^{*}_{i1} = \frac{\pi_R + c(\bar{\delta})^{-1} - 1}{\pi_R/\delta_{i1}}\tau_{i1}^{-1}$ and $\delta^{**}_{i1} = \delta_{i1}\tau_{i1}^{-1}$, where $c(\bar{\delta}) = (1 - \bar{\delta}^{(1-\alpha)(\sigma-1)})^{-1}$ and satisfying $\delta^{**}_{i1} > \delta^{*}_{i1} > \underline{\delta}^{'}_{i1}$, such that: (i) if $|\delta^{'}_{i1}| \in (\underline{\delta}^{'}_{i1}, \delta^{*}_{i1})$, we have $c_{ftz}^{1-\sigma} - c_{d}^{1-\sigma}$ decreases, P^{M}_{ftz} increases; (ii) if $|\delta^{'}_{i1}| \in (\delta^{*}_{i1}, \delta^{**}_{i1})|$, we have $c_{ftz}^{1-\sigma} - c_{d}^{1-\sigma}$ increases, P^{M}_{ftz} increases; (iii) if $|\delta^{'}_{i1}| > \delta^{**}_{i1}$, we have $c_{ftz}^{1-\sigma} - c_{d}^{1-\sigma}$ increases, P^{M}_{ftz} decreases.*

The difference between the unit input bundle costs $c_{ftz}^{1-\sigma} - c_{d}^{1-\sigma}$ is lower if c_{ftz} increases more than c_d. When tariff rate τ_{i1} increases and the discount rate function is not sensitive as the case 1, this difference decreases because, for FTZ firms, their relatively larger negative effects from the extra tariff rate exceed the "Cushion Effects". Along with the increasing $|\delta^{'}_{it}|$, the "Cushion Effects" provided by FTZs dominate and finally reduce the aggregate price of the intermediate composite consumed in the zones.

If the amplification rate $|\delta^{'}_{i1}|$ is at a moderate level, e.g. case 2 in Proposition 4, both firms inside or outside FTZs suffer from tariff shocks because their costs of the composite of intermediate goods increase. Protected under the "Cushion Effects" from the zones, the unit input bundle cost of FTZ firms increases less than their domestic counterparts. For an even larger amplification rate, FTZ firms spend less to buy one unit of the intermediate composite compared to the pre-tariff war period.

The aggregate price of final products P_1 depends on the additional fixed costs paid to join FTZs as well as the amplification rate of the discount rate function. If δ_{i1} is insensitive, the negative effects dominate the amplified "Cushion Effects" for FTZ firms, and the final goods are more expensive for consumers. When the "Cushion Effects" received by FTZ firms are significant enough, the protection can produce positive effects on the consumers if the extra fixed costs paid to enter FTZs are lower. Proposition 5 summarizes these consumer-side effects.

[12]Detailed proofs of Proposition 4 and Proposition 5 are in the Appendix.

Proposition 5 *If $|\delta_{i1}^{'}| > \underline{\delta}_{i1}^{'}$ and $N > N^*$, when τ_{i1} increases, there is cutoff $\delta_{i1}^* = \frac{\pi_R + c(\bar{\delta})^{-1} - 1}{\pi_R/\delta_{i1}} \tau_{i1}^{-1}$, where $c(\bar{\delta}) = (1 - \bar{\delta}^{(1-\alpha)(\sigma-1)})^{-1}$ and satisfying $\delta_{i1}^* > \underline{\delta}_{i1}^{'}$, such that: (i) if $|\delta_{i1}^{'}| \in (\underline{\delta}_{i1}^{'}, \delta_{i1}^*)$, we have $c_{ftz}^{1-\sigma} - c_d^{1-\sigma}$ decreases, P_1 increases; (ii) if $|\delta_{i1}^{'}| > \delta_{i1}^*$ and $f_{ftz} - f_d$ is large, we have $c_{ftz}^{1-\sigma} - c_d^{1-\sigma}$ increases, P_1 increases; (iii) if $|\delta_{i1}^{'}| > \delta_{i1}^*$ and $f_{ftz} - f_d$ is small, we have $c_{ftz}^{1-\sigma} - c_d^{1-\sigma}$ increases, P_1 decreases.*

Looking at case 2 of Proposition 5 when the amplification rate is at a moderate level, FTZ firms are relatively less affected by the tariff shocks and thus the most productive domestic firms transfer their production activities to the zones. The lower the extra costs of operating in FTZs are, the larger the number of relocated firms, producing larger total "Cushion Effects" which offset the total negative effects, and the welfare of consumers increases during the tariff war. Early work in this literature includes Amiti, Redding and Weinstein (2019*b*) and Fajgelbaum et al. (2019) who find near-complete pass-through of U.S. tariff increases to domestic prices, implying welfare losses, though of a relatively small magnitude. In the model that combines FTZ producers in the analysis, the loss of welfare is attributed to the great barrier for firms to get access to protection in the zones, as in case 3 of Proposition 5.

