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

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Abstract

Using confidential U.S. Census data, we show that tariff pass-through to U.S. import prices during the U.S.–China trade dispute was incomplete within continuing trade relationships, even though it was complete in aggregate. We develop an empirical decomposition showing that complete aggregate pass-through reflects import reallocation toward higher-priced new relationships and importers. We then derive a welfare decomposition that applies to a broad class of heterogeneous-importer models. The formula identifies the key statistics needed to estimate the welfare effects of tariffs and shows how importer heterogeneity and sourcing adjustments matter. Quantitatively, ignoring these margins understates the welfare losses from tariffs. Our methods can be used to study other forms of pass-through and heterogeneous responses to common cost shocks.

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

JEL classification: F10, F40.

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1 Introduction

The return of tariffs has renewed a central question in international economics: who bears the cost of the trade protection? The U.S.–China trade dispute provides a sharp setting in which to study this question. Between 2018 and 2019, the United States imposed new tariffs on roughly $450 billion of imports from China, raising the average tariff rate from about 3% to 18% (Bekkers and Schroete, 2020). The incidence and welfare consequences of these tariffs depend critically on pass-through: whether foreign exporters absorb part of the shock by reducing pre-duty prices, or whether the tariff is fully passed through to the costs paid by U.S. importers.

Recent studies using product–country level aggregate data find that the U.S. tariffs were passed through almost fully to U.S. import prices (Amiti et al., 2019, 2020; Cavallo et al., 2021; Fajgelbaum et al., 2020). This finding is puzzling because standard incidence logic predicts that, in trade between large economies such as the U.S. and China, market power on both sides should lead exporters and importers to share the tariff burden. Earlier work using similar approaches typically finds incomplete pass-through to import prices (Fajgelbaum and Khandelwal, 2022).

This paper argues that the resolution lies in importer heterogeneity *within* a product–country market. Product–country level import prices average over importers with different import prices and pass-through rates. When tariffs affect not only prices of continuing relationships but also which firms import, how much they import, and which relationships survive, aggregate pass-through can differ from firm-level pass-through. The distinction matters for incidence because it reflects which importers receive price concessions from foreign suppliers. It also matters for welfare because welfare depends on firm-level import price indices and sourcing sets, not only on aggregate product-country level import prices.

We make three contributions. First, we develop an empirical decomposition that separates aggregate tariff pass-through into firm-level price changes, import-share reallocation, and the entry and exit of trade relationships. Since the decomposition is accounting-based rather than model-specific, it can be applied whenever an aggregate response reflects both heterogeneous micro-level adjustment and reallocation. Applied to the U.S.–China trade dispute, it explains why aggregate tariff pass-through to import prices in this episode appears high. Second, we derive a welfare decomposition for a broad class of heterogeneous-importer models. The formula identifies the sufficient statistics for welfare estimation and clarifies why aggregate pass-through is insufficient. Welfare depends not only on the average change

in import prices, but also on how price changes are distributed across firms and on the entry and exit margins of trade relationships. Third, we develop a quantitative model with endogenous firm-level import prices and sourcing decisions to measure each margin's contribution to welfare and to quantify the bias from ignoring importer heterogeneity.

We first empirically decompose the aggregate tariff pass-through using data on U.S. firm–product–country import transactions from the Longitudinal Firm Trade Transactions Database of the U.S. Census Bureau. We classify each trade relationship as continuing, starting, or ending, and compare these margins in periods with and without tariff increases. The decomposition reveals that the aggregate pass-through is not driven by price changes within continuing relationships. In the baseline sample, product–country level pass-through to pre-duty import prices is 0.84, implying more than complete pass-through to the tariff-inclusive costs paid by U.S. importers.[1] Within continuing firm–product–country relationships, however, pre-duty prices in fact fall, with a pass-through coefficient of about -0.25. Foreign exporters thus absorb part of the tariff burden when the existing trade relationship survives. The positive aggregate coefficient therefore reflects composition change, not exporters raising prices. Tariffs shift trade toward higher-priced starting relationships, whose positive contribution more than offsets the negative contribution of ending relationships.

The micro evidence explains this composition effect. New firm–product–country relationships have higher import prices than continuing relationships, both in periods with and without tariff increases. Tariffs reduce relationship formation and increase relationship exit, but the new relationships that still form, especially those formed by large importers, account for larger import shares. Because new relationships and large importers tend to pay higher prices within product–country markets than continuing relationships and small importers, the post-tariff import basket shifts toward higher-price trade relationships and firms.[2]

These findings raise a welfare question that aggregate pass-through alone cannot answer. Tariffs affect welfare not only through price changes within continuing import relationships, but also through firms' decisions to add or drop imported varieties, substitution toward domestic inputs, and the resulting reallocation of production across firms. We therefore derive a welfare decomposition that maps these firm-level margins into aggregate welfare effects and quantifies each margin's contribution to the welfare cost of tariffs faced by the U.S.

[1] When we restrict the baseline sample to earlier periods, the estimate is close to zero, implying *complete* aggregate pass-through. Across specifications, aggregate pass-through is complete or more than complete, never incomplete (Appendix A.2).

[2] We show that these patterns are not driven by global value chain participation, exporter switching, or variety switching within product–country markets in Appendix A.3.

The import-price block separates an intensive margin (price changes for continuing imported varieties) from an extensive margin (changes in firms' sourcing sets). The remaining blocks capture substitution toward domestic varieties by importers and non-importers, and the general-equilibrium allocation of output.

Importer heterogeneity enters the welfare calculation through offsetting forces. On the one hand, incomplete pass-through within continuing relationships reduces the welfare cost of tariffs faced by the U.S. because foreign exporters absorb part of the tariff burden. On the other hand, sourcing adjustments and cross-firm reallocation can raise welfare cost by changing the imported varieties available to U.S. firms and shifting production across firms with different import price and import exposure. Which force dominates is therefore a quantitative question. We address this question with a structural model featuring endogenous sourcing, firm-level import prices, and relationship-level price dispersion. We discipline the model using pre-tariff moments on firms and imports, together with empirical moments on pass-through, price gaps, and relationship entry and exit.

Importer heterogeneity is central for welfare. In the benchmark calibration, a 10 percentage point tariff increase reduces first-order welfare by 4.8 percent. In a counterfactual economy without importer heterogeneity, the corresponding first-order welfare loss is only 1.5 percent. Including higher-order terms, the welfare loss is 6.8 percent in the benchmark and 2.8 percent without heterogeneity.

These mechanisms are not specific to tariffs. The wedge between aggregate and firm-level responses arises whenever a common cost shock hits importers unevenly. In that sense, our framework extends beyond tariffs. Our empirical decomposition and welfare formulas apply to other common cost shocks that generate heterogeneous firm-level responses, including exchange-rate movements (Burstein and Gopinath, 2014) and trade sanctions.

Related literature A long literature has studied incomplete pass-through to import prices, emphasizing the roles of invoicing, market power, imported inputs, relationship duration, quality upgrading, and strategic complementarities (cf. Fajgelbaum and Khandelwal, 2022). Recent studies of the U.S.–China trade dispute document complete pass-through using aggregate data (Amiti et al., 2019, 2020; Cavallo et al., 2021; Fajgelbaum et al., 2020; Jiang et al., 2023; Jiao et al., 2024). Relative to previous work, we develop an empirical framework to decompose aggregate tariff pass-through, and identify and quantify a composition channel that operates through importer and relationship reallocation. This channel reconciles incomplete pass-through within continuing relationships with complete or more-

than-complete aggregate pass-through, and provides a unified framework for studying similar aggregation problems under other common cost shocks.[3]

We also build on the literature on importer dynamics and firm heterogeneity (see, e.g., Alviarez et al., 2023; Blaum et al., 2018, 2019; Gopinath and Neiman, 2014; Halpern et al., 2015; Lu et al., 2024). Existing importer models typically emphasize either firm-level import prices or endogenous sourcing, but not both.[4] Welfare implications of tariff shocks under heterogeneous importers have received less attention.[5] We close this gap on two fronts: theoretically, our first- and second-order welfare formulas identify the sufficient statistics and general-equilibrium channels that map micro pass-through and sourcing adjustment into welfare; quantitatively, our model embeds both firm-level price responses and endogenous sourcing decisions, allowing us to measure how each margin contributes to the tariff cost.

