Firm-Level Origins of Tariff Pass-Through: Importer Heterogeneity and Welfare Decomposition

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Abstract

We develop a decomposition framework and use confidential U.S. Census data to show that pass-through to U.S. import prices during the U.S.–China trade dispute is incomplete among firms that continue importing the same products from the same countries. Previous findings of complete pass-through reflect a reallocation of imports toward higher-price firms and costlier new supplier relationships within product–country markets. We then build a model with firm-level import prices and sourcing strategies and estimate that most welfare losses arise from extensive-margin effects on the import price index, driven by sourcing adjustments of importers.

Keywords: Tariff pass-through, firm heterogeneity, welfare, trade policy, U.S.-China trade dispute.

JEL classification: F10, F30, F40, F51.

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1 Introduction

After decades of rising global integration, recent trade policies have sharply reversed this trend through substantial tariff increases. The most prominent example is the U.S.–China trade dispute, which involved one of the largest and most abrupt tariff escalations in recent history. Between 2018 and 2019, the United States imposed new import tariffs on roughly $450 billion of trade, raising the average tariff rate to 17% (Bekkers and Schroete, 2020). How import prices respond to these tariffs is central to evaluating the incidence of trade policy: tariff pass-through determines how the burden is shared between foreign exporters and domestic buyers, how trade patterns adjust, and ultimately how welfare is affected.

Recent studies find complete tariff pass-through to U.S. import prices, implying that foreign exporters did not adjust their prices and that U.S. importers fully bore the tariffs. This pattern appears widespread across sectors and products (Amiti et al., 2019b, 2020; Fajgelbaum et al., 2020). These findings are surprising: earlier work using similar methods typically documents incomplete pass-through and assumes that large economies such as the U.S. and China can influence prices. Although several explanations for complete pass-through have been proposed, there is far from a consensus on the underlying mechanisms (Fajgelbaum and Khandelwal, 2022). Existing studies rely primarily on aggregate product-country data and therefore overlook firm-level heterogeneity. Given firms' central role in importing, examining their heterogeneous adjustment to tariff increases can shed light on the mechanisms behind the finding of complete pass-through.

In this paper, we make two contributions. First, we develop an empirical decomposition framework that breaks aggregate tariff pass-through into firm-level adjustments in import prices, import shares, and sourcing strategies. We show that firm-level pass-through is incomplete, and that the gap between aggregate and firm-level pass-through is driven by the reallocation of import shares across firms facing different import prices as they adjust their sourcing strategies. Second, to highlight how firm heterogeneity shapes the welfare effects of tariffs, we develop a model, derive formulas for the first-order welfare effects of tariffs, and identify the data moments needed for welfare estimation. We find that the extensive-margin effect on the import price index—driven by firms' sourcing adjustments and omitted from previous welfare estimates based on aggregate datasets—is the main source of welfare

losses from the tariffs. Our empirical and theoretical framework illustrates how aggregate outcomes can mask important welfare-relevant firm-level heterogeneity and can be applied to other forms of pass-through.

We first decompose aggregate tariff pass-through to U.S. import prices, moving from the product–country level to the U.S. firm–product–country level. This decomposition is enabled by the unique scope of confidential data from the Longitudinal Firm Trade Transactions Database (LFTTD) of the U.S. Census Bureau. We classify firm–product–country observations as continuing pairs (firms that keep importing from a product–country market), starting pairs (firms that begin importing from a new product–country market), and ending pairs (firms that stop importing from a product–country market).

We find that tariff pass-through is incomplete among continuing pairs. This result is robust to defining trade pairs at either the product–country or exporter–product–country level, and does not depend on whether an importer is part of a global value chain or likely to switch varieties within a product–country market. Starting pairs pay higher prices than continuing pairs in normal times, and their price responses to tariff increases are not significantly different from those of continuing pairs. Although fewer starting pairs are formed after tariff hikes, they account for a larger share of total imports because more ending pairs occur. The rising import share of these high-price starting pairs contributes to complete aggregate tariff pass-through, and after tariff increases these high-price starting pairs are more likely to be formed by large firms. Therefore, the complete aggregate tariff pass-through to U.S. import prices is driven by the differential responses among heterogeneous U.S. importers within product-country markets.

To assess whether these heterogeneous responses are relevant for the welfare effects of tariff increases, we develop a model of importers. The model nests standard import frameworks but allows for firm-specific sourcing strategies, variety attributes, and import prices. After the tariff increase, firms endogenously adjust their import price, import quantity and sourcing strategies. In the model, U.S. firms sell goods to both households and other firms, with production relying on domestic intermediate inputs and, for those incurring fixed import costs, foreign intermediates as well. Foreign countries supply differentiated product varieties. Exogenous shocks to trade relationships and firm productivity lead firms to continually op-

timize their sourcing strategies over time. These firm-specific sourcing strategies reflect a trade-off: importing more varieties raises fixed import costs but also generates gains through increased variety and efficiency. Import prices are determined by three key elements: (i) the age of the trade relationship, with younger relationships paying higher prices; (ii) exporters' marginal costs, which can differ across U.S. importers because they purchase varieties with different attributes even within the same product–country market; and (iii) two-sided market power. Two-sided market power is shaped by a combination of exporters' oligopoly markups and importers' oligopsony markdowns, weighted by the importers' relative bargaining power. These markups and markdowns depend on the demand and supply elasticities, as well as the relative importance of each trading partner in the other's overall trade.

Based on the model, we derive a first-order welfare decomposition formula and show that the welfare impact of a tariff increase can be separated into (i) an import price index effect, (ii) a domestic variety substitution effect for both importers and non-importers, and (iii) a general equilibrium effect that captures the allocation between consumers' consumption and firms' production. The import price index effect itself can be further decomposed into (a) changes in import prices for continuing trade relationships (import price index intensive margin), and (b) adjustments in the import price index resulting from firms altering their sourcing strategies (import price index extensive margin). In particular, the reduction in imported variety of firms after a tariff increase, reflected by more ending pairs, contributes to welfare loss via an extensive margin in the import price index. Our welfare formula identifies data moments necessary for welfare estimation, including firm-level tariff pass-through and adjustments in sourcing strategies that affect aggregate tariff pass-through, firm size distribution, and the relative importance of each imported variety to the firm.

We then take the model to the data to quantify the welfare effects of a tariff increase and find that the import price index effect dominates both the domestic variety substitution effect and the general equilibrium effect. Our novel result is that, within the import price index effect, both the intensive and extensive margins reduce welfare, but the extensive margin—driven by firms adding or dropping varieties in response to tariffs—dominates. This extensive-margin channel is typically absent from welfare estimates based on aggregate trade flows. Our results therefore both highlight the role of firm sourcing strategies in explaining aggregate tariff pass-through and reveal a quantitatively important, previously understudied

source of welfare losses.

Previous analyses of the welfare effects of tariff increases typically assume complete aggregate tariff pass-through and abstract from importer heterogeneity. To illustrate how importer heterogeneity reshapes welfare implications, we shut it down in our model as a counterfactual. The comparison shows that, when importer heterogeneity is incorporated, welfare losses from tariff increases can be mitigated through the intensive margin of the import price index, because firm-level pass-through is incomplete. Meanwhile, importer heterogeneity can amplify welfare losses through the extensive margin: after a tariff increase, there is substantial variety reduction at the importer–product–country level, even though variety reduction at the product–country level is limited. Overall, the extensive-margin effect dominates. In addition, we extend the welfare formula to incorporate firm-level inefficiencies or distortions that are common in the data (e.g., output market power, such that U.S. firms charge variable markups), and show that modeling importer heterogeneity can further amplify the welfare loss of tariff increases due to additional output and input distortions induced by the tariff increase.

Besides welfare estimation, we also use our model to uncover the mechanisms behind our empirical findings. Our estimated model suggests that younger trade relationships pay higher prices and that fixed import costs are the main reason why starting pairs contribute to complete tariff pass-through. The intuition is as follows. After a tariff increase, the number of importers in each affected product–country market falls, especially among smaller firms that are less able to cover the fixed import costs. This raises the import share of starting firms, particularly large ones. Because new trade relationships tend to pay higher prices, their increased import shares following a tariff hike drive the observed complete aggregate tariff pass-through to import prices.

Related Literature. Our paper contributes to several strands of literature. First, there is a large literature on the incomplete pass-through of cost shocks (tariff or exchange rate) into import prices (cf. Fajgelbaum and Khandelwal, 2022). Existing theories explain incomplete pass-through by taking into account factors such as intermediate input costs, currency of invoicing, age of trade relationships, quality upgrading, and price complementarities among exporters, importers, or competitors, broadly defined, adjusting to exchange rate or tariff

changes (see, e.g., Amiti et al., 2014, 2019a, 2022; Auer and Schoenle, 2016; Heise, 2024; Ludema and Yu, 2016; Pennings, 2017). However, recent studies focusing on the U.S.-China trade dispute have found complete tariff pass-through (Amiti et al., 2019b, 2020; Cavallo et al., 2021; Fajgelbaum et al., 2020; Jiang et al., 2023; Jiao et al., 2024) using either U.S. or Chinese bilateral trade data.[1] Alviarez et al. (2023) instead take into account firm-level variation and specifically focus on the intensive margin adjustment of firms with fixed trade relationships, showing that ignoring two-sided market power can exaggerate tariff pass-through. Compared to previous studies that focus on specific channels, we develop an empirical decomposition framework that offers a new perspective on pass-through by considering both extensive and intensive margin responses. Importantly, we highlight the critical role of the extensive margin—firms switching import source countries or products in response to cost shocks—in explaining complete or even more-than-complete pass-through at the aggregate level. On the other hand, our decomposition framework can be flexibly adapted to study any form of heterogeneity within a product-country market, making it a powerful tool for a wide range of applications—including analyses of heterogeneous responses across regions to tariff increases or exchange rate pass-through.

Second, our paper contributes a new welfare formula and a rich quantitative model to the theoretical literature on importer dynamics (see, e.g., Alviarez et al., 2023; Blaum et al., 2018, 2019; Gopinath and Neiman, 2014; Halpern et al., 2015; Lu et al., 2024). Welfare analysis in importer models is rare. Existing models typically focus on specific channels and either examine firm-level import prices while assuming no adjustment in sourcing strategy, or allow for sourcing strategy adjustment but assume identical price changes across firms.[2] In contrast, we derive a welfare formula that identifies which data moments are relevant for welfare effects—a crucial contribution given the growing policy relevance of import tariffs and the increasing interest in understanding their impact on importing firms.[3] Our com-

[1] Cavallo et al. (2021) find complete tariff pass-through after controlling for exchange rates and the producer price index. Jiao et al. (2024) use data at the firm-product-country level in China, but only focus on one prefecture-level city due to data availability issues.

[2] See Table B.1 for a thorough summary.

[3] Although Arkolakis et al. (2012) show that the welfare effect of trade can be measured with aggregate data, we show that firm heterogeneity matters as firms' import intensities are not equalized. Blaum et al. (2018) show that the firm-level data on value added and domestic expenditure shares in material spending is sufficient to compute the change in consumer prices due to a shock to the import environment. In our paper, given that firm-level domestic expenditure shares in material spending are unobservable, we show how observable firm-level imports and tariff pass-through discipline the welfare effects of tariffs.

prehensive model, which incorporates many mechanisms established in the literature, helps reconcile macro-micro discrepancies in tariff pass-through and clarifies the welfare implications associated with each margin of firm adjustment. Of note, our welfare formula hinges on the assumption that firm technology or the attribute of imported variety are invariant to the tariff increase. As we focus on the short-run effect of tariff, this assumption is innocuous.

Third, our paper contributes new empirical evidence to the growing literature on trade policy and global supply chain disruptions. Several studies have emphasized the negative impact of tariff increases—via supply chain disruption—on imports (Handley et al., 2023; Monarch and Schmidt-Eisenlohr, 2023) and exports (Handley et al., 2025). There is also work documenting the reallocation of trade toward third countries or non-targeted products (Fajgelbaum et al., 2024). In line with this literature, we find that tariff increases lead to fewer new trade relationships and more frequent dissolutions of existing ones. We further document differences in import prices across firms and across continuing, starting, and ending trade relationships, which is important for understanding the gap between aggregate and firm-level pass-through.

Roadmap. The rest of the paper is organized as follows. Section 2 decomposes aggregate tariff pass-through using U.S. firm-product-country level data and presents new empirical facts. Section 3 outlines the model, details its mechanisms, and provides a first-order welfare decomposition formula that nests not only our model but also existing importer models. Section 4 brings the model to the data, assesses the relative importance of various mechanisms in shaping the welfare effects of tariff increases. Section 5 concludes.

2 Empirical Facts

In this section, we show that the tariff pass-through observed at the aggregate level masks underlying firm-level adjustments in import prices, import shares, and sourcing strategies.

2.1 Data

The baseline sample is constructed using data from Longitudinal Foreign Trade Transactions Database (LFTTD). LFTTD contains transaction-level data on imports for all import shipments above $2,000 and $250 for certain quota items, which is collected by U.S. Customs and Border Protection via import declaration form (U.S. Customs Forms 7501 and 7533). The Customs forms contain the importer's Employer Identification Number (EIN), detailed 10-digit Harmonized System product codes (HS10), import value, import quantity, tariff duties paid on each shipment, country of origin, date of the transaction, and whether the transaction is between related parties. This enables a direct link between observed import prices and realized tariff burdens, which is crucial for analyzing tariff pass-through.

We aggregate the LFTTD data to the monthly level, such that for each U.S. firm i, we observe imports of product j from country c in year-month t, with products defined at the HS10 level. The key variable in our analysis is the unit value at the firm-product-country level, which is defined as

$$p_{ijct} \equiv \frac{v_{ijct}}{m_{ijct}}, \tag{2.1}$$

where v_{ijct} denotes firm i's before-duty import value of product j from country c in year-month t, and m_{ijct} denotes the corresponding import quantity. This unit value represents the price charged by foreign exporters to the U.S. market.

We also compute a unit value at the product-country level by aggregating across all importing firms. This is defined as

$$p_{jct} \equiv \frac{v_{jct}}{m_{jct}} = \frac{\sum_{i \in \Omega_{jct}} v_{ijct}}{\sum_{i \in \Omega_{jct}} m_{ijct}}, \tag{2.2}$$

where Ω_{jct} denotes the set of firms that import product j from country c in year-month t.

It is direct that the product-country level unit value is a weighted average of firm-product-country level unit value:

$$p_{jct} = \sum_{i \in \Omega_{jct}} \frac{m_{ijct}}{\sum_{i \in \Omega_{jct}} m_{ijct}} \frac{v_{ijct}}{m_{ijct}} = \sum_{i \in \Omega_{jct}} x_{ijct} p_{ijct}, \tag{2.3}$$

where $x_{ijct} \equiv \frac{m_{ijct}}{\sum_{i \in \Omega_{jct}} m_{ijct}}$ denotes a firm i's import quantity share among all firms that import from the same product-country pair (j, c) in year-month t.

2.2 A Firm-Level Decomposition of Aggregate Tariff Pass-Through

In this section, we decompose aggregate tariff pass-through at the product-country level, as studied in the existing literature, down to the firm-product-country level. We proceed in two steps.

First, following Melitz and Polanec (2015), we decompose the change in the product–country-level unit value over time, $p_{jct'} - p_{jct}$, into the contributions of continuing, starting, and ending firm–product–country pairs, and then divide by p_{jct}:

$$\underbrace{\frac{p_{jct'} - p_{jct}}{p_{jct}}}_{\approx \Delta \ln(p_{jct})} = \underbrace{\frac{\bar{p}^S_{jct'} - \bar{p}^S_{jct}}{p_{jct}}}_{\text{Average Continuing}} + \underbrace{\frac{\sum_{i \in S_{jc}} (x_{ijct'} - \bar{x}^S_{jct'})(p_{ijct'} - \bar{p}^S_{jct'}) - \sum_{i \in S_{jc}} (x_{ijct} - \bar{x}^S_{jct})(p_{ijct} - \bar{p}^S_{jct})}{p_{jct}}}_{\text{Between Continuing}} + \underbrace{x^E_{jct'} \frac{p^E_{jct'} - p^S_{jct'}}{p_{jct}}}_{\text{Starting}} + \underbrace{x^X_{jct} \frac{p^S_{jct} - p^X_{jct}}{p_{jct}}}_{\text{Ending}}. \tag{2.4}$$

Average Continuing. The first component on the right-hand side of equation (2.4) stands for the changes in the unweighted average of unit value across firms that continue importing from a product-country pair from period t to period t'. Let S_{jc} be a set of firms that import product j from country c in both periods t and t', and let n^S_{jc} denote the size of set S_{jc}. Then $\bar{p}^S_{jct}$ is the unweighted average of unit value in the set S_{jc} in period t, given as $\bar{p}^S_{jct} \equiv \sum_{i \in S_{jc}} \frac{p_{ijct}}{n^S_{jc}}$.

Between Continuing. The second component captures the unit value changes induced by the reallocation of import shares among firms that continue importing from a product-country pair from period t to period t'. This component is non-degenerate as firms could face different unit values. Using a similar notation as above, $\bar{x}^S_{jct}$ is the unweighted average of import quantity share of firms in the set S_{jc} in period t: $\bar{x}^S_{jct} \equiv \sum_{i \in S_{jc}} \frac{x_{ijct}}{n^S_{jc}}$.

Starting. The third component captures the unit value changes arising from the difference in unit values between firms that newly start importing a product-country pair in period t'

and firms that continue importing this pair from period t to period t'.[4] This component is non-degenerate because starting and continuing pairs may have different unit values. Let E_{jc} denote the set of firms with zero imports in period t but positive imports in period t' for the product-country pair (j, c). The unit value for these starting pairs, i.e., those in E_{jc}, is defined as $p^E_{jct'} \equiv \sum_{i \in E_{jc}} \frac{x_{ijct'}}{x^E_{jct'}} p_{ijct'}$, where $x^E_{jct'} \equiv \sum_{i \in E_{jc}} x_{ijct'}$. Similarly, the unit value of continuing pairs, i.e., those in S_{jc}, is given as $p^S_{jct'} \equiv \sum_{i \in S_{jc}} \frac{x_{ijct'}}{x^S_{jct'}} p_{ijct'}$, where $x^S_{jct'} \equiv \sum_{i \in S_{jc}} x_{ijct'}$.

Ending. The last component measures the changes accounted for by the ending pairs of firms, that is, those with zero imports in period t' but positive imports in period t for the product-country pair (j, c), consisting of set X_{jc}. We employ a similar notation as $p^X_{jct} \equiv \sum_{i \in X_{jc}} \frac{x_{ijct}}{x^X_{jct}} p_{ijct}$, where $x^X_{jct} \equiv \sum_{i \in X_{jc}} x_{ijct}$.

Second, with this decomposition, we examine the extent to which U.S. import tariffs are passed through to the prices paid by U.S. importers, not only at the product-country (aggregate) level, but also through the response of each four decomposed component to tariff changes. Specifically, we estimate following Amiti et al. (2019b):

$$\Delta \ln p_{jct} = \alpha + \beta \Delta \ln(1 + \tau_{jct}) + \eta_{ct} + \delta_j + \epsilon_{jct}, \tag{2.5}$$

where $\Delta \ln p_{jct}$ represents the 12-month change in the unit value, calculated as the difference between the unit value in year-month $t+12$ and that in year-month t; $\Delta \ln(1+\tau_{jct})$ is the 12-month change of the applied tariff rate for product-country market (j, c); η_{ct} is the country-time fixed effect, which absorbs the effects of aggregate dynamics, such as the exchange rate fluctuations; δ_j controls for the product fixed effect.Next, we replace $\Delta \ln p_{jct}$ in equation (2.5) with each of the four decomposed components specified in equation (2.4).

Three points are worth noting. First, we use applied tariff rates τ_{jct} as our baseline analysis, which is directly from LFTTD and measured by the ratio of collected duty to import value for each product-country pair (j, c) in year-month t.[5] The tariff increases during 2018-2019 U.S.-China trade dispute was unexpected by U.S. importers and foreign exporters. As Fajgelbaum et al. (2020) argue, there is little evidence of pre-trends in the affected industries,

[4] A trade relationship is considered new if a firm begins importing a new product or starts importing from a different country.

[5] If there are no transactions for a specific product-country pair in any given month, we leave it as missing, instead of substituting alternative values for the applied tariff.

therefore we interpret the tariff change as a policy surprise. Additionally, substantial loss of observations would occur if scheduled tariff rates were used instead, as explained in Appendix A.2. Second, we use 12-month difference in unit value as the baseline analysis to take into account the seasonality issue or the lumpy nature of imports. Moreover, what matters is the difference between 2018-2019 U.S.-China trade dispute period and previous period. Third, our baseline sample extends that of Amiti et al. (2019b) to cover the period from January 2017 to December 2019. We restrict the sample to the end of 2019 to study short-run tariff pass-through, excluding the disruption to global trade caused by the pandemic.

The coefficient of interest in equation (2.5) is β. If the value of β is negative (positive), it implies that the foreign exporters decrease (increase) prices in response to the tariff increases. If the value is significantly close to zero or insignificant, it indicates that that foreign exporters barely change their prices, and all of the tariff burden is passed on to U.S. importers, which is called "complete tariff pass-through" in the literature.

The estimation results are reported in Table 2.1. Column (1) shows that foreign export prices (unit values) increase in response to higher tariffs. In other words, there is more-than-complete tariff pass-through to U.S. importers, indicating higher import costs faced by U.S. importers.[6] Columns (2) to (5) decompose the aggregate tariff pass-through and show that the observed aggregate tariff pass-through is driven by the starting pairs, highlighted by the different sign of regression coefficient in Column (4) compared to other columns.

Column (2) indicates that firms with continuing trade relationships on average experience incomplete tariff pass-through, as their unit values decrease with higher tariffs. Column (3) reports the covariance between import quantity share and unit value among these firms; the significantly negative coefficient indicates that, following tariff increases, lower-priced firms tend to gain import quantity share, contributing to incomplete pass-through.

Columns (4) and (5) indicate that new relationships contribute positively to complete aggregate tariff pass-through, while ending relationships contribute negatively. According to the decomposition in equation (2.4), the response of these pairs to tariff increases stems from two channels: (i) changes in their aggregate import share, $\frac{x^E_{jct'}}{p_{jct}}$ and $\frac{x^X_{jct}}{p_{jct}}$, and (ii) differences in aggregate unit values between starting (ending) and continuing pairs, $\frac{p^E_{jct'} - p^S_{jct'}}{p_{jct}}$ and

[6] In Appendix A.3, we detail how our results are comparable to those in Amiti et al. (2019b).

Table 2.1: Decomposition of Aggregate Tariff Pass-through

	(1) $\Delta \ln p_{jct}$	(2) Average	(3) Between	(4) Starting	(5) Ending	(6) $\frac{x^E_{jct'}}{p_{jct}}$	(7) $\frac{p^E_{jct'}-p^S_{jct'}}{p_{jct}}$	(8) $\frac{x^X_{jct}}{p_{jct}}$	(9) $\frac{p^S_{jct}-p^X_{jct}}{p_{jct}}$
$\Delta \ln(1+\tau_{jct})$	0.84	-0.247	-0.253	1.821	-1.271	0.615	4.525	0.358	-1.872
	(2.23)**	(1.88)*	(4.48)***	(8.77)***	(12.77)***	(1.15)	(8.05)***	(15.76)***	(9.57)***
Obs.	2099000	2099000	2099000	2099000	2099000	2099000	2099000	2099000	2099000
adjusted R^2	0.04	0.02	0	0.06	0.08	0.08	0.07	0.35	0.07

Notes: The table presents baseline regressions (2.5). In Columns (1) to (5), we project changes in unit value and its four components specified in equation (2.4) on changes in tariff. Columns (6) and (7) present the results for responses of share of starting country-product pairs and differences in import prices between starting and continuing pairs. Columns (8) and (9) are the counterparts for exit component. The difference terms are calculated as 12-month log difference. The sample ranges from January 2017 to December 2019. Standard errors are clustered at HS-8 digit level. t-statistics are reported in parentheses. The data cleaning procedure is detailed in Appendix A.1. * significant at 10%; ** significant at 5%; *** significant at 1%.

$\frac{p^S_{jct}-p^X_{jct}}{p_{jct}}$. The last four columns of Table 2.1 suggest that, after tariff increases, firms starting relationships account for a larger import share (Column 6) and tend to face higher unit values than continuing firms (Column 7), contributing to complete pass-through. Conversely, firms paying higher unit values are more likely to end relationships (Column 9), contributing to incomplete pass-through; the increased import share of ending pairs after tariff increases (Column 8) may further reinforce their contribution to incomplete pass-through.

2.2.1 Robustness and Consistency with Previous Literature

The findings in Table 2.1 remain robust to alternative tariff measures, different sample selections, and various fixed-effect specifications, as detailed in Appendix A.3. For example, (i) when we use scheduled tariff from Fajgelbaum et al. (2020), our main results hold: aggregating across firms, foreign export prices tend to rise in response to tariff hikes, while among continuing pairs, foreign exporters lower prices. (ii) Since our sample period extends beyond that in Amiti et al. (2019b), we replicate the decomposition using their exact sample, and the results remain consistent. (iii) To address concerns that our results are driven by tariffs targeting China after July 2018, we also examine earlier phases of tariff increases and find similar patterns. Extending the sample backward to include pre-dispute periods beginning in 2015, which adds more observations without tariff changes, does not alter the robustness of our decomposition results.

2.2.2 A Decomposition Framework with Richer Firm Heterogeneity

In Appendix A.4, we develop a more disaggregated decomposition framework such that we are able to understand which types of firms are more likely to form continuing, starting, or ending pairs and how they contribute to aggregate tariff pass-through. In the following sections, we present additional facts to shed light on the mechanisms behind firms' heterogeneous adjustments.

2.2.3 Understanding Continuing Pairs

In this section, we focus on continuing firm-product-country pairs—relationships that persist despite tariff increases, as identified by equation (2.4).

We find that (i) the result of incomplete tariff pass-through among continuing pairs holds across various empirical specifications; (ii) large continuing firms experience less incomplete tariff pass-through and gain larger import quantity shares than small continuing firms; and (iii) these findings are not driven by exporter switching, global value chains, or variety switching.[7] The detailed analysis is left in Appendix A.5.

As discussed in Sections 3 and 4, these findings inform the model setup and the mechanisms underlying firm-level incomplete tariff pass-through. However, because firm sourcing adjustments contribute so strongly to aggregate tariff pass-through, the mechanisms behind firm-level incomplete tariff pass-through do not play a dominant role in determining the welfare effects of tariffs.

2.2.4 Understanding Starting and Ending pairs

The analyses for starting and ending pairs based on Table 2.1 (Columns (7) and (9)) show how their unit values respond to tariff changes relative to continuing pairs. However, they do not reveal how the unit values of starting or ending pairs compare to those of continuing pairs before the tariff increase. Moreover, the response to tariff changes reflects both individual

[7] Alviarez et al. (2023) document that larger importers face more incomplete tariff pass-through. Our results differ from theirs due to differences in empirical approach. Specifically, our analysis is conducted at the importer-product-country level, while theirs is at the importer-exporter-product level. Their level of disaggregation helps them focus on repeated relationships, whereas our aggregation allows us to implement the decomposition.

starting or ending firms' unit value adjustments and their import share changes relative to continuing pairs.[8] In this section, we compare starting and ending pairs with continuing pairs to examine differences in their unit values and import shares before and after the tariff increase.