By comprehensively investigating the results of propositions and lemmas, more implications can be obtained. Firstly, given the insensitive discount rate function, e.g. $|\delta_{i1}^{'}| \in (\underline{\delta}_{i1}^{'}, \delta_{i1}^*)$. Prior to the trade war, the protected firms consume more foreign intermediate goods from country i because of the discounted tariffs imposed, thus the negative effects from extra duties are larger on them. Due to the insignificant "Cushion Effects" reflected in the small $|\delta_{i1}^{'}|$, producers in the zones suffer larger increases in their tariffs compared to the domestic firms, as in case 1 of Proposition 4. Noting that the additional duties are finally paid by consumers rather than FTZ firms, and P_1 is higher as the case 1 of Proposition 5. Therefore, under the amplified benefits of FTZ firms in purchasing foreign inputs (as $\bar{\delta}$ decreases), joining FTZs is more profitable for productive domestic firms as Proposition 1 indicates. For the moderate level amplification rate, e.g. $|\delta_{i1}^{'}| \in (\delta_{i1}^*, \delta_{i1}^{**})$, "Cushion Effects" offset a great share of tariff-related surcharges, making FTZ firms spend less on extra duties when purchasing one unit of input bundle. If the extra fixed costs charged to manufacture in FTZs are affordable, the extensive effects of more new entrants to the zones create a greater amount of duty reductions, these positive effects spread to the whole market profoundly which makes consumers better off. Along with a further rising amplification rate, the expense on per-unit intermediate goods drops for FTZ firms. Also, final products are less costly for consumers when this strong protection is easily obtainable for domestic producers.

6 Conclusion

Foreign Trade Zones (FTZs) are established to offer firms tariff-related benefits when importing foreign products. Due to the widespread tariff inversions, US firms heavily reliant on foreign products for production are incentivized to manufacture in FTZs. The cost savings and streamlined importing process afforded by FTZs enhance their competitiveness in more interconnected trading markets. The US-China trade war resulted in significant additional tariffs being imposed on US producers when importing Chinese products, and FTZ firms were prevented from utilizing the lower tariff rates between components and products. However, the remaining two channels of "Cushion Effects" still play a vital role to mitigate tariff burdens, firms utilized these zones to defer and exempt duty payments, thus shielding themselves from policy shocks. The literature documents that the tariff war escalated production costs and harmed social welfare can magnify the adverse impact considering the importance of FTZ in sourcing foreign products.

By studying the complied zone-level data, the evidence of the existence of "Cushion Effects" is presented in Section 3. On the intensive margin, FTZ firms' sales to both foreign and domestic markets experienced a notable uptick during the tariff war, and such an upward trend can be attributed to the considerable positive effects of tariff shocks over the zones. The effects of these tariff shocks are more prominent when focusing on newly entered producers during the tariff war, who also demonstrate a proclivity to stockpile products to benefit from the short-term deferral of additional duties. On the extensive margin, our identification results suggest that the introduction of supplementary tariffs played a significant role in attracting new firms to the FTZs during the US-China trade war. However, the number of pre-existing firms operating in FTZs was not influenced by the occurrence of tariff shocks but rather was drawn in by the prospect of reduced tariff rates available before the trade war. The "Cushion Effects" provided by FTZs are quantitatively measured by the amount of duty exempted, temporarily deferred, and non-paid by the end of the year, and are positively correlated with the zone-level tariff shocks.

A comparative analysis of import behaviors between firms operating within and outside of FTZs provide additional evidence on the protective effects of these zones against escalated tariffs. By examining monthly import data across products classified under the HTS10 code, it is observed that Chinese imports as a share of total foreign imports have steadily increased within FTZs while experiencing a significant decline among domestic firms. The stylized facts identified by the quantitative model in Section 4 show that non-FTZ firms responded to the trade war by bringing forward the timing of the importing process and increasing import volumes before the new tariffs came into effect. With the onset of the tariff war, non-FTZ producers showed a tendency to substitute the domestic and non-affected foreign sources of inputs for their Chinese counterparts. While those effects on FTZ producers have a much smaller magnitude, which further confirms that "Cushion Effects" have alleviated the tariff shocks. The robustness of empirical identifications is tested by controlling other rounds of tariff waves aimed at other countries. Decomposing the overall effects according to products' categories (intermediate and consumption products), or lists belonged to, the results are consistent. The replaced sanctioned products are primarily final goods rather than intermediate components. And FTZ firms always expanded their imports of high-tech intermediates in Lists 2 under the protection, which explains their great increase in the Chinese import volume during the trade war.

Motivated by the empirical findings and based on the model setup of Melitz (2003) and Eaton and Kortum (2002), a two-layer Melitz-type model using the decreasing discount rate function with regard to tariff rate is proposed to describe the amplified "Cushion Effects" during the trade war. In light of the reduced tariff rates, FTZ firms have a greater propensity to procure foreign products, thereby facing substantial adverse repercussions from tariff shocks. However, if the sensitivity of a particular discount rate assigned to a sanctioned product surpasses a certain threshold, the augmented levies are counterbalanced by the ample cushion effects, consequently reducing the cost of procuring an intermediate composite unit for firms located within the zones. Considering a large number of US importers and the reality that extra duties are ultimately borne by consumers, domestic firms engaged in production have opted to locate within FTZs due to their heightened profitability. And both the share of sanctioned goods purchased by FTZ firms and their sales of final products increases compared with the domestic producers, which corresponds to the empirical identification results. In this case, FTZ firms bear a lesser burden of additional duties compared to their non-FTZ counterparts, if the entry barrier to the zones is low, it can lead to a net welfare gain for consumers as the overall reduction of aggregate duties paid. These findings imply that the government may consider enhancing the protection provided by FTZs by relaxing the criteria for entry.

The newly compiled data of FTZ firms enable the identification of "Cushion Effects" in several dimensions, and quantitative results of US FTZs were rare in previous literature. Motivated by the protections provided to FTZ firms in both intensive and extensive margins, the negative effects of the US-China trade war can be alleviated as about 30% of the US imports are sourced through the Zones.

Embedding the features of FTZ producers in a two-tier Melitz-type model and the derived micro-side implications and comparative statistics are compensation of Grant (2020) about the tariff policy of US FTZs.

References

Akinci, Gokhan, and James Crittle. 2008. "Special economic zone: performance, lessons learned, and implication for zone development." The World Bank.

Alder, Simon, Lin Shao, and Fabrizio Zilibotti. 2016. "Economic reforms and industrial policy in a panel of Chinese cities." *Journal of Economic Growth*, 21: 305–349.