Our paper also contributes to the literature on trade policy and supply-chain disruption. Tariffs affect firms not only by changing prices, but also by disrupting relationships, discouraging new sourcing links, and reallocating imports across firms, products, and countries (Fajgelbaum et al., 2024; Handley et al., 2023, 2025; Monarch and Schmidt-Eisenlohr, 2023). We provide an integrated framework that links these firm-level adjustments to aggregate pass-through measurement and to the welfare costs of tariffs, showing that micro reallocation drives both.

Roadmap Section 2 develops the empirical decomposition and presents the firm-level evidence. Section 3 derives the welfare decomposition. Section 4 presents the quantitative model. Section 5 reports the welfare results, and Section 6 concludes.

2 Empirical Facts

This section develops our empirical decomposition of aggregate tariff pass-through and presents the resulting pass-through estimates. We document that aggregate tariff pass-

[3] Alviarez et al. (2023) document incomplete firm-level pass-through within fixed relationships instead of focusing on aggregate tariff pass-through and welfare.

[4] See Table B.1 for a summary of existing importer models.

[5] Although Arkolakis et al. (2012) show that the welfare effects of trade can be measured using aggregate data, we show that firm heterogeneity matters in our setting because firms' import intensities are not equalized. Blaum et al. (2018) show that firm-level data on value added and domestic expenditure shares in material spending are sufficient to compute changes in consumer prices following shocks to the import environment. In our setting, firm-level domestic expenditure shares in material spending are unobservable; we instead show how observable firm-level imports and tariff pass-through can be used to discipline the welfare effects of tariffs.

through at product–country level masks substantial firm-level adjustment in import prices, import shares, and sourcing strategies.

2.1 Data

The baseline sample is constructed from the Longitudinal Foreign Trade Transactions Database (LFTTD), which provides transaction-level data on U.S. imports. For each shipment, LFTTD records the importer's Employer Identification Number (EIN), 10-digit Harmonized System product code (HS10), source country, value, quantity, and customs duties paid.[6] This enables a direct link between observed import prices and realized tariff burdens, which is well suited for analyzing tariff pass-through.

We aggregate the LFTTD to the firm–product–country–month level. Thus, for each U.S. firm i, product j, source country c, and year-month t, we observe imports with products defined at the HS10 level. The key variable in our analysis is the firm–product–country unit value, which captures the before-duty price paid by importer i to foreign exporters of product j from country c in year-month t:

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

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.

The corresponding aggregate unit value at the product–country level pools imports across all firms:

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

where Ω_{jct} denotes the set of firms that import product j from country c in year-month t. This product–country unit value is the outcome variable typically used to estimate aggregate tariff pass-through in the existing literature.

The product–country unit value can therefore be written as a quantity-weighted average of firm–product–country unit values:

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

[6] LFTTD is collected by U.S. Customs and Border Protection from import declaration forms (Customs Forms 7501 and 7533). It covers shipments above $2,000, with a lower threshold of $250 for certain quota items, and also reports the date of transaction and whether the transaction is between related parties.

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 j–country c pair in year-month t. This identity provides the starting point for our decomposition: changes in p_{jct} reflect changes in firm-level prices, in firm-level import shares, and in the set of firms importing each product–country pair.

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

Building on the identity in Section 2.1, we decompose p_{jct} into firm-level sources and estimate tariff pass-through in the aggregate and for each component. We proceed in two steps.

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

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

Average Continuing The first component of equation (2.4) captures the average price change across firms that continue importing the same product–country pair in both periods t and t', holding the set of importers fixed. Let S_{jc} be a set of firms that import product j from country c in both periods, 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 reallocation of import shares across continuing firms. When firms with different unit values gain or lose import shares, the aggregate unit value changes even if each firm's unit value is unchanged. Analogously, $\bar{x}^S_{jct}$ 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 contribution of new firms entering the product–country market. When entrants pay prices that differ from the average of continuing firms,

their entry shifts the aggregate price.[7] 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 firms $i \in E_{jc}$, 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 firms $i \in S_{jc}$, 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 contribution of firms that exit the product–country market. Their imports drop out of the aggregate, and any price gap between exiters and continuers shifts the aggregate price. Let X_{jc} denote the set of firms with positive imports in period t but zero imports in period t' for the pair (j, c). 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, we use this decomposition to estimate tariff pass-through at both the aggregate product–country level and each of the four decomposed components. Specifically, we estimate the specification following Amiti et al. (2019):

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

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 $t' = t + 12$ 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. That is, we estimate equation (2.5) both at the aggregate level using $\Delta \ln p_{jct}$ and at the component level, replacing $\Delta \ln p_{jct}$ with each of the four components in equation (2.4).

Our baseline uses applied tariff rates τ_{jct} from LFTTD, 12-month log differences in unit values, and a sample from January 2017 to December 2019 that extends Amiti et al. (2019) to cover the full tariff-hike period and ends at December 2019 to exclude pandemic disruptions.[8] We discuss robustness to alternative tariff measures, sample windows, and fixed-effect

[7] A trade relationship is considered new if a firm begins importing a new product or starts importing from a different country in period t' compared to period t.

[8] Applied rates are measured as the ratio of collected duty to import value for each product–country pair in year-month t. 12-month differences absorb seasonality and the lumpy nature of imports. Moreover, the relevant comparison is between the tariff hike period and the pre-dispute period. The 2018–2019 U.S.–China tariff increases were unexpected; Fajgelbaum et al. (2020) document little evidence of pre-trends.

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%.

specifications below and in Appendix A.2.

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 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.[9] 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. In fact, the starting margin dominates all the other components, driving the aggregate pass-through to be positive.

According to the decomposition in equation (2.4), the response of these pairs to tariff

[9]Across sample windows, tariff measures, and fixed-effect specifications, aggregate pass-through is complete or more than complete, never incomplete. See Appendix A.2.

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 $\frac{p^S_{jct} - p^X_{jct}}{p_{jct}}$. 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.

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.2. 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. (2019), 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 examine earlier phases of tariff increases and find similar patterns. Extending the sample to include pre-dispute periods from 2015 leaves the decomposition results robust.

2.3 Firm-Level Margins of Tariff Adjustment

We present additional facts to shed light on the mechanisms behind U.S. importers' heterogeneous adjustments.

Starting and Ending pairs Table 2.1 shows how starting and ending pairs contribute to tariff pass-through relative to continuing pairs. These estimates combine two margins: changes in firm-level unit values and changes in the import shares.[10] Moreover, these estimates do not reveal whether starting and ending pairs differ from continuing pairs before the tariff shock. We therefore compare starting and ending pairs with continuing pairs separately in terms of unit values and import shares, both before and after the tariff increase.

[10]The unit value of starting pairs, $p^E_{jct'}$, and continuing pairs, $p^S_{jct'}$, are import-share-weighted averages of firm–product–country unit values. Hence, the response of $p^E_{jct'} - p^S_{jct'}$ to a tariff increase reflects both changes in individual unit values and changes in the import shares of the underlying firms.

The results, reported in Appendix A.4, reveal three patterns. First, starting and ending pairs pay higher unit values than continuing pairs even before the tariff increase. Second, after the tariff increase, the unit-value gap between starting and continuing pairs does not rise significantly, but starting pairs account for a larger share of imports because the set of importers shrinks and post-tariff entrants are larger. Third, tariff increases also reduce the number of starting pairs and raise the number of ending pairs. The appendix further shows that large importers pay higher unit values than small importers and, following a tariff increase, account for a larger share of imports. These reallocations toward higher-price importers and trade relationships contribute to complete aggregate tariff pass-through.