We find that (i) before the tariff increase, starting and ending pairs pay higher unit values than continuing pairs; (ii) in response to the tariff increase, unit value differences between starting and continuing pairs become insignificantly higher, and the import share of starting pairs rises because there are fewer importers overall and starting pairs after the tariff increase are typically larger, which positively contributes to complete aggregate tariff pass-through; and (iii) in response to the tariff increase, there are fewer starting pairs and more ending pairs. The analysis is left in Appendix A.6. There, we also document that large importers pay higher unit values than small importers and that, following a tariff increase, larger importers account for a greater share of imports, thereby contributing to complete aggregate tariff pass-through.

As detailed in Sections 3 and 4, these findings inform the model setup and clarify the mechanisms underlying firm-level sourcing-strategy adjustments after the tariff increase. Moreover, the fact that there are fewer starting pairs and more ending pairs helps us understand the welfare losses due to extensive-margin effects on the import price index.

3 The Model

In this section, we introduce the model, derive the welfare implications of a tariff increase, and discuss the mechanisms underlying aggregate and firm-level tariff pass-through.

[8] The unit value of starting (continuing) pairs, $p^E_{jct'}$ ($p^S_{jct'}$), is a weighted average of firm–product–country-level unit values among starting (continuing) pairs, where the weight is import quantity share. Thus, after a tariff increase, the response of the unit value of starting pairs relative to continuing pairs, $p^E_{jct'} - p^S_{jct'}$, depends not only on how individual firm–product–country unit values change, but also on how their import shares change in response to the tariff increase.

3.1 Model Setup

The economy consists of U.S. households, U.S. firms, and foreign varieties. It operates in discrete time and over an infinite horizon. Foreign varieties originate from a total of $\mathcal{C}$ countries, and each country supplies $\mathcal{J}$ differentiated products. When different U.S. firms import a variety from the same product–country market, they may pay different prices. As the empirical findings in Section 2 show that exporter switching within a product-country market does not alter the results on firm-level tariff pass-through, we abstract from modeling the matching between U.S. firms and foreign exporters and focus solely on how U.S. firms import different foreign varieties.

At the beginning of each period t, a U.S. firm draws a productivity level A_t and an import price shock $f(\Theta_t)$ from an exogenous process. After the productivity and import price shock are realized, firms make their production, pricing, and import decisions for the period t. Therefore, we can omit the subscript t for simplicity.

Production technology There is a unit mass of U.S. firms $i \in [0, 1]$. A U.S. firm i with a productivity level A_i hires labor L_i and purchases intermediate inputs X_i to produce y_i amounts of a unique variety i according to the following Cobb-Douglas production function:

$$y_i = A_i L_i^{1-\alpha} X_i^{\alpha}, \quad 0 < \alpha < 1. \tag{3.1}$$

Intermediate inputs X_i are aggregated from domestic inputs h_i and foreign inputs m_i:

$$X_i = [h_i^{\frac{\sigma-1}{\sigma}} + m_i^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1, \tag{3.2}$$

where σ determines the elasticity of substitution between domestic and foreign inputs. Domestic and foreign inputs are aggregated from domestically produced varieties h_{ik} and foreign-produced varieties m_{ijc}, respectively, as follows:

$$h_i = \left(\int_0^1 h_{ik}^{\frac{\theta-1}{\theta}} dk \right)^{\frac{\theta}{\theta-1}}, \quad \theta > 1, \tag{3.3}$$

$$m_i = \left[\int_{b_i^*}^{\infty} (b_{ijc} \cdot m_{ijc})^{\frac{\epsilon-1}{\epsilon}} dF(b) \right]^{\frac{\epsilon}{\epsilon-1}}, \quad \epsilon > 1, \tag{3.4}$$

where θ governs the elasticity of substitution across domestic varieties, ϵ governs the elasticity of substitution across foreign varieties, j denotes the product, c represents the sourcing country, and k indexes U.S. firms.[9] The term b_{ijc} represents a firm-specific imported variety attribute for product j produced by country c and exported to U.S. firm i, which can be interpreted as a demand shifter. b_i^* represents the cutoff value for this shifter, such that the firm imports only if b_{ijc} is above this threshold. The cumulative distribution function of the shifter is denoted by $F(b)$.[10] As in other importer models, more productive importers tend to be larger in terms of sales or import quantities.

Output market and domestic input of U.S. firms In the output market, each U.S. firm produces a unique variety and engages in monopolistic competition. The output of U.S. firms is used both for the production of final goods, c_i, consumed by U.S. households, and as an intermediate input, h_{ki}, utilized by other U.S. firms k.

U.S. households. In each period, a representative household in the U.S. supplies labor L given wage rate $W \equiv 1$ to maximize the consumption of composite final good C:

$$C = \left(\int_i c_i^{\frac{\rho-1}{\rho}} di \right)^{\frac{\rho}{\rho-1}}, \tag{3.5}$$

subject to the flow budget constraint $PC = WL + \Pi + T$, where c_i represents the consumer demand for variety i, $\rho > 1$ represents the elasticity of substitution across varieties, Π denotes the profit of U.S. firms, $P = \left(\int_i p_i^{1-\rho} di \right)^{\frac{1}{1-\rho}}$ is the price of final good, and p_i is the price of variety i set by firm i according to a standard constant markup pricing rule. T is the aggregate tariff collected, given by $T = \int_0^1 \left[\int_{j \in \mathcal{J}} \left(\sum_{c \in \mathcal{C}} (\tau_{jc} - 1) p_{ijc} m_{ijc} \right) dj \right] di$, where τ_{jc} is the gross tariff rate, p_{ijc} is the pre-tariff price of imported variety (i.e., unit value), and m_{ijc} is the quantity imported. The consumption maximization problem leads to a standard demand function:

$$c_i = \left(\frac{p_i}{P} \right)^{-\rho} C. \tag{3.6}$$

[9] k can be equal to i, which corresponds to roundabout production. U.S. firms use the output of all other U.S. firms as intermediate inputs, including their own output.

[10] Although we implicitly assume there is only one exporter for each product-country pair that supplies differentiated varieties to different U.S. importers, each exporter treat other exporters as competitors, with the elasticity of substitution given by $\epsilon > 1$.

Roundabout production. In each period, a U.S. firm i sells output to another U.S. firm k according to a standard demand function

$$h_{ki} = \left(\frac{p_{ki}^H}{p_k^H}\right)^{-\theta} \left(\frac{p_k^H}{p_k^X}\right)^{-\sigma} X_k, \tag{3.7}$$

where p_{ki}^H is determined by firm i according to a standard constant markup pricing rule, $p_k^H = \left(\int_0^1 (p_{ki}^H)^{1-\theta} di\right)^{\frac{1}{1-\theta}}$, $p_k^X = \left[(p_k^H)^{1-\sigma} + (p_k^F)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$, and $p_k^F = \left[\int_{b_k^*}^{\infty} \left(\frac{\tau_{jc} p_{kjc}}{b_{kjc}}\right)^{1-\epsilon} dF(b)\right]^{\frac{1}{1-\epsilon}}$.

Thus, firm output y_i serves both as a final consumption good and as an intermediate input in domestic production:

$$y_i = c_i + \int_0^1 h_{ki} dk = \left(\frac{p_i}{P}\right)^{-\rho} C + \int_0^1 \left(\frac{p_{ki}^H}{p_k^H}\right)^{-\theta} \left(\frac{p_k^H}{p_k^X}\right)^{-\sigma} X_k dk. \tag{3.8}$$

Throughout, we set $\rho = \theta$ so that price consistency is ensured between final consumer goods c_i and domestically produced intermediate inputs h_{ki}, such that $p_i = p_{ki}^H = \frac{\rho}{\rho-1}\psi(A_i, b_i^*), \forall k$, where $\psi(A_i, b_i^*)$ denotes the marginal cost of production. Therefore, equation (3.8) can be rewritten as

$$y_i = D p_i^{-\rho}, \quad D \equiv P^\rho C + \int_0^1 (p_k^H)^\rho \left(\frac{p_k^H}{p_k^X}\right)^{-\sigma} X_k dk, \tag{3.9}$$

where D can be interpreted as an aggregate demand shifter.

Fixed import cost A U.S. firm i uses the full range of domestic intermediate inputs for production but imports only a subset of foreign varieties due to the presence of fixed import costs. The fixed import cost provides a simple way to generate variation in import exposure and is common in importer models. Following Gopinath and Neiman (2014), the fixed import cost, measured in wage units, is EN_i^η, where $E > 0$ reflects the cost scale, N_i is the number of imported varieties of firm i, and $\eta > 0$ implies a convex cost in the number of varieties. Importing foreign varieties offers variety gains, and, if they are more cost-effective than domestic inputs (e.g., if $b_{ijc} > 1$), efficiency gains. Thus, the firm faces a trade-off between fixed import costs and gains of importing foreign inputs.

A firm faces tariff τ_{jc} when importing product j from country c. After the tariff increase,

firms are less likely to cover fixed import cost and more likely to reduce the number of imported varieties.

Firm-specific import price The import price that the U.S. firm i pays is

$$\tau_{jc} p_{ijc}(A_i, \Theta_{ijc}) = \mu_{ijc}(A_i, \Theta_{ijc}) \frac{c_{ijc}(A_i)}{f(\Theta_{ijc})}, \tag{3.10}$$

where τ_{jc} denotes the gross tariff rate, $p_{ijc}(A_i, \Theta_{ijc})$ is the pre-tariff import price (i.e., unit value), $c_{ijc}(A_i)$ is the marginal cost of production of exporters, $f(\Theta_{ijc})$ denotes the import price shock, and $\mu_{ijc}(A_i, \Theta_{ijc})$ is the markup, defined as

$$\mu_{ijc}(A_i, \Theta_{ijc}) = (1 - \iota_i)\mu_{ijc}^{\text{oligopoly}}(A_i, \Theta_{ijc}) + \iota_i \mu_{ijc}^{\text{oligopsony}}(A_i, \Theta_{ijc}), \tag{3.11}$$

where $\mu_{ijc}^{\text{oligopoly}}(A_i, \Theta_{ijc})$ denotes the exporters' market power, $\mu_{ijc}^{\text{oligopsony}}(A_i, \Theta_{ijc})$ denotes the importers' market power, and $\iota_i \in [0, 1]$ represents the importers' relative bargaining power.

The pricing functions (3.10) and (3.11) are designed to be estimated using the data while capturing several mechanisms discussed in the literature. Specifically, first,

$$c_{ijc}(A_i) = \tilde{c}_1 A_i^{\tilde{c}_2} + \tilde{c}_{jc}, \tag{3.12}$$

and $\frac{\partial c_{ijc}(A_i)}{\partial A_i} > 0$, i.e., the marginal cost of production of exporters depends on the importers' productivity. It enables the model to capture the empirical fact that large importers often pay higher import prices than small importers for the same product from the same country, even though their greater market power would typically be expected to result in lower import prices. One potential micro-foundation is larger importers import higher quality goods that require higher marginal cost of production (cf. Blaum et al., 2019). This implies that, for each product-sourcing country, different U.S. importers import distinct varieties, each with its own marginal cost of production. One alternative micro-foundation is that large importers often manage complex supply chains involving logistics, compliance, and regulatory costs (e.g., certifications or security measures), which are factored into the import price. Therefore, a higher price does not necessarily reflect higher quality. To this end, we allow for the possibility that the firm-specific imported variety attribute b_{ijc} correlates with firm

productivity A_i. A higher positive correlation between b_{ijc} and A_i indicates that a higher marginal cost of production for exporters is more likely to reflect higher quality of imports that contributes to higher output of importers, while a lower positive correlation suggests that the higher import prices faced by larger importers are due to other factors. More details are presented in Section 4.

Second, the functional form for the import price shock is

$$f(\Theta) = 1 - \lambda_f e^{-\gamma_f \Theta}, \tag{3.13}$$

where $0 < \lambda_f < 1$ pins down the magnitude of the extra price paid at $\Theta = 0$ relative to $\Theta \to \infty$, and $\gamma_f > 0$ governs the speed at which the $f(\Theta)$ shrinks with Θ.

Θ evolves over time according to the following process:

$$\Theta_t = \begin{cases} \min\{\Theta_{t-1} + 1, \bar{N}\} & \text{with probability } g(\Theta_{t-1}), \\ 0 & \text{with probability } 1 - g(\Theta_{t-1}), \end{cases} \tag{3.14}$$

where

$$g(\Theta) = g_M - (g_M - g_0)e^{-\gamma_g \Theta}, \tag{3.15}$$

g_0 is the probability that $\Theta_t = 1$, g_M is the probability that $\Theta_t = \bar{N}$, and $0 < g_0 < g_M < 1$. The parameter $\gamma_g > 0$ governs how quickly the probability of Θ_t converges to g_M.

$\frac{\partial g(\Theta)}{\partial \Theta} > 0$ and $\frac{\partial f(\Theta)}{\partial \Theta} > 0$ jointly imply that some importers face lower import prices than others due to factors unrelated to productivity. One potential micro-foundation is that Θ can be interpreted as the number of years that the importer has imported from a given product–country pair. Then $g(\Theta)$ can be interpreted as the survival probability of the trade relationship, which is increasing in the number of years that the importer has imported from that product–country pair. The condition $\frac{\partial f(\Theta)}{\partial \Theta} > 0$ captures that import prices decline as trade relationships age. The assumptions $\frac{\partial g(\Theta)}{\partial \Theta} > 0$ and $\frac{\partial f(\Theta)}{\partial \Theta} > 0$ are consistent with the empirical evidence and model setups in Monarch and Schmidt-Eisenlohr (2023) and Heise (2024), which attribute the observed import price patterns to information frictions and the costly formation of relationship capital.

Together, $\frac{\partial g(\Theta)}{\partial \Theta} > 0$ and $\frac{\partial f(\Theta)}{\partial \Theta} > 0$ predict that starting pairs and ending pairs pay higher import prices than continuing pairs.

Third, equation (3.11) can be micro-founded by Nash-in-Nash bargaining, as demonstrated in Alviarez et al. (2023). It is worth noting that although the pricing functions are estimated using the data, the import price is endogenous and jointly determined by both importers and exporters. This endogeneity arises because, as discussed further below, the import price depends on the market shares of both importers and exporters, which are themselves functions of the importers' choices of import quantities. However, firms take exporters' marginal cost of production $c_{ijc}(A_i)$ and the age of the trade relationship Θ_{ijc} as given and cannot affect them. These assumptions are reasonable because our analysis is primarily short-run, and it typically takes time for firms to switch varieties or adjust trade relationships.[11]

The importers' relative bargaining power is firm-specific: $\iota_i = \hat{\iota}_1 A_i^{\hat{\iota}_2}$, $\iota_i \in [0,1]$.[12] This variation not only adds additional flexibility to the model, but also helps explain the empirical fact that larger importers face less incomplete tariff pass-through, as detailed later. It is straightforward that when importers' relative bargaining power is sufficiently large, meaning ι_i is close to 1, the markup mainly depends on the importer market power. Conversely, when importers' relative bargaining power is sufficiently small, meaning ι_i is close to 0, the markup primarily depends on the exporter market power.

The exporters' market power is characterized as an oligopoly markup

$$\mu_{ijc}^{\text{oligopoly}} = \frac{\varepsilon_{ijc}}{\varepsilon_{ijc} - 1} \geq 1, \tag{3.16}$$

where $\varepsilon_{ijc} = (1 - s_{ijc})\epsilon + s_{ijc}\tilde{\nu}$ is importer's demand elasticity, $s_{ijc} \equiv \frac{\tau_{jc} p_{ijc} m_{ijc}}{\sum_{jc} \tau_{jc} p_{ijc} m_{ijc}}$ is the share of exporter's sales over importer i's total imports. Also, $\tilde{\nu} = (1 - s_i^f)\sigma + s_i^f((1 - s_i^X) \times 1 + \rho)$, where $s_i^f \equiv \frac{p_i^F m_i}{p_i^F m_i + p_i^H h_i}$ is the foreign input share among all intermediate inputs, and $s_i^X \equiv \frac{p_i^X X_i}{p_i^X X_i + W L_i}$ is the intermediate input share among all inputs of the firm.[13] As in usual models of oligopoly markup, the importer demand elasticity ε_{ijc} is decreasing in the exporters' sales

[11] Moreover, Section 2 shows that our empirical findings are robust to supplier switching and variety switching.
[12] ι_i is exogenously given in the model, motivated by the estimation results in Alviarez et al. (2023) that endogenizing ι_i leads to similar results.
[13] If $\alpha = 1$ and $\sigma = 1$ in our model, the expression for $\tilde{\nu}$ is the same as Alviarez et al. (2023).

share s_{ijc}, and the oligopoly markup $\mu_{ijc}^{\text{oligopoly}}$ is increasing in the exporters' sales share s_{ijc}.

The importers' market power is characterized as an oligopsony markdown

$$\mu_{ijc}^{\text{oligopsony}} = \kappa \frac{1-(1-x_{ijc})^{\frac{1}{\kappa}}}{x_{ijc}} \leq 1, \tag{3.17}$$

where $\kappa \in (0,1]$ is the returns to scale of exporters' production, $x_{ijc} \equiv \frac{m_{ijc}}{\sum_i m_{ijc}}$ is the share of importer i's quantity relative to the total quantity supplied by the exporter (j,c), and exporters' total cost of production is $TC_{ijc} = \Phi_{ijc}(A_i)(m_{ijc})^{\frac{1}{\kappa}}$.[14] Furthermore, if $\kappa = 1$, exporters have a constant returns to scale production function, and there is no importer market power ($\mu_{ijc}^{\text{oligopsony}} = 1$). Therefore, importer market power exists with $\mu_{ijc}^{\text{oligopsony}} < 1$ only if $\kappa \in (0,1)$, which corresponds to exporters operating under a decreasing returns to scale production function. As in usual models of oligopsony markdown, $\mu_{ijc}^{\text{oligopsony}}$ is decreasing in the importers' buyer share x_{ijc}.

Firm's optimization problem Each U.S. firm $i \in [0,1]$ chooses the labor input L_i, the output prices p_i and $\{p_{ki}^H\}_{k\in[0,1]}$, the set of domestic inputs $\{h_{ik}\}_{k\in[0,1]}$, the demand shifter cutoff b_i^* and the quantity of foreign inputs $\{m_{ijc}\}_{j\in[0,1]}^{c\in\mathbb{C}}$, given the wage rate $W \equiv 1$, the output price of other firms $\{p_{kk'}^H\}_{k\in[0,1]}^{k'\in[0,1]}$ and the prices of foreign inputs $\{p_{ijc}\}_{j\in[0,1]}^{c\in\mathbb{C}}$.

The measure of imported varieties is $N_i(b_i^*) = \int_{b_i^*}^{\infty} dF(b) = \int_{b_i^*}^{\infty} f(b)db$, where $f(b)$ is the probability density function corresponding to the cumulative distribution function $F(b)$ and represents the fraction of foreign inputs with the price-adjusted demand shifter $\frac{b_{ijc}}{\tau_{jc}p_{ijc}}$ equal to b. It is easy to see that this shifter serves as a sufficient statistic to represent the rank of gains from imported varieties. Consequently, the number of imported varieties is a function of this price-adjusted demand shifter.

The U.S. firm i solves the following profit maximization and cost minimization problem:

$$\pi(A_i) \equiv \max_{p_i, b_i^*} D^{\frac{1}{\rho}} y_i^{1-\frac{1}{\rho}} - \psi(A_i, b_i^*) y_i - E\left(N_i(b_i^*)\right)^{\eta}, \tag{3.18}$$

[14] If $\kappa = 1$, the exporters' marginal cost of production $MC_{ijc}(A_i) \equiv c_{ijc}(A_i) = \Phi_{ijc}(A_i)$.

where

$$\psi(A_i, b_i^*) \equiv \min_{L_i, h_{ik}, m_{ijc}} \left\{ WL_i + \int_0^1 p_{ik}^H h_{ik} dk + \int_{b_i^*}^{\infty} \tau_{jc} p_{ijc} m_{ijc} dF(b) \right\} \tag{3.19}$$

$$\text{s.t.} \quad y_i = 1, \quad (3.1), (3.2), (3.3), (3.4), (3.9)\&(3.10) \quad \text{hold.} \tag{3.20}$$

Solving these problems leads to the following optimality conditions:

$$p_i = p_{ki}^H = \frac{\rho}{\rho - 1} \psi(A_i, b_i^*), \tag{3.21}$$

$$L_i = \frac{\psi(A_i, b_i^*)(1-\alpha)}{W} y_i, \quad y_i = \left(\frac{\psi(A_i, b_i^*)}{D^{\frac{1}{\rho}}} \frac{\rho}{\rho - 1} \right)^{-\rho}, \tag{3.22}$$

$$h_{ik} = \left(\frac{p_{ik}^H}{p_i^H} \right)^{-\theta} h_i, \quad h_i = \left(\frac{p_i^H}{p_i^X} \right)^{-\sigma} X_i, \quad X_i = \frac{\psi(A_i, b_i^*)\alpha}{p_i^X} y_i, \tag{3.23}$$

$$m_{ijc} = b_{ijc}^{\epsilon - 1} \left(\frac{\tau_{jc} p_{ijc}}{p_i^F} \right)^{-\epsilon} m_i, \quad m_i = \left(\frac{p_i^F}{p_i^X} \right)^{-\sigma} X_i, \tag{3.24}$$

$$\eta (N_i(b_i^*))^{\eta - 1} E = \left(p_i^F \right)^{\epsilon} \left(\frac{\tau_{jc} p_{ijc}}{b_i^*} \right)^{1-\epsilon} \left(\frac{p_i^F}{p_i^X} \right)^{-\sigma} \frac{y_i}{(\epsilon - 1) A_i} \left(\frac{W}{1-\alpha} \right)^{1-\alpha} \left(\frac{p_i^X}{\alpha} \right)^{\alpha - 1}, \tag{3.25}$$

where $\psi(A_i, b_i^*) = \frac{1}{A_i} \left(\frac{W}{1-\alpha} \right)^{1-\alpha} \left(\frac{p_i^X}{\alpha} \right)^{\alpha}$, $p_i^X = \left[(p_i^H)^{1-\sigma} + (p_i^F)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$, $p_i^H = \left(\int_0^1 (p_{ik}^H)^{1-\theta} dk \right)^{\frac{1}{1-\theta}}$, and $p_i^F = \left[\int_{b_i^*}^{\infty} \left(\frac{\tau_{jc} p_{ijc}}{b_{ijc}} \right)^{1-\epsilon} dF(b) \right]^{\frac{1}{1-\epsilon}}$.

3.2 Equilibrium

In each period t, a stationary competitive equilibrium consists of prices $\{p_{it}, p_{kit}^H, p_{ijct}, p_{it}^H, p_{it}^F, p_{it}^X, W_t\}_{i,k \in [0,1]}^{j \in [0,1], c \in \mathbb{C}}$ and an allocation $\{C_t, c_{it}, y_{it}, X_{it}, L_{it}, m_{it}, h_{it}, h_{ikt}, m_{ijct}, b_{it}^*\}_{i,k \in [0,1]}^{j \in [0,1], c \in \mathbb{C}}$ such that after the realization of productivity and the age of trade relationship,

(i) representative households choose C_t and c_{it} to solve their utility maximization problem;

(ii) U.S. firms $i \in [0,1]$ solve the profit maximization problem and cost minimization problem by choosing output prices p_{it}, $\{p_{kit}^H\}_{k \in [0,1]}$, labor input L_{it}, intermediate input X_{it}, domestic inputs $\{h_{ikt}\}_{k \in [0,1]}$, demand shifter cutoff b_{it}^* and foreign inputs $\{m_{ijct}\}_{j \in [0,1]}^{c \in \mathbb{C}}$;

(iii) the goods market clearing condition holds, i.e., equation (3.9) holds for all U.S. firms;

(iv) the labor market clearing condition holds such that households supply labor inelastically

to meet the total labor demand of all U.S. firms, i.e., $L = \int_0^1 L_{it} di$.[15]

3.3 Welfare Decomposition

In this section, we derive first-order approximations of welfare changes in response to tariff changes around the initial equilibrium, corresponding to the period before the tariff increase.

We decompose the welfare effect of a tariff increase into three effects: an import price index effect, a domestic variety substitution effect, and a general equilibrium effect that determines the allocation between consumption and production. These effects can be further broken down into five channels, as shown in Proposition 3.1. Its proof is in Appendix B.3.

Proposition 3.1 *The first-order approximation of the welfare change due to the tariff change can be decomposed into five components:*

$$
\begin{aligned}
d\ln(\frac{C}{L}) = & \underbrace{-\alpha \int_{i^{\hat{*}}} e_i \left[\int_{b_i^*}^{\infty} \omega_{ijc} \left(d\ln(\tau_{jc}) + d\ln(p_{ijc}) \right) dF(b) \right] di}_{\textit{import price index intensive margin}} \\
& \underbrace{-\alpha \int_{i^{\hat{*}}} e_i \left(\frac{s_i^*}{\epsilon - 1} db_i^* \right) di}_{\textit{import price index extensive margin}} \quad \underbrace{-\alpha \int_{i^{\hat{*}}} e_i s_i^h \left(d\ln(p_i^H) - d\ln(p_i^F) \right) di}_{\textit{importer domestic variety substitution effect}} \\
& \underbrace{-\alpha \int^{i^*} e_i d\ln(p_i^H) di - \alpha \int_{i^*}^{i^{\hat{*}}} e_i [\ln(p_i^H) - \ln(p_i^X)] di}_{\textit{non-importer domestic variety substitution effect}} \underbrace{+ d\ln(\frac{P^\rho C}{D})}_{\textit{allocation effect}}.
\end{aligned} \tag{3.26}
$$

where $0 < \alpha < 1, \epsilon > 1, e_i = \dfrac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}$ *is the U.S. consumers' expenditure share on U.S. firm* i, $\omega_{ijc} = \dfrac{\tau_{jc} p_{ijc} m_{ijc}}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b) m_{ijc}(b) f(b) db}$ *is the share of a specific foreign variety in determining firm* i*'s overall cost of imported inputs,* $s_i^h = \dfrac{p_i^H h_i}{p_i^H h_i + p_i^F m_i}$ *is the share of domestic intermediate inputs in firm* i*'s total intermediate input use,* p_{ijc}^* *is the foreign export price of marginal varieties,* $s_i^* = \omega_i^* f(b_i^*)$ *is the import cost share of marginal varieties, and* $\omega_i^* = \dfrac{\tau_{jc} p_{ijc}^* m_{ijc}^*}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b) m_{ijc}(b) f(b) db}$ *is the share of marginal foreign variety in determining imported*

[15] To keep the first-order welfare decomposition tractable, we abstract from the labor used to cover fixed import costs in the labor market clearing condition. Moreover, although fixed importing costs are commonly modeled in the literature, these costs may be shared with foreign exporters (e.g., they may be equivalent to fixed exporting costs, so that after a tariff increase fewer firms serve the U.S. market). It is therefore reasonable to remain agnostic about which side ultimately bears the fixed cost.

inputs cost of firm i. i^* ($\hat{i^*}$) denotes the marginal importer such that firms with productivity no less than A_{i^*} ($A_{\hat{i^*}}$) are importers before (after) tariff increase, while those with lower productivity are non-importers. D is specified in equation (3.9).