Amiti, Mary, Stephen J Redding, and David E Weinstein. 2019*a*. "The impact of the 2018 tariffs on prices and welfare." *Journal of Economic Perspectives*, 33(4): 187–210.

Amiti, Mary, Stephen J. Redding, and David E. Weinstein. 2019*b*. "The Impact of the 2018 Tariffs on Prices and Welfare." *Journal of Economic Perspectives*, 33(4): 187–210.

Bell, Tom W. 2016. "Special Economic Zones in the United States: From Colonial Charters, to Foreign-Trade Zones, Toward USSEZs." *Buff. L. Rev.*, 64: 959.

Bobonis, Gustavo J, and Howard J Shatz. 2007. "Agglomeration, adjustment, and state policies in the location of foreign direct investment in the United States." *The Review of Economics and Statistics*, 89(1): 30–43.

Bown, Chad P. 2019. "The 2018 US-China trade conflict after forty years of special protection." *China Economic Journal*, 12(2): 109–136.

Bown, Chad P, Paola Conconi, Aksel Erbahar, and Lorenzo Trimarchi. 2021*a*. "Trade protection along supply chains."

Bown, Chad P., Paola Conconi, Aksel Erbahar, and Lorenzo Trimarchi. 2021*b*. "Trade Protection Along Supply Chains."

Boyenge, Jean-Pierre Singa, et al. 2007. *ILO database on export processing zones (revised).* ILO Geneva.

Brooks, Wyatt J, Joseph P Kaboski, and Yao Amber Li. 2016. "Growth policy, agglomeration, and (the lack of) competition." National Bureau of Economic Research.

Caliendo, Lorenzo, and Fernando Parro. 2015. "Estimates of the Trade and Welfare Effects of NAFTA." *The Review of Economic Studies*, 82(1): 1–44.

Cavallo, Angelo, Antonio Ghezzi, and Raffaello Balocco. 2019. "Entrepreneurial ecosystem research: Present debates and future directions." *International entrepreneurship and management journal*, 15: 1291–1321.

Din, Musleh-ud. 1994. "Export processing zones and backward linkages." *Journal of Development Economics*, 43(2): 369–385.

Eaton, Jonathan, and Samuel Kortum. 2002. "Technology, Geography, and Trade." *Econometrica*, 70(5): 1741–1779.

Fajgelbaum, Pablo D, Pinelopi K Goldberg, Patrick J Kennedy, and Amit K Khandelwal. 2019. "The Return to Protectionism*." *The Quarterly Journal of Economics*, 135(1): 1–55.

Fajgelbaum, Pablo D, Pinelopi K Goldberg, Patrick J Kennedy, and Amit K Khandelwal. 2020. "The return to protectionism." *The Quarterly Journal of Economics*, 135(1): 1–55.

Farole, Thomas, Gokhan Akinci, et al. 2011. *Special economic zones: progress, emerging challenges, and future directions.* World Bank Publications.

Flaaen, Aaron, Ali Hortaçsu, and Felix Tintelnot. 2020. "The production relocation and price effects of US trade policy: the case of washing machines." *American Economic Review*, 110(7): 2103–2127.

Flaaen, Aaron, and Justin R Pierce. 2019. "Disentangling the effects of the 2018-2019 tariffs on a globally connected US manufacturing sector."

Ghosh, Sucharita, C Lockwood Reynolds, and Shawn M Rohlin. 2016. "The spillover effects of United States foreign trade zones." *Applied Economics*, 48(43): 4112–4130.

Grant, Matthew. 2020. "Why Special Economic Zones? Using Trade Policy to Discriminate across Importers." *American Economic Review*, 110(5): 1540–71.

Grossman, Gene M., and Elhanan Helpman. 1994. "Endogenous Innovation in the Theory of Growth." *Journal of Economic Perspectives*, 8(1): 23–44.

Hamada, Koichi. 1974. "An economic analysis of the duty-free zone." *Journal of international Economics*, 4(3): 225–241.

Hamilton, Carl, and Lars EO Svensson. 1982. "On the welfare effects of a 'duty-free zone'." *Journal of international Economics*, 13(1-2): 45–64.

Handley, Kyle, Fariha Kamal, and Ryan Monarch. 2020. "Rising import tariffs, falling export growth: when modern supply chains meet old-style protectionism." National Bureau of Economic Research.

Jayanthakumaran, Kankesu. 2003. "Benefit–cost appraisals of export processing zones: A survey of the literature." *Development Policy Review*, 21(1): 51–65.

Jiang, Yufan, Hongyan Wang, and Zuankuo Liu. 2021. "The impact of the free trade zone on green total factor productivity——evidence from the shanghai pilot free trade zone." *Energy Policy*, 148: 112000.

Koopman, Robert, Zhi Wang, and Shang-Jin Wei. 2008. "How Much of Chinese Exports is Really Made In China? Assessing Domestic Value-Added When Processing Trade is Pervasive." National Bureau of Economic Research Working Paper 14109.

Lane, Jesse M. 2020. "Foreign-Trade Zones in the Southeastern United States." *southeastern geographer*, 60(2): 141–158.

Lane, Jesse M, and Zhi-Jun Liu. 2022. "The Impact of Foreign-Trade Zones on County Level Development: A Temporal Analysis." *Papers in Applied Geography*, 8(4): 452–467.

Li, M. 2018. "CARD Trade War Tariffs Database." Available from: `https://www.card.iastate.edu/china/trade-war-data`.

Lu, Yi, Jin Wang, and Lianming Zhu. 2019. "Place-Based Policies, Creation, and Agglomeration Economies: Evidence from China's Economic Zone Program." *American Economic Journal: Economic Policy*, 11(3): 325–60.