Continuing Pairs Equation (2.4) isolates continuing firm–product–country pairs, namely trade relationships that remain active after the tariff increase. Appendix A.3 shows that incomplete pass-through among continuing pairs is a robust finding across specifications. It also reveals systematic heterogeneity within this margin. Larger continuing importers experience more complete pass-through and gain larger import quantity shares.[11] The appendix further shows that these patterns are not explained by exporter switching, global value chains, or variety switching.

These facts discipline the model mechanisms in Section 4. They show the forces behind firm-level incomplete pass-through among continuing relationships. Quantitatively, however, sourcing reallocation across firms and relationships plays a larger role in aggregate pass-through and welfare, so the continuing-relationship channel is not the dominant source of tariff-induced welfare losses.[12]

3 Unified Welfare Decomposition for Importer Models

We derive a unified welfare decomposition formula based on common elements of existing heterogeneous-importer models. We demonstrate that, despite vast differences in modeling importer heterogeneity across the literature, the welfare effect of a tariff increase can be analytically decomposed into a common set of sufficient statistics and general equilibrium

[11] Alviarez et al. (2023) document that larger importers face more incomplete tariff pass-through. The difference reflects the level of analysis. Their estimates are at the importer–exporter–product level, which is well suited for studying repeated bilateral relationships. Our analysis is at the importer–product–country level, which allows us to implement the aggregate pass-through decomposition.

[12] In Appendix E.2 of Supplementary Material, 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.

mechanisms.

3.1 General Setups among Existing Importer Models

To build our unified framework, we adopt a common benchmark that combines a nested-CES production with monopolistic competition in importers' output and domestic intermediate-input markets, perfect competition in labor markets, and homothetic importer demand. The framework abstracts from explicit importer–exporter matching and summarizes foreign sourcing through a cutoff rule over imported varieties. We formalize this benchmark below.[13]

Production technology There is a unit mass of U.S. firms. Firm i, with productivity A_i, hires labor L_i and purchases intermediates X_i to produce a differentiated variety y_i:

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

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

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

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

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

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

where θ governs the elasticity of substitution across domestic varieties, ϵ governs the elasticity of substitution across foreign varieties, j denotes the imported product, c represents the sourcing country, and k indexes U.S. firms.[14] $\hat{b}_{ijc}$ is the variety attribute that is specific to a firm i. This captures quality or demand differences among firms for varieties within the same product-country market.

[13] In Table B.1, we list papers that deviate from these standard setups and detail their approaches to importer pricing and sourcing strategies.

[14] 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.

The shifter $b_{ijc} = \frac{\hat{b}_{ijc}}{\tau_{jc} p_{ijc}}$ captures the price-adjusted variety attribute of product j from country c for firm i. Each firm ranks its imported varieties by this shifter. We remain agnostic in this section about the micro-foundation of the import price p_{ijc}. Equivalently, firms can be viewed as observing the tariff-inclusive price schedule before choosing their sourcing set. The monotone cutoff b_i^* arises from this ranking: any variety with $b_{ijc} \geq b_i^*$ is imported, and no variety with $b_{ijc} < b_i^*$ is imported. By construction, this ensures that the sourcing decision is monotone in the price-adjusted variety attribute. Section 4 provides one quantitative environment that generates such a pricing schedule and cutoff rule.

Output market and domestic roundabout Each U.S. firm produces a differentiated variety under monopolistic competition. Firm i's output is used both as a final consumption good, c_i, by U.S. households and as an intermediate input, h_{ki}, by other firms k.

U.S. households. In each period, the representative U.S. household supplies labor L at wage rate $W \equiv 1$ and consumes a 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 $P = \left(\int_i p_i^{1-\rho} di \right)^{1/(1-\rho)}$ is the final-good price index, $\rho > 1$ is the elasticity of substitution across varieties, Π denotes aggregate profits of U.S. firms, and T is tariff revenue rebated to households.[15] Firm i sets the variety price p_i according to a constant-markup rule. The consumption maximization leads to a standard demand function:

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

Roundabout production. Firm i sells its variety to firm k as an intermediate input according to the standard CES demand

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

Firm i prices its variety p_{ki}^H at a constant markup. Firm k combines a continuum of domestic varieties indexed by $i \in [0, 1]$ with elasticity of substitution θ. The domestic intermediate

[15] The aggregate tariff revenue is given by $T = \int_0^1 \left[\int_j \left(\sum_c (\tau_{jc} - 1) p_{ijc} m_{ijc} \right) dj \right] di$, where τ_{jc} is the gross tariff rate, p_{ijc} is the pre-tariff price of imported variety, and m_{ijc} is the quantity imported.

price index faced by firm k is $p_k^H = \left(\int_0^1 (p_{ki}^H)^{1-\theta} di\right)^{1/(1-\theta)}$. Firm k also imports a continuum of foreign varieties as intermediate goods with elasticity ϵ. The foreign intermediate price index is $p_k^F = \left[\int_{b_k^*}^{\infty} \left(\frac{\tau_{jc} p_{kjc}}{\hat{b}_{kjc}}\right)^{1-\epsilon} dF(b)\right]^{1/(1-\epsilon)}$. The composite intermediate price index is then $p_k^X = \left[(p_k^H)^{1-\sigma} + (p_k^F)^{1-\sigma}\right]^{1/(1-\sigma)}$.

This yields a roundabout production structure, where firm i's output is used both for final consumption and as an intermediate input in domestic production:

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

We impose $\rho = \theta$ so that the same variety price applies to final demand and domestic intermediate demand. Hence, $p_i = p_{ki}^H = \frac{\rho}{\rho-1}\psi(A_i, b_i^*)\ \forall k$, where $\psi(A_i, b_i^*)$ is firm i's marginal cost. Under this restriction, 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 Firm i uses the full continuum of domestic intermediate inputs but imports only a subset of foreign varieties. This selection is governed by fixed import costs, a standard device for generating heterogeneity in import exposure. Foreign sourcing provides variety gains and, when $b_{ijc} > 1$, efficiency gains relative to domestic inputs. Firm i therefore chooses its import set by trading off these gains against the fixed cost of sourcing. Following Gopinath and Neiman (2014), the fixed cost of importing N_i foreign varieties is measured in wage units and given by EN_i^η, where $E > 0$ governs the cost scale and $\eta > 0$ governs the convexity in the number of imported varieties.

A firm importing product j from country c faces the gross ad valorem tariff τ_{jc}. A tariff increase raises the tariff-inclusive cost of foreign varieties, reduces the value of covering fixed import costs, and induces firms to drop varieties.

Labor market clearing and final goods market clearing Aggregate production labor is supplied inelastically such that $L = \int_i L_i \, di$ given wage rate W. General-equilibrium adjustment operates through aggregate demand D and the allocation of final output between

consumption and intermediate use.[16]

3.2 Welfare Decomposition

For expositional simplicity, in the main text we approximate the welfare effect of a tariff shock to first order around the pre-tariff equilibrium and decompose the resulting change into its underlying margins. This decomposition clarifies the role of firm heterogeneity in shaping tariff-induced welfare effects. The second-order decomposition and decomposition with firm-level inefficiencies are presented in Appendix B, which further demonstrate how firm heterogeneity matters for welfare implications.[17]

Assumption 3.1 *Firm-variety shifters and firm productivity are invariant to the tariff change; that is,* $d\ln(\hat{b}_{ijc}) = 0$ *and* $d\ln(A_i) = 0$.