The first two terms on the right-hand side of equation (3.26) represent the import price index effect—that is, the impact of the tariff on a U.S. importer's import price index, p_i^F. Specifically, the first term on the right-hand side of equation (3.26) represents the import price index intensive margin, reflecting price changes in continuing imported varieties due to shifts in tariffs and foreign prices. An increase in post-tariff import prices leads to a welfare loss attributed to the import price index intensive margin. Each U.S. firm i's welfare effect is weighted by consumers' expenditure share on this firm (e_i), which is positively correlated with firm size. Moreover, if larger firms face more tariff pass-through than smaller ones, the weighted average predicts a greater welfare loss compared to a simple average. Additionally, the effects are weighted by ω_{ijc}, which captures the relative importance of each variety in a firm's foreign intermediate input cost. A larger weight implies a greater impact on welfare when affected by tariff changes.

The second term represents the negative effect of sourcing strategy adjustments on welfare. Specifically, a higher tariff typically contributes to an increase in b_i^*, which leads to the loss of imported varieties and reduces welfare. The magnitude of this extensive margin effects is governed by the consumers' expenditure share e_i and the share of marginal varieties s_i^* (i.e., the share of varieties dropped after the tariff increase). A higher share of marginal varieties results in greater welfare loss.

The third and fourth terms capture the domestic variety substitution effect, reflecting how changes in the relative price of domestic versus foreign inputs affect importers' input mix and non-importers' input prices, thereby influencing aggregate consumption. The third term accounts for the importers' domestic variety substitution effect. When tariff hike raises p_i^F more than p_i^H, this term becomes more positive. It captures the substitution toward cheaper domestic inputs when foreign inputs become more expensive, which mitigates the overall welfare loss. The magnitude of this effect is determined by the consumers' expenditure share e_i and the share of domestic intermediate inputs in the firm's total input use s_i^h. A higher s_i^h leads to a greater mitigation of the welfare loss through importers' substitution toward

domestic varieties.

The fourth term captures the domestic variety substitution effect for non-importers. If increased domestic demand raises domestic input costs, non-importers face higher intermediate input prices, resulting in welfare losses.On the other hand, the tariff increase causes more firms to stop importing and switch from foreign to domestic inputs, leading to further welfare loss due to reduced variety and decreased efficiency from this substitution.

The fifth term, labeled the allocation effect, accounts for the general equilibrium adjustment in reallocation between U.S. households' consumption and U.S. firms' production. Since tariff increases typically boost demand for domestic production but reduce consumption, the allocation effect of higher tariffs contributes to the welfare loss.

3.3.1 Role of Firm Heterogeneity

Suppose we eliminate firm heterogeneity in the importing market by assuming (i) all importers import all varieties, removing any sourcing strategy adjustments, and (ii) all importers are identical. However, the distinction between importers and non-importers remains, allowing us to analyze the domestic variety substitution effect for varieties with different levels of import exposure. Moreover, the fractions of importers and non-importers are fixed. Under these assumptions, the welfare decomposition simplifies as shown in Proposition 3.2.

Proposition 3.2 *In the absence of importer heterogeneity, the first order approximation of the welfare change due to the tariff change can be decomposed into four components:*

$$d\ln(\frac{C}{L}) = \underbrace{-\alpha \int_{i^*} e_i \left[\int_b \omega_{ijc} \left(d\ln(\tau_{jc}) + d\ln(p_{ijc})\right) dF(b)\right] di}_{\textit{import price index intensive margin}} \underbrace{-\alpha \int_{i^*} e_i s_i^h \left(d\ln(p_i^H) - d\ln(p_i^F)\right) di}_{\textit{importer domestic variety substitution effect}}$$
$$\underbrace{-\alpha \int^{i^*} e_i d\ln(p_i^H) di}_{\textit{non-importer domestic variety substitution effect}} \underbrace{+d\ln(\frac{P^\rho C}{D})}_{\textit{allocation effect}}. \tag{3.27}$$

where $0 < \alpha < 1, e_i = \dfrac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}$, $\omega_{ijc} = \dfrac{\tau_{jc} p_{ijc} m_{ijc}}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b) m_{ijc}(b) f(b) db}$, *and* $s_i^h = \dfrac{p_i^H h_i}{p_i^H h_i + p_i^F m_i}$. i^* *denotes the marginal importer such that firms with productivity no less than* A_{i^*} *are importers, while those with lower productivity are non-importers.*

Compared to the welfare decomposition with importer heterogeneity, three differences arise. First, the extensive margin of the import price index effect is absent because all foreign varieties are imported by all importers; as a result, there are no welfare losses from this margin. This is consistent with our empirical observations that extensive-margin adjustments are much less frequent at the product–country level than at the U.S. firm–product–country level (see Gopinath and Neiman (2014) for similar findings). Therefore, ignoring importer heterogeneity leads to an underestimation of welfare losses from the extensive margin. Second, in the absence of importer heterogeneity, welfare estimation relies on aggregate tariff pass-through (see, e.g., Fajgelbaum et al. (2020)). If tariff pass-through is complete at the aggregate level but incomplete at the firm level, ignoring importer heterogeneity could lead to an overestimation of welfare losses from the intensive margin of the import price index effect. Third, the domestic variety substitution and general equilibrium effects may differ depending on the magnitude of firms' equilibrium responses, requiring quantitative assessment.

3.3.2 Generality of the Welfare Formula and the Model Setup

While welfare analysis inevitably relies on a specific framework, we proceed with care. We follow standard practice in the trade literature and adopt commonly used model environments. Appendix B.2 summarizes the usual setups of importer models. Our main departure from this literature is to introduce firm-specific sourcing strategies, variety attributes, and import prices.

Our first-order welfare decomposition formula (3.26) for tariff increases applies to models with different forms of importer heterogeneity: under standard setups, it delivers an import price index effect, a domestic variety substitution effect, and a general equilibrium effect capturing the reallocation between consumption and production. Because our model features richer firm-level structure, these three effects admit a correspondingly richer interpretation.

3.3.3 Key Data Moments for Welfare Estimation

Our welfare formula implies that estimating the welfare effects of changes in the import price index requires the following data moments: firm-level tariff pass-through ($d\ln(p_{ijc})$), adjustments in sourcing strategies in response to tariff increases ($s_i^* db_i^*$), the firm size distri-

bution before the tariff increase (e_i), and the pre-tariff relative importance of each imported variety for the firm (ω_{ijc}). These moments are either highly correlated with the empirical decomposition of aggregate tariff pass-through or directly observable in our data.

The remaining components of the welfare decomposition rely mainly on the pre-tariff firm size distribution (e_i), the share of domestic intermediate inputs in firms' total intermediate input use (s_i^h), and import participation ratio (i^*). These moments are also directly observable in the data.

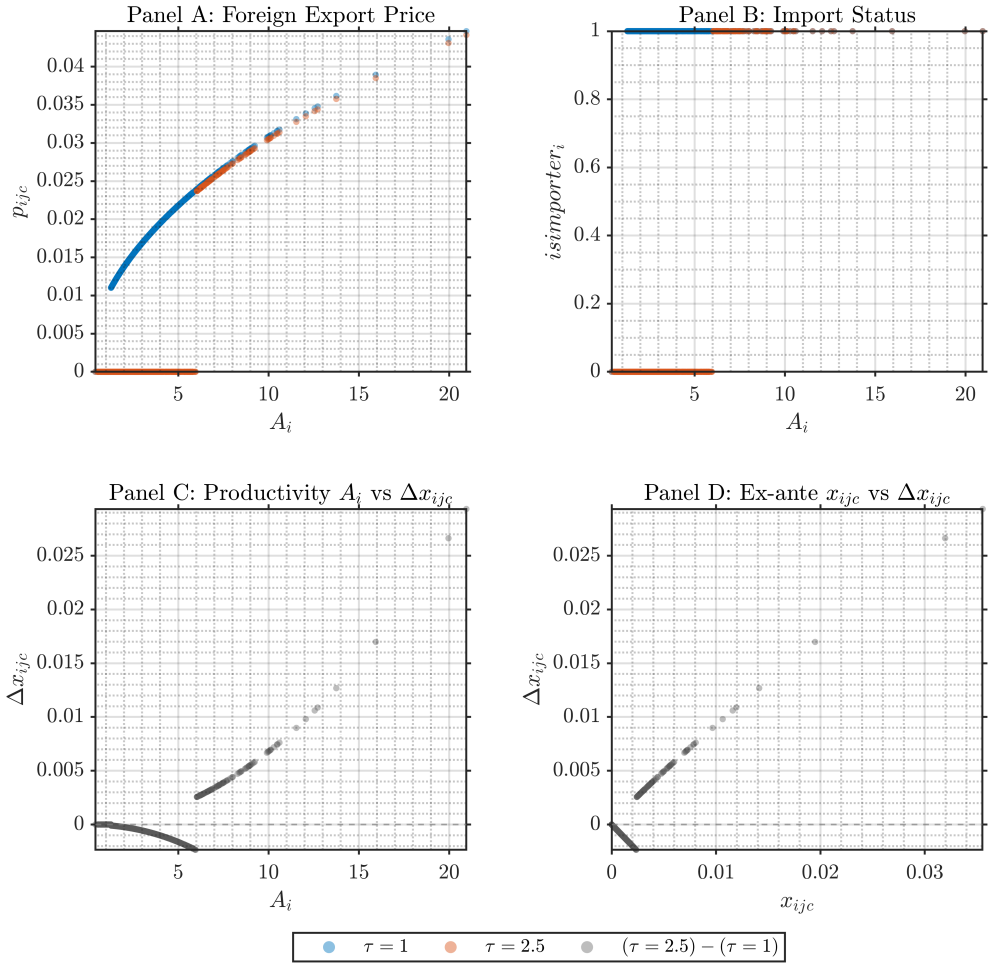
3.4 Model Mechanism on Tariff Pass-Through

In this section, we show how the model generates tariff pass-through at both the firm and aggregate levels through its effects on U.S. firms' import prices, import shares, and trade relationships. We first describe how trade relationships adjust after a tariff increase, and then how firm-level unit values respond. We show that $\frac{\partial c_{ijc}(A_i)}{\partial A_i} > 0$ and $\frac{\partial f(\Theta_{ijc})}{\partial \Theta_{ijc}} > 0$ are required for firms—especially large firms that form new trade relationships after tariff hikes—to contribute to complete aggregate tariff pass-through. We also show that, with constant returns to scale in exporter production ($\kappa = 1$) and high importer bargaining power (high ι_i), importers have limited scope to reduce unit values after tariff increases, despite incomplete tariff pass-through.

3.4.1 Tariff Increase and Trade Relationship Adjustment

Figure 3.1 illustrates how firms with varying productivity adjust their trade relationships *within a product-country market* in response to a tariff increase, highlighting its effects on foreign export prices, import status, and import share. Panel A shows that more productive firms pay higher foreign export prices due to higher marginal production costs among exporters ($\frac{\partial c_{ijc}(A_i)}{\partial A_i} > 0$). After a tariff increase, foreign exporters lower their prices to offset reduced demand. Panel B demonstrates that only productive firms import from the market, as less productive firms cannot cover the fixed import cost. The tariff hike raises the productivity cutoff required to import, reducing the number of importers. Panel C reveals that imports become more concentrated among productive firms post-tariff, as they are better able to maintain access to foreign varieties. Panel D shows a similar concentration effect

Figure 3.1: Extensive Margin Adjustment After Tariff Increase



Notes: The figure shows how the foreign exporter price received by importers, import status, and import quantity shares respond when the tariff rises from 100% to 250% in a product-country market. The exercise holds firm productivity A_i and the age of trade relationships Θ_{ijc} fixed across tariff regimes, assumes exporters operate under constant returns to scale $\kappa = 1$, and imposes an exporter marginal cost with no country–product variation but increases with importer productivity $c'_{ijc}(A_i) > 0$. Panel A shows that the foreign export price p_{ijc} increases with firm productivity A_i, and the higher tariff $\tau = 250\%$ shifts the price schedule downward relative to $\tau = 100\%$. Panel B shows that import status $isimporter_i$ is increasing in A_i; the tariff increase raises the productivity cutoff for importing (more low-A_i firms are non-importers). Panel C shows that the change in import share $\Delta x_{ijc} \equiv x_{ijc}(\tau = 250\%) - x_{ijc}(\tau = 100\%)$ tends to rise with A_i, with small negative responses concentrated among the least productive firms, and the firms at the margin experiences the largest decrease since they give up importing. Panel D shows that Δx_{ijc} is increasing in the ex-ante share x_{ijc}, indicating reallocation toward firms with larger pre-tariff import shares.

based on initial import shares x_{ijc}, indicating that firms with a strong initial presence in international trade are more resilient to tariff increases, leading to a redistribution of import shares toward larger importers. Since larger firms tend to import goods with higher marginal costs, these extensive margin adjustments contribute to complete tariff pass-through at the product-country level.

Similarly, because more trade relationships end after tariff hikes, new trade relationships account for a larger share of imports. When new relationships pay higher prices than continuing ones ($\frac{\partial f(\Theta_{ijc})}{\partial \Theta_{ijc}} > 0$), this reallocation of import shares implies that new relationships contribute positively to achieving complete tariff pass-through at the product–country level.

Figure B.3 further illustrates how firms adjust their trade relationships *across different product-country markets* following a tariff increase. More productive firms are more likely to import, source a greater variety of products, and import more costly varieties. However, higher tariffs make these expensive intermediates less viable, leading firms to drop them from their sourcing portfolios. The tariff hike also pushes marginal importers to exit the importing market.

3.4.2 Tariff Pass-Through to Continuing Trade Relationship

Conditional on fixed trade relationships before and after the tariff increase, we discuss the mechanisms driving firm-level tariff pass-through based on Propositions 3.3 and 3.4. Their proofs are left in Appendices B.5 and B.6 .

Proposition 3.3 *Under the assumption of competitors' non-responsiveness and sufficiently low values of each pass-through components, the import price pass-through elasticity is*

$$\frac{d\ln(\tau_{jc}p_{ijc})}{d\ln\tau_{jc}} \approx \underbrace{\frac{1}{1+\Gamma^{s}_{ijc}(\epsilon-1)(1-s_{ijc})}}_{\equiv\Phi^{SC}_{ijc}} \underbrace{\frac{1}{1+\Gamma^{x}_{ijc}\varepsilon_{ijc}(1-x_{ijc})}}_{\equiv\Phi^{SS}_{ijc}} \underbrace{\frac{1}{1+\frac{1-\kappa}{\kappa}x_{ijc}\varepsilon_{ijc}}}_{\equiv\Phi^{TT}_{ijc}}, \tag{3.28}$$

where

$$\Gamma^{s}_{ijc} = (1-\iota_i)\frac{\mu^{oligopoly}_{ijc}}{\mu_{ijc}}\frac{1}{\varepsilon_{ijc}-1}\frac{\epsilon-\varepsilon_{ijc}}{\varepsilon_{ijc}}; \tag{3.29}$$

$$\Gamma^{x}_{ijc} = \iota_i \frac{\mu^{oligopsony}_{ijc}}{\mu_{ijc}} \left[\frac{x_{ijc}(1-x_{ijc})^{\frac{1}{\kappa}-1}}{\kappa(1-(1-x_{ijc})^{\frac{1}{\kappa}})} - 1 \right]. \tag{3.30}$$

Notably, tariff pass-through depends on four factors: importers' buyer share x_{ijc}, exporters' supplier share s_{ijc}, importers' relative bargaining power ι_i, and exporters' returns to scale κ.[16] Moreover, it is easy to see that when the exporters have constant returns to scale in production ($\kappa = 1$), importers are not able to lower the import price by adjusting markdowns. Appendix B.8.1 discusses the detailed mechanisms of firm-level tariff pass-through.

Proposition 3.4 *Under the assumption of competitors' non-responsiveness and sufficiently low values of the pass-through components, greater importer bargaining power ι implies that importers bear a larger share of the tariff burden and experience a lower degree of incomplete tariff pass-through (i.e., $\frac{d\left(\frac{d\ln(\tau_{jc}p_{ijc})}{d\ln\tau_{jc}}\right)}{d\iota} \geq 0$ where $\iota \in [0,1]$), all else being equal.*

Proposition 3.4 further highlights that, all else equal, greater importer bargaining power increases tariff pass-through to importers, as exporters' markup reductions in response to a tariff increase become less influential in price determination, thereby shifting more of the tariff burden onto importers. Therefore, to account for the empirical finding that larger importers experience higher pass-through, it is useful to allow bargaining power to increase with importer size, i.e., to introduce $\frac{\partial \iota_i(A_i)}{\partial A_i} > 0$.

4 Quantitative Analysis

As underscored by both the empirical findings and the model, various mechanisms are operating concurrently. In this section, we take the model to the data to determine the relative strength of each mechanism and assess the welfare implications of tariff increases.

[16] If $\iota_i = \iota$, equation (3.28) coincides with that in Alviarez et al. (2023). The terms $\frac{\partial c_{ijc}(A_i)}{\partial A_i}$ and $\frac{\partial f(\Theta_{ijc})}{\partial \Theta_{ijc}}$ do not directly affect firm-level tariff pass-through, as they are independent of tariff changes. However, by influencing the foreign export price, they affect importers' buyer shares x_{ijc} and exporters' supplier shares s_{ijc}.

4.1 Parameterization

Table 4.1 lists all of the parameters. We categorize parameters as either externally or internally estimated and discuss them in turn.

4.1.1 External Estimation

The externally estimated parameters include those that govern the elasticity of substitution across the outputs and inputs of firms. Specifically, the elasticity of substitution across domestic varieties θ is set to 4, similar to the U.S. downstream import demand elasticity in Broda and Weinstein (2006). We set the demand elasticity ρ that importers face to be the same as θ, as explained in Section 3. The elasticity of substitution between domestic varieties and foreign varieties σ is set to 1.19 and the elasticity of substitution across foreign varieties ϵ to be 2.53, following Fajgelbaum et al. (2020). We set the share of material inputs in all inputs α to 0.5, following He (2024) that uses the U.S. data.[17] The size of tariff before the onset of the U.S.-China trade dispute is also set externally based on the LFTTD, which is on average 3.9 percent.

4.1.2 Internal Estimation (Simulated Method of Moments)

The remaining parameters are estimated by jointly matching data moments that capture tariff pass-through and its decomposition, as well as the distribution of firms and imports that are relevant for welfare analysis. Specifically, we simulate the model for two periods, in which firms are subject to idiosyncratic productivity shocks and trade relationship changes to induce time-varying sourcing strategies and meaningful starting and ending pairs. We then introduce a uniform tariff increase to all varieties from 3.9 percent to 17 percent, enabling us to compute the heterogeneous responses of the firms to the tariff change and thus to identify the pass-through of the tariff and its decomposition. Without loss of generality, we assume that there are no tariff variations across products or countries to focus on across-firm reallocation within product-country markets. We simulate the model with 3,000 firms, each potentially importing 10 products from 9 other countries. Although all internal parameters

[17] Gopinath and Neiman (2014) finds $\alpha = 2/3$ using data in Argentina.

Table 4.1: Parameterization

Parameter	Notation	Value
Panel A. External Parameterization		
A1. Demand		
EOS across final goods	ρ	4
A2. Production Technology		
EOS across domestic inputs	θ	4
EOS across foreign inputs	ϵ	2.53
EOS between H and F input	σ	1.19
Intermediate input share	α	0.5
A3. Tariff		
Tariff before trade dispute	τ_{jc}	0.039
Panel B. Internal Parameterization		
B1. Distribution of Firms and Imports		
Firm productivity, Shape	A_x	4.08
Firm productivity, Scale	A_α	0.65
Convexity of import cost	η	1.30
Scale of import cost	E	282.50
Cost shifter, Weight on productivity	$\tilde{c}_1$	0.48
Cost shifter, Exponential	$\tilde{c}_2$	-1.74
Cost shifter, Minimum	$\tilde{c}_3$	0.92
Cost shifter, Exporter difference	$\tilde{c}_4$	0.89
Demand/productivity shifter, Weight on productivity	γ	0.27
Demand/productivity shifter, Elasticity	θ_b	0.61
B2. Tariff Pass-Through Decomposition		
Exporters' returns to scale	κ	0.97
Bargaining power, Constant	$\hat{\iota}_1$	0.75
Bargaining power, Exponential	$\hat{\iota}_2$	0.53
Firm productivity, Persistence	ρ_A	0.71
Survival probability of trade relationship, min	g_0	0.18
Survival probability of trade relationship, max	g_M	0.60
Survival probability of trade relationship, curvature	γ_g	2.52
Price discount of trade relationship, weight	λ_f	0.31
Price discount of trade relationship, curvature	γ_f	1.66

Notes: We compute the applied tariff τ_{jct} using data from the LFTTD for the years 2015–2017, and years 2018-2019 separately. For each product-country pair jc, we first calculate the time average. Then we compute the mean of the applied tariff.

are estimated jointly, certain parameters are more closely associated with specific moments, as discussed below.

Firm distribution and import distribution As discussed in Section 3.3, several distributional moments are key to understanding the effect of changes in the import price index on welfare. First, each firm's share in U.S. consumers' total expenditure, $e_i = \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}$. The model predicts that $\frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'} = \frac{L_i}{\int_{i'} L_{i'} di'}$ as shown in Appendix B.3, so we approximate this share by each U.S. firm's employment share among all U.S. firms, which is observable in the data. Second, the import share of each variety in a firm's overall import costs, $\omega_{ijc} = \frac{\tau_{jc} p_{ijc} m_{ijc}}{\sum_{jc \in \Omega_i} \tau_{jc} p_{ijc} m_{ijc}}$, where Ω_i denotes the set of imported varieties by importer i, is directly observable in the data.

As for the domestic variety substitution effect of a tariff increase on welfare, it depends on U.S. firms' import exposure. In our framework, the employment share of importers, the import participation ratio, and the share of domestic intermediate inputs in total intermediates observed in the data provide key discipline for quantifying this effect. In what follows, we discuss how specific parameters are linked to these moments.

Firm-specific productivity A_i is assumed to follow a Pareto distribution with the scale parameter A_x and the shape parameter A_α. For a given level of import costs, the scale and shape parameters A_x, A_α determine the employment share of importers among all U.S. firms, since firm productivity determines employment.

The scale and convexity of import costs are estimated to match the import participation ratio and the employment share of small importers relative to large importers. A more convex import cost function increases the incentive for large importers to drop foreign varieties after tariff increases. Therefore, in order to account for the empirical finding that small importers are more likely than large firms to drop foreign varieties after a tariff increase, the convexity of import costs must not be too high.

We set the marginal cost of production for exporters c_{ijc} to take the functional form of $c_{ijc}(A_i) = \tilde{c}_1 A_i^{\tilde{c}_2} + \tilde{c}_{jc}$ where A_i is the initial productivity of the firm i and $\tilde{c}_{jc} \sim U[\tilde{c}_3, \tilde{c}_3 + \tilde{c}_4]$, and estimate the parameters $\tilde{c}_1, \tilde{c}_2, \tilde{c}_3, \tilde{c}_4$. The uniform distribution of $\tilde{c}_{jc}$ is to allow for a variation across the foreign variety. This reflects different costs of production across sourcing countries or products. A positive $\tilde{c}_1$ and $\tilde{c}_2$ imply that larger importers face higher marginal costs from exporters and, consequently, pay higher unit values. This pattern aligns with our empirical evidence (Table A.7) as well as the findings of Blaum et al. (2019). Naturally,

the parameters governing exporters' marginal costs of production are closely related to the import cost share of each variety across different importers.

As for the import demand shifter b_{ijc}, we assume it is symmetric across foreign varieties and its functional form is

$$b_i = \left((1-\gamma)\hat{\eta}^{\frac{\theta_b - 1}{\theta_b}} + \gamma A_i^{\frac{\theta_b - 1}{\theta_b}} \right)^{\frac{\theta_b}{\theta_b - 1}},$$

where $\hat{\eta} > 1$, $0 < \gamma < 1$, $0 < \theta_b < 1$ such that firm productivity A_i and import demand shifter $\hat{\eta}$ are complements (see Blaum et al. (2019)). We set $\hat{\eta} = 2$ and estimate the values of the parameters θ_b and γ. This value of $\hat{\eta}$ ensures that $b_i > 1$. A lower θ_b or a higher γ indicates that higher productivity firms have greater demand for an imported variety, which helps mitigate the reduction in demand caused by the higher cost $c_{ijc}(A_i)$. Similar to c_{ijc}, these parameters are closely related to the import cost share of each variety across different importers.

The detailed construction of the targeted data moments is specified in Appendix C.1.

Pass-through decomposition We allow the productivity to be time varying with a persistence of ρ_A. Precisely, firms draw the initial productivity from the Pareto distribution with the scale parameter A_x and the shape parameter A_α. Then they draw a random shock ε_{Ai} so that their productivity next period becomes $\rho_A A_i + \varepsilon_{Ai}$. We incorporate an age-specific survival probability of a trade relationship, $g(\Theta)$, and an age-specific unit-value discount, $f(\Theta)$, to match our empirical observations; these features are consistent with the previous literature, as discussed in Section 3.

The persistency ρ_A, the survival probability $g(\Theta)$, and the price discount $f(\Theta)$ for trade relationships of different ages are closely related to the contribution of starting and ending pairs to aggregate tariff pass-through, as the value of these parameters determines the formation and dissolution of trade relationships among heterogeneous importers, as well as the differences in their unit values.

Exporters' returns to scale κ and bargaining power parameter $\hat{\iota}_1$ are estimated by matching the observed changes in unit values for large and small continuing firms in response to

tariff increases.[18] As explained in Section 3.4.2, the returns to scale of exporter production κ close to one helps generate a limited reduction in import prices; larger importers having higher bargaining power $\iota_i'(A_i) > 0$ help explain why larger continuing importers experience more tariff pass-through.

Our estimate of firm size-dependent bargaining power is consistent with the existing literature. Previous empirical evidence suggests that larger firms possess greater bargaining power. Studies such as Pfeffer and Salancik (1978), Porter (1980), Sutton (1991), Dobson et al. (1998), Basker (2007), Mayer and Ottaviano (2008), and Ellison and Snyder (2010), among others, highlight that larger firms often have access to more resources and fewer dependencies. These may include stronger financial capital, established brand recognition, the ability to purchase inputs in bulk, switch suppliers at lower cost, and integrate into supply chain networks, allowing them to negotiate more favorable terms with suppliers. Card et al. (2015) further substantiate this view by demonstrating how large firms dictate wage levels, work conditions, and even undermine competition.