Melitz, Marc J. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica*, 71(6): 1695–1725.

Miyagiwa, Kaz F. 1986. "A reconsideration of the welfare economics of a free-trade zone." *Journal of International Economics*, 21(3-4): 337–350.

Moberg, Lotta. 2015. "The political economy of special economic zones." *Journal of institutional economics*, 11(1): 167–190.

Newman, Carol, and John M Page. 2017. "Industrial clusters: The case for special economic zones in Africa." WIDER Working Paper.

Seyoum, Belay. 2017. "US foreign trade zones and import intensity examining determinants of import intensity in US foreign trade zones." *European Business Review*, 29(1): 103–122.

Seyoum, Belay, and Juan Ramirez. 2012. "Foreign trade zones in the United States: A study with special emphasis on the proposal for trade agreement parity." *Journal of Economic Studies*, 39(1): 13–30.

Siroën, Jean-Marc, Ayçil Yücer, et al. 2014. "Trade performance of free trade zones." *Document De Travail*, 1–28.

UNCTAD. 2019. *World investment report 2019: Special economic zones.* UN.

Wang, Jin. 2013. "The economic impact of special economic zones: Evidence from Chinese municipalities." *Journal of development economics*, 101: 133–147.

Wong, Liana. 2019. "U.S. Foreign-Trade Zones: Background and Issues for Congress." Congressional Research Service R42686.

Yao, Daqing, and John Whalley. 2016. "The China (Shanghai) pilot free trade zone: Background, developments and preliminary assessment of initial impacts." *The World Economy*, 39(1): 2–15.

Young, Leslie. 1987. "Intermediate goods and the formation of duty-free zones." *Journal of Development Economics*, 25(2): 369–384.

Young, Leslie. 1991. "Unemployment and the optimal export-processing zone." *Journal of Development Economics*, 37(1-2): 369–385.

Young, Leslie, and Kaz F Miyagiwa. 1987. "Unemployment and the formation of duty-free zones." *Journal of Development Economics*, 26(2): 397–405.

Zeng, Douglas Zhihua. 2015. "Global experiences with special economic zones: Focus on China and Africa." *World Bank Policy Research Working Paper*, , (7240).

Zheng, Guo, Elisa Barbieri, Marco R Di Tommaso, and Lei Zhang. 2016. "Development zones and local economic growth: zooming in on the Chinese case." *China Economic Review*, 38: 238–249.

7 Appendix

7.1 Proof of Lemma 1 - Lemma 3

Lemma 1 As foreign countries are symmetric, the discount rates are equal and $\delta_{i1} \triangleq \delta_1,\ i \neq 1$. For $i = 1$, let $\delta_1 = 1$. Then $\bar{\delta}$ can be further expressed as

$$\bar{\delta} = \frac{P^M_{ftz}}{P^M_d} = \gamma \left(\sum_i \delta_1^{-\theta} T_i (d_{i1}\tau_{i1}w_i)^{-\theta} \right)^{-1/\theta} / P^M_d$$

If assuming that $\bar{\delta} < \delta_1$, we have

$$\begin{aligned} &\left(\delta_1^{-\theta} \sum_{i \neq 1} T_i (d_{i1}\tau_{i1}w_i)^{-\theta} + T_1(w_1)^{-\theta} \right)^{-1/\theta} < \delta_1 \left(\sum_i T_i (d_{i1}\tau_{i1}w_i)^{-\theta} \right)^{-1/\theta} \\ \Longrightarrow \quad & \delta_1^{-\theta} \sum_{i \neq 1} T_i (d_{i1}\tau_{i1}w_i)^{-\theta} + T_1(w_1)^{-\theta} > \sum_i \delta_1^{-\theta} T_i (d_{i1}\tau_{i1}w_i)^{-\theta} \\ \Longrightarrow \quad & T_1(w_1)^{-\theta} > \delta_1^{-\theta} T_1(w_1)^{-\theta} \end{aligned}$$

above inequality is contracting and thus $\bar{\delta} > \delta_{i1}$, $\pi_R = (\frac{\delta_{i1}}{\bar{\delta}})^{-\theta} > 1$. This property indicates that the FTZ producers' benefits of discounted input costs are weakened when taking into account the supply of domestic intermediate goods without trade costs.

Lemma 2 Taking partial derivation of price indexes of intermediate goods to $\tau_{i1},\ i \neq 1$, we have

$$\begin{aligned} \partial P^M_{ftz} / \partial \tau_{i1} &= P^M_{ftz} \pi_{i1(ftz)} (\delta'_{i1}/\delta_{i1} + \tau_{i1}^{-1}) \\ \partial P^M_d / \partial \tau_{i1} &= P^M_d \pi_{i1} \tau_{i1}^{-1} \end{aligned}$$

Thus the partial derivation of $\bar{\delta}$ to $\tau_{i1},\ i \neq 1$ is

$$\partial \bar{\delta} / \partial \tau_{i1} = \frac{(\partial P^M_{ftz}/\partial \tau_{i1}) P^M_d - (\partial P^M_d / \partial \tau_{i1}) P^M_{ftz}}{(P^M_d)^2} = \bar{\delta} \pi_{i1} \pi_R (\delta'_{i1}/\delta_{i1} + \tau_{i1}^{-1}) - \bar{\delta} \pi_{i1} \tau_{i1}^{-1}$$

Let $\partial \bar{\delta} / \partial \tau_{i1} < 0$, we have the lower bound

$$\underline{\delta}'_{i1} = \frac{\pi_R - 1}{\pi_R / \delta_{i1}} \tau_{i1}^{-1} > 0$$