Throughout, we impose Assumption 3.1. This assumption is innocuous as we focus on the short-run effect of a tariff shock. Additionally, this assumption, joint with constant elasticity of substitution (CES) production functions, ensures that firm-level import expenditure ratio across imported varieties can account for persistent cross-firm unit-value and demand/quality dispersion, so the unobserved shifters $\hat{b}_{ijc}$ do not need to be estimated separately to evaluate the welfare effects of tariffs. For continuing varieties, quality cancels out of log price changes. For entering and exiting varieties, their pre- and post-shock expenditure shares within the firm's foreign input bundle summarize their shifter-adjusted economic importance.

Proposition 3.1 (First-Order Welfare Decomposition) *Under Assumption 3.1, the first-order approximation of the welfare change due to tariff change can be decomposed into five components:*

$$d\ln\left(\frac{C}{L}\right) = \underbrace{-\alpha \int_{i^*} e_i \left[\int_{b_i^*}^{\infty} \omega_{ijc} \left(d\ln(\tau_{jc}) + d\ln(p_{ijc})\right) dF(b)\right] di}_{\text{intensive margin of import price effect}} \quad \underbrace{-\alpha \int_{i^*} e_i \left(\frac{s_i^*}{\epsilon - 1} db_i^*\right) di}_{\text{extensive margin of import price effect}}$$

[16] To keep the first-order welfare decomposition transparent, we abstract from labor used to cover fixed import costs. This assumption does not affect the qualitative mechanism and is innocuous because the welfare decomposition is intended to theoretically demonstrate how each channel matters. It is also consistent with previous literature that remains agnostic about the incidence of fixed sourcing costs, which may be borne partly by foreign exporters rather than entirely by U.S. importers.

[17] These extensions show that at second order, tariff-induced import share reallocation among firms and varieties matter for welfare implications. Specifically, welfare also depends on the variance of firm-level cost changes, the variance of price changes across varieties within firms, the interaction between intensive price changes and extensive-margin cutoff changes, the density of varieties near the sourcing cutoff and the covariance between price changes and firm welfare weights. On the other hand, once firm-level inefficiencies are introduced, reallocation across firms becomes first-order important to the welfare.

$$\underbrace{-\alpha \int_{i^*} e_i s_i^h \left(d\ln(p_i^H) - d\ln(p_i^F)\right) di}_{\text{importer domestic variety substitution effect}} \quad \underbrace{-\alpha \int^{i^*} e_i d\ln(p_i^H) di}_{\text{non-importer domestic variety substitution effect}} \quad \underbrace{+d\ln\left(\frac{P^\rho C}{D}\right)}_{\text{allocation effect}}, \tag{3.10}$$

where $\epsilon > 1, e_i = \dfrac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}$ *is the expenditure share of U.S. consumers on firm* i*'s variety,* $\omega_{ijc} = \dfrac{\tau_{jc} p_{ijc} m_{ijc}}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b) m_{ijc}(b) f(b) db}$ *is the share of foreign variety* (j,c) *in firm* i*'s imported intermediate input bundle,* $s_i^h = \dfrac{p_i^H h_i}{p_i^H h_i + p_i^F m_i}$ *is the share of domestic inputs in firm* i*'s total intermediate input bundle,* p_{ijc}^* *denotes the foreign export price evaluated at the firm's sourcing cutoff,* $s_i^* = \omega_i^* f(b_i^*)$ *is the import expenditure density at the sourcing cutoff, 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 normalized expenditure weight evaluated at the sourcing cutoff.* i^* *denotes the marginal importer such that firms with productivity no less than* A_{i^*} *are importers before tariff increase, while those with lower productivity are non-importers.* D *is specified in equation* (3.9)*.*

Proof: See Appendix B.2.

Proposition 3.1 decomposes the welfare effect of tariff change into three blocks: an import price block, a domestic variety substitution block, and an aggregate allocation block. The first block contains two margins: an intensive margin, which captures tariff and foreign-price changes for continuing imported varieties, and an extensive margin, which captures changes in firms' sourcing sets. The second block also has two components, reflecting substitution toward domestic varieties by importers and non-importers. The third block captures the general-equilibrium allocation of output between consumption and intermediate use.

As demonstrated in Section 2.2, aggregate pass-through is a trade-weighted average of unit-value changes across firms within product-country markets. By contrast, Proposition 3.1 shows that welfare depends on a firm-size- and input-cost-weighted average of firm-level import price-index changes, where the weights reflect a firm's expenditure shares on continuing, entering, and exiting foreign varieties across product-country markets, as well as consumers' expenditure shares across firms. Thus, these are distinct objects. Welfare depends on which firms face the price changes, which trade relationships adjust, and how those adjustments affect firm-level import price indices. Therefore, two economies exhibiting the exact same aggregate tariff pass-through can experience drastically different welfare effects depending on their underlying micro-heterogeneity.

Among the import price effect, the intensive margin depends on how tariff-inclusive price

changes are distributed across firms and varieties. This term is weighted by the expenditure share of U.S. consumers on firm i, e_i, and the share of foreign variety (j, c) in firm i's imported intermediate input bundle, ω_{ijc}. Therefore, the same tariff pass-through has larger welfare effects when it affects large firms or imported varieties that account for a larger share of firms' input costs.

The extensive margin of import price effect measures the welfare loss from reductions in firms' import source. A tariff hike raises the cost of foreign sourcing and shifts firms' sourcing cutoffs b_i^* upward, thereby reducing the set of imported varieties. This effect is governed by the expenditure weight at the cutoff, s_i^*, and by the elasticity of substitution across foreign varieties, ϵ. This margin is lost in representative firm models that impose a common or fixed set of imported varieties. Ignoring importer heterogeneity therefore omits the welfare cost of firm-level sourcing adjustment, even when aggregate product–country variety sets appear stable.

The domestic variety substitution effects capture how firms adjust when foreign inputs become more expensive relative to domestic inputs. For continuing importers, substitution toward domestic inputs partly offsets the increase in the foreign input price index. For non-importers, the adjustment reflects their reliance on domestic inputs. The allocation effect collects the remaining general-equilibrium adjustment in the division of output between final consumption and intermediate use. It also includes the effect of tariff revenue rebated to consumers.

We next shut down importer heterogeneity while preserving the distinction between importers and non-importers. Specifically, we keep the pre-tariff import participation cutoff i^* fixed. Conditional on importing, all importers are assigned the same import set, import shares, and tariff-induced price changes. Hence, the model removes heterogeneity across importing firms and eliminates firm-level sourcing-set adjustment.[18] The resulting decomposition is given in Proposition 3.2.

Proposition 3.2 (Welfare Decomposition without Importer Heterogeneity) *Under Assumption 3.1, the first-order approximation of the welfare change due to tariff change can*

[18]This restriction reflects the fact that extensive-margin adjustments are largely hidden in product–country aggregates, even though they are frequent at the firm–product–country level. Gopinath and Neiman (2014) document a similar pattern.

be decomposed into four components:

$$d\ln(\frac{C}{L}) = \underbrace{-\alpha \int_{i^*} e_i \left[\int_b \omega_{ijc} \left(d\ln(\tau_{jc}) + d\ln(p_{ijc}) \right) dF(b) \right] di}_{\text{intensive margin of import price effect}} \underbrace{-\alpha \int_{i^*} e_i s_i^h \left(d\ln(p_i^H) - d\ln(p_i^F) \right) di}_{\text{importer domestic variety substitution effect}}$$
$$\underbrace{-\alpha \int^{i^*} e_i d\ln(p_i^H) di}_{\text{non-importer domestic variety substitution effect}} \qquad \underbrace{+d\ln(\frac{P^\rho C}{D})}_{\text{allocation effect}}. \tag{3.11}$$

where $e_i = \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}$, $\omega_{ijc} = \frac{\tau_{jc} p_{ijc} m_{ijc}}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b) m_{ijc}(b) f(b) db}$, *and* $s_i^h = \frac{p_i^H h_i}{p_i^H h_i + p_i^F m_i}$. 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.* D *is specified in equation* (3.9).