4.1.3 Targeted and Untargeted Moments

The moments that we plan to target are presented in Panel A of Table 4.2. Note that the current calibration is preliminary, and a more careful calibration will be conducted after we disclose all relevent targeted and untargeted moments.

The results indicate that the model closely reproduces the patterns observed in the data. In particular, Panel A.2 shows that tariff pass-through to U.S. importers at the aggregate (product–country) level is more than complete in both the data and the model. That is, as tariffs increase, the unit values charged by exporters rise at the aggregate level. By contrast, tariff pass-through to U.S. importers among continuing pairs is incomplete, as shown in average and between components. It is starting pairs that mainly drives the more-than-complete tariff pass-through at the aggregate level, both in the model and data.

[18] In the quantitative exercise, we normalize the size of ι given the productivity A_i so that $\iota \in [0.01, 1]$.

Table 4.2: Targeted and Untargeted Moments

Moment	Data	Model
Panel A. Targeted Moments		
A1. Distribution of Firms and Imports		
Employment share of large importers	0.48	0.90
Employment share of small importers	0.01	0.00
Import participation ratio	0.05	0.01
Mean $\sum_{jc\in\Omega_i}\omega_{ijc}$ among large importers in continuing pairs		0.58
Mean $\sum_{jc\in\Omega_i}\omega_{ijc}$ among small importers in continuing pairs		0.002
Mean $\sum_{jc\in\Omega_i}\omega_{ijc}$ among large importers in starting pairs		0.00
Mean $\sum_{jc\in\Omega_i}\omega_{ijc}$ among small importers in starting pairs		0.00
Mean $\sum_{jc\in\Omega_i}\omega_{ijc}$ among large importers in ending pairs		0.34
Mean $\sum_{jc\in\Omega_i}\omega_{ijc}$ among small importers in ending pairs		0.01
A2. Decomposing Aggregate Tariff Pass-Through		
Aggregate	0.84	0.93
Average	-0.25	-0.03
Between	-0.25	0.00
Starting	1.82	1.18
Starting share	0.62	0.64
Starting price	4.53	4.53
Ending	-1.27	-0.22
Ending share	0.36	1.98
Ending price	-1.87	-0.04
B. Untargeted		
B1. Decomposing with Firm Size Heterogeneity		
Average (large)		-0.02
Average (small)		-0.01
Between (large)		0.00
between (small)		0.00
Starting (large)		-0.01
Starting (small)		1.19
Ending (large)		-0.15
Ending (small)		-0.07

Notes: The data moments in Panel A are constructed based on the data procedures described in Appendix C.1 (to be disclosed); the data moments in Panel B are computed from Table 2.1 and Table A.3; the data moments in Panel C are from the regression results in Section A.4 (to be disclosed). The model moments are derived accordingly. For now we assign some data moments related to $\sum_{jc\in\Omega_i}\omega_{ijc}$ to conduct calibration. Once these data moments are disclosed from Census, we will redo the calibration.

Table 4.3: Decomposing Welfare Effect of Tariff Increase

Change in welfare	Value
$\Delta \ln(C/L)$	-0.113
First-order decomposition	
Import price intensive	-0.046
Import price extensive	-0.115
Importer domestic substitution	-0.003
Non-importer domestic substitution	0.000
General equilibrium effect	-0.022

4.2 Welfare Implication

In this section, we analyze the welfare impact of tariff increases and highlight how firm heterogeneity reshapes these welfare implications.

Table 4.3 presents the welfare effects of tariff increase in the baseline model. The tariff increase of 13.1 percentage points across all varieties reduces the welfare by 65.1 percent. It also presents the first-order decomposition of welfare changes as discussed in Proposition 3.1. Specifically, the import price index effect dominates both the domestic variety substitution effect and the general equilibrium effect. The import price index and general equilibrium effects generate welfare losses. The domestic variety substitution effect also generates welfare losses through the roundabout production structure: domestic intermediate input prices rise significantly as marginal production costs increase when fewer foreign intermediates are used. This mechanism is so strong that substitution toward domestic inputs does not mitigate the welfare loss.

Within the import price index effect, both intensive and extensive margins reduce welfare, but the extensive margin—driven by firms adding or dropping varieties in response to the tariff—generally dominates. This extensive-margin effect is typically absent from previous welfare estimates that abstract from firm-level sourcing adjustments. Our results therefore uncover an important, previously overlooked source of welfare losses.

Role of firm heterogeneity Previous analyses of the welfare effects of tariff increases often assume complete aggregate tariff pass-through and do not account for importer heterogeneity. To highlight how firm heterogeneity shapes welfare effects of the tariff increase,

Table 4.4: Welfare Decomposition without Firm Heterogeneity

Change in welfare	Value
$\Delta \ln(C/L)$	-0.018
First-Order Decomposition	
Import price intensive	-0.046
Import price extensive	-0.000
Importer domestic substitution	0.027
Non-importer domestic substitution	0.000
General equilibrium effect	-0.002

Table 4.4 reports the welfare decomposition in a counterfactual economy without firm heterogeneity, thereby mimicking a model in which heterogeneity arises only across sourcing products, origin countries and import exposure. Specifically, we shut down relationship shocks, firm productivity heterogeneity and size-dependency of bargaining power. Instead, we consider two representative firms: a representative non-importer and a representative importer, calibrated to match the employment share of importers relative to non-importers in the baseline economy. In this representative firm environment, the import price index extensive-margin channel is eliminated, because firms no longer adjust sourcing on the extensive margin. As a result, welfare changes operate primarily through the intensive margin of the import price index, the domestic-substitution channel, and the general equilibrium channel. The domestic substitution channel becomes positive because, as foreign inputs become more expensive, substitution toward cheaper domestic inputs mitigates the overall welfare loss. Moreover, the residual general equilibrium component largely vanishes because there is little cross-firm reallocation left to generate additional general equilibrium responses.

Taken together, this counterfactual highlights that abstracting from firm heterogeneity can substantially understate welfare losses that arise from sourcing adjustments of firms.

4.3 Additional Discussion

4.3.1 Welfare Decomposition with "Inefficiencies"

The welfare decomposition above implies that, in the baseline model, reallocation of import shares across heterogeneous firms does not affect the first-order welfare impact of tariffs: U.S. consumers' expenditure share on firm i, e_i, remains unchanged. Yet firm-level inefficiencies

are pervasive in the data, and once these are introduced, reallocation across firms becomes first-order important.[19] In Appendix B.4, we show that incorporating importer heterogeneity in the presence of firm-level inefficiencies further amplifies the welfare loss from tariff increases, relative to the efficient benchmark, by inducing additional distortions in output and input allocation.

4.3.2 Why This Time is Different Compared to Previous Episodes

As pointed out by Fajgelbaum and Khandelwal (2022), previous literature using methods similar to Amiti et al. (2019b) and Fajgelbaum et al. (2020) often documents incomplete pass-through. Our empirical decomposition framework and quantitative model help us understand why there is more aggregate tariff pass-through to importers this time. Specifically, importers' adjustments to their sourcing strategies can contribute to complete or more-than-complete aggregate tariff pass-through, even if, at the individual importer level, pass-through remains incomplete. This occurs because firms within a given product-country pair pay different import prices, and because new, continuing, and ending trade relationships within a product-country pair are associated with varying import prices. When tariffs increase, import reallocation across high-price firms or trade relationships can therefore result in complete or more-than-complete tariff pass-through at the aggregate level.

If the tariff increases in the U.S.-China trade dispute are more substantial than in previous episodes, or if U.S. importers adjust their sourcing strategies more significantly (for example, by forming more new or ending more existing trade relationships as a result of different risk management strategies or lower adjustment costs) in response to tariff increases compared to importers in other studies, or if the differences in import prices across firms or trade relationships are more pronounced, we would expect a larger contribution of importers' sourcing strategy adjustments to aggregate tariff pass-through.

[19] See, e.g., Baqaee and Rubbo (2023) for a comprehensive review.

5 Conclusion

We use confidential firm-linked trade data from the U.S. Census Bureau to analyze tariff pass-through to U.S. importers during the U.S.-China trade dispute. We develop a unified empirical and theoretical framework that enables researchers to re-evaluate how tariff pass-through adjusts along the intensive and extensive margins during major trade policy changes and to assess the resulting welfare consequences. Our framework can be readily adapted to study heterogeneous responses to common cost shocks—such as regional exchange-rate pass-through—as well as other applications.

We focus on the short-run effects of tariffs during the U.S.–China trade dispute, since international trade is subsequently affected by the COVID-19 pandemic in 2020. Comparing price responses across the short, medium, and long run to uncover time-varying patterns of tariff pass-through is an intriguing direction that we leave for future research.

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Online Appendix for "Firm-Level Origins of Tariff Pass-Through: Importer Heterogeneity and Welfare Decomposition"

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A Data Appendix

A.1 Data Cleaning

Truncation issue and sample selection. Throughout, in all our regressions, for the unit value change and its four components, we drop outliers at top 5 percentile level and bottom 5 percentile level. For the change of tariff over time, we drop outliers at top 1 percentile level and bottom 1 percentile level.

A.2 Scheduled Tariff Construction

We generate monthly U.S. scheduled import tariffs using data from Fajgelbaum et al. (2020), which provides country–product level information for 2018 and 2019. The dataset includes details such as the effective month of tariff changes in 2018, maximum tariff, and scaled tariff. The authors obtained U.S. statutory import tariffs by scraping publicly available documents from the U.S. International Trade Commission (USITC). The USITC releases the benchmark tariff schedule annually, subsequently updating it throughout the trade dispute. These events of tariff adjustments cover the washing machine industry, solar panel industry, steel and aluminum industry, varieties with Chinese origin, and varieties with EU origin. Although Fajgelbaum et al. (2020) provides a time series of scheduled tariffs, we derive our own due to the original data's sparsity and missing values.

Our goal is to convert the dataset from an annual to a monthly frequency. To achieve this, we use the maximum tariff, scaled tariff, and effective month of tariff change to construct a monthly time series of U.S. scheduled import tariffs. The steps involved are as follows.

Step 1. Determining the Effective Month of Tariff Change in 2019. We assume that there is only one tariff change per year for each product. Given that the dataset in their paper provides only the earliest change month of tariff, if there are subsequent tariff adjustments in 2019, we need to determine the effective change month for 2019. The scaled tariff denotes a weighted average of the cumulative tariff increases, with the weights reflecting

the proportion of the year during which the tariffs were active:

$$\tau_{2019}^{Scaled} = \frac{M_{2019}^{E} - 1}{12}\tau_{2018}^{Max} + \frac{12 - M_{2019}^{E} + 1}{12}\tau_{2019}^{Max},$$

where τ_{2019}^{Scaled} stands for the scaled tariff increase in 2019. M_{2019}^{E} denotes the effective change month of the tariff in 2019, indicating the month from which the tariff increase takes effect. For instance, if $M_{2019}^{E} = 9$, it signifies that from January to August, the tariff remains unchanged, while starting from September, the tariff is increased. τ_{2019}^{Max} denotes the maximum tariff increase in 2019. Therefore, we can rearrange the equation to derive M_{2019}^{E}:

$$M_{2019}^{E} = 12 \times \frac{\tau_{2019}^{Max} - \tau_{2019}^{Scaled}}{\tau_{2019}^{Max} - \tau_{2018}^{Max}} + 1.$$

Step 2. Deriving the Initial Tariff Increase in 2018. Again, utilizing the scaled tariff and the effective change month, we ascertain the initial tariff increase in January 2018. The scaled tariff increase in 2018 is derived as follows:

$$\tau_{2018}^{Scaled} = \frac{M_{2018}^{E} - 1}{12}\tau_{2018}^{Initial} + \frac{12 - M_{2018}^{E} + 1}{12}\tau_{2018}^{Max},$$

where $\tau_{2018}^{Initial}$ is the initial tariff increase in 2018. Rearranging the equation, we derive $\tau_{2018}^{Initial}$:

$$\tau_{2018}^{Initial} = 12 \times \frac{\tau_{2018}^{Scaled} - \tau_{2018}^{Max}}{M_{2018}^{E} - 1} + \tau_{2018}^{Max}.$$

Step 3. Expand Annual data to Monthly data. Generate year-month index. For example, 201901 denotes January 2019. Replicate $\tau_{2018}^{Initial}$, τ_{2018}^{Max}, τ_{2019}^{Max}, M_{2018}^{E}, and M_{2019}^{E} to monthly level on country-product basis.

Step 4. Merge Scheduled Tariff in January 2018 from Fajgelbaum et al. (2020) Obtain 201801 level scheduled tariff τ^{201801} from $m_stattariff1$ in the replication file named $m_flow_hs10_fm_new.dta$. Then, merge the data series to the dataset generated from step 3 by year, month, hs10, and country. For the observations that miss τ^{201801}, we replace them to be 0. Till now, we have a time series for the monthly tariff increase from 2018 to 2019, as well as the scheduled tariff level of January 2018.

Step 5. Generate Monthly Data of Scheduled Tariff $\tau^{Scheduled}$. If $Month < M_{2018}^{E}$,

$\tau^{Scheduled} = \tau^{Initial}_{2018} + \tau^{201801}$. If $M^E_{2018} \leq Month < 201901$, $\tau^{Scheduled} = \tau^{Max}_{2018} + \tau^{201801}$. If $201901 \leq Month < M^E_{2019}$, $\tau^{Scheduled} = \tau^{Max}_{2018} + \tau^{201801}$. If $Month \geq M^E_{2019}$, $\tau^{Scheduled} = \tau^{Max}_{2019} + \tau^{201801}$. There are two special cases. The first case is that M^E_{2018} does not exist. This means there is no tariff change in 2018. In this case, $\tau^{Scheduled} = \tau^{Max}_{2018} + \tau^{201801} = \tau^{Initial}_{2018} + \tau^{201801}$ for all months in 2018. The second case is that M^E_{2019} does not exist. This means there is no tariff change in 2019. In this case, $\tau^{Scheduled} = \tau^{Max}_{2018} + \tau^{201801}$ for all months in 2019.

A.3 Robustness for Decomposing Aggregate Tariff Pass-Through

In this section, we demonstrate that the findings in Table 2.1 remain robust to alternative tariff measures, different sample selections, and various fixed-effect specifications.

Scheduled Tariff In line with the literature, including our direct counterpart Amiti et al. (2019b), we use applied tariffs to construct the baseline measure of tariff increases. As a robustness check, we construct the scheduled tariff based on data from Fajgelbaum et al. (2020) as explained in Appendix A.2.[20] This robustness check addresses the potential endogeneity concern associated with applied tariffs, as scheduled tariffs are predetermined and not subject to contemporaneous economic conditions.

Panel A of Table A.1 presents the estimation results. The results confirm the presence of the gap between the complete aggregate tariff pass-through and the incomplete tariff pass-through among the continuing trade relationships, as shown in Columns (1) and (2). Column (4) indicates that the starting component contributes to the higher unit value after tariff increases, consistent with the baseline analysis.

Shorter Sample and Compare with Amiti et al. (2019b) We restrict the sample period to January 2017 through December 2018, in order to ensure comparability with the analysis of Amiti et al. (2019b). Amiti et al. (2019b) find a β of around -0.012, which is statistically insignificant and indicates complete pass-through. In contrast, our analysis yields a statistically significant β of around 0.803, as shown in Panel B of Table A.1, indicating

[20] We do not directly utilize the statutory tariff data from Fajgelbaum et al. (2020) due to its sparse time series coverage.

Table A.1: Robustness Checks

	(1) $\Delta \ln p_{jct}$	(2) Average	(3) Between	(4) Starting	(5) Ending	(6) $\frac{x^E_{jct'}}{p_{jct}}$	(7) $\frac{p^E_{jct'}-p^S_{jct'}}{p_{jct}}$	(8) $\frac{x^X_{jct}}{p_{jct}}$	(9) $\frac{p^S_{jct}-p^X_{jct}}{p_{jct}}$
A. Scheduled Tariff									
$\Delta \ln(1+\tau^{scheduled}_{jct})$	0.13	-0.108	0.017	0.155	-0.029	-0.591	0.285	0.042	0.039
	(1.96)**	(2.45)**	(0.77)	(4.20)***	(1.32)	(1.37)	(2.66)***	(8.62)***	(0.77)
Obs.	230000	230000	230000	230000	230000	230000	230000	230000	230000
adjusted R^2	0.12	0.04	0.01	0.22	0.28	0.18	0.17	0.53	0.2
B. Shorter Sample from 2017 to 2018									
$\Delta \ln(1+\tau_{jct})$	0.803	-0.128	-0.359	1.849	-1.366	0.139	5.360	0.319	-2.075
	(1.68)*	(0.70)	(4.66)***	(6.33)***	(9.01)***	(0.37)	(7.02)***	(11.01)***	(7.26)***
Obs.	1042000	1042000	1042000	1042000	1042000	1042000	1042000	1042000	1042000
adjusted R^2	0.04	0.02	0.00	0.06	0.08	0.07	0.07	0.35	0.08
C. Add Pre-dispute Period									
$\Delta \ln(1+\tau_{jct})$	0.724	-0.246	-0.365	1.888	-1.497	0.612	5.035	0.279	-1.888
	(1.82)*	(2.13)**	(7.95)***	(8.92)***	(16.20)***	(0.93)	(9.47)***	(14.40)***	(11.56)***
Obs.	4019000	4019000	4019000	4019000	4019000	4019000	4019000	4019000	4019000
adjusted R^2	0.04	0.01	0	0.06	0.08	0	0.07	0.34	0.07
D. General Tariff Increases									
$\Delta \ln(1+\tau_{jct})$	0.965	-0.707	-0.361	2.12	-1.527	0.067	6.886	0.319	-2.124
	(1.47)	(2.67)***	(3.22)***	(5.09)***	(7.14)***	(0.11)	(6.30)***	(8.56)***	(5.32)***
Obs.	516000	516000	516000	516000	516000	516000	516000	516000	516000
adjusted R^2	0.05	0.02	-0.01	0.06	0.08	0.09	0.07	0.35	0.08
E. Tariffs on Chinese Imported Goods									
$\Delta \ln(1+\tau_{jct})$	0.974	-0.012	-0.236	1.739	-1.18	0.63	4.006	0.364	-1.767
	(2.63)***	(0.09)	(3.86)***	(8.35)***	(10.66)***	(0.98)	(6.93)***	(14.11)***	(8.15)***
Obs.	1583000	1583000	1583000	1583000	1583000	1583000	1583000	1583000	1583000
adjusted R^2	0.04	0.02	0	0.06	0.08	0.07	0.07	0.35	0.07
F. Alternative Fixed Effect 1									
$\Delta \ln(1+\tau_{jct})$	0.538	-0.263	-0.281	0.941	-0.658	0.245	4.234	0.227	-1.565
	(1.38)	(1.92)*	(4.94)***	(4.36)***	(6.61)***	(0.37)	(7.24)***	(9.36)***	(8.35)***
Obs.	2096000	2096000	2096000	2096000	2096000	2096000	2096000	2096000	2096000
adjusted R^2	0.05	0.02	-0.01	0.08	0.1	0.09	0.08	0.36	0.1
G. Alternative Fixed Effect 2									
$\Delta \ln(1+\tau_{jct})$	0.692	-0.359	-0.258	1.328	-0.812	0.773	5.097	0.32	-1.838
	(1.70)*	(2.55)**	(4.36)***	(5.73)***	(7.06)***	(0.97)	(8.15)***	(10.74)***	(8.41)***
Obs.	2099000	2099000	2099000	2099000	2099000	2099000	2099000	2099000	2099000
adjusted R^2	0.03	0.01	0	0.02	0.03	0.02	0.04	0.25	0.04
H. Alternative Fixed Effect 3									
$\Delta \ln(1+\tau_{jct})$	0.75	-0.271	-0.228	1.301	-0.794	0.782	4.569	0.333	-1.875
	(2.02)**	(2.05)**	(4.11)***	(6.16)***	(7.52)***	(1.13)	(7.99)***	(12.10)***	(9.23)***
Obs.	2100000	2100000	2100000	2100000	2100000	2100000	2100000	2100000	2100000
adjusted R^2	0.03	0.01	0	0.03	0.03	0.02	0.04	0.25	0.04
I. Alternative Fixed Effect 4									
$\Delta \ln(1+\tau_{jct})$	0.538	-0.263	-0.281	0.941	-0.658	0.245	4.234	0.227	-1.565
	(1.38)	(1.92)*	(4.94)***	(4.36)***	(6.61)***	(0.37)	(7.24)***	(9.36)***	(8.35)***
Obs.	2096000	2096000	2096000	2096000	2096000	2E+06	2096000	2096000	2096000
adjusted R^2	0.05	0.02	-0.01	0.08	0.1	0.09	0.08	0.36	0.1

Notes: The table presents robustness check for the baseline results in Table 2.1. The difference terms are calculated as 12-month log difference. Panel A uses scheduled tariffs. Panel B uses the sample from January 2017 to December 2018. Panel C uses an alternative sample ranging from January 2015 to December 2019. Panel D applies sample ranging from January 2017 to June 2018, while the sample of Panel E is from July 2018 to December 2019. Panel F controls for country-time and country-sector fixed effects. Panel G controls for country-time and sector-time fixed effects. Panel H controls for country-time and sector fixed effects. Panel I controls for country-time, sector, and country-sector fixed effects. The sector is defined at the HS4 level. Standard errors are clustered at HS-8 digit level. * significant at 10%; ** significant at 5%; *** significant at 1%.

more-than-complete pass-through. This discrepancy arises from differences in handling extreme values: Amiti et al. (2019b) exclude observations where the ratio of unit values in t

relative to $t-12$ exceeds 3 or falls below 1/3, whereas we drop outliers at the top and bottom 5 percentiles. Notably, we are able to replicate their results when applying their method for treating extreme values. However, we drop the top and bottom 5 percentiles as our baseline analysis to maximize sample coverage. Panel B of Table A.1 also highlights the critical role of starting component in driving aggregate tariff pass-through.

Furthermore, comparing Panel B of Table A.1 with Table 2.1, which uses a longer data series, we find that over time, U.S. importers with continuing trade relationships begin to face significant incomplete pass-through, while aggregate-level tariff pass-through becomes increasingly more-than-complete, i.e., foreign export prices increase in response to tariff changes. These findings highlight the crucial role of compositional shifts in sourcing patterns in reconciling the discrepancy between aggregate-level tariff pass-through and the incomplete pass-through observed among firms with continuing trade relationships.

General Tariff Increases v.s. Tariffs on Chinese Imported Goods Although the Trump administration initiated an investigation into imposing tariffs on China as early as March 22, 2018, the first round of U.S. import tariffs on 34 billion worth of Chinese goods did not take effect until July 8, 2018. Prior to July, the tariff increases were universally directed towards all U.S. trading partners. For instance, tariffs were imposed on solar panels and washing machines on January 22, and subsequently, the Trump administration announced tariffs on steel and aluminum imports. After July, U.S. import tariffs specifically targeted China. Therefore, we designate July 2018 as a cutoff and divide our baseline sample into two sub-periods.

We perform the same baseline regressions for both sub-periods to assess the robustness of our empirical findings. As depicted in Panel D and E of Table A.1, whether during the period of general tariff increases or the period of China-specific tariffs, our baseline findings remain consistent. Interestingly, the incomplete pass-through for continuing pairs that keep importing from China is insignificant. However, at the aggregate level, there is more-than-complete tariff pass-through. This is driven by the adjustment of starting pairs. Therefore, the adjustments of starting pairs in both periods of the tariff dispute are important for understanding the aggregate-level tariff pass-through.

Pre-dispute Period v.s. Dispute Period We extend the baseline sample to include data from January 2015 to December 2019. This extended sample includes periods without significant tariff changes, allowing us to compare the effects of tariff increases with grace periods in the affected product-country markets. Using this alternative sample, we apply the same specification as in equation (2.1) and find that the baseline findings remain robust, as shown in Panel C of Table A.1.

Alternative Fixed Effects Our baseline results control for country-time and product fixed effects, which absorb time-varying country-level aggregate shocks and time-invariant differences across products. Motivated by Fajgelbaum et al. (2020) and Jiao et al. (2024), we check the robustness of our results to alternative sets of fixed effects. The results are summarized in Panels F, G, H and I of Table A.1, indicating that our findings of incomplete tariff pass-through among continuing pairs and the contribution of starting pairs remain robust.

A.4 A Decomposition with Richer Firm Heterogeneity

The analysis in the main text classifies all firm–product–country level observations into three groups according to their trade relationship status: continuing, starting, and ending. To understand which firms are more likely to form each type of pair, and how they contribute to aggregate tariff pass-through, we develop a more disaggregated decomposition framework. This framework leverages variation across firms within product-country markets to identify which firms contribute to complete or incomplete tariff pass-through. Because firm size is a widely used dimension of heterogeneity, we examine how it shapes firms' contributions to aggregate tariff pass-through.

Rewriting the decomposition in equation (2.4), we have

$$\underbrace{\frac{p_{jct'}-p_{jct}}{p_{jct}}}_{\approx\Delta\ln(p_{jct})}=\underbrace{\frac{\sum_G\frac{(p_{jct'}^{S^G}-p_{jct}^{S^G})}{n^G}}{p_{jct}}}_{\text{Average Continuing}}+\underbrace{\frac{\sum_G(\tilde{x}_{jct'}^{S^G}-\bar{x}_{jct'}^{S^G})(p_{jct'}^{S^G}-\bar{p}_{jct'}^{S^G})-\sum_G(\tilde{x}_{jct}^{S^G}-\bar{x}_{jct}^{S^G})(p_{jct}^{S^G}-\bar{p}_{jct}^{S^G})}{p_{jct}}}_{\text{Between Continuing}}$$

$$+\underbrace{\frac{\sum_G x_{jct'}^{E^G}(p_{jct'}^{E^G}-p_{jct'}^{S})}{p_{jct}}}_{\text{Starting}}+\underbrace{\frac{\sum_G x_{jct}^{X^G}(p_{jct}^{S}-p_{jct}^{X^G})}{p_{jct}}}_{\text{Ending}}, \tag{A.1}$$

where $G \in \{\text{large firm}, \text{small firm}\}$, $\tilde{x}_{jct}^{S^G} \equiv \frac{x_{jct}^{S^G}}{x_{jct}^{S}}$ is the import quantity share of group G among continuing pairs, $\bar{x}_{jct}^{S^G} \equiv \frac{\sum_G \tilde{x}_{jct}^{S^G}}{n^G}$ is the unweighted average of $\tilde{x}_{jct}^{S^G}$ across G for continuing pairs, $p_{jct}^{S^G}$ denotes the unit value of continuing pairs in group G, $\bar{p}_{jct}^{S^G} \equiv \frac{\sum_G p_{jct}^{S^G}}{n^G}$ is the unweighted average of $p_{jct}^{S^G}$ across G for continuing pairs, and n^G denotes the number of groups of firms. The notation for other variables is symmetrically given. The derivation is in Appendix A.4.1. The explanation for each component can be specified as follows.