Lemma 3 When $|\delta'_{i1}| > \underline{\delta}'_{i1}$ we have $|\partial \bar{\delta} / \partial \tau_{i1}| < 0$, and

$$|\partial \bar{\delta} / \partial \tau_{i1}| - |\delta'_{i1}| = (\bar{\delta} \frac{\pi_R}{\delta_{i1}} \pi_{i1} - 1) |\delta'_{i1}| - \bar{\delta} \pi_{i1} (\pi_R - 1) \tau_{i1}^{-1}$$

If $\pi_{i1} > (\bar{\delta} \frac{\pi_R}{\delta_{i1}})^{-1} = (\frac{\delta_{i1}}{\bar{\delta}})^{\theta+1} \triangleq \pi^*_{i1}$, let $|\partial \bar{\delta} / \partial \tau_{i1}| - |\delta'_{i1}| < 0$ we have the upper bound

$$\bar{\delta}'_{i1} = \frac{\pi_{i1} \bar{\delta} (\pi_R - 1)}{\pi_{i1} \bar{\delta} \frac{\pi_R}{\delta_{i1}} - 1} \tau_{i1}^{-1} > \underline{\delta}'_{i1}$$

If $\pi_{i1} < \pi^*_{i1}$, we have $|\partial \bar{\delta} / \partial \tau_{i1}| - |\delta'_{i1}| < 0$ given $|\delta'_{i1}| > \underline{\delta}'_{i1}$.

For $\pi_{i1} > \pi^*_{i1}$, we can further derive the detailed conditions embedded in this inequality under the symmetric assumption of foreign countries.

$$
\begin{aligned}
&\pi_{i1} > (\frac{\delta_{i1}}{\bar{\delta}})^{\theta+1} \\
\Rightarrow &\pi_{i1} > (\delta_{i1})^{\theta+1}(\Phi_{ftz}/\Phi_d)^{1+1/\theta} \\
\Rightarrow &\pi_{i1} > \left(\delta_{i1}^{\theta}((N-1)T_i\delta_{i1}^{-\theta}(d_{i1}\tau_{i1}w_i)^{-\theta} + T_1 w_1^{-\theta})(\Phi_d)^{-1}\right)^{1+1/\theta} \\
\Rightarrow &\pi_{i1} > \left(((N-1)T_i(d_{i1}\tau_{i1}w_i)^{-\theta} + \delta_{i1}^{\theta}T_1 w_1)(\Phi_d)^{-1}\right)^{1+1/\theta} \\
\Rightarrow &\pi_{i1} > 1 - (1-\delta_{i1}^{\theta}\pi_{11})^{1+1/\theta} \\
\Rightarrow &\delta_{i1}^{\theta} < 1 - \frac{1-\pi_{i1}^{\frac{\theta}{\theta+1}}}{\pi_{11}}
\end{aligned}
$$

The above inequality depends on the value of the left-hand side term, if we have

$$
\begin{aligned}
&\frac{1-\pi_{i1}^{\frac{\theta}{\theta+1}}}{\pi_{11}} > 1 \\
\Rightarrow &\pi_{11} + (N-1)\pi_{i1} - \pi_{i1}^{\frac{\theta}{\theta+1}} > \pi_{11} \\
\Rightarrow &(N-1)\pi_{i1}^{\frac{1}{\theta+1}} > 1 \\
\Rightarrow &N > \pi_{i1}^{-\frac{1}{\theta+1}} + 1
\end{aligned}
$$

When the number of countries N is larger than the lower bound $N^* \triangleq \pi_{i1}^{-\frac{1}{\theta+1}} + 1$, the competition among foreign exporters is strong and we can not have $\pi_{i1} > \pi_{i1}^*$. And otherwise, we have $\pi_{i1} > \pi_{i1}^*$ and thus we need the upper bound $\bar{\delta}_{i1}^{'}$ to ensure $|\partial\bar{\delta}/\partial\tau_{i1}| - |\delta_{i1}^{'}| < 0$.

7.2 Free Entry Condition

The expected revenues of domestic and FTZ firms are

$$
\begin{aligned}
\bar{r}_d &= \int_{\varphi_d^*}^{\varphi_{ftz}^*} \left(\frac{c_d/\rho\varphi}{P_1}\right)^{1-\sigma}(1-s_0)Y_1 dG_1(\varphi) = \frac{\mu_1}{\sigma-\mu_1-1}\left(\frac{c_d}{\rho P_1}\right)^{1-\sigma}(1-s_0)Y_1\left((\varphi_{ftz}^*)^{\sigma-\mu_1-1} - (\varphi_d^*)^{\sigma-\mu_1-1}\right) \\
\bar{r}_{ftz} &= \int_{\varphi_{ftz}^*}^{\infty} \left(\frac{c_{ftz}/\rho\varphi}{P_1}\right)^{1-\sigma}(1-s_0)Y_1 dG_1(\varphi) = \frac{\mu_1}{\sigma-\mu_1-1}\left(\frac{c_{ftz}}{\rho P_1}\right)^{1-\sigma}(1-s_0)Y_1\left(-(\varphi_{ftz}^*)^{\sigma-\mu_1-1}\right)
\end{aligned}
$$

Thus, we have The total revenue of a firm entering the market of country i is

$$
r_1 = M_1^e(\bar{r}_d + \bar{r}_{ftz})
$$

The expected fixed costs of domestic and FTZ firms are

$$
\begin{aligned}
\bar{f}_d &= \int_{\varphi_d^*}^{\varphi_{ftz}^*} c_d f_d dG_1(\varphi) = c_d f_d\left((\varphi_d^*)^{-\mu_1} - (\varphi_{ftz}^*)^{-\mu_1}\right) \\
\bar{f}_{ftz} &= \int_{\varphi_{ftz}^*}^{\infty} c_{ftz} f_{ftz} dG_1(\varphi) = c_{ftz} f_{ftz}\left((\varphi_{ftz}^*)^{-\mu_1}\right)
\end{aligned}
$$