These absent margins reveal the core limitation of representative-importer approaches: they misattribute composition effects to common price changes and omit the firm-level sourcing adjustments that enter welfare directly. Such approaches can overstate losses from continuing-import price changes when firm-level pass-through is incomplete, while understating losses from firm-level sourcing adjustment. Whether the omission of importer heterogeneity leads to overestimation or underestimation of welfare losses is therefore a quantitative question.[19]

3.3 Welfare Estimation

Proposition 3.1 separates the first-order welfare effect of tariffs into an import-price-index block, domestic-input substitution terms, and an aggregate allocation term. The import-price-index block is the component most directly disciplined by firm-level import data. In particular, Proposition 3.3 shows that the firm-level import price index can be written as a Feenstra-style CES price index: price changes among continuing imported varieties enter through the intensive margin, while changes in the firm's sourcing set enter through the Feenstra variety-adjustment term. Appendix B.6 then maps these two components to observable firm–product–country expenditure shares, tariff-induced price changes among continuing relationships, and tariff-induced entry and exit of relationships in the data. Hence, the first-order import-price index effect, one key component of welfare, can be estimated

[19]The domestic-substitution and allocation effects are also quantitative, as removing importer heterogeneity changes equilibrium input prices and sourcing responses. Aggregate pass-through raises $d\ln p_i^F$ in the representative-importer case, altering the relative price $d\ln p_i^H - d\ln p_i^F$ and hence the strength of substitution toward domestic inputs.

without separately identifying distribution $F(b)$ and without taking a stand on the full micro-foundation of import pricing, relationship formation, or sourcing decisions. For example, if a foreign variety with a high shifter b_{ijc}, whether due to quality or demand factors, is dropped after a tariff increase, it contributes more substantially to welfare losses than a variety with a low shifter, because its removal corresponds to the loss of a foreign variety with a larger expenditure share in the firm's input cost bundle.

Proposition 3.3 (Sufficient Statistics for First-Order Welfare Decomposition) *Under Assumption 3.1, the discrete first-order counterpart of Proposition 3.1 can be written as*

$$d\ln\left(\frac{C}{L}\right) = -\alpha\sum_{i\in\mathcal{M}_t} e_i d\ln p_i^F - \alpha\sum_{i\in\mathcal{M}_t} e_i s_i^h \left(d\ln p_i^H - d\ln p_i^F\right) - \alpha\sum_{i\notin\mathcal{M}_t} e_i d\ln p_i^H + d\ln\left(\frac{P^\rho C}{D}\right),$$

where the firm-level sufficient-statistics measure of the import price index change is

$$d\ln p_i^F \equiv \sum_{jc\in\Omega_i^{\text{con}}} \omega_{ijct}\, d\ln(\tau_{jct}p_{ijct}) + \frac{1}{\epsilon-1}\left[\sum_{jc\in\Omega_{it}} \omega_{ijct}\mathbb{I}_{ijct}^{\text{exit}} - \sum_{jc\in\Omega_{it'}} \omega_{ijct'}\mathbb{I}_{ijct'}^{\text{new}}\right]. \tag{3.12}$$

Here $\mathcal{M}_t$ denotes the set of firms that import before the tariff shock. For each $i\in\mathcal{M}_t$, let Ω_{it} and $\Omega_{it'}$ denote the firm's imported product–country varieties before and after the tariff shock, respectively, and define $\Omega_i^{\text{con}} \equiv \Omega_{it}\cap\Omega_{it'}$, $\Omega_i^{\text{exit}} \equiv \Omega_{it}\setminus\Omega_i^{\text{con}}$, $\Omega_i^{\text{new}} \equiv \Omega_{it'}\setminus\Omega_i^{\text{con}}$. $e_i \equiv \frac{p_i c_i}{\int_{i'} p_{i'}c_{i'}\,di'} = \frac{l_i}{\int_{i'} l_{i'}\,di'}$ is the employment share of firm i,

$$\omega_{ijct} \equiv \frac{\tau_{jct}p_{ijct}m_{ijct}}{\sum_{\ell r\in\Omega_{it}}\tau_{\ell rt}p_{i\ell rt}m_{i\ell rt}}, \qquad \omega_{ijct'} \equiv \frac{\tau_{jct'}p_{ijct'}m_{ijct'}}{\sum_{\ell r\in\Omega_{it'}}\tau_{\ell rt'}p_{i\ell rt'}m_{i\ell rt'}}$$

are the pre- and post-shock tariff-inclusive import expenditure shares within firm i's foreign-input bundle,

$$\mathbb{I}_{ijct}^{\text{exit}} \equiv \mathbf{1}\{jc\in\Omega_i^{\text{exit}}\}, \qquad \mathbb{I}_{ijct'}^{\text{new}} \equiv \mathbf{1}\{jc\in\Omega_i^{\text{new}}\},$$

and $s_i^h \equiv \frac{p_i^H h_i}{p_i^H h_i + p_i^F m_i}$ is firm i's domestic-input share in total intermediate spending. The aggregate demand shifter D is defined in equation (3.9).
Proof: See Appendix B.5.

Although the import price index part of welfare is tightly linked to the observed firm-level pass-through and sourcing adjustment, the other welfare components cannot be directly observed in our data. The domestic variety substitution terms depend on how firms substitute between domestic and foreign inputs, the non-importer terms depend on equilibrium changes

in domestic input prices, and the allocation term depends on the equilibrium response of demand and production. We therefore introduce the full quantitative model to discipline these remaining equilibrium channels and to quantify the overall welfare effect of tariffs.

4 The Full Model

The economy consists of U.S. households, U.S. firms, and foreign products. It operates in discrete time and over an infinite horizon. Foreign products originate from a total of $\mathcal{C}$ countries, and each country supplies $\mathcal{J}$ differentiated products. Within each product–country market, a U.S. firm sources a firm-specific foreign variety, so different importers may purchase different varieties from the same market. Motivated by the evidence in Section 2 that exporter switching within product–country markets does not affect the main firm-level pass-through results, we abstract from importer–exporter matching and focus instead on importers' choices over foreign varieties.

The model explains why incomplete pass-through within continuing relationships can coexist with complete pass-through in aggregate data. Tariffs lower foreign prices for continuing relationships, but they also change which firms and relationships account for aggregate imports: more relationships are ended, fewer new relationships are formed, and import shares shift toward larger importers and higher-price sourcing relationships. Since aggregate unit values average over heterogeneous firms and relationships, this reallocation can offset, or dominate, the within-relationship price decline. Firm-specific import prices and endogenous sourcing jointly generate this mechanism, as detailed in Appendix C.1.

4.1 Setup

Keeping the setups in Section 3, we introduce the additional setups specified below.