Continuing. Equation (A.1) explicitly captures the average continuing component for small and large firms separately, as well as the import share reallocation between these two groups. It is important to note that this decomposition offers a different interpretation of the "between continuing" component compared to the baseline approach in equation (2.4). While the baseline emphasizes the role of low-price firms—regardless of their size—in accounting for higher import quantity shares following a tariff increase, equation (A.1) focuses on how import share shifts between small and large firms influence the pass-through. This term is non-degenerate because small and large firms face different unit values.

Starting and Ending. Equation (A.1) also explicitly captures the contribution of large versus small starting (ending) pairs to unit value changes. This allows us to determine whether large firms contribute more to unit value changes driven by starting pairs, or whether small firms contribute more to changes driven by ending pairs—either through changes in import share or differences in unit value relative to continuing pairs. Additionally, the import share of starting pairs for large or small firms, $x_{jct'}^{E^G}$, can be further decomposed as $x_{jct'}^{E^G} = n_{jct'}^{E^G} \times \bar{x}_{ijct'}^{E^G}$, where $n_{jct'}^{E^G}$ denotes the number of starting pairs in group $G \in \{\text{large}, \text{small}\}$ in product-market (j, c) at period t', and $\bar{x}_{jct'}^{E^G} \equiv \frac{\sum_{i \in E_{jct'}^G} x_{ijct'}}{n_{jct'}^{E^G}}$ is their average import share. This decomposition allows us to determine whether changes in the import share of starting pairs after a tariff increase are driven by the number of starting firms or by changes in their average import share. Note that a lower $n_{jct'}^{E^G}$ but higher $\bar{x}_{ijct'}^{E^G}$ after tariff increase would suggest either fewer but larger starting importers, or fewer importers per product-country pair, which leads to a higher $\bar{x}_{ijct'}^{E^G}$. The analysis for ending pairs follows analogously.

We reestimate equation (2.5) by replacing the left-hand side, $\Delta \ln p_{jct}$, with the decomposed components in equation (A.1). The estimation results will be disclosed. Based on the empirical findings discussed elsewhere in the draft, we expect to find that (i) large continuing firms experience a smaller reduction in unit value than small continuing firms after a tariff increase, indicating less incomplete tariff pass-through. (ii) Large continuing firms account for a larger share of imports than small continuing firms following the tariff increase, contributing to complete tariff pass-through as they face higher unit values;[21] (iii) There are fewer new trade relationships. Conditional on starting new relationships, large firms contribute to complete aggregate tariff pass-through, as they account for a larger import share and face higher unit values than continuing pairs after tariff increases. (iv) There are more ending trade relationships. Conditional on ending relationships, small firms contribute to incomplete tariff pass-through, as those facing high unit values are more likely to exit after tariff increases.

A.4.1 Derivation Details

In this section, we derive equation (A.1). First, we generate two groups by classifying each firm as either large or small: $G \in \{\text{large}, \text{small}\}$. This classification is time-invariant for each firm. Specifically, a firm is considered large if its imports in 2017 is at least equal to the mean imports across all firms in 2017. For firms that entered the market after 2017, we classify their size by comparing their imports level in their entry year to the 2017 mean imports. While we use the mean imports as the cutoff, it is possible to employ alternative thresholds such as the 75th percentile or 90th percentile. Additionally, our decomposition framework is flexible and can accommodate classifications into more than two groups.

Second, we rewrite group means. Specifically, for $M \in \{E, X, S\}$, p^M_{jct} and x^M_{jct} defined in Section 2.2 can be rewritten as

$$p^M_{jct} \equiv \frac{1}{x^M_{jct}} \sum_G x^{M^G}_{jct} p^{M^G}_{jct}, \quad x^M_{jct} \equiv \sum_G x^{M^G}_{jct}, \quad p^{M^G}_{jct} \equiv \sum_{i \in M^G_{jc}} \frac{x_{ijct}}{x^{M^G}_{jct}} p_{ijct}, \quad x^{M^G}_{jct} \equiv \sum_{i \in M^G_{jc}} x_{ijct},$$

[21] We will report the mean level of $(\tilde{x}^{S^G}_{jct'} - \bar{x}^{S^G}_{jct'})$ and $(p^{S^G}_{jct'} - \bar{p}^{S^G}_{jct'})$ across product-country markets for each G to highlight that large continuing firms face higher unit value and account for larger import share than small continuing firms. This is also supported by Table A.7.

where $G \in \{\text{large}, \text{small}\}$, and M_{jc}^{G} denotes the set of firms of M pairs that import product j from country c.

Third, we use these group means to rewrite the decomposition to have equation (A.1). Specifically, we derive in two steps.

Step 1. It is easy to show that

$$p_{jct} \equiv \sum_{M} x_{jct}^{M} p_{jct}^{M},\ p_{jct}^{M} \equiv \frac{1}{x_{jct}^{M}} \sum_{G} x_{jct}^{M^G}\, p_{jct}^{M^G},\ x_{jct}^{M} \equiv \sum_{G} x_{jct}^{M^G},\ p_{jct}^{M^G} \equiv \sum_{i \in M_{jc}^{G}} \frac{x_{ijct}}{x_{jct}^{M^G}} p_{ijct},\ x_{jct}^{M^G} \equiv \sum_{i \in M_{jc}^{G}} x_{ijct},$$

where $M \in \{E, X, S\},\ G \in \{\text{large}, \text{small}\}$. Specifically,

$$\begin{aligned} p_{jct} &\equiv \sum_{M} \sum_{i \in M_{jc}} x_{ijct} p_{ijct} = \sum_{M} \sum_{i \in M_{jc}} \frac{m_{ijct}}{\sum_{i \in \Omega_{jct}} m_{ijct}} p_{ijct} = \sum_{M} \frac{\sum_{i \in M_{jc}} m_{ijct}}{\sum_{i \in \Omega_{jct}} m_{ijct}} \sum_{i \in M_{jc}} \frac{m_{ijct}}{\sum_{i \in M_{jc}} m_{ijct}} p_{ijct} \\ &= \sum_{M} \sum_{i \in M_{jc}} x_{ijct} \sum_{i \in M_{jc}} \frac{x_{ijct}}{\sum_{i \in M_{jc}} x_{ijct}} p_{ijct} \equiv \sum_{M} x_{jct}^{M} p_{jct}^{M}, \end{aligned}$$

where $x_{jct}^{M} \equiv \sum_{i \in M_{jc}} x_{ijct}$, $p_{jct}^{M} \equiv \sum_{i \in M_{jc}} \frac{x_{ijct}}{x_{jct}^{M}} p_{ijct}$, Ω_{jct} denotes the set of all firms that import product j from country c in year-month t, and $\Omega_{jct} = \sum_{M} M_{jc}$. Similarly,

$$\begin{aligned} p_{jct}^{M} &\equiv \sum_{i \in M_{jc}} \frac{x_{ijct}}{x_{jct}^{M}} p_{ijct} = \sum_{G} \sum_{i \in M_{jc}^{G}} \frac{x_{ijct}}{x_{jct}^{M}} p_{ijct} = \sum_{G} \frac{\sum_{i \in M_{jc}^{G}} x_{ijct}}{x_{jct}^{M}} \sum_{i \in M_{jc}^{G}} \frac{x_{ijct}}{\sum_{i \in M_{jc}^{G}} x_{ijct}} p_{ijct} \\ &\equiv \frac{1}{x_{jct}^{M}} \sum_{G} x_{jct}^{M^G}\, p_{jct}^{M^G}. \end{aligned}$$

Step 2. We redecompose based on equation (2.4):

$$\begin{aligned} p_{jct'} - p_{jct} &= p_{jct'}^{S} - p_{jct}^{S} + x_{jct'}^{E}(p_{jct'}^{E} - p_{jct'}^{S}) + x_{jct}^{X}(p_{jct}^{S} - p_{jct}^{X}) \\ &= \frac{1}{x_{jct'}^{S}} \sum_{G} x_{jct'}^{S^G} p_{jct'}^{S^G} - \frac{1}{x_{jct}^{S}} \sum_{G} x_{jct}^{S^G} p_{jct}^{S^G} + (\sum_{G} x_{jct'}^{E^G})(\frac{1}{x_{jct'}^{E}} \sum_{G} x_{jct'}^{E^G} p_{jct'}^{E^G} - p_{jct'}^{S}) \\ &\quad + (\sum_{G} x_{jct}^{X^G})(p_{jct}^{S} - \frac{1}{x_{jct}^{X}} \sum_{G} x_{jct}^{X^G}\, p_{jct}^{X^G}). \end{aligned} \tag{A.2}$$

Note that

$$p_{jct}^{S} = \sum_{G} \frac{x_{jct}^{S^G}}{x_{jct}^{S}} p_{jct}^{S^G} = \bar{p}_{jct}^{S^G} + \sum_{G} (\tilde{x}_{jct}^{S^G} - \bar{x}_{jct}^{S^G})(p_{jct}^{S^G} - \bar{p}_{jct}^{S^G}), \tag{A.3}$$

where $\tilde{x}_{jct}^{S^G} \equiv \frac{x_{jct}^{S^G}}{x_{jct}^{S}}$, $\bar{x}_{jct}^{S^G} \equiv \frac{\sum_G \tilde{x}_{jct}^{S^G}}{n^G}$ is the unweighted average of $\tilde{x}_{jct}^{S^G}$ across G, $\bar{p}_{jct}^{S^G} \equiv \frac{\sum_G p_{jct}^{S^G}}{n^G}$ is the unweighted average of $p_{jct}^{S^G}$ across G, and n^G denotes the number of groups of firms. Therefore, the continuing component can be further written as

$$\begin{aligned} p_{jct'}^{S} - p_{jct}^{S} &= \bar{p}_{jct'}^{S^G} - \bar{p}_{jct}^{S^G} + \sum_{G} (\tilde{x}_{jct'}^{S^G} - \bar{x}_{jct'}^{S^G})(p_{jct'}^{S^G} - \bar{p}_{jct'}^{S^G}) - \sum_{G} (\tilde{x}_{jct}^{S^G} - \bar{x}_{jct}^{S^G})(p_{jct}^{S^G} - \bar{p}_{jct}^{S^G}) \\ &= \sum_{G} \frac{(p_{jct'}^{S^G} - p_{jct}^{S^G})}{n^G} + \sum_{G} (\tilde{x}_{jct'}^{S^G} - \bar{x}_{jct'}^{S^G})(p_{jct'}^{S^G} - \bar{p}_{jct'}^{S^G}) - \sum_{G} (\tilde{x}_{jct}^{S^G} - \bar{x}_{jct}^{S^G})(p_{jct}^{S^G} - \bar{p}_{jct}^{S^G}). \end{aligned} \tag{A.4}$$

The starting component can be further written as

$$\begin{aligned} x_{jct'}^{E}(p_{jct'}^{E} - p_{jct'}^{S}) &= (\sum_{G} x_{jct'}^{E^G})(\frac{1}{x_{jct'}^{E}} \sum_{G} x_{jct'}^{E^G} p_{jct'}^{E^G} - p_{jct'}^{S}) = x_{jct'}^{E}(\sum_{G} \frac{x_{jct'}^{E^G}}{x_{jct'}^{E}} p_{jct'}^{E^G} - p_{jct'}^{S}) \\ &= x_{jct'}^{E}(\sum_{G} \frac{x_{jct'}^{E^G}}{x_{jct'}^{E}} p_{jct'}^{E^G} - p_{jct'}^{S} \sum_{G} \frac{x_{jct'}^{E^G}}{x_{jct'}^{E}}) = \sum_{G} x_{jct'}^{E^G}(p_{jct'}^{E^G} - p_{jct'}^{S}). \end{aligned} \tag{A.5}$$

Similarly, the ending component can be rewritten.

Therefore, we have

$$\begin{aligned} p_{jct'} - p_{jct} = &\sum_{G} \frac{(p_{jct'}^{S^G} - p_{jct}^{S^G})}{n^G} + \sum_{G} (\tilde{x}_{jct'}^{S^G} - \bar{x}_{jct'}^{S^G})(p_{jct'}^{S^G} - \bar{p}_{jct'}^{S^G}) - \sum_{G} (\tilde{x}_{jct}^{S^G} - \bar{x}_{jct}^{S^G})(p_{jct}^{S^G} - \bar{p}_{jct}^{S^G}) \\ &+ \sum_{G} x_{jct'}^{E^G}(p_{jct'}^{E^G} - p_{jct'}^{S}) + \sum_{G} x_{jct}^{X^G}(p_{jct}^{S} - p_{jct}^{X^G}). \end{aligned} \tag{A.6}$$

A.5 Continuing Pairs: Empirical Findings

First, we estimate the average effects of tariff increases at the firm-product-country level:

$$\Delta y_{ijct} = \alpha + \beta \Delta \ln(1 + \tau_{jct}) + \eta_{ct} + \delta_{j} + \epsilon_{ijct}, \tag{A.7}$$

where Δy_{ijct} denotes the change in (i) log of unit value of firm i in product-country market jc, $\ln(p_{ijct})$; (ii) import quantity share within a product-country market, x_{ijct}; or (iii) log of after-duty import price, $\ln(p_{ijct}(1+\tau_{ijct}))$. We control for country-year-month (η_{ct}) and product fixed effects (δ_j). The coefficient of interest is β. The estimation results are in Panel A of Table A.2. When tariffs increase, the unit values of continuing firm-product-country pairs decrease on average (Column 1), confirming the finding from Section 2.2 that tariff pass-through to U.S. importers is incomplete. However, the after-duty price still rises (Column 3). Moreover, we observe that the import quantity share of firms increases with tariff changes (Column 2), suggesting that product-country pairs that experience higher tariff increases have import shares more significantly reallocated toward continuing firms.

We measure firm size as the log of employment in 2017, $\ln(emp)_{i,2017}$, prior to the trade dispute, using data from LBD. We estimate the heterogeneous effects of tariff increases at the firm-product-country level:

$$\Delta y_{ijct} = \alpha + \beta_1 \Delta \ln(1+\tau_{jct}) + \beta_2 \ln(emp)_{i,2017} + \beta_3 \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017} + \eta_{ct} + \delta_j + \epsilon_{ijct}, \tag{A.8}$$

where Δy_{ijct} denotes the change in (i) log of unit value of firm i in product-country market (j,c), $\ln(p_{ijct})$; (ii) import quantity share within a product-country market, x_{ijct}; or (iii) log of after-duty import price, $\ln(p_{ijct}(1+\tau_{ijct}))$. We control for country-year-month fixed effect (η_{ct}) and product fixed effect (δ_j). The coefficient of interest is β_3. The estimation results, shown in Table A.2, suggest that continuing pairs of larger firms have smaller reduction in unit values, higher post-tariff import prices, and a larger import quantity share when tariffs go up. In other words, large continuing firms face higher tariff pass-through and constitute a larger import share after a tariff increase than small continuing firms.

Alternative measure of firm size. The baseline results for continuing pairs are robust to alternative measures of firms size (e.g., import quantity share), as shown in Table A.3.

Understanding heterogeneity in pass-throughs. The unit value is jointly determined by importers and exporters in the real world. What explains the finding that larger continuing importers face less incomplete tariff pass-through? Note that our finding is based on that U.S. importers' trade relationships are defined at the product-country level. However, U.S. importers may switch exporters within a product-country market, and after a tariff in-

crease, larger importers might trade with more expensive exporters—especially if low-priced exporters exit the market post-tariff. Consequently, exporter switching could contribute to the observation that larger importers experience less incomplete pass-through. If exporter switching cannot explain this finding, the result could be due to two different reasons. First, larger importers may be less willing to reduce unit values because the imported varieties are traded among related parties or possess other attractive attributes post-tariff increase. Second, larger importers have less scope to reduce unit values because pre-tariff prices are already low or because foreign exporters can easily sell to alternative markets, limiting the importers' influence on unit values. To this end, we examine each possible explanation in turn.

Exporter switching? To investigate, we include exporter information in our control variables. Specifically, among all continuing pairs, for importer i who imports product j from country c in period t, we estimate:

$$\Delta y_{ijct} = \alpha + \beta_1 \Delta \ln(1+\tau_{jct}) + \beta_2 \ln(emp)_{i,2017} + \beta_3 \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017} + I_{ijct'} + \eta_{ct} + \delta_j + \epsilon_{ijct}, \tag{A.9}$$

where $I_{ijct'}$ is a dummy variable equal to one if the number of suppliers or the specific suppliers of importer i for product-country pair (j, c) change in the next period t'. As shown in Table A.4, the heterogeneity in firms' tariff pass-through remains robust even after controlling for whether a firm ever switches the supplier of product j in country c. On the other hand, even without exporter switching, exporters may exert different market power when trading with various importers, leading to heterogeneous effects on tariff pass-through for different U.S. importers. To address this, we control for the exporter's supplier share, defined as $s_{ijc} \equiv \frac{(1+\tau_{jc})p_{ijc}m_{ijc}}{\sum_{jc}(1+\tau_{jc})p_{ijc}m_{ijc}}$, which measures the exporter's sales as a proportion of importer i's total imports.[22] The results will be disclosed.

Global value chain? It is possible that larger U.S. importers are more likely to import goods from their trading partners that belong to related parties. Therefore, foreign exporters may not need to reduce prices to mitigate the potential decrease in import demand after a tariff increase. Using the same estimation specified in equation (A.9), we replace $I_{ijct'}$ with

[22] The heterogeneous effect of s_{ijc} on tariff pass-through to importers, discussed in Section 3, illustrates the underlying mechanism for this concern.

the log of export value at time t for firm i to test whether the results hold for the subsample of firms that both export and import. As shown in Table A.5, the heterogeneity in firms' tariff pass-through remains robust.

Variety switching? Rauch (1999) constructs a product differentiation index I_3, showing that some products are standardized while others are differentiated with numerous varieties:

$$I_3 = \begin{cases} I_w, & \text{if goods traded on an organized exchange,} \\ I_r, & \text{if reference priced,} \\ I_n, & \text{if differentiated products.} \end{cases} \tag{A.10}$$

It is possible that larger U.S. importers tend to import more expensive varieties with other attractive attributes within a product-country market after tariff increases, which could contribute to the observed heterogeneity in tariff pass-through among continuing firms. To address this, we introduce I_3 into equation (A.8) and estimate the following:

$$\begin{aligned} \Delta y_{ijct} =& \alpha + \beta_1 \Delta \ln(1+\tau_{jct}) + \beta_2 \ln(emp)_{i,2017} + \beta_3 I_3 \\ &+ \beta_4 \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017} + \beta_5 \Delta \ln(1+\tau_{jct}) \times I_3 + \beta_6 \Delta \ln(emp)_{i,2017} \times I_3 \\ &+ \beta_7 \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017} \times I_3 + \eta_{ct} + \delta_j + \epsilon_{ijct}. \end{aligned} \tag{A.11}$$

For standardized products within an HS10 category (I_w), we expect limited variety switching. Table A.6 shows there is no significant difference between standardized and differentiated products, which suggests that variety switching does not explain the observed heterogeneity.[23]

To summarize, our empirical findings suggest that larger importers experience less incomplete tariff pass-through is not due to exporter switching or a lower willingness to reduce unit values. Instead, it remains possible that larger importers have less scope to reduce unit values after a tariff increase. Relatedly, Jiao et al. (2024) document that low profit margins as the main reason for Chinese exporters not reducing prices in response to US tariffs.

[23] To address the adjustment on the exporter side, we could also add two controls: $I_{ijct'}$, a dummy variable equal to one if the number of suppliers or the specific suppliers of importer i for product-country pair (j,c) change in the next period t', and $s_{ijct} \equiv \frac{(1+\tau_{jct})p_{ijct}m_{ijct}}{\sum_{jc}(1+\tau_{jct})p_{ijct}m_{ijct}}$, the exporters' supplier share.

Table A.2: Responses of Continuing Pairs

	(1) Δln(unit value)	(2) Δimport quantity share	(3) Δln(import price)
A. Average Effect			
$\Delta \ln(1+\tau_{jct})$	-0.178	0.05	0.805
	(8.00)***	(16.82)***	(32.88)***
Obs.	7571000	7571000	7571000
FEs	Yes	Yes	Yes
adjusted R^2	0.02	0.01	0.02
B. Heterogeneous effects			
$\Delta \ln(1+\tau_{jct})$	-0.305	-0.07	0.666
	(5.71)***	(5.90)***	(11.98)***
$\ln(emp)_{i,2017}$	-0.001	0	-0.001
	(4.82)***	(1.58)	(4.23)***
$\Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	0.03	0.011	0.025
	(4.64)***	(8.29)***	(3.81)***
Obs.	2723000	2723000	2723000
FEs	Yes	Yes	Yes
adjusted R^2	0.02	0.01	0.02

Notes: The table presents the estimation results of estimating equation (A.8). The difference terms are calculated as 12-month log difference. Panel A estimates the average effects of tariff increases, while Panel B shows the corresponding heterogeneous effects. Standard errors are clustered at HS-8 digit level. t-statistics are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table A.3: Responses of Continuing Pairs: Alternative Heterogeneity Measure

	(1) Δln(unit value)	(2) Δimport quantity share	(3) Δln(import price)
$\Delta \ln(1+\tau_{jct})$	-0.325	0.038	0.658
	(5.54)***	(10.91)***	(10.01)***
$\mathcal{I}^{x2}_{ijc,2017}$	0.029	0	0.029
	(8.67)***	(1.39)	(8.28)***
$\mathcal{I}^{x3}_{ijc,2017}$	0.051	0.001	0.05
	(15.07)***	(5.01)***	(14.47)***
$\mathcal{I}^{x4}_{ijc,2017}$	0.071	-0.012	0.07
	(20.08)***	(36.29)***	(19.45)***
$\Delta \ln(1+\tau_{jct}) \times \mathcal{I}^{x2}_{ijc,2017}$	0.105	-0.023	0.121
	(1.17)	(7.85)***	(1.25)
$\Delta \ln(1+\tau_{jct}) \times \mathcal{I}^{x3}_{ijc,2017}$	0.152	-0.008	0.157
	(1.78)*	(2.63)***	(1.68)*
$\Delta \ln(1+\tau_{jct}) \times \mathcal{I}^{x4}_{ijc,2017}$	0.214	0.067	0.199
	(2.64)***	(12.08)***	(2.24)**
Obs.	7571000	7571000	7571000
FEs	Yes	Yes	Yes
adjusted R^2	0.02	0.01	0.03

Notes: This table presents the estimation results of estimating equation (A.8) using import quantity share as the measure of firm heterogeneity. A firm i's import quantity share in each product-country market (j,c) is defined as $x_{ijc,2017} = m_{ijc,2017} / \sum_i m_{ijc,2017}$. We classify firm-product-country pairs into four groups within each product-country market based on their 2017 import quantity shares. For example, $\mathcal{I}^{x2}_{ijc,2017}$ equals 1 if the import quantity share falls within the second quartile of the distribution. The difference terms are calculated as 12-month log difference. Standard errors are clustered at HS-8 digit level. t-statistics are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table A.4: Responses of Continuing Pairs: Export Switching

	(1) Δln(unit value)	(2) Δimport quantity share	(3) Δln(import price)
$\Delta \ln(1+\tau_{jct})$	-0.308	0.056	0.713
	(5.72)***	(6.18)***	(12.72)***
$\ln(emp)_{i,2017}$	-0.001	0	-0.001
	(4.97)***	(1.48)	(4.30)***
$\Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	0.03	0.008	0.023
	(4.63)***	(6.55)***	(3.42)***
$I_{ijct'}$	0.007	-0.011	0.007
	(4.30)***	(26.08)***	(4.18)***
Obs.	2587000	2587000	2587000
FEs	Yes	Yes	Yes
adjusted R^2	0.02	0.01	0.02

Notes: The table presents the estimation results of estimating equation (A.9). The difference terms are calculated as 12-month log difference. Standard errors are clustered at HS-8 digit level. t-statistics are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table A.5: Responses of Continuing Pairs: Global Value Chain

	(1) Δln(unit value)	(2) Δimport quantity share	(3) Δln(import price)
$\Delta \ln(1+\tau_{jct})$	-0.237	-0.101	0.707
	(4.13)***	(6.90)***	(12.15)***
$\ln(emp)_{i,2017}$	-0.001	0	-0.001
	(1.98)**	(0.82)	(1.45)
$\Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	0.022	0.013	0.019
	(3.08)***	(8.60)***	(2.67)***
$ln(\text{export value})_{it}$	-0.001	0	-0.001
	(1.56)	(0.5)	(1.74)*
Obs.	2370000	2370000	2370000
FEs	Yes	Yes	Yes
adjusted R^2	0.02	0.01	0.02

Notes: The table presents the estimation results of estimating equation (A.9) that controls for importers' export value. The difference terms are calculated as 12-month log difference. Standard errors are clustered at HS-8 digit level. t-statistics are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

A.6 Starting and Ending Pairs: Empirical Findings

We compare starting pairs with continuing ones at time t' by estimating

$$y_{ijct'} = \alpha + \beta_1 \Delta \ln(1+\tau_{jct}) + \beta_2 \mathbb{1}_{ijct}^{\text{new c-j}} + \beta_3 \Delta \ln(1+\tau_{jct}) \times \mathbb{1}_{ijct}^{\text{new c-j}} + \eta_{ct} + \delta_j + \epsilon_{ijct}, \quad \text{(A.12)}$$

where $\mathbb{1}_{ijct}^{\text{new c-j}}$ is the indicator that takes the value 1 if the pair ijc is a starting pair at period t' compared to period t. $y_{ijct'}$ refers to a firm' unit value, post-tariff import price and import quantity share at period t'. Panel A of Table A.7 summarizes the estimation results. On average, firms with new relationships exhibit higher unit values within each product-

Table A.6: Responses of Continuing Pairs: Variety Switching

	(1)	(2)	(3)
	Δln(unit value)	Δimport quantity share	Δln(import price)
$\Delta \ln(1+\tau_{jct})$	-0.127	1.262	1.044
	(0.06)	(0.66)	(0.49)
$I_r \times \Delta \ln(1+\tau_{jct})$	-0.136	-1.198	-0.372
	(0.06)	(0.62)	(0.17)
$I_n \times \Delta \ln(1+\tau_{jct})$	-0.33	-1.475	-0.553
	(0.15)	(0.77)	(0.26)
$\ln(emp)_{i,2017}$	0.006	0	0.006
	(4.33)***	(1.3)	(4.41)***
$\Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	-0.296	-0.153	-0.338
	(0.76)	(0.42)	(0.91)
$I_r \times \ln(emp)_{i,2017}$	-0.006	0	-0.006
	(3.52)***	(0.45)	(3.51)***
$I_n \times \ln(emp)_{i,2017}$	-0.006	0	-0.006
	(4.94)***	(0.72)	(4.93)***
$I_r \times \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	0.316	0.15	0.357
	(0.8)	(0.41)	(0.96)
$I_n \times \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	0.343	0.175	0.373
	(0.87)	(0.48)	(1)
Obs.	516000	516000	516000
adjusted R^2	0	0.01	0

Notes: The table presents the estimation results of estimating equation (A.11). The product differentiation index is from the liberal classification in Rauch (1999). The difference terms are calculated as 12-month log difference. Standard errors are clustered at HS-8 digit level. t-statistics are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

country market compared to continuing firms. Among product-country pairs subject to tariff increases during the trade dispute, unit value differences between new and continuing relationships become higher, though insignificant. New relationships capture a higher import share compared to those in markets not significantly affected by tariff increases.