The total fixed cost of a firm entering the market of country i is

$$
f_1 = M_1^e(\bar{f}_d + \bar{f}_{ftz})
$$

The zero profit conditions for the firms with cutoff productivity are

$$(1-s_0)Y_1P_1^{\sigma-1}\left(c_{ftz}/\rho\varphi^*_{ftz}\right)^{1-\sigma}-(1-s_0)Y_1P_1^{\sigma-1}\left(c_d/\rho\varphi^*_{ftz}\right)^{1-\sigma}=\sigma\left(f_{ftz}-f_d\right)$$

$$(1-s_0)Y_1P_1^{\sigma-1}\left(c_d/\rho\varphi^*_d\right)^{1-\sigma}=\sigma f_d$$

By plugging the equations of zero profit condition into the expected fixed cost $\bar{f}_i$ and comparing with the expected revenue expression, we have

$$r_1=\frac{\sigma\mu_1}{\mu_1+1-\sigma}f_1$$

Therefore, the total profit of final producers in the country i is

$$\pi_1=r_1/\sigma-f_1=\frac{\sigma-1}{\sigma\mu_1}r_1$$

Therefore, under Pareto distribution, the aggregate profit is a constant share $\frac{\sigma-1}{\sigma\mu_1}$ of sales revenue, and the free entry condition can be written as

$$\frac{\sigma-1}{\sigma\mu_1}(1-s_0)Y_1=M_1^eF_1$$

Furthermore, plugging the number of entrants $M_1^e=(1-s_0)\frac{\sigma-1}{\sigma\mu_1}\frac{Y_1}{F_1}$, we can write P_1 as

$$\begin{aligned}&P_1=\lambda J(c_d,c_{ftz})^{-1}\text{ where}\\&\lambda=\rho^{-1}\sigma^{1/(\sigma-1)}(\sigma-1)^{-1/\mu_1}(1-\sigma+\mu_1)^{1/\mu_1}((1-s_0)Y_1)^{1/(1-\sigma)}(F_1)^{1/\mu_1}>0\\&J(c_d,c_{ftz})=\left[(f_{ftz}-f_d)^{\frac{\sigma-1-\mu_1}{\sigma-1}}(c_{ftz}^{1-\sigma}-c_d^{1-\sigma})^{\frac{\mu_1}{\sigma-1}}+(f_d)^{\frac{\sigma-1-\mu_1}{\sigma-1}}c_d^{-\mu_1}\right]^{1/\mu_1}\end{aligned}$$

7.3 Proof of Proposition 1

We first prove the decreasing productivity cutoff of FTZ firms when τ_{i1} increases and $|\delta'_{i1}|>|\underline{\delta}'_{i1}|$. According to Lemma 2, we have $\partial\bar{\delta}/\partial\tau_{i1}<0$ and the FTZ cutoff can be expressed as

$$\varphi^*_{ftz}=\left[\frac{\sigma(f_{ftz}-f_d)}{(1-s_0)Y_1}\right]^{\frac{1}{\sigma-1}}\frac{1}{\rho}\frac{(\bar{\delta}^{(1-\alpha)(1-\sigma)}-1)^{\frac{1}{1-\sigma}}c_d}{P_1}\triangleq\left[\frac{\sigma(f_{ftz}-f_d)}{(1-s_0)Y_1}\right]^{\frac{1}{\sigma-1}}\frac{1}{\rho}\frac{k_1(\tau_{i1})}{k_2(\tau_{i1})}$$

where $k_1(\tau_{i1})=(\bar{\delta}^{(1-\alpha)(1-\sigma)}-1)^{\frac{1}{1-\sigma}}c_d$, $k_2(\tau_{i1})=P_1$. As $\Delta\tau_{i1}=\tau_{i1}-1$, we have $\partial\bar{\delta}/\partial\tau_{i1}=(\partial\bar{\delta}/\partial\Delta\tau_{i1})/(\partial\Delta\tau_{i1}/\partial\tau_{i1})=\partial\bar{\delta}/\partial\Delta\tau_{i1}$. Taking derivation of $\frac{k_1(\tau_{i1})}{k_2(\tau_{i1})}$,

$$\partial\left(\frac{k_1(\tau_{i1})}{k_2(\tau_{i2})}\right)/\partial\tau_{i1}=\frac{k_1'(\tau_{i1})k_2(\tau_{i1})-k_2'(\tau_{i1})k_1(\tau_{i1})}{(k_2(\tau_{i1}))^2}\qquad(3)$$

where

$$\begin{aligned}k_1'(\tau_{i1})&=(1-\alpha)k_1(\tau_{i1})(-\xi_1+\xi_2)\\k_2'(\tau_{i1})&=(1-\alpha)k_2(\tau_{i1})\left(m(-\xi_1)+\xi_2\right)\end{aligned}$$

and

$$\xi_1 = \frac{-\partial\bar{\delta}/\partial\tau_{i1}}{\bar{\delta}}(1-\bar{\delta}^{(1-\alpha)(\sigma-1)})^{-1} > 0$$

$$\xi_2 = \frac{T_i(d_{i1}\tau_{i1(d)}w_i)^{-\theta}}{\Phi_d}\tau_{i1}^{-1} = \pi_{i1(d)}\tau_{i1}^{-1} > 0$$

$$m = \frac{(f_{ftz}-f_d)^{\frac{\sigma-1-\mu_1}{\sigma-1}}(\bar{\delta}^{(1-\alpha)(1-\sigma)}-1)^{\frac{\mu_1}{\sigma-1}}}{(f_{ftz}-f_d)^{\frac{\sigma-1-\mu_1}{\sigma-1}}(\bar{\delta}^{(1-\alpha)(1-\sigma)}-1)^{\frac{\mu_1}{\sigma-1}}+(f_d)^{\frac{\sigma-1-\mu_1}{\sigma-1}}} < 1$$