Productivity and relationship capital At the beginning of each period t, U.S. firm i draws productivity A_{it} and relationship capital Θ_{ijct} for product j in foreign country c from an exogenous process. This generates a time-varying sourcing strategy for firms. The productivity follows an exogenous AR(1) process:

$$A_{i,t+1} = \rho_A A_{it} + \sigma_A \varepsilon_{i,t+1}, \qquad \varepsilon_{i,t+1} \sim \mathcal{N}(0,1), \quad 0 < \rho_A < 1,\ \sigma_A > 0. \tag{4.1}$$

Productivity captures persistent differences in firm efficiency, which shape firm size, import demand, and sourcing choices.[20] The relationship capital Θ_{ijct} evolves according to

$$\Theta_{ijc,t+1} = \rho_\Theta \, \Theta_{ijc,t} + \sigma_\Theta \, \varepsilon_{ijc,t+1}, \quad \varepsilon_{ijc,t+1} \sim \mathcal{N}(0,1), \quad 0 < \rho_\Theta < 1, \ \sigma_\Theta > 0. \tag{4.2}$$

Relationship capital captures the decline in import prices as buyer–supplier relationships mature, reflecting relationship-specific cost amortization, supplier learning-by-doing, and reduced hold-up frictions (Heise, 2024; Monarch and Schmidt-Eisenlohr, 2023). Θ_{ijct} summarizes these relationship-specific gains and lowers the import price paid by firm i. Equation (4.2) parsimoniously captures relationship dynamics. The persistence parameter ρ_Θ governs the durability of relationship capital, with $1 - \rho_\Theta$ interpreted as its depreciation rate. The innovation $\sigma_\Theta \, \varepsilon_{ijc,t+1}$ captures idiosyncratic shocks to relationship quality, such as changes in logistics, communication, or supplier-specific conditions. This specification can be micro-founded by a learning-by-doing process à la Dasgupta and Stiglitz (1988), as in Heise (2024).[21][22]

After A_{it} and Θ_{ijct} are realized, firm i chooses production, pricing, and sourcing for period t. We can therefore omit the time subscript for simplicity.

Timing and ranked sourcing At the beginning of period t, firm i observes its productivity A_{it}, relationship capital $\{\Theta_{ijct}\}_{j,c}$, tariffs $\{\tau_{jct}\}_{j,c}$, and the aggregate or lagged market-share objects that enter the bilateral pricing schedule. Conditional on these objects, the firm takes the pricing schedule as given when choosing its sourcing set sequentially, ordered by lagged import scope $N_{i,t-1}$. Prices are therefore taken as given in the individual sourcing problem, but are endogenous in equilibrium through the aggregate fixed point. The pricing schedule is

$$\tau_{jct} p_{ijct}(A_{it}, \Theta_{ijct}) = \mu_{ijct}(A_{it}, \Theta_{ijct}) \frac{c_{ijct}(A_{it})}{f(\Theta_{ijct})}, \tag{4.3}$$

where τ_{jct} denotes the gross tariff rate, p_{ijct} is the foreign export price (i.e., unit value), c_{ijct} is the exporter marginal cost, $f(\Theta_{ijct})$ denotes the import price discount due to relationship capital accumulation, and μ_{ijct} is the markup. The tariff- and price-adjusted variety attribute

[20] Initial productivity is drawn from a Pareto distribution with scale parameter A_x and shape parameter A_α.
[21] It is also analogous to standard processes of customer-capital accumulation, e.g., Paciello et al. (2019).
[22] We initialize the cross-section of active relationships by drawing from the invariant distribution implied by the AR(1) process: $\Theta_{ijc,1} \sim \mathcal{N}\left(0, \ \frac{\sigma_\Theta^2}{1-\rho_\Theta^2}\right)$.

of importing product j from country c for firm i is

$$b_{ijct} \equiv \frac{\hat{b}_{ijc}}{\tau_{jct} p_{ijct}(A_{it}, \Theta_{ijct})} = \frac{\hat{b}_{ijc} f(\Theta_{ijct})}{\mu_{ijct}(A_{it}, \Theta_{ijct}) c_{ijct}(A_{it})}. \tag{4.4}$$

A higher b_{ijct} implies a larger price-adjusted sourcing gain. Firms therefore rank foreign varieties by b_{ijct}, which is a sufficient statistic for the ordering of import gains, and choose an import scope cutoff over this ranking.

With sequential sourcing choices, active importers with larger inherited sourcing networks move first, while firms with no prior import relationships move afterward. Since this order is based on past sourcing activity, it is predetermined with respect to current sourcing choices. Taking the pricing schedule as given, firm i chooses how far down its importer-specific ranking to source:

$$\Omega_{it}(b_{it}^*) = \{(j, c) : b_{ijct} \geq b_{it}^*\}.$$

The cutoff b_{it}^* is therefore a ranked-choice device that reduces the extensive-margin problem from choosing among all possible sourcing networks to choosing a one-dimensional import scope.[23]

After sourcing sets and quantities are chosen, the market-share objects entering the pricing schedule are updated. Equilibrium is then computed as a fixed point in these market-share objects and the resulting bilateral prices. Thus, the model allows prices to be endogenous in equilibrium while preserving a tractable ranked-sourcing problem at the firm level. We do not solve a fully strategic network-formation game in which each firm internalizes how adding or dropping a single variety changes bilateral markups and market shares.

Firm-specific import price The pricing schedule in equation (4.3) makes the markup the key endogenous component of firm-specific import prices. We specify this markup as a weighted combination of exporter-side oligopoly power and importer-side oligopsony power:

$$\mu_{ijc}(A_i, \Theta_{ijc}) = (1 - \iota_i)\mu_{ijc}^{\text{oligopoly}}(A_i, \Theta_{ijc}) + \iota_i \mu_{ijc}^{\text{oligopsony}}(A_i, \Theta_{ijc}), \tag{4.5}$$

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

[23] With $J \times C$ foreign varieties, an unrestricted sourcing problem has 2^{JC} possible networks. Under the ranked protocol, the feasible sets are the top $0, 1, \ldots, JC$ varieties, yielding $JC + 1$ choices in a finite implementation and a scalar cutoff in the continuum formulation.

Although tariffs do not affect $c_{ijc}(A_i)$ and $f(\Theta_{ijc})$ given Assumption 3.1, they affect firm-level import prices and import shares by affecting firm-level import quantity m_{ijc} and markup $\mu_{ijc}(A_i, \Theta_{ijc})$. Given differences in import prices across firms arising from differences in A_i and Θ_{ijc}, import-share reallocations across firms in response to tariff changes matter for aggregate tariff pass-through. Therefore, although tariff pass-through is incomplete at the firm level because of endogenous import price adjustment, aggregate pass-through may be complete or incomplete, depending on the relative strength of import-share reallocation.

The pricing functions (4.3) and (4.5) are estimated from the data and are flexible enough to capture several mechanisms emphasized in the literature. First, exporter marginal costs vary with importer productivity:

$$c_{ijc}(A_i) = A_i^{\tilde{c}} \tag{4.6}$$

with $\frac{\partial c_{ijc}(A_i)}{\partial A_i} > 0$. This enables the model to match the empirical pattern that larger importers pay higher prices within the same product–country market, despite their greater market power. One interpretation is quality sorting: larger importers source higher-quality varieties that are more costly to produce (Blaum et al., 2019). On the other hand, higher prices may reflect importer-specific logistics, compliance, or supply-chain requirements rather than quality alone.

We allow the variety attribute $\hat{b}_{ijc}$ to be correlated with firm productivity A_i to distinguish these interpretations. A high correlation between $\hat{b}_{ijc}$ and A_i points to quality sorting: larger importers pay more because they source higher-quality varieties. A low correlation instead implies that their higher prices mainly reflect importer-specific compliance costs. Specifically, the variety attribute takes the CES form

$$\hat{b}_{ijc} = \left((1-\gamma)\, \hat{\eta}^{(\theta_b - 1)/\theta_b} + \gamma\, A_i^{(\theta_b - 1)/\theta_b} \right)^{\theta_b/(\theta_b - 1)}, \tag{4.7}$$

where $\hat{\eta} > 1$, $0 < \gamma < 1$, and $0 < \theta_b < 1$, following Blaum et al. (2019). The parameter γ governs how strongly $\hat{b}_{ijc}$ correlates with firm productivity: higher γ implies that larger firms source higher-quality varieties (quality sorting), while lower γ implies that quality matters less.