Accounting for firm size heterogeneity, Panel B of Table A.7 shows that starting pairs established by larger firms, on average, face higher unit values compared to continuing pairs of large firms, as reflected by the positive coefficient on the interaction term $\mathbb{1}_{ijct}^{\text{new c-j}} \times \ln(emp)_{i,2017}$. Additionally, starting pairs established by larger firms capture a much higher import share compared to those in markets not significantly impacted by tariff increases, as reflected by the positive coefficient on the interaction term $\mathbb{1}_{ijct}^{\text{new c-j}} \times \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$. This likely occurs because, as detailed later, although there are fewer starting pairs after tariff increases, the overall number of importers per product-country market declines, resulting in a higher import share for starting pairs. Moreover, following tariff increases, only larger firms—which tend to face higher unit values—are more likely to initiate

new trade relationships. This contributes both to the unit value difference between starting and continuing pairs and to the increased import share of starting pairs.

The corresponding estimation for ending pairs is shown in Table A.8. Ending pairs face higher unit values than continuing pairs on average, and account for a larger import share after the tariff increase. However, in product-country markets subject to higher tariffs during the U.S.-China trade dispute, a greater fraction of firm-product-country pairs with low unit values are terminated compared to those in less-affected markets, as indicated by the negative coefficient on the interaction term $\mathbb{1}_{ijct}^{\text{exit c-j}} \times \Delta \ln(1+\tau_{jct})$. This effect is mainly driven by small firms, as shown by the positive coefficient on the interaction term $\mathbb{1}_{ijct}^{\text{exit c-j}} \times \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$. This likely occurs because tariff increases make importing unprofitable for more firms, lowering the threshold unit value at which relationships are ended: before the tariff increase, only firms facing very high unit values tended to exit, but after the increase, even those facing moderately high unit values are more likely to terminate relationships.

It is important to note that the estimations in this section use unweighted averages across firm-product-country pairs, while the analyses in Section 2.2 and Appendix A.4 rely on weighted averages across starting or ending pairs. Any apparent inconsistencies arise from these different approaches, but a unified explanation can be provided to reconcile both.

Understanding firms' sourcing strategy adjustments after tariff increase. So far, what remains unclear is why and how tariff increases affect firms' sourcing strategy adjustments, thereby contributing to changes in the unit value and import share of starting and ending pairs. There are two possible explanations. First, in response to tariff increases, firms may add varieties with more attractive attributes (e.g., higher quality) and drop varieties with less attractive attributes—regardless of unit value—to maintain profitability or competitiveness. This can be described as a variety switching (quality upgrading) motive. Second, firms may respond by dropping costly varieties and adding similar varieties that are less costly, which we refer to as a cost-saving motive.

We find that the cost-saving motive is more likely for two main reasons. First, as detailed in Appendix A.6.1, there are fewer starting pairs and more ending pairs after the tariff increase. Second, as detailed in Appendix A.6.2, firms that start new trade relationships after the tariff increase mainly do so to import existing products from alternative sourcing coun-

Table A.7: Comparing Starting and Continuing Pairs

	ln(unit value)$_{ijct'}$	quantity share$_{ijct'}$	ln(import price)$_{ijct'}$
A. Average Effects			
$\mathbb{1}_{ijct}^{\text{new c-j}}$	0.299	-0.063	0.301
	(27.53)***	(46.29)***	(27.74)***
$\Delta \ln(1+\tau_{jct})$	-0.195	0.066	0.656
	(1.17)	(4.35)***	(3.95)***
$\mathbb{1}_{ijct}^{\text{new c-j}} \times \Delta \ln(1+\tau_{jct})$	0.024	0.118	0.019
	(0.23)	(7.31)***	(0.18)
Obs.	7858000	7858000	7858000
adjusted R^2	0.68	0.3	0.68
B. Heterogeneous Effects			
$\mathbb{1}_{ijct}^{\text{new c-j}}$	0.234	-0.053	0.24
	(13.06)***	(21.44)***	(13.41)***
$\Delta \ln(1+\tau_{jct})$	-0.315	0.045	0.552
	(0.94)	(0.98)	(1.65)*
$\mathbb{1}_{ijct}^{\text{new c-j}} \times \Delta \ln(1+\tau_{jct})$	-0.127	0.016	-0.054
	(0.43)	(0.26)	(0.18)
$\ln(emp)_{i,2017}$	0.021	0.001	0.022
	(8.59)***	(3.42)***	(8.98)***
$\Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	-0.04	0.007	-0.049
	(1.1)	(1.27)	(1.35)
$\mathbb{1}_{ijct}^{\text{new c-j}} \times \ln(emp)_{i,2017}$	0.019	-0.001	0.019
	(10.04)***	(4.44)***	(9.83)***
$\mathbb{1}_{ijct}^{\text{new c-j}} \times \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	0.041	0.009	0.034
	(1.04)	(1.35)	(0.87)
Obs.	2464000	2464000	2464000
adjusted R^2	0.68	0.31	0.68

Notes: Panel A presents the estimation results of equation (A.12). Panel B further includes firm employment in 2017 as the measure of firm heterogeneity. The difference terms are calculated as 12-month log difference. Standard errors are clustered at HS-8 digit level. t-statistics are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

tries, rather than to import new products. Since the variety switching (quality upgrading) motive is typically associated with changes in the range of imported products, these findings suggest that the cost-saving motive is more prevalent.

We remain agnostic about why starting and ending pairs face higher unit values than continuing pairs or why firms adjust their sourcing strategies during normal times (i.e., before tariff increases). We take these patterns as given and focus instead on firms' responses to tariff increases and their implications for aggregate tariff pass-through. As shown in Section 3.3, the welfare effects of tariff increases operate through these firm responses to tariff increases and their impact on aggregate tariff pass-through.

Table A.8: Comparing Ending and Continuing Pairs

	ln(unit value)$_{ijct}$	quantity share$_{ijct}$	ln(import price)$_{ijct}$
A. Average Effects			
$\mathbb{1}_{ijct}^{\text{exit c-j}}$	0.282	-0.063	0.284
	(26.26)***	(47.54)***	(26.54)***
$\Delta \ln(1+\tau_{jct})$	0.124	-0.047	-0.091
	(1.31)	(3.38)***	(0.95)
$\mathbb{1}_{ijct}^{\text{exit c-j}} \times \Delta \ln(1+\tau_{jct})$	-0.544	0.188	-0.549
	(7.86)***	(19.47)***	(7.93)***
Obs.	16100000	16100000	16100000
adjusted R^2	0.68	0.34	0.68
B. Heterogeneous Effects			
$\mathbb{1}_{ijct}^{\text{exit c-j}}$	0.248	-0.058	0.254
	(13.37)***	(24.09)***	(13.72)***
$\Delta \ln(1+\tau_{jct})$	0.351	0.129	0.147
	(1.72)*	(4.87)***	(0.72)
$\mathbb{1}_{ijct}^{\text{exit c-j}} \times \Delta \ln(1+\tau_{jct})$	-0.649	0.137	-0.655
	(3.63)***	(5.45)***	(3.67)***
$\ln(emp)_{i,2017}$	0.024	0.001	0.025
	(10.32)***	(2.68)***	(10.71)***
$\Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	-0.105	-0.014	-0.107
	(4.04)***	(4.57)***	(4.13)***
$\mathbb{1}_{ijct}^{\text{exit c-j}} \times \ln(emp)_{i,2017}$	0.013	0	0.013
	(7.59)***	(1.12)	(7.37)***
$\mathbb{1}_{ijct}^{\text{exit c-j}} \times \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	0.06	0	0.059
	(2.51)**	(0.14)	(2.43)**
Obs.	5067000	5067000	5067000
adjusted R^2	0.68	0.34	0.68

Notes: Panel A presents the estimation results of equation (A.12) for the ending pairs. Panel B further includes firm employment in 2017 as the measure of firm heterogeneity. The difference terms are calculated as 12-month log difference. Standard errors are clustered at HS-8 digit level. t-statistics are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

A.6.1 Fewer Starting Pairs, More Ending Pairs

When a firm starts a new trade relationship, it may begin importing a new product, source from a new country, or both. Conversely, a firm may end an existing trade relationship by ceasing to import a particular product, ceasing to import from a specific country, or both. Let $1_{ijct}^{\text{new c-j}} = 1$ indicate that the firm initiates a new product-country trade relationship, and let $1_{ijct}^{\text{exit c-j}} = 1$ indicate that the firm terminates one.

To examine whether firms adjust their import relationships in response to tariff increases, we first estimate the following linear probability model:

$$\mathcal{I}_{ijct} = \alpha + \beta \Delta \ln(1+\tau_{jct}) + \eta_{ct} + \delta_j + \epsilon_{ijct} \tag{A.13}$$

Table A.9: Probability of Starting and Ending a Trade relationship

	$\mathbb{1}_{ijct}^{\text{new c-j}}$	$\mathbb{1}_{ijct}^{\text{exit c-j}}$
$\Delta \ln(1+\tau_{jct})$	-0.173	0.315
	(15.37)***	(27.40)***
Obs.	26110000	26110000
adjusted R^2	0.1	0.04

Notes: This table presents the estimation results of estimating equation (A.13). The difference terms are calculated as 12-month log difference. Standard errors are clustered at HS-8 digit level. t-statistics are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

where the dependent variable $\mathcal{I}_{ijct} \in \{1_{ijct}^{\text{new c-j}}, 1_{ijct}^{\text{exit c-j}}\}$ indicates either the formation or dissolution of a product-country import relationship. The coefficient of interest, β, captures how the likelihood of forming or ending such relationships responds to changes in tariffs. The estimation results are presented in Table A.9. Higher tariffs reduce the likelihood that firms establish new product-country pairs and increase the likelihood of terminating existing import relationships.

A.6.2 New Product or New Country?

In this section, we study whether the extensive margin changes arise from changes of the importing product margin or shifts in the sourcing country. If a firm has a starting import relationship ($\mathbb{1}_{ijct}^{\text{new c-j}} = 1$), they could fall into one of the four cases:

1. $\mathbb{1}_{ijct}^{\text{new j}} = 1$: firm i imports new product j from existing trading partner c at t'.
2. $\mathbb{1}_{ijct}^{\text{new c}} = 1$: firm i sources existing product j from a new trading partner c at t'.
3. $\mathbb{1}_{ijct}^{\text{new j, new c}} = 1$: firm i imports new product j from new trading partner c at t'.
4. $\mathbb{1}_{ijct}^{\text{old j, old c}} = 1$: Firm i imports existing product j from existing trading partner c at period t', but product j was imported from other existing countries at t.

Similarly, ending pairs ($\mathbb{1}_{ijct}^{\text{exit c-j}} = 1$) also have four alternatives:

1. $\mathbb{1}_{ijct}^{\text{exit j}} = 1$: firm i stops importing product j, but still imports other products from existing sourcing country c at period t'.

2. $\mathbb{1}_{ijct}^{\text{exit c}} = 1$: firm i stops sourcing from country c, but still imports product j from other countries at t'.

3. $\mathbb{1}_{ijct}^{\text{exit j, exit c}} = 1$: firm i stops importing product j, and stops importing from country c at t'.

4. $\mathbb{1}_{ijct}^{\text{sur j, sur c}} = 1$: firm i stops importing product j from country c, but product j is imported from other countries, and firm i still imports other products from country c at t'.

We then reestimate equation (A.13) by replacing the dependent variables with specific starting or ending categories. The results for starting pairs, presented in Panel A of Table A.10, indicate that firms are generally less likely to import new products or source from new countries, as shown in Columns (1) to (3). However, firms are more likely to import existing products from a new country—often a trade partner they had previously engaged with, as illustrated in Column (4).

The estimation results for ending pairs, displayed in Panel B of Table A.10, show that firms are more likely to terminate existing import relationships, either by ceasing to import specific products or by discontinuing imports from certain countries.

Table A.10: Probability of Starting and Ending

A. Probability of Starting				
	(1)	(2)	(3)	(4)
	$\mathbb{1}_{ijct}^{\text{new c}}$	$\mathbb{1}_{ijct}^{\text{new j}}$	$\mathbb{1}_{ijct}^{\text{new j, new c}}$	$\mathbb{1}_{ijct}^{\text{old j, old c}}$
$\Delta \ln(1+\tau_{jct})$	-0.007	-0.137	-0.046	0.017
	(2.55)**	(18.59)***	(6.05)***	(3.83)***
Obs.	26110000	26110000	26110000	26110000
adjusted R^2	0.03	0.12	0.04	0.03
B. Probability of Ending				
	(1)	(2)	(3)	(4)
	$\mathbb{1}_{ijct}^{\text{exit c}}$	$\mathbb{1}_{ijct}^{\text{exit j}}$	$\mathbb{1}_{ijct}^{\text{exit j, exit c}}$	$\mathbb{1}_{ijct}^{\text{sur j, sur c}}$
$\Delta \ln(1+\tau_{jct})$	0.014	0.126	0.091	0.084
	(6.07)***	(15.15)***	(13.93)***	(14.37)***
Obs.	26110000	26110000	26110000	26110000
adjusted R^2	0.03	0.04	0.03	0.03

Notes: This table presents the estimation results of estimating equation (A.13). The difference terms are calculated as 12-month log difference. Standard errors are clustered at HS-8 digit level. t-statistics are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

B Model Appendix

B.1 Solving the Model

Households' Problem: The consumption maximization problem leads to a standard demand function:

$$c_{it} = \left(\frac{p_{it}}{P_t}\right)^{-\rho} C_t, \tag{B.1}$$

where $P_t = (\int_i p_{it}^{1-\rho} di)^{\frac{1}{1-\rho}}$.

Firms' Problem: As shown in equation (3.18), the firm maximizes its profit by choosing the amount it produces y_i and the cutoff shifter b_i^* for imported intermediates.

The first order condition with respect to y_i yields

$$y_i = \left(\frac{\psi\left(A_i, b_i^*\right)}{D^{\frac{1}{\rho}}} \frac{\rho}{\rho - 1}\right)^{-\rho}, \tag{B.2}$$

where D is specified in equation (3.9). The variety price is set as a constant markup over the unit cost

$$p_i = \frac{\rho}{\rho - 1} \psi\left(A_i, b_i^*\right). \tag{B.3}$$

The first order condition with respect to b_i^* solves the extensive margin cutoff

$$\frac{\partial \pi(A_i)}{\partial b_i^*} = -\frac{\partial \psi\left(A_i, b_i^*\right)}{\partial b_i^*} y_i - \eta N_i(b_i^*)^{\eta-1} E \frac{\partial N_i(b_i^*)}{\partial b_i^*} = 0, \tag{B.4}$$

where

$$\frac{\partial \psi\left(A_i, b_i^*\right)}{\partial b_i^*} = \frac{1}{A_i} \left(\frac{W}{1-\alpha}\right)^{1-\alpha} \left(\frac{p_i^X}{\alpha}\right)^{\alpha-1} \frac{\partial p_i^X}{\partial b_i^*}, \tag{B.5}$$

$$\frac{\partial p_i^X}{\partial b_i^*} = \left(\frac{p_i^F}{p_i^X}\right)^{-\sigma} \frac{\partial p_i^F}{\partial b_i^*}, \tag{B.6}$$

$$\frac{\partial p_i^F}{\partial b_i^*} = -\frac{1}{1-\epsilon} (p_i^F)^{\epsilon} \left(\frac{\tau_{jc} p_{ijc}^*}{b_i^*}\right)^{1-\epsilon} f(b_i^*), \tag{B.7}$$

and p_{ijc}^* is foreign export price of marginal variety.

Since $N_i(b_i^*) = \int_{b_i^*}^{\infty} f(b)db$, and as $b \to +\infty, f(b) \to 0$

$$\frac{\partial N_i(b_i^*)}{\partial b_i^*} = -f(b_i^*). \tag{B.8}$$

By substituting (B.7) into (B.6), then substituting (B.6) into (B.5), and finally using (B.5), (B.8), and (B.4), we have

$$\frac{1}{1-\epsilon}(p_i^F)^{\epsilon}\left(\frac{\tau_{jc}p_{ijc}}{b_i^*}\right)^{1-\epsilon}\left(\frac{p_i^{F*}}{p_i^X}\right)^{-\sigma}\frac{1}{A_i}\left(\frac{W}{1-\alpha}\right)^{1-\alpha}\left(\frac{p_i^X}{\alpha}\right)^{\alpha-1}y_i + \eta N_i(b_i^*)^{\eta-1}E = 0.$$

Conditional on the cutoff b_i^*, we solve the cost minimization problem at each layer separately.

The primary input cost minimization is formulated as follows

$$\min_{L_i, X_i}\left\{WL_i + p_i^X X_i\right\}$$

$$\text{s.t.} \quad y_i = A_i L_i^{1-\alpha} X_i^{\alpha}.$$

The first order conditions yield

$$L_i = (1-\alpha)\frac{\psi\left(A_i, b_i^*\right)}{W}y_i, \tag{B.9}$$

$$X_i = \alpha\frac{\psi\left(A_i, b_i^*\right)}{p_i^X}y_i, \tag{B.10}$$

where

$$\psi\left(A_i, b_i^*\right) = \lambda = \frac{1}{A_i}\left(\frac{W}{1-\alpha}\right)^{1-\alpha}\left(\frac{p_i^X}{\alpha}\right)^{\alpha}. \tag{B.11}$$

The intermediate composite input aggregation is formulated as follows

$$\min_{h_i, z_i}\left\{p_i^H h_i + p_i^F m_i\right\}$$

$$\text{s.t.} \quad X_i = \left(h_i^{\frac{\sigma-1}{\sigma}} + m_i^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}.$$

The first order conditions yield

$$h_i = \left(\frac{p_i^H}{p_i^X}\right)^{-\sigma} X_i, \tag{B.12}$$

$$m_i = \left(\frac{p_i^F}{p_i^X}\right)^{-\sigma} X_i, \tag{B.13}$$

where

$$p_i^X = \left((p_i^H)^{1-\sigma} + (p_i^F)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}. \tag{B.14}$$

The domestic intermediates aggregation is formulated as follows

$$\min_{h_{ik}} \left\{ \int_0^1 p_{ik}^H h_{ik} dk \right\}$$

$$\text{s.t.} \quad h_i = \left(\int_0^1 h_{ik}^{\frac{\theta-1}{\theta}} dk \right)^{\frac{\theta}{\theta-1}}.$$

The first order condition leads to

$$h_{ik} = \left(\frac{p_{ik}^H}{p_i^H}\right)^{-\theta} h_i, \tag{B.15}$$

where

$$p_i^H = \lambda = \left(\int_0^1 (p_{ik}^H)^{1-\theta} dk \right)^{\frac{1}{1-\theta}}. \tag{B.16}$$

The foreign input variety aggregation is formulated as follows

$$\min_{z_{ij}} \left\{ \int_{b_i^*}^{\infty} \tau_{jc} p_{ijc} m_{ijc} dF(b) \right\}$$

$$\text{s.t.} \quad m_i = \left[\int_{b_i^*}^{\infty} (b_{ijc} m_{ijc})^{\frac{\epsilon-1}{\epsilon}} dF(b) \right]^{\frac{\epsilon}{\epsilon-1}}.$$

The first order condition yields

$$m_{ijc} = b_{ijc}^{\epsilon-1} \left(\frac{\tau_{jc} p_{ijc}}{p_i^F}\right)^{-\epsilon} m_i, \tag{B.17}$$

where

$$p_i^F = \lambda = \left[\int_{b_i^*}^{\infty} \left(\frac{\tau_{jc} p_{ijc}}{b_{ijc}}\right)^{1-\epsilon} dF(b) \right]^{\frac{1}{1-\epsilon}}. \tag{B.18}$$

B.2 Existing Models of Heterogeneous Importer Behaviors

Among the large class of importer models we survey, the typical setups include: (i) a nested-CES production function; (ii) monopolistic competition in importers' output markets; (iii) monopolistic competition in importers' intermediate input markets; (iv) perfect competition in importers' labor input markets; and (v) homothetic importer demand. Most are partial equilibrium models that remain silent on the matching between importers and exporters, and abstract from general equilibrium effects in foreign countries. In Table B.1, we list papers that deviate from these standard setups and detail the pricing and sourcing strategies of importers modeled in the existing literature.

B.3 Proof of Proposition 3.1

Proof The first-order approximation of the welfare change in response to tariff change, measured by the change in real per capita consumption, is

$$d\ln(C/L) = \int_i \frac{c_i^{\frac{\rho-1}{\rho}}}{\int_{i'} c_{i'}^{\frac{\rho-1}{\rho}} di'} d\ln(c_i)di - d\ln(L). \tag{B.19}$$

Given that $c_i = \left(\frac{p_i}{P}\right)^{-\rho} C$, it follows that $\frac{c_i^{\frac{\rho-1}{\rho}}}{\int_{i'} c_{i'}^{\frac{\rho-1}{\rho}} di'} = \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}$. Since $p_i = \frac{\rho}{\rho-1}\psi(A_i, b_i^*)$, we have $d\ln(p_i) = d\ln(\psi(A_i, b_i^*))$. Substituting the expression for $d\ln(c_i)$, the expenditure share and $d\ln(p_i)$ yields:

$$d\ln(C/L) = -\rho \int_i \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'} d\ln(\psi(A_i, b_i^*))di + d\ln(P^\rho C) - d\ln(L). \tag{B.20}$$

Given $\psi(A_i, b_i^*) = \frac{1}{A_i}\left(\frac{W}{1-\alpha}\right)^{1-\alpha}\left(\frac{p_i^X}{\alpha}\right)^{\alpha}$ and $p_i^X = \left[(p_i^H)^{1-\sigma} + (p_i^F)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$, the first-order approximation of the firm-level unit cost becomes:

$$d\ln(\psi(A_i, b_i^*)) = (1-\alpha)d\ln(W) + \alpha d\ln(p_i^X). \tag{B.21}$$

Table B.1: Models of Heterogeneous Importer Behaviors

Setups	Papers
A. Production functions	
Not nested-CES	
B. Market structure in importers' output market	
Not monopolistic competition	
Perfect competition	Ramanarayanan (2017)
C. Market structure in intermediate input market	
Not monopolistic competition	
Oligopolistic competition	Alviarez et al. (2023)
Perfect competition	Bernard et al. (2018)
	Blaum (2024)
D. Market structure in labor input market	
Not perfect competition	
E. Importer Demand	
Not homothetic	Blaum et al. (2019)
F. Importing status	
Importer only	Alviarez et al. (2023)
Importer and non-importer	
Due to fixed cost	Gopinath and Neiman (2014)
	Halpern et al. (2015)
	Lu et al. (2024)
	Bernard et al. (2018)
	Blaum (2024)
Partial irreversibility	Ramanarayanan (2017)
Costly and (re)negotiation	Grossman et al. (2024)
G. Importer sourcing strategy	
Depend on per-period "shock"	Gopinath and Neiman (2014)
	Halpern et al. (2015)
	Alviarez et al. (2023)
	Bernard et al. (2018)
	Blaum et al. (2023)
	Blaum (2024)
Dynamic	
Longer-lasting relationships more likely to survive	Monarch and Schmidt-Eisenlohr (2023)
	Heise (2024)
Switch less if supplier provides higher quality or lower prices	Monarch (2022)
More imported varieties as importers age	Lu et al. (2024)
Smaller import value inputs more likely to be dropped (due to lower input productivity)	Lu et al. (2024)
H. Imported variety pricing	
With trade relationship adjustment	
Decreased unit value via continuous switching	Lu et al. (2024)
Decreased unit value as relationship ages and hence increased import quantity as relationship ages	
(due to learning mechanism)	Monarch and Schmidt-Eisenlohr (2023)
(due to relationship capital)	Heise (2024)
Nash-in-Nash bargaining	Grossman et al. (2024)
Without trade relationship adjustment	
Exogenous	Gopinath and Neiman (2014)
	Halpern et al. (2015)
	Ramanarayanan (2017)
	Devereux et al. (2017)
Two-sided market power	Alviarez et al. (2023)
I. Importer and exporter matching	
Exogenous or static	Alviarez et al. (2023)
	Blaum et al. (2023)
Search and matching	Grossman et al. (2024)
J. General equilibrium effect in foreign country	
Labor market clearing	Monarch and Schmidt-Eisenlohr (2023)

Notes: In this table, we list papers that deviate from standard setups of importer models and detail their pricing and sourcing strategies of importers.

Substituting (B.21) into the welfare change equation (B.20) gives:

$$\begin{aligned} d\ln(C/L) =& -\rho\alpha\int_i \frac{p_i c_i}{\int_{i'} p_{i'}c_{i'}di'} d\ln(p_i^X)di - \rho(1-\alpha)d\ln(W) + d\ln(P^\rho C) - d\ln(L) \\ =& -\rho\alpha\int^{i^*} \frac{p_i c_i}{\int_{i'} p_{i'}c_{i'}di'} d\ln(p_i^H)di - \rho\alpha\int_{i^*}^{\hat{i^*}} \frac{p_i c_i}{\int_{i'} p_{i'}c_{i'}di'}[\ln(p_i^H) - \ln(p_i^X)]di \\ & -\rho\alpha\int_{\hat{i^*}} \frac{p_i c_i}{\int_{i'} p_{i'}c_{i'}di'} d\ln(p_i^X)di - \rho(1-\alpha)d\ln(W) + d\ln(P^\rho C) - d\ln(L), \end{aligned} \tag{B.22}$$

where i^* ($\hat{i^*}$) denotes the marginal importer such that firms with productivity no less than A_{i^*} ($A_{\hat{i^*}}$) are importers before (after) tariff increase, while those with lower productivity are non-importers.