Thus, the numerator of (1) is

$$k_1^{'}(\tau_{i1})k_2(\tau_{i1}) - k_2^{'}(\tau_{i1})k_1(\tau_{i1}) = (1-\alpha)k_1(\tau_{i1})k_2(\tau_{i1})(m-1)\xi_1 < 0$$

and I have proved that

$$\frac{\partial\varphi_{ftz}^*}{\partial\tau_{i1}} < 0$$

Similarly, for the productivity cutoff of domestic firms, it can be expressed as

$$\varphi_d^* = \left[\frac{\sigma f_d}{(1-s_0)Y_1}\right]^{\frac{1}{\sigma-1}}\frac{1}{\rho}\frac{c_d}{P_1} \triangleq \left[\frac{\sigma f_d}{(1-s_0)Y_1}\right]^{\frac{1}{\sigma-1}}\frac{1}{\rho}\frac{k_3(\tau_{i1})}{k_2(\tau_{i1})}$$

where $k_3(\tau_{i1}) = c_d$. Taking derivation of φ_d^* is equal to taking derivation of $\frac{k_3(\tau_{i1})}{k_2(\tau_{i1})}$,

$$\partial\left(\frac{k_3(\tau_{i1})}{k_2(\tau_{i2})}\right)/\partial\tau_{i1} = \frac{k_3^{'}(\tau_{i1})k_2(\tau_{i1}) - k_2^{'}(\tau_{i1})k_3(\tau_{i1})}{(k_2(\tau_{i1}))^2}$$

where

$$k_3^{'}(\tau_{i1}) = (1-\alpha)k_3(\tau_{i1})\xi_2$$

Thus, the numerator of (2) is

$$k_3^{'}(\tau_{i1})k_2(\tau_{i1}) - k_2^{'}(\tau_{i1})k_3(\tau_{i1}) = (1-\alpha)k_2(\tau_{i1})k_3(\tau_{i1})m\xi_1 > 0$$

and I have proved that

$$\frac{\partial\varphi_d^*}{\partial\tau_{i1}} > 0$$

7.4 Proof of Proposition 2

The relative share of intermediates sourced from i is

$$\pi_R^{-1} = \left(\frac{\bar{\delta}}{\delta}\right)^{-\theta}$$

Taking derivation of above equation to τ_{i1}

$$\partial\pi_R^{-1}/\partial\tau_{i1} = -\theta\left(\frac{\bar{\delta}}{\delta_{i1}}\right)^{-\theta-1}\delta_{i1}^{-2}\left(\frac{\partial\bar{\delta}}{\partial\tau_{i1}}\delta_{i1} - \delta_{i1}^{'}\bar{\delta}\right) < 0$$

Under conditions of Lemma 2 and Lemma 3, we have $\partial\bar{\delta}/\partial\tau_{i1} < 0$ and $|\partial\bar{\delta}/\partial\tau_{i1}| < |\delta_{i1}^{'}|$, together with $\bar{\delta} > \delta_{i1}$ proved in Lemma 1, the inequality of Proposition 2 is obtained.

7.5 Proof of Proposition 3

$$\frac{\bar{r}_d}{\bar{r}_{ftz}} = \left(\frac{P_d^M}{P_{ftz}^M}\right)^{(1-\alpha)(1-\sigma)} \frac{\varphi_{ftz}^{*\ \sigma-\mu_1-1} - \varphi_d^{*\sigma-\mu_1-1}}{-\varphi_{ftz}^{*\ \sigma-\mu_1-1}} = (\frac{1}{\bar{\delta}})^{(1-\alpha)(1-\sigma)} \left[-1 + \left(\frac{\varphi_d^*}{\varphi_{ftz}^*}\right)^{\sigma-\mu_1-1}\right] \triangleq k_4(\tau_{i1})k_5(\tau_{i1})$$

Given the condition of Lemma 2, we have $\partial\bar{\delta}/\partial\tau_{i1} < 0$. Taking derivation of the above equation, we have

$$\partial\left(\frac{\bar{r}_d}{\bar{r}_{ftz}}\right)/\partial\tau_{i1} = k_4^{'}(\tau_{i1})k_5(\tau_{i1}) + k_5^{'}(\tau_{i1})k_4(\tau_{i1})$$

where

$$k_4^{'}(\tau_{i1}) = (1-\alpha)(\sigma-1)k_4(\tau_{i1})(\partial\bar{\delta}/\partial\tau_{i1})/\bar{\delta} < 0$$
$$k_5^{'}(\tau_{i1}) = (\sigma-\mu_1-1)\left(\frac{\varphi_d^*}{\varphi_{ftz}^*}\right)^{\sigma-\mu_1-2}\left[\frac{\partial\varphi_d^*}{\partial\tau_{i1}}\frac{1}{\varphi_{ftz}^*} - \frac{\varphi_d^*}{(\varphi_{ftz}^*)^2}\frac{\partial\varphi_{ftz}^*}{\partial\tau_{i1}}\right] < 0$$