Second, relationship capital lowers import prices through the discount function

$$f(\Theta_{ijc}) = \exp(\Theta_{ijc}), \tag{4.8}$$

which satisfies $\frac{\partial f(\Theta_{ijc})}{\partial \Theta_{ijc}} > 0$ and $f(\Theta_{ijc}) > 0$ for all Θ_{ijc}. This specification makes relationship capital a source of firm–relationship price dispersion. Adverse relationship-capital shocks raise prices and make relationships more likely to end. Ending pairs are therefore drawn disproportionately from the lower tail of the Θ_{ijc} distribution, whereas new relationships enter with low accumulated capital and hence relatively high prices.[24]

U.S. firms take the exporter marginal cost $c_{ijc}(A_i)$ and the relationship-capital discount $f(\Theta_{ijc})$ as given. Thus, importer-specific variety attributes and relationship capital do not adjust contemporaneously to a tariff hike.[25] Tariffs therefore act as wedges on the existing cost structure, with firms adjusting through import quantities and sourcing choices.

Third, equation (4.5) captures the two-sided market power documented by Alviarez et al. (2023). The import prices here are endogenous because importers' and exporters' market shares are endogenous. The importers' relative bargaining power is firm-specific:

$$\iota_i = \frac{1}{1 + \exp(-\hat{\iota} \ln A_i)}, \qquad \iota_i \in (0, 1).$$

A larger $\hat{\iota}$ generates a steeper size gradient: larger firms have greater bargaining power.[26] This variation helps the model match the empirical pattern that larger importers exhibit more complete tariff pass-through. When ι_i is close to one, prices are shaped primarily by importer market power; when ι_i is close to zero, they are shaped primarily by exporter market power.

The exporters' market power is characterized as an oligopoly markup

$$\mu_{ijc}^{\text{oligopoly}} = \frac{\varepsilon_{ijc}}{\varepsilon_{ijc} - 1} \geq 1, \tag{4.9}$$

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.[27] As in

[24] This prediction is consistent with the empirical pattern that younger trade relationships have higher unit values and smaller transaction volumes than mature relationships. See evidence in Table A.7, as well as Heise (2024).

[25] This timing is appropriate for our short-run analysis: switching varieties or rebuilding trade relationships takes time, and Section 2 shows that the empirical results are robust to supplier and variety switching.

[26] ι_i is exogenously given in the model and estimated by the data. This is motivated by the estimation results in Alviarez et al. (2023) that endogenizing ι_i leads to similar results.

[27] If $\alpha = 1$ and $\sigma = 1$ in our model, the expression for $\tilde{\nu}$ is the same as Alviarez et al. (2023).

standard models of oligopoly markup, the importer demand elasticity ε_{ijc} is decreasing in the exporters' sales 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

$$\mu_{ijc}^{\text{oligopsony}} = \kappa \frac{1-(1-x_{ijc})^{\frac{1}{\kappa}}}{x_{ijc}} \leq 1, \tag{4.10}$$

where $\kappa \in (0,1]$ is the return 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 $TC_{ijc} = \Phi_{ijc}(A_i)(m_{ijc})^{\frac{1}{\kappa}}$.[28] When $\kappa = 1$, exporters operate under constant returns to scale and importer market power is absent ($\mu_{ijc}^{\text{oligopsony}} = 1$). A markdown arises only when $\kappa \in (0,1)$, corresponding to decreasing returns in exporter production. As in standard oligopsony models, the markdown is stronger for importers with larger buyer shares.

Firm's optimization problem Given the output price of other firms $\{p_{ik}^H\}_{k\in[0,1]}$, 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 shifter cutoff b_i^*, the quantity of foreign inputs $\{m_{ijc}\}_{j\in[0,1]}^{c\in\mathbb{C}}$, 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 shifter $\frac{\hat{b}_{ijc}}{\tau_{jc}p_{ijc}}$ equal to b.

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

$$\pi(A_i) \equiv \max_{y_i, b_i^*} D^{\frac{1}{\rho}} y_i^{1-\frac{1}{\rho}} - \psi(A_i, b_i^*) y_i - E\left(N_i(b_i^*)\right)^{\eta}, \tag{4.11}$$

where

$$\psi(A_i, b_i^*) \equiv \min_{L_i, h_{ik}, m_{ijc}} \left\{ WL_i + \int_0^1 p_{ik}^H h_{ik} dk + \int_{b_i^*}^{\infty} \tau_{jc} p_{ijc} m_{ijc} dF(b) \right\} \tag{4.12}$$

$$\text{s.t.} \quad y_i = 1, \quad (3.1), (3.2), (3.3), (3.4), (3.9)\&(4.3) \quad \text{hold.} \tag{4.13}$$

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

Solving these problems leads to the following optimality conditions:

$$p_i = p_{ki}^H = \frac{\rho}{\rho - 1}\psi(A_i, b_i^*), \tag{4.14}$$

$$L_i = \frac{\psi(A_i, b_i^*)(1-\alpha)}{W} y_i, \quad y_i = \left(\frac{\psi(A_i, b_i^*)}{D^{\frac{1}{\rho}}} \frac{\rho}{\rho - 1}\right)^{-\rho}, \tag{4.15}$$

$$h_{ik} = \left(\frac{p_{ik}^H}{p_i^H}\right)^{-\theta} h_i, \quad h_i = \left(\frac{p_i^H}{p_i^X}\right)^{-\sigma} X_i, \quad X_i = \frac{\psi(A_i, b_i^*)\alpha}{p_i^X} y_i, \tag{4.16}$$

$$m_{ijc} = \hat{b}_{ijc}^{\epsilon-1}\left(\frac{\tau_{jc} p_{ijc}}{p_i^F}\right)^{-\epsilon} m_i, \quad m_i = \left(\frac{p_i^F}{p_i^X}\right)^{-\sigma} X_i, \tag{4.17}$$

$$\eta(N_i(b_i^*))^{\eta-1} E = \left(p_i^F\right)^{\epsilon} (b_i^*)^{\epsilon-1} \left(\frac{p_i^F}{p_i^X}\right)^{-\sigma} \frac{y_i}{(\epsilon-1)A_i} \left(\frac{W}{1-\alpha}\right)^{1-\alpha} \left(\frac{p_i^X}{\alpha}\right)^{\alpha-1}, \tag{4.18}$$

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

4.2 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 given the realization of productivity A_{it} and relationship capital Θ_{ijct},

(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 $\{h_{ikt}\}_{k\in[0,1]}$, shifter cutoff b_{it}^* and foreign inputs $\{m_{ijct}\}_{j\in[0,1]}^{c\in\mathbb{C}}$;

(iii) the goods market clearing condition, 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, $L = \int_0^1 L_{it} di$.

5 Quantitative Analysis

In this section, we quantify the welfare effects of tariff increases.

5.1 Estimation Strategy

Table 5.1 reports the parameter values. Panel A lists externally set parameters. They are fixed exogenously. Panel B lists internally estimated parameters. They are estimated using simulated methods of moments. They target firm-level moments relevant for tariff pass-through and welfare. Table 5.2 reports the data and model values for these moments.

5.1.1 External Estimation

We set the elasticity of substitution across domestic varieties θ to 4, similar to Broda and Weinstein (2006). We set the demand elasticity ρ to be the same as θ, as explained in Section 3.1. We follow Fajgelbaum et al. (2020) for the foreign-input elasticities: $\sigma = 1.19$ between domestic and foreign inputs, and $\epsilon = 2.53$ across foreign varieties. We set the intermediate-input share α to 0.5, following He (2024).[29] We set the pre-dispute tariff to 3.9 percent, the average applied tariff in the LFTTD over 2015–2017.

Furthermore, we fix several parameters by normalization or following the existing estimates. We fix the scale of the import cost E as a normalization. The persistence of firm productivity shocks ρ_A is taken from Lee and Mukoyama (2015). The weights γ and θ_b in the shifter are set to values from Grieco et al. (2022), ensuring that firm productivity A_i and the shifter are complements as in Blaum et al. (2019).