Further expanding terms of (B.22) gives:

$$\begin{aligned} d\ln(C/L) =& -\rho\alpha\int^{i^*} \frac{p_i c_i}{\int_{i'} p_{i'}c_{i'}di'} d\ln(p_i^H)di - \rho\alpha\int_{i^*}^{\hat{i^*}} \frac{p_i c_i}{\int_{i'} p_{i'}c_{i'}di'}[\ln(p_i^H) - \ln(p_i^X)]di \\ & -\rho\alpha\int_{\hat{i^*}} \frac{p_i c_i}{\int_{i'} p_{i'}c_{i'}di'} d\ln(p_i^F)di - \rho\alpha\int_{\hat{i^*}} \frac{p_i c_i}{\int_{i'} p_{i'}c_{i'}di'}\frac{p_i^H h_i}{p_i^H h_i + p_i^F m_i}(d\ln(p_i^H) - d\ln(p_i^F))di \\ & -\rho(1-\alpha)d\ln(W) + d\ln(P^\rho C) - d\ln(L). \end{aligned} \tag{B.23}$$

We now decompose the change in p_i^F, where $p_i^F = \left[\int_{b_i^*}^{\infty}\left(\frac{\tau_{jc}p_{ijc}}{b_{ijc}}\right)^{1-\epsilon} dF(b)\right]^{\frac{1}{1-\epsilon}}$. Define

$$Z_i \equiv \int_{b_i^*}^{\infty}\left(\frac{\tau_{jc}p_{ijc}}{b_{ijc}}\right)^{1-\epsilon} dF(b) \quad \Rightarrow \quad p_i^F = Z_i^{\frac{1}{1-\epsilon}}. \tag{B.24}$$

Taking logarithms,

$$\ln p_i^F = \frac{1}{1-\epsilon}\ln Z_i \quad \Rightarrow \quad d\ln p_i^F = \frac{1}{1-\epsilon}\cdot\frac{dZ_i}{Z_i}. \tag{B.25}$$

Applying Leibniz's Rule to compute dZ_i,

$$dZ_i = -\left(\frac{\tau_{jc}p_{ijc}^*}{b_i^*}\right)^{1-\epsilon} f(b_i^*)db_i^* + \int_{b_i^*}^{\infty}(1-\epsilon)\left(d\ln\tau_{jc} + d\ln p_{ijc}\right)\left(\frac{\tau_{jc}p_{ijc}}{b_{ijc}}\right)^{1-\epsilon} dF(b).$$

Then we have

$$\frac{dZ_i}{Z_i} = (1-\epsilon)\int_{b_i^*}^{\infty} \omega_{ijc}\left(d\ln(\tau_{jc}) + d\ln(p_{ijc})\right) dF(b) - s_i^* db_i^*, \tag{B.26}$$

where $\omega_{ijc} = \left(\frac{\tau_{jc}p_{ijc}}{b_{ijc}p_i^F}\right)^{1-\epsilon}$ is the share of a specific foreign variety in determining a firm's overall cost of imported inputs, p_{ijc}^* is foreign export price of marginal variety, $\omega_i^* = \left(\frac{\tau_{jc}p_{ijc}^*}{b_i^* p_i^F}\right)^{1-\epsilon}$ is the share of marginal foreign variety in imported inputs cost of firm i, and $s_i^* = \omega_{ijc}^* f(b_i^*)$ is the share of the marginal variety of firm i.

Substituting (B.26) into (B.25), we obtain the first-order approximation:

$$d\ln p_i^F = \int_{b_i^*}^{\infty} \omega_{ijc}\left(d\ln(\tau_{jc}) + d\ln(p_{ijc})\right) dF(b) - \frac{s_i^*}{1-\epsilon} db_i^*. \tag{B.27}$$

Plugging (B.27) into (B.23), and defining

$$e_i = \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}, \quad s_i^h = \frac{p_i^H h_i}{p_i^H h_i + p_i^F m_i},$$

we arrive at

$$\begin{aligned} d\ln(C/L) = & \underbrace{-\rho\alpha \int_{i^{\hat{*}}} e_i \left[\int_{b_i^*}^{\infty} \omega_{ijc}\left(d\ln(\tau_{jc}) + d\ln(p_{ijc})\right) dF(b)\right] di}_{\text{import price index intensive margin}} \underbrace{-\rho\alpha \int_{i^{\hat{*}}} e_i \left(\frac{s_i^*}{\epsilon - 1} db_i^*\right) di}_{\text{import price index extensive margin}} \\ & \underbrace{-\rho\alpha \int_{i^{\hat{*}}} e_i s_i^h \left(d\ln(p_i^H) - d\ln(p_i^F)\right) di}_{\text{importer domestic variety substitution effect}} \underbrace{-\rho\alpha \int^{i^*} e_i d\ln(p_i^H) di - \rho\alpha \int_{i^*}^{i^{\hat{*}}} e_i [\ln(p_i^H) - \ln(p_i^X)] di}_{\text{non-importer domestic variety substitution effect}} \\ & \underbrace{-\rho(1-\alpha) d\ln(W)}_{\text{wage effect}} \underbrace{+ d\ln(P^\rho C) - d\ln(L)}_{\text{GE effect}}. \end{aligned} \tag{B.28}$$

Given $m_{ijc} = b_{ijc}^{\epsilon-1}\left(\frac{\tau_{jc}p_{ijc}}{p_i^F}\right)^{-\epsilon} m_i$, it is easy to show that

$$\omega_{ijc} = \left(\frac{\tau_{jc}p_{ijc}}{b_{ijc}p_i^F}\right)^{1-\epsilon} = \frac{\tau_{jc}p_{ijc}m_{ijc}}{\sum_{jc\in\Omega_i}\tau_{jc}p_{ijc}m_{ijc}} = \frac{\tau_{jc}p_{ijc}m_{ijc}}{\int_{b_i^*}^{\infty}\tau_{jc}p_{ijc}(b)m_{ijc}(b)f(b)db}, \tag{B.29}$$

where Ω_i denotes the sets of imported varieties by importer i, with the measure of imported

intermediates $N_i(b_i^*)$. Therefore, we have

$$\omega_i^* = \left(\frac{\tau_{jc} p_{ijc}^*}{b_i^* p_i^F}\right)^{1-\epsilon} = \frac{\tau_{jc} p_{ijc}^* m_{ijc}^*}{\sum_{jc\in\Omega_i} \tau_{jc} p_{ijc} m_{ijc}} = \frac{\tau_{jc} p_{ijc}^* m_{ijc}^*}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b) m_{ijc}(b) f(b) db}, \tag{B.30}$$

where $\tau_{jc} p_{ijc}^* m_{ijc}^*$ is the import cost of marginal variety of firm i.

The GE effect can be further decomposed, taking into account the labor market clearing condition and goods market clearing condition. Specifically, given that $L = \int_i L_i di$, we have

$$d\ln(L) = \int_i \frac{L_i}{\int_{i'} L_{i'} di'} d\ln(L_i) di, \tag{B.31}$$

$$d\ln(L_i) = (1-\rho) d\ln(\psi(A_i, b_i^*)) + d\ln(D) + d\ln(\frac{1-\alpha}{W}), \tag{B.32}$$

where D is the aggregate demand shifter defined in equation (3.9). Therefore,

$$d\ln(L) = (1-\rho) \int_i \frac{L_i}{\int_{i'} L_{i'} di'} d\ln(\psi(A_i, b_i^*)) di + d\ln(D) + d\ln(\frac{1-\alpha}{W}), \tag{B.33}$$

where $d\ln(\frac{1-\alpha}{W}) = 0$ when W is normalized to 1. Rewriting equation (B.20), we have

$$\begin{aligned} d\ln(\frac{C}{L}) = &-\rho \int_i \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'} d\ln(\psi(A_i, b_i^*)) di + d\ln(P^\rho C) - d\ln(D) - d\ln(\frac{1-\alpha}{W}) \\ &- (1-\rho) \int_i \frac{L_i}{\int_{i'} L_{i'} di'} d\ln(\psi(A_i, b_i^*)) di. \end{aligned} \tag{B.34}$$

Also note that $\frac{L_i}{L_{i'}} = \frac{p_i c_i}{p_{i'} c_{i'}} = \left(\frac{\psi(A_i, b_i^*)}{\psi(A_{i'}, b_{i'}^*)}\right)^{1-\rho}$, so $\frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'} = \frac{L_i}{\int_{i'} L_{i'} di'}$. Therefore,

$$d\ln(\frac{C}{L}) = -\int_i \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'} d\ln(\psi(A_i, b_i^*)) di + d\ln(\frac{P^\rho C}{D}) - d\ln(\frac{1-\alpha}{W}), \tag{B.35}$$

□

where $-\int_i \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'} d\ln(\psi(A_i, b_i^*)) di$ captures the unit cost effect, $d\ln(\frac{P^\rho C}{D})$ captures the resource allocation between consumption and production, and $d\ln(\frac{1-\alpha}{W}) = 0$.

So equation (B.28) can be rearranged as equation (3.26).

B.4 Welfare Decomposition with "Inefficiencies"

Recent studies emphasize that large firms dominate the U.S. output market and charge markups that can hurt consumer welfare. To this end, we introduce variable markups in the final goods consumption market. In fact, these variable markups can be interpreted as a wedge between price and marginal cost, which may arise from various distortions (cf. Baqaee and Rubbo, 2023). The consumption goods price of U.S. firms, p_i, is now given by

$$p_i = \frac{\rho_i}{\rho_i - 1}\psi(A_i, b_i^*),\ \ \rho_i \equiv \rho - (\rho - 1)e_i,\ \ e_i \equiv \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}, \tag{B.36}$$

where $\psi(A_i, b_i^*)$ denotes the marginal cost of production. While the intermediate goods price is still $p_{ki}^H = \frac{\rho}{\rho-1}\psi(A_i, b_i^*), \forall k$. The first-order welfare effect of tariff increase can be decomposed as follows:

Proposition B.1 *With variable markups in the final goods consumption market, the first-order approximation of the welfare change due to the tariff change can be decomposed into seven components:*

$$\begin{aligned} d\ln(\frac{C}{L}) = & \underbrace{-\alpha \int_{\hat{i^*}} e_i \left[\int_{b_i^*}^{\infty} \omega_{ijc} \left(d\ln(\tau_{jc}) + d\ln(p_{ijc}) \right) dF(b) \right] di}_{\textit{import price index intensive margin}} \\ & \underbrace{-\alpha \int_{\hat{i^*}} e_i \left(\frac{s_i^*}{\epsilon - 1} db_i^* \right) di}_{\textit{import price index extensive margin}} \ \underbrace{-\alpha \int_{\hat{i^*}} e_i s_i^h \left(d\ln(p_i^H) - d\ln(p_i^F) \right) di}_{\textit{importer domestic variety substitution effect}} \\ & \underbrace{-\alpha \int^{i^*} e_i d\ln(p_i^H) di - \alpha \int_{i^*}^{\hat{i^*}} e_i [\ln(p_i^H) - \ln(p_i^X)] di}_{\textit{non-importer domestic variety substitution effect}} \underbrace{+ d\ln(P^\rho C) - \int_i l_i M_i di}_{\textit{new allocation effect}} \\ & \underbrace{-\rho \int_i e_i \frac{1}{\rho_i(1-\rho_i)} d\rho_i di}_{\textit{markup distortion}} \underbrace{-(\rho - 1)[\int_i e_i d\ln(\psi(A_i, b_i^*)) di - \int_i l_i d\ln(\psi(A_i, b_i^*)) di]}_{\textit{input distortion}}, \end{aligned} \tag{B.37}$$

where $e_i = \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}$, $l_i \equiv \frac{L_i}{\int_{i'} L_{i'} di'}$, $\omega_{ijc} = \frac{\tau_{jc} p_{ijc} m_{ijc}}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b) m_{ijc}(b) f(b) db}$, $s_i^h = \frac{p_i^H h_i}{p_i^H h_i + p_i^F m_i}$, $\omega_i^* = \frac{\tau_{jc} p_{ijc}^* m_{ijc}^*}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b) m_{ijc}(b) f(b) db}$, p_{ijc}^* *is the foreign export price of marginal varieties,* $s_i^* = \omega_i^* f(b_i^*)$. i^* ($\hat{i^*}$) *denotes the marginal importer such that firms with productivity no less than* A_{i^*} ($A_{\hat{i^*}}$) *are*

importers before (after) tariff increase, while those with lower productivity are non-importers. $M_i = \frac{\tilde{D}(\frac{\rho}{\rho-1})^{-\rho} d\ln(\tilde{D}) + P^\rho C(\frac{\rho_i}{\rho_i-1})^{-\rho}[d\ln(P^\rho C) + \rho \frac{1}{\rho_i-1} d\ln(\rho_i)]}{\tilde{D}(\frac{\rho}{\rho-1})^{-\rho} + P^\rho C(\frac{\rho_i}{\rho_i-1})^{-\rho}}$ *with* $\tilde{D} = \int_0^1 (p_k^H)^\rho \left(\frac{p_k^H}{p_k^X}\right)^{-\sigma} X_k dk$.

It is easy to see that if markups are constant across firms, the welfare decomposition reduces to the baseline case. When markups vary across firms, two additional sources of welfare loss emerge: (i) dispersion in markups across consumption goods, which creates allocative inefficiency since consumers face different price-cost margins, and (ii) input misallocation, as the discrepancy between labor shares and sales shares reflects that more productive firms may be constrained from expanding due to higher markups. Both distortions contribute to reduced aggregate welfare compared to the constant markup case.

B.4.1 Proof of Proposition B.1

Proof In this alternative model setup, U.S. firms produce imperfectly substitutable varieties and charge variable markups for household consumption, whereas the price for intermediate input production is set equal to marginal cost. The labor input for consumption goods production and intermediate goods production is revised separately:

$$L_i^{\mathrm{C}} = \frac{\psi(A_i, b_i^*)(1-\alpha)}{W} c_i, \;\; c_i = p_i^{-\rho} P^\rho C; \tag{B.38}$$

$$L_i^{\mathrm{I}} = \frac{\psi(A_i, b_i^*)(1-\alpha)}{W} y_i^{\mathrm{I}}, \;\; y_i^{\mathrm{I}} = \int_0^1 h_{ki} dk = (\frac{\rho}{\rho-1}\psi(A_i, b_i^*))^{-\rho} \int_0^1 (p_k^H)^\rho \left(\frac{p_k^H}{p_k^X}\right)^{-\sigma} X_k dk. \tag{B.39}$$

It is easy to show that $\frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'} \neq \frac{L_i}{\int_{i'} L_{i'} di'}$. Then we can have

$$d\ln(\frac{C}{L}) = d\ln(C) - d\ln(L) \tag{B.40}$$

$$= -\rho \int_i e_i \frac{1}{\rho_i(1-\rho_i)} d\rho_i di - \rho \int_i e_i d\ln(\psi(A_i, b_i^*)) di + d\ln(P^\rho C) \tag{B.41}$$

$$- (1-\rho) \int_i l_i d\ln(\psi(A_i, b_i^*)) di - \int_i l_i M_i di \tag{B.42}$$

$$- (1-\rho) \int_i e_i d\ln(\psi(A_i, b_i^*)) di + (1-\rho) \int_i e_i d\ln(\psi(A_i, b_i^*)) di \tag{B.43}$$

$$= - \int_i e_i d\ln(\psi(A_i, b_i^*)) di + \underbrace{d\ln(P^\rho C) - \int_i l_i M_i di}_{\text{new allocation effect}} \tag{B.44}$$

$$\underbrace{-\rho\int_i e_i\frac{1}{\rho_i(1-\rho_i)}d\rho_i di}_{\text{markup distortion}}\underbrace{-(\rho-1)[\int_i e_i d\ln(\psi(A_i,b_i^*))di-\int_i l_i d\ln(\psi(A_i,b_i^*))di]}_{\text{input distortion}}, \tag{B.45}$$

where $e_i=\frac{p_ic_i}{\int_{i'}p_{i'}c_{i'}di'}$ is the U.S. consumers' expenditure share on U.S. firm i, $l_i\equiv\frac{L_i}{\int_{i'}L_{i'}di'}$ is the U.S. firm i's labor input share, $\omega_{ijc}=\frac{\tau_{jc}p_{ijc}m_{ijc}}{\int_{b_i^*}^{\infty}\tau_{jc}p_{ijc}(b)m_{ijc}(b)f(b)db}$ is the share of a specific foreign variety in determining firm i's overall cost of imported inputs, $s_i^h=\frac{p_i^Hh_i}{p_i^Hh_i+p_i^Fm_i}$ is the share of domestic intermediate inputs in firm i's total intermediate input use, p_{ijc}^* is the foreign export price of marginal varieties, $s_i^*=\omega_i^*f(b_i^*)$ is the import cost share of marginal varieties, and $\omega_i^*=\frac{\tau_{jc}p_{ijc}^*m_{ijc}^*}{\int_{b_i^*}^{\infty}\tau_{jc}p_{ijc}(b)m_{ijc}(b)f(b)db}$ is the share of marginal foreign variety in determining imported inputs cost of firm i. i^* ($i^{\hat{*}}$) denotes the marginal importer such that firms with productivity no less than A_{i^*} ($A_{i^{\hat{*}}}$) are importers before (after) tariff increase, while those with lower productivity are non-importers.

$$M_i=\frac{\tilde{D}(\frac{\rho}{\rho-1})^{-\rho}d\ln(\tilde{D})+P^{\rho}C(\frac{\rho_i}{\rho_i-1})^{-\rho}[d\ln(P^{\rho}C)+\rho\frac{1}{\rho_i-1}d\ln(\rho_i)]}{\tilde{D}(\frac{\rho}{\rho-1})^{-\rho}+P^{\rho}C(\frac{\rho_i}{\rho_i-1})^{-\rho}},$$

where

$$\tilde{D}=\int_0^1(p_k^H)^{\rho}\left(\frac{p_k^H}{p_k^X}\right)^{-\sigma}X_kdk. \qquad \square$$

The derivation for $-\int_i e_i d\ln(\psi(A_i,b_i^*))di$ is the same as that in the proof of Proposition 3.1.

B.5 Proof of Proposition 3.3

Proof A full log-differential of the pricing equation (3.10) yields the log change in post-tariff import price, which is specified as follows:

$$d\ln(\tau_{jc}p_{ijc})=d\ln\mu_{ijc}+d\ln\tilde{c}_{ijc}+d\ln\tau_{jc}, \tag{B.46}$$

where $\tilde{c}_{ijc} \equiv \frac{c_{ijc}(A_i)}{f(\Theta_{ijc})}$ and

$$d\ln \mu_{ijc} = \Gamma^s_{ijc} d\ln s_{ijc} + \Gamma^x_{ijc} d\ln x_{ijc}, \quad \Gamma^s_{ijc} \equiv \frac{\partial \ln \mu_{ijc}}{\partial \ln s_{ijc}}, \quad \Gamma^x_{ijc} \equiv \frac{\partial \ln \mu_{ijc}}{\partial \ln x_{ijc}}. \tag{B.47}$$

The pass-through elasticity of a tariff increase $d\ln \tau_{jc}$ is therefore

$$\Phi_{ijc} \equiv \frac{d\ln(\tau_{jc} p_{ijc})}{d\ln \tau_{jc}} = \Gamma^s_{ijc} \frac{d\ln s_{ijc}}{d\ln \tau_{jc}} + \Gamma^x_{ijc} \frac{d\ln x_{ijc}}{d\ln \tau_{jc}} + \frac{d\ln \tilde{c}_{ijc}}{d\ln \tau_{jc}} + 1. \tag{B.48}$$

It is straightforward to show how the exporter's sales share, the importer's quantity share, and the exporter's marginal cost of production respond to tariff changes:

$$\frac{d\ln s_{ijc}}{d\ln \tau_{jc}} = (1-\epsilon)(1-s_{ijc}) \left[\frac{d\ln \tau_{jc} p_{ijc}}{d\ln \tau_{jc}} + \frac{d\ln \tau_{j'c'} \tilde{p}_{ij'c'}}{d\ln \tau_{jc}} \right], \tag{B.49}$$

$$\frac{d\ln x_{ijc}}{d\ln \tau_{jc}} = -(1-x_{ijc}) \left[\varepsilon_{ijc} \frac{d\ln \tau_{jc} p_{ijc}}{d\ln \tau_{jc}} + \frac{d\ln \tilde{m}_{i'jc}}{d\ln \tau_{jc}} \right], \tag{B.50}$$

$$\frac{d\ln \tilde{c}_{ijc}}{d\ln \tau_{jc}} = \frac{1-\kappa}{\kappa} \left(-\varepsilon_{ijc} x_{ijc} \frac{d\ln \tau_{jc} p_{ijc}}{d\ln \tau_{jc}} + (1-x_{ijc}) \frac{d\ln \tilde{m}_{i'jc}}{d\ln \tau_{jc}} \right), \tag{B.51}$$

where $\frac{d\ln \tau_{jc} \tilde{p}_{ij'c'}}{d\ln \tau_{jc}}$ represents the elasticity of the selling prices of an exporter (j,c)'s competitors in response to a tariff increase, and $\frac{d\ln \tilde{m}_{i'jc}}{d\ln \tau_{jc}}$ represents the elasticity of the quantities purchased by the competitors of importer i in response to a tariff increase. The detailed derivations are in Appendix B.5.1.

Therefore, under the assumption of competitors' non-responsiveness and sufficiently low values of each pass-through components, the import price pass-through elasticity is as follows:

$$\frac{d\ln(\tau_{jc} p_{ijc})}{d\ln \tau_{jc}} \approx \frac{1}{1+\Gamma^s_{ijc}(\epsilon-1)(1-s_{ijc})} \frac{1}{1+\Gamma^x_{ijc}\varepsilon_{ijc}(1-x_{ijc})} \frac{1}{1+\frac{1-\kappa}{\kappa} x_{ijc}\varepsilon_{ijc}}, \tag{B.52}$$

where

$$\Gamma^s_{ijc} = (1-\iota_i) \frac{\mu^{oligopoly}_{ijc}}{\mu_{ijc}} \frac{1}{\varepsilon_{ijc}-1} \frac{\epsilon-\varepsilon_{ijc}}{\varepsilon_{ijc}}; \tag{B.53}$$

$$\Gamma^x_{ijc} = \iota_i \frac{\mu^{oligopsony}_{ijc}}{\mu_{ijc}} \left[\frac{x_{ijc}(1-x_{ijc})^{\frac{1}{\kappa}-1}}{\kappa(1-(1-x_{ijc})^{\frac{1}{\kappa}})} - 1 \right]. \tag{B.54}$$

□

B.5.1 Deriving $\frac{d\ln(s_{ijc})}{d\ln(\tau_{jc})}$ and $\frac{d\ln(x_{ijc})}{d\ln(\tau_{jc})}$

The elasticity of the exporter's supplier share s_{ijc} with respect to the tariff increase, $\frac{d\ln s_{ijc}}{d\ln \tau_{jc}}$, can be derived in four steps. First, utilizing demand function of importers, we have $s_{ijc} = (\tau_{jc}p_{ijc}/p_i^F)^{1-\epsilon}$. Second, given the price index $p_i^F = (\sum_{jc}(\tau_{jc}p_{ijc})^{1-\epsilon})^{1/(1-\epsilon)}$, we have $\ln(p_i^F) = 1/(1-\epsilon)\ln(\sum_{jc}(\tau_{jc}p_{ijc})^{1-\epsilon})$, which leads to that $\partial\ln(p_i^F)/\partial\ln(\tau_{jc}p_{ijc}) = \partial\ln(p_i^F)/\partial(\tau_{jc}p_{ijc}) \times (\tau_{jc}p_{ijc}) = s_{ijc}$. Third, based on the second step, we have $d\ln(p_i^F) = \sum_{jc} s_{ijc}d\ln(\tau_{jc}p_{ijc}) = s_{ijc}d\ln(\tau_{jc}p_{ijc}) + (1-s_{ijc})d\ln(\tilde{p}_{ij'c'})$, where $d\ln(\tilde{p}_{ij'c'}) = \sum_{\forall j'c'\neq jc}\frac{s_{ij'c'}}{1-s_{ijc}}d\ln(\tau_{j'c'}p_{ij'c'})$. Fourth, based on the first and the third step, we expand $d\ln(s_{ijc})$ to derive the expression for $\frac{d\ln s_{ijc}}{d\ln \tau_{jc}}$.

The elasticity of the importer's buyer share x_{ijc} with respect to the tariff increase, $\frac{d\ln x_{ijc}}{d\ln \tau_{jc}}$, is symmetrically derived in four steps. First, given the definition that $x_{ijc} = m_{ijc}/\sum_i m_{ijc}$, we have $\ln(x_{ijc}) = \ln(m_{ijc}) - \ln(\sum_i m_{ijc})$. Second, given that $\ln(m_{jc}) = \ln(\sum_i m_{ijc})$, we have $\partial\ln(m_{jc})/\partial\ln(m_{ijc}) = \partial\ln(m_{jc})/\partial m_{ijc} * m_{ijc} = x_{ijc}$. Third, based on step 2, we have $d\ln(m_{jc}) = \sum_i x_{ijc}d\ln(m_{ijc}) = x_{ijc}d\ln(m_{ijc}) + (1-x_{ijc})d\ln(\tilde{m}_{i'jc})$, where $d\ln(\tilde{m}_{i'jc}) = \sum_{\forall i'\neq i}\frac{x_{i'jc}}{1-x_{ijc}}d\ln(m_{i'jc})$. Fourth, Based on the first and third step, expand $d\ln(x_{ijc})$ to derive the expression for $\frac{d\ln x_{ijc}}{d\ln \tau_{jc}}$.

B.6 Proof of Proposition 3.4

Proof Suppose that $\tilde{v}$ and $s_{ijc} \in [0,1]$ are constants that are identical across importers. It is direct that $\varepsilon_{ijc} = (1-s_{ijc})\epsilon + s_{ijc}\tilde{\nu}$ becomes a constant and, hence, $\mu_{ijc}^{\text{oligopoly}} = \frac{\varepsilon_{ijc}}{\varepsilon_{ijc}-1}$ becomes a constant. We prove in two steps.

First, we prove in the case of $\kappa = 1$. In this case, $\mu_{ijc}^{\text{oligopsony}} = 1$. Based on equation (3.28), we have $\Phi_{ijc}^{SS} = \phi_{ijc}^{TT} = 1$. Then we have

$$\frac{1-\iota}{\mu_{ijc}} = \frac{1-\iota}{(1-\iota)\mu_{ijc}^{\text{oligopoly}} + \iota}. \tag{B.55}$$

It is easy to see that

$$\frac{d(\frac{1-\iota}{\mu_{ijc}})}{d\iota} < 0, \tag{B.56}$$

and hence

$$\frac{d\Gamma_{ijc}^{s}}{d\iota} < 0, \ \frac{d\Phi_{ijc}^{SC}}{d\iota} \geq 0. \tag{B.57}$$

Therefore, we have $\frac{d\left(\frac{d\ln(\tau_{jc}p_{ijc})}{d\ln\tau_{jc}}\right)}{d\iota} \geq 0$.

Second, we prove in the case of $\kappa \in (0,1)$. Suppose $x_{ijc} \in [0,1]$ is a constant that is identical across importers. Therefore, $\mu_{ijc}^{\text{oligopsony}} = \kappa\frac{1-(1-x_{ijc})^{\frac{1}{\kappa}}}{x_{ijc}}$ is a constant.

It is easy to show that

$$\frac{d(\frac{1-\iota}{\mu_{ijc}})}{d\iota} < 0, \tag{B.58}$$

and hence

$$\frac{d\Gamma_{ijc}^{s}}{d\iota} < 0, \ \frac{d\Phi_{ijc}^{SC}}{d\iota} \geq 0. \tag{B.59}$$

Given $x_{ijc} \in [0,1]$ and $\kappa \in (0,1)$, it can be shown that $\left[\frac{x_{ijc}(1-x_{ijc})^{\frac{1}{\kappa}-1}}{\kappa(1-(1-x_{ijc})^{\frac{1}{\kappa}})} - 1\right] \in [-1,0)$. Next, it can be shown that

$$\frac{d\Gamma_{ijc}^{x}}{d\iota} < 0, \ \frac{d\Phi_{ijc}^{SS}}{d\iota} \geq 0. \tag{B.60}$$

It is obvious that

$$\frac{d\Phi_{ijc}^{TT}}{d\iota} = 0. \tag{B.61}$$

□

Therefore, we have $\frac{d\left(\frac{d\ln(\tau_{jc}p_{ijc})}{d\ln\tau_{jc}}\right)}{d\iota} \geq 0$.