Thus, I have proved that

$$\partial\left(\frac{\bar{r}_d}{\bar{r}_{ftz}}\right)/\partial\tau_{i1} < 0$$

7.6 Proof of Proposition 4 and Proposition 5

In the proof of Proposition 1, the first derivative of $k_1(\tau_{i1}) = (c_{ftz}^{1-\sigma} - c_d^{1-\sigma})^{\frac{1}{1-\sigma}}$ is

$$k_1^{'}(\tau_{i1}) = (1-\alpha)k_1(\tau_{i1})(-\xi_1 + \xi_2) \triangleq (1-\alpha)k_1(\tau_{i1})\xi(\delta_{i1}^{'})$$

where

$$\xi(\delta_{i1}^{'}) = \frac{\partial\bar{\delta}/\partial\tau_{i1}}{\bar{\delta}}(1-\bar{\delta}^{(1-\alpha)(\sigma-1)})^{-1} + \pi_{i1(d)}\tau_{i1}^{-1} \triangleq [\pi_{i1(ftz)}(\frac{\delta_{i1}^{'}}{\delta_{i1}} + \tau_{i1}^{-1}) - \pi_{i1}\tau_{i1}^{-1}]c(\bar{\delta}) + \pi_{i1}\tau_{i1}^{-1}$$

Plug $\underline{\delta}_{i1}^{'}$ and $\bar{\delta}_{i1}^{'}$ into $\xi(\delta_{i1}^{'})$, we have

$$\xi(\underline{\delta}_{i1}^{'}) = \pi_{i1}\tau_{i1}^{-1} > 0$$
$$\xi(\bar{\delta}_{i1}^{'}) = \pi_{i1}\tau_{i1}^{-1}(\frac{1-\pi_R}{\pi_{i1}\bar{\delta}(\pi_R/\delta_{i1})}c(\bar{\delta}) + 1)$$

If $\xi(\bar{\delta}_{i1}^{'}) < 0$, we have

$$\pi_{i1} < \pi_{i1}^{**} = \frac{\delta_{i1}}{\bar{\delta}}[(\pi_R - 1)c(\bar{\delta}) + 1]\pi_R^{-1}$$

As $\pi_{i1}^{**} > \pi_R^{-1}$ (the upper bound of π_{i1} as $\pi_{i1(ftz)} = \pi_R\pi_{i1} < 1$) and $|\frac{1-\pi_R}{\pi_{i1}\bar{\delta}(\pi_R/\delta_{i1})}c(\bar{\delta})|$ increase in π_{i1}, we have $\xi(\bar{\delta}_{i1}^{'}) < 0$ for any $\pi_{i1} < \pi_R^{-1}$. Furthermore, we can find δ_{i1}^* such that $\xi(\delta_{i1}^*) = 0$, which is

$$\delta_{i1}^* = -\frac{\pi_R + c(\bar{\delta})^{-1} - 1}{\pi_R/\delta_{i1}}\tau_{i1}^{-1}$$

The first derivative of P_{ftz}^M is

$$\partial P_{ftz}^M/\partial\tau_{i1} = P_{ftz}^M\pi_{i1(ftz)}(\frac{\delta_{i1}^{'}}{\delta_{i1}} + \tau_{i1}^{-1})$$

Plug $\underline{\delta}_{i1}^{'}$ and $\bar{\delta}_{i1}^{'}$ into $\partial P_{ftz}^{M}/\partial \tau_{i1}$, we have

$$(\partial P_{ftz}^{M}/\partial \tau_{i1})|_{\underline{\delta}_{i1}^{'}} = \pi_R^{-1}\tau_{i1}^{-1} > 0$$
$$(\partial P_{ftz}^{M}/\partial \tau_{i1})|_{\bar{\delta}_{i1}^{'}} = \frac{-\delta_{i1}+\pi_{i1}\bar{\delta}}{\pi_{i1}\bar{\delta}\pi_R - \delta_{i1}}\tau_{i1}^{-1} < 0$$

The second inequality is because $\pi_{i1} < \pi_R^{-1} = (\frac{\delta_{i1}}{\bar{\delta}})^{\theta}$. We can find δ_{i1}^{**} such that $(\partial P_{ftz}^{M}/\partial \tau_{i1})|_{\delta_{i1}^{**}=0}$, which is

$$\delta_{i1}^{**} = -\delta_{i1}\tau_{i1}^{-1}$$

Compared the δ_{i1}^{*} and δ_{i1}^{**}, we have

$$|\delta_{i1}^{*}| < |\delta_{i1}^{**}|$$

Proposition 4 follows. Again from the proof of Proposition 1, we have the first derivative of $k_2(\tau_{i1}) = P_1$,

$$k_2^{'}(\tau_{i1}) = (1-\alpha)k_2(\tau_{i1})\left(m(-\xi_1)+\xi_2\right) \triangleq (1-\alpha)k_2(\tau_{i1})\tilde{\xi}(\delta_{i1}^{'})$$

where

$$m = \frac{(f_{ftz}-f_d)^{\frac{\sigma-1-\mu_1}{\sigma-1}}(\bar{\delta}^{(1-\alpha)(1-\sigma)}-1)^{\frac{\mu_1}{\sigma-1}}}{(f_{ftz}-f_d)^{\frac{\sigma-1-\mu_1}{\sigma-1}}(c_{ftz}^{1-\sigma}-c_d^{1-\sigma})^{\frac{\mu_1}{\sigma-1}}+(f_d)^{\frac{\sigma-1-\mu_1}{\sigma-1}}c_d^{-\mu_1}} < 1$$

m depends on the difference between fixed costs of FTZ and domestic firms $f_{ftz}-f_d$. When the difference is small, we have a large m as its power $\frac{\sigma-1-\mu_1}{\sigma-1} < 0$. Thus, the larger the m is, the closer the value of $\tilde{\xi}(\delta_{i1}^{'})$ is to $\xi(\delta_{i1}^{'})$. For example, if $\xi(\delta_{i1}^{'}) < 0$ and m is close to 1, we have $\xi(\delta_{i1}^{'}) < \tilde{\xi}(\delta_{i1}^{'}) < 0$, the aggregate "Cushion Effects" to consumers reflected by P_1 are relatively smaller. Proposition 5 summarizes other cases.