B.7 Computation Algorithm

1. Initialize the number of countries, products, and firms. Specifically, generate a state space with three-dimension matrix $nf \times nc \times np$, where nf denotes the number of

U.S. firms, nc denotes the number of sourcing countries (therefore does not include domestic country U.S.), and np denotes the number of products.

2. Initialize parameters. Initialize the distribution of firm productivity $A_i \sim \hat{F}(a)$. Initialize the distributions of trade relationship. Initialize unadjusted demand shifter b^u_{ijc}. The adjusted demand shifter is $b_{ijc} = b^u_{ijc}/(\tau_{jc}p_{ijc})$. We normalize U.S. wage $W \equiv 1$.

3. Inner loop: Guess the firm-specific cutoff threshold b^*_i for demand shifter. Firms will only import intermediates that is above this threshold, namely $b_{ijc} \geq b^*_i$. Given the cutoff, we solve the intensive margin adjustment by looping over the quantity of imported intermediates m_{ijc}, the quantity of domestic intermediates h_{ik}, the pre-tariff price of imported intermediates p_{ijc}, the price of domestic goods p_i, and the aggregate demand shifter D. The criterion function is measured as the sum of absolute value of the difference between updated $\{m_{ijc}, h_{ik}, p_{ijc}, p_i, D\}$ and their counterparts in the previous loop.We update the aggregate demand shifter with $D = y_i p_i^{\rho}$. We finish the inner loop when the criterion function converges to a value lower that $1e-6$.

4. Outer loop: Given the solved prices and quantities in inner loop, loop over demand shifter cutoff b^*_i so that the left hand side of equation (3.25) converges to a value lower that $1e-6$. We use binary search algorithm to clear the extensive margin condition. When left hand side of equation (3.25) is larger than 0, the marginal gain of including extra foreign intermediates outweighs the marginal import cost. In this case, we adjust the value of b^*_i down. When left hand side of equation (3.25) is smaller than 0, we update b^*_i with a higher value.

5. Going back to Step 4 (inner loop) with a new set of tariff τ_{jc}, and repeat the model simulation.

Computation trick on outer loop In the original implementation of the model, the extensive margin—namely, the binary decision of whether a firm imports a product from a given country—was determined by a sharp threshold rule:

$$\text{isimport}_{ijc} = \mathbb{1}\{b_{ijc} > b^{\star}_{ijc}\}.$$

This discrete cutoff generates a discontinuous mapping from prices and costs to firm-level import decisions, which leads to numerical instability and non-convergence when solving for the equilibrium threshold $b^{\star}_{ijc}$. To smooth the firm-level extensive margin decision and facilitate convergence, we incorporate i.i.d. idiosyncratic preference shocks into the import decision. Specifically, we assume that firms observe an additive i.i.d. Type I Extreme Value shock to their latent import profitability. Under this assumption, the probability that firm i imports product j from country c is given by:

$$P^{\text{import}}_{ijc} = \frac{1}{1 + \exp\left(-\frac{b_{ijc} - b^{\star}_{ijc}}{\sigma_{\varepsilon}}\right)},$$

where $\sigma_{\varepsilon} > 0$ governs the dispersion of the shock. This smooth logistic function replaces the discontinuous indicator function and yields a continuous import probability that responds gradually to changes in underlying fundamentals.

Implementation Details:

- The threshold condition isimport_{ijc} is replaced with the smoothed probability P^{import}_{ijc}.
- All computations involving extensive margin aggregates—such as foreign price indices, expected import shares, and the entry condition—are updated to use P^{import}_{ijc} in place of the binary import indicator.
- We set $\sigma_{\varepsilon} = 0.2$ as a conservative baseline, balancing numerical smoothness with the economic realism of near-binary entry behavior. Values in the range $[0.05, 0.2]$ are generally robust across parameterizations.

B.8 Extra Model Characterizations

B.8.1 Understanding Tariff Pass-Through to Continuing Trade Relationship

Given $\iota_i = \iota$, $\forall i$, and κ, the mechanisms underlying the three components in equation (3.28) are as follows.

The first component (SC) $\Phi^{SC}_{ijc} \leq 1$ reflects strategic complementarities among exporters and highlights that exporters reduce their markup to stabilize their market share after tariff

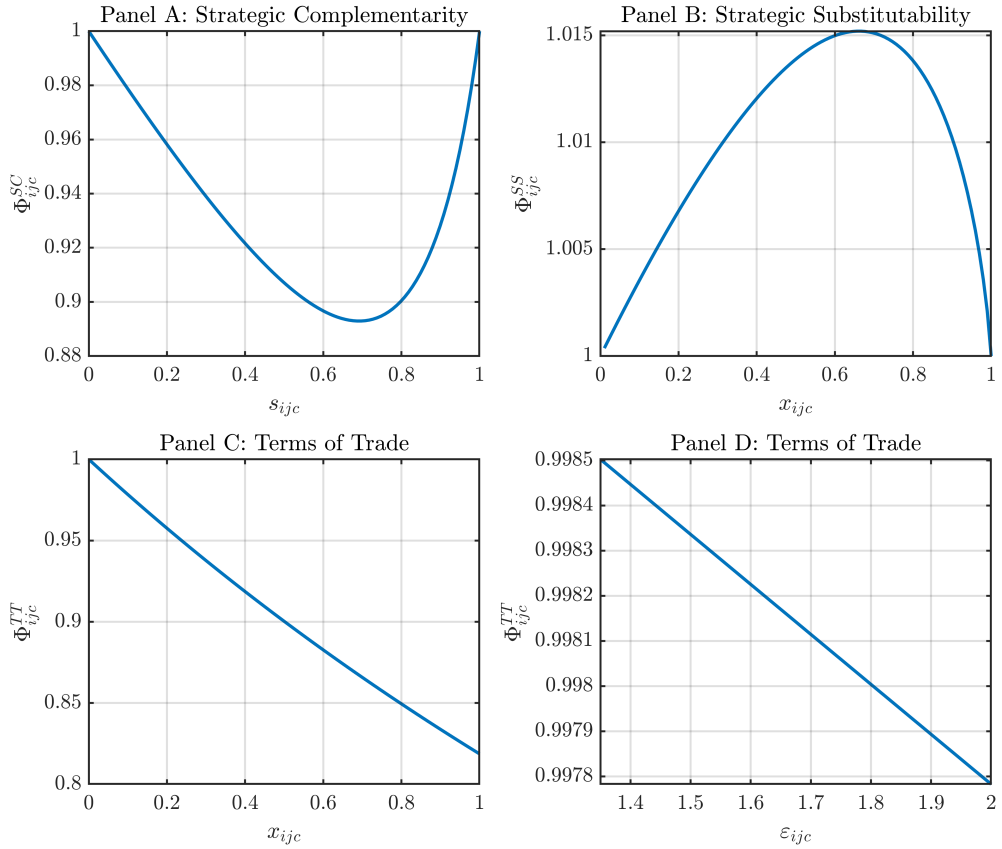
increases. Figure B.1 panel A indicates that Φ_{ijc}^{SC} follows a "U-shape": when the exporters' supplier share s_{ijc} is either very small or very large, there is high tariff pass-through to import price, implying minimal changes in markups. When $s_{ijc} = 0$, the exporter has no market power and behaves as a price taker, while the importer possesses significant market power over the exporter prior to the tariff increase. As a result, the exporter has no room to further reduce its markup in response to the tariff increase, leading to full tariff pass-through to the importer. In contrast, when $s_{ijc} = 1$, the exporter is sufficiently dominant to dictate prices to the importer, again resulting in complete tariff pass-through to the importer. However, when the supplier share is moderate, exporters are more willing to reduce their markups to maintain their market share, leading to lower tariff pass-through to the importer.

The second component (SS) $\Phi_{ijc}^{SS} \geq 1$ reflects strategic substitutability among importers, highlighting that importers raise import price by reducing markdowns following tariff increases. Figure B.1 panel B indicates that Φ_{ijc}^{SS} follows a "hump-shape": when the importers' buyer share x_{ijc} is either very small or very large, tariff pass-through to import prices is low, indicating less change in markdowns. However, when buyer share lies in the intermediate range, importers are more inclined to reduce markdowns, and hence face more tariff pass-through. The underlying mechanism mirrors that of the strategic complementarity (SC) component.

The third component (TT) $\Phi_{ijc}^{TT} \leq 1$ reflects the cost channel. This component arises only when importers have market power $\kappa < 1$. Figure B.1 panel C indicates a lower tariff pass-through to import prices as the importers' buyer share x_{ijc} increases, since larger importers adjust markdowns by more to cushion import price change. Panel D indicates a higher tariff pass-through to import price if there is a lower importers' demand elasticity ε_{ijc}, as importers with less elastic demand are more likely to absorb the tariff burden.

As shown in Figure B.2, in the presence of decreasing returns to scale of export production ($\kappa < 1$), two key findings emerge when studying the relationship between tariff pass-through and importers' bargaining power ι. First, holding all else constant, tariff pass-through to import price increases with importers' bargaining power. When tariffs rise, the pre-tariff import prices of importers decline by less when importers have more bargaining power. This occurs because higher bargaining power limits exporters' ability to reduce markups in

Figure B.1: Decomposition of Tariff Pass-Through Elasticities



Notes: The figure illustrates how the three components of tariff pass-through—namely, the strategic complementarity component (SC), the strategic substitutability component (SS), and the cost component (TT)—vary with model variables. In this plot, we fix importers' bargaining power $\iota = 0.3$, and importer market power $\kappa = 0.9$. Panel A shows that the SC component exhibits a "U-shape" relationship with exporters' supplier share s_{ijc}, defined as $s_{ijc} \equiv \frac{\tau_{jc} p_{ijc} m_{ijc}}{\sum_{jc} \tau_{jc} p_{ijc} m_{ijc}}$. Panel B shows that the SS component displays a "hump-shape" relationship with x_{ijc}, defined as $x_{ijc} \equiv \frac{m_{ijc}}{\sum_i m_{ijc}}$. Panel C shows that the TT component decreases as importers' buyer share x_{ijc} increases, while Panel D shows that the TT component decreases with importers' demand elasticity ε_{ijc}. A component value below 1 suggests incomplete tariff pass-through, a value above 1 implies more-than-complete pass-through, and a value equals to 1 indicates complete pass-through to import prices.

response to tariff shocks, as their pre-tariff prices are already suppressed through negotiations with strong importers. Consequently, importers bear a greater share of the tariff shock, amplifying the overall pass-through effect. Second, a larger buyer share x_{ijc} is still associated with a lower tariff pass-through to import prices, since larger importers adjust markdowns by more to cushion import price change.

Moreover, the discrepancy between the two columns of Figure B.2 illustrates the relationship between tariff pass-through and exporters' returns to scale κ given a level of ι.

First, overall tariff pass-through to import prices increases as exporters' returns to scale rise (higher κ). Second, whether larger importers (with higher import share x_{ijc}) face less complete tariff pass-through depends on exporters' returns to scale. Specifically, when exporters have decreasing returns to scale ($\kappa < 1$), U.S. importers with a larger import share x_{ijc} experience less complete tariff pass-through, as explained above. However, when exporters have constant returns to scale ($\kappa = 1$), U.S. importers face identical tariff pass-through regardless of their import share. This is because the TT and SS components become degenerate, preventing importers from extracting technological rent from exporters by setting markdowns. Conditional on facing the same exporter supplier share s_{ijc}, there is no variation in tariff pass-through across different U.S. importers.

B.8.2 Understanding Tariff Increase and Trade Relationship Adjustment

Trading relationship adjustment across product-country markets after a tariff increase. Figure B.3 provides a detailed illustration of how firms adjust their trade relationships across product-country markets in response to a tariff increase, shedding light on the impact of tariffs on foreign export prices, demand/productivity shifter cutoffs, import status, and the number of imported varieties. Panel A reveals that more productive firms import intermediates with higher foreign export prices. This suggests that productive firms are willing to pay a premium for higher-quality or strategically important intermediates. However, when tariffs increase, the additional costs make these expensive intermediates less viable, forcing firms to eliminate such imports from their sourcing list. Panel B illustrates that more productive firms have lower demand/productivity shifter cutoffs, indicating that they can sustain imports more easily due to their ability to overcome the convex import cost. The tariff hike, however, raises the cutoff for all firms, tightening the criteria for import viability. This increase in the cutoff reflects a reduction in the attractiveness of foreign intermediates. The cost of introducing a marginal foreign intermediate outweighs the efficiency gain. Panel C highlights that more productive firms are more likely to participate in international trade by importing intermediates. The tariff increase forces marginal importers to exit. Panel D shows that the number of imported varieties correlates positively with firm productivity, as more productive firms typically import a larger range of inputs to enhance

the efficiency gains from foreign intermediates. After the tariff increase, all firms reduce their number of imported varieties.

C Quantitative Appendix

C.1 Constructing Targeted and Untargeted Moments

This section describes the procedure we take to compute moments from data that is to be compared with the model results.

1. **Tariff rate at jc market**: We compute the applied tariff τ_{jct} using data from the LFTTD for the years 2015–2017, and years 2018-2019 separately. For each product-country pair jc, we first calculate the time average. Then we compute the mean of the applied tariff $\bar{\tau}_{jc}$ across product-country pairs.

2. **Import participation ratio before tariff increase**: We find Business Dynamics Statistics of U.S. Goods Traders reports import participation ratio (e.g., the fraction of firms that are importers) using data from LFTTD, so we report the mean import participation ratio for the years 2015–2017 based on this public dataset.

3. **Employment share of large/small importers before tariff increase**: We use the Business Dynamics Statistics of U.S. Goods Traders, which report firm employment by importing status and firm size. Using this dataset, large firms are defined as those with at least 20 employees; they account for 12 percent of all U.S. firms and 83 percent of total U.S. firm employment in 2015–2017. Small firms are all other firms. Based on this firm-size classification, we focus on importers. For large and small importers, respectively, we compute their employment shares among all U.S. firms in 2015–2017. We find that large importers account for 48 percent of total employment, while small importers account for 1 percent.

4. **Domestic intermediate inputs share in total intermediate inputs s^h before tariff increase**: The aggregate level data for $s^h = \frac{\sum_i p_i^H h_i}{\sum_i (p_i^H h_i + p_i^F m_i)}$ is available from 2017 OECD Inter-Country Input-Output Tables (ICIO). We calculate the share of

domestic (US produced) intermediate inputs in US total intermediate inputs using U.S. manufacturing (ISIC Rev 4, 10-33). Within all intermediate goods used, US source 74.72 percent from abroad, and only 25.28 percent of intermediate goods is from U.S domestic supply.

5. ω_{ijct} **of all pairs**: For each firm i, at year-month t during 2015–2019, the share of a foreign variety in its total cost of imported inputs is computed as the ratio of after-duty import value for a specific product-country pair ($\tau_{jc}p_{ijct}m_{ijct}$) to the firm's total after-duty import value summed across all product-country pairs ($\sum_{jc}\tau_{jc}p_{ijct}m_{ijct}$).

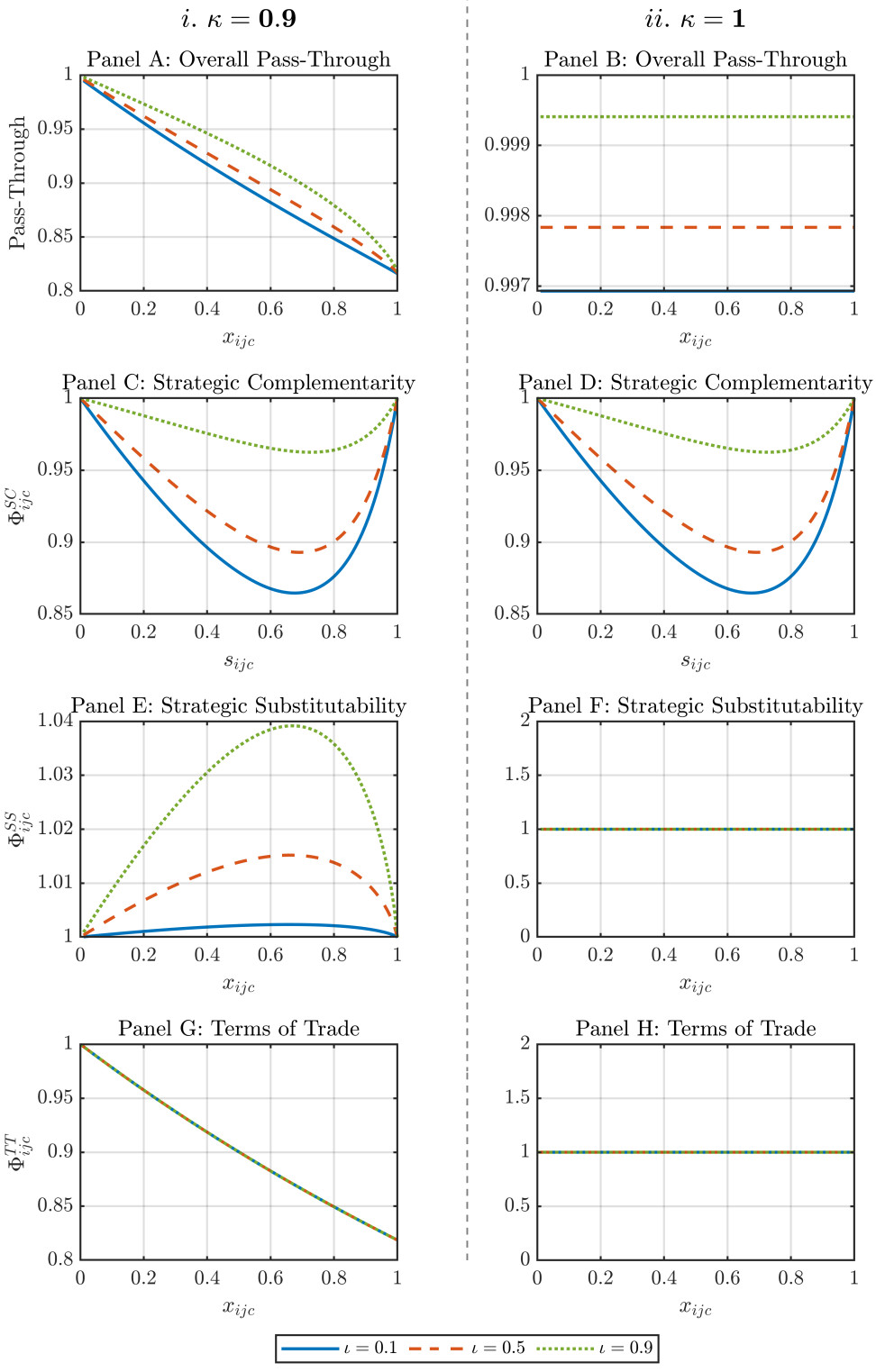
6. ω_{ijct} of all pairs is computed according to the above. First, using 2017-2019 LFTTD data, we use equation (2.4) to identify continuing pairs, starting pairs, and ending pairs from t to t'. Then for year-month t, we compute $\omega_{it}^{S} \equiv \sum_{jc\in\{\text{continuing pair of firm } i\}} \omega_{ijct}$, $\omega_{it}^{X} \equiv \sum_{jc\in\{\text{ending pair of firm } i\}} \omega_{ijct}$.
For year-month t', we compute $\omega_{it'}^{S} \equiv \sum_{jc\in\{\text{continuing pair of firm } i\}} \omega_{ijct'}$,
$\omega_{it'}^{E} \equiv \sum_{jc\in\{\text{starting pair of firm } i\}} \omega_{ijct'}$.

   Second, we define large firms as firms that have total import value above the mean in 2017. Specifically, the total import value in each year-month t of firm i is computed as $\sum_{jc} v_{ijct}$, where v_{ijct} is firm i's before-duty import value of product j from country c in year-month t. If the firm has positive import value in 2017, we compare its import value with mean of total import value among importers in 2017 such that it is a large firm if its import value is larger than the mean in 2017. For firms that have zero import value in 2017, we compute their total import value in 2018 and 2019, and take simple average over these two years, and then compare to the mean in 2017 to measure the firm size. Therefore, we classify firms as $i \in \{\text{large, small}\}$, which is time-invariant. Moreover, each firm has a size measure: either total import value in 2017 or the average of total import value in 2018 and 2019. We use V_i to denote the firm size.

   Third, we compute $\omega_t^{S,large} \equiv \sum_{i\in\text{large}} \frac{V_i}{\sum_{i\in\text{large}} V_i}\omega_{it}^{S}$, $\omega_t^{S,small} \equiv \sum_{i\in\text{small}} \frac{V_i}{\sum_{i\in\text{small}} V_i}\omega_{it}^{S}$,
$\omega_t^{X,large} \equiv \sum_{i\in\text{large}} \frac{V_i}{\sum_{i\in\text{large}} V_i}\omega_{it}^{X}$, $\omega_t^{X,small} \equiv \sum_{i\in\text{small}} \frac{V_i}{\sum_{i\in\text{small}} V_i}\omega_{it}^{X}$,
$\omega_{t'}^{S,large} \equiv \sum_{i\in\text{large}} \frac{V_i}{\sum_{i\in\text{large}} V_i}\omega_{it'}^{S}$, $\omega_{t'}^{S,small} \equiv \sum_{i\in\text{small}} \frac{V_i}{\sum_{i\in\text{small}} V_i}\omega_{it'}^{S}$,
$\omega_{t'}^{E,large} \equiv \sum_{i\in\text{large}} \frac{V_i}{\sum_{i\in\text{large}} V_i}\omega_{it'}^{E}$, $\omega_{t'}^{E,small} \equiv \sum_{i\in\text{small}} \frac{V_i}{\sum_{i\in\text{small}} V_i}\omega_{it'}^{E}$.

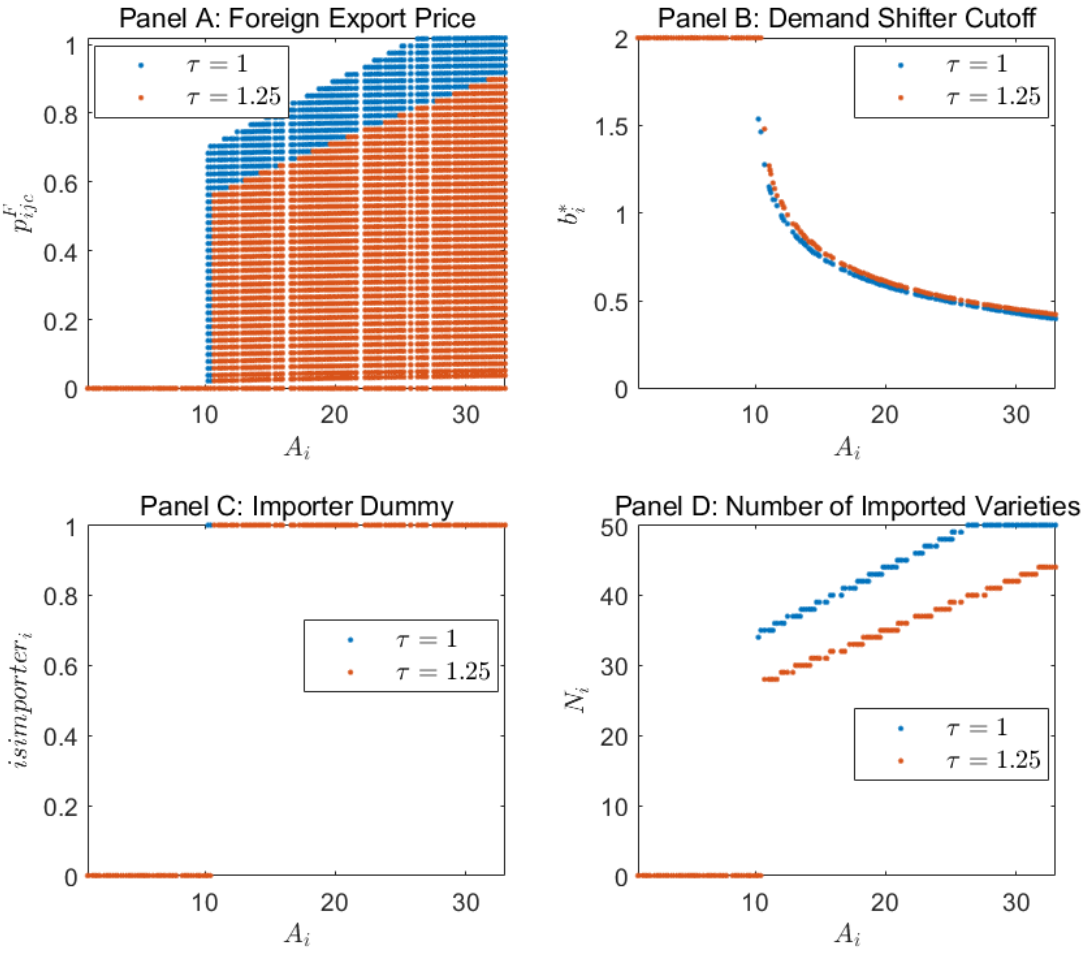
Fourth, we take simple average across periods to drop the t dimension. In specific, we need to first make sure there is no truncation issue such that starting pairs and ending pairs have identical number of periods (if we have 10 changes of periods from t to t', we have 10 sets of starting pairs and 10 sets of ending pairs, according to equation (2.4)). This gives us 8 moments ($\omega_t^{S,large}$ and $\omega_{t'}^{S,large}$ are two separate targets).

Figure B.2: Tariff Pass-through and Its Components



Notes: The figure illustrates how the strategic complementarity component (SC), the strategic substitutability component (SS), the cost component (TT), and the overall tariff pass-through vary with importers' bargaining power ι, given κ. Figures in the left column are obtained with $\kappa = 0.9$, whereas figures in the right column are obtained with $\kappa = 1$.

Figure B.3: Extensive Margin Adjustment After Tariff Increases (Across Product-Country Markets)



Notes: This figure illustrates with $f(\Theta_{ijc}) = 1$, how the foreign export price p_{ijc}, cutoff of the demand/productivity shifter b_i^*, import status, and number of imported varieties N_i-vary with firm productivity A_i before and after a uniform tariff increase of 25 percent. Varieties across product-country markets differ in marginal cost of production. Panel A shows that more productive firms import varieties with higher foreign export prices, and a tariff increase causes firms to give up expensive foreign varieties. For a given level of foreign export price p_{ijc}, it represents the price of a variety faced by importers with different productivity levels A_i. Panel B shows that more productive firms have lower demand/productivity shifter cutoff, and a tariff increase raises the cutoff for all firms. Panel C shows that more productive firms are more likely to be an importer, and a tariff increase forces the marginal importers to exit. Panel D shows that more productive firms import more varieties, and a tariff hike decreases the number of varieties imported by all firms.