5.1.2 Internal Estimation (Simulated Method of Moments)

We simulate the model for two periods. In the first period, firms draw productivity and relationship capital. In the second period, firms receive idiosyncratic shocks. At the same time, the tariff rises from 3.9 percent to 13.9 percent on all foreign varieties. This generates time-varying sourcing decisions, entry and exit of trade relationships, and heterogeneous price responses. We assume no tariff variation across products or countries.[30]

We estimate eight parameters by matching eight data moments. The discussion below maps each parameter to its most closely related moment.

[29] Gopinath and Neiman (2014) finds $\alpha = 2/3$ using Argentine data.

[30] We simulate 20,000 firms, each importing one product from five countries. The foreign variety is defined at product-country level. Different U.S. firms can import different versions of the variety from the same product-country markets.

Table 5.1: Parameterization

Parameter	Notation	Value
Panel A. External Parameterization		
EOS across final goods	ρ	4
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
Gross tariff rate before trade dispute	τ_{jc}	1.039
Scale of import cost	E	0.02
Shifter, constant input	$\hat{\eta}$	5
Firm productivity, persistence	ρ_A	0.70
Shifter, weight on productivity	γ	0.50
Shifter, elasticity	θ_b	0.80
Panel B. Internal Estimation		
B1. Distribution of Firms and Imports		
Firm productivity, shape	α_p	3.80
Firm productivity, scale	x_m	3.94
Convexity of import cost	η	0.40
Cost shifter, elasticity	$\tilde{c}$	0.32
B2. Tariff Pass-Through and Firm-Specific Import Price		
Relationship persistence	ρ_Θ	0.93
Relationship volatility	σ_Θ	0.23
Exporters' returns to scale	κ	0.94
Bargaining power, prod. slope	$\hat{\iota}$	5.00

Firm productivity distribution Firm productivity A follows a Pareto distribution with shape α_p and scale x_m. Higher productivity raises a firm's employment in equilibrium. The shape α_p thus targets the employment share of large firms. The scale x_m targets the employment share of importers.

Import participation The convexity of the fixed import cost η targets the import participation rate. Higher η makes it costlier to add varieties to the sourcing set. Fewer firms then choose to import.

Marginal cost of foreign suppliers We estimate the cost-productivity elasticity $\tilde{c}$. A positive $\tilde{c}$ means larger importers face higher marginal costs and pay higher prices, which affect their sourcing strategy and input demand. $\tilde{c}$ therefore is related to the employment share of large firms within importers.

Relationship capital Variety-level relationship capital for each firm Θ_{ijc} shifts the marginal cost of imports through a discount $f(\Theta_{ijc})$. More persistent relationships give established pairs a larger price advantage. Thus ρ_Θ targets the price gap between continuing and starting pairs. More volatile shocks widen the gap between long-lived and exiting matches. Therefore σ_Θ targets the price gap between continuing and ending pairs.

Bargaining power and pass-through Exporter returns to scale κ and the size gradient of bargaining power $\hat{\iota}$ jointly determine firm-level pass-through among continuing pairs. A κ close to one generates limited price reductions on the exporter side in response to tariff hikes. A positive $\hat{\iota}$ means that larger importers bargain harder, leaving less room for exporters to reduce prices after tariff hikes and resulting in more complete pass-through to U.S. import prices.[31] We estimate κ and $\hat{\iota}$ to match firm-level pass-through among continuing pairs and its interaction with importer size.

Our estimate of κ is close to one and is consistent with the literature. Fajgelbaum et al. (2020) estimate an inverse foreign export supply elasticity of -0.002 and cannot reject a horizontal supply curve. Fajgelbaum et al. (2024) find that Chinese exports to the rest of the world rose when exports to the U.S. fell, leaving total Chinese exports roughly unchanged. Jiao et al. (2024) use firm-level data and find no decline in firm-level world sales. These patterns are consistent with relatively elastic foreign supply.[32]

Our estimate of size-dependent bargaining power is also consistent with the literature. Earlier work documents that larger firms have access to more resources and fewer dependencies (see, among others, Pfeffer and Salancik (1978), Porter (1980), Sutton (1991), Dobson et al. (1998), Basker (2007), Mayer and Ottaviano (2008), Ellison and Snyder (2010), and Card et al. (2015)). Larger firms can switch suppliers at lower cost, purchase in bulk, and use stronger financial capital and brand recognition to negotiate better terms.

5.1.3 Targeted and Untargeted Moments

Panel A of Table 5.2 reports the targeted moments. The model reproduces the cross-sectional distribution of firms and imports reasonably well. The import participation rate (4.9% in the model vs 5.0% in the data) and the employment share of large firms (0.35 vs 0.52) are close to their empirical counterparts. Within importers, the model also matches the concentration of employment among large firms (0.81 vs 0.84). The model fits firm-level pass-through (-0.20

[31] See Propositions C.1 and C.2 for the details of these mechanisms.
[32] Alviarez et al. (2023) estimate a less elastic foreign supply, which may reflect differences in sample coverage.

vs −0.18) and the increase in pass-through with importer size (0.02 vs 0.03). The model also reproduces the qualitative ranking of price gaps: continuing pairs pay less than starting and ending pairs.

Panel B reports untargeted moments. Panel B.1 shows that the model successfully reproduces untargeted moments related to the distribution of firms and imports, such as the sales share of importers (0.65 in the model vs 0.76 in the data) and the share of domestic intermediates in total inputs (0.96 vs 0.91). The model also gets the broad shape of the firm-size distribution: employment shares for medium firms are close to the data.

Panel B.2 reports the untargeted decomposition of aggregate tariff pass-through. Although magnitudes are smaller than in the data, the model reproduces the compositional structure of the decomposition. Aggregate pass-through is positive and is above the pass-through for average continuing relationships. The starting margin dominates the aggregate, and the ending margin contributes negatively. That is, firm-level pass-through is incomplete but aggregate pass-through is complete, and the gap is driven by reallocation toward higher-priced starting pairs.

5.2 Welfare Implication

Table 5.3 reports the welfare effects of the tariff increase, which rises by 10 percentage points across all varieties, from 3.9 to 13.9 percent. In the baseline model (first column), the first-order decomposition from Proposition 3.1 implies a welfare loss of 4.8 percent. The intensive margin lowers welfare because tariffs raise the cost of continuing imports, though by less than the full tariff because firm-level pass-through is incomplete. The extensive margin lowers welfare as firms reduce their sourcing sets, although its contribution is small in this calibration.[33] The importer domestic substitution channel partially offsets these losses: when foreign inputs become more expensive, importers shift toward domestic inputs. The non-importer domestic substitution channel lowers welfare because the rise in domestic input prices, driven by roundabout production, raises costs for non-importing firms. The general equilibrium component is also substantial in the baseline, reflecting the reallocation of re-

[33]The small contribution of the extensive margin is driven by the assumption that fixed import costs are the same for all firms in the model. As a result, small firms are more sensitive to tariff increases and adjust their sourcing strategies after tariff hikes in the model. However, the data (e.g., Table A.9) suggest that large importers are much less likely than small importers to start a new trade relationship after tariff increases. Our current calibrated model abstracts from this feature of the data and underestimates the contribution of the extensive margin to the import price index. Therefore, it may underpredict the welfare losses from tariffs.

Table 5.2: Targeted and Untargeted Moments

Moment	Data	Model
Panel A. Targeted Moments		
Import participation rate	0.05	0.05
Employment share of importers	0.49	0.28
Employment share (large firms)	0.52	0.35
Employment share within importers (large firms)	0.84	0.81
Price gap: cont. vs starting	0.30	0.02
Price gap: cont. vs ending	0.28	0.20
Firm pass-through	−0.18	−0.20
Firm pass-through × size	0.03	0.02
Panel B. Untargeted Moments		
B.1. Distribution of Firms and Imports		
Sales share of importers	0.76	0.65
Domestic intermediate input share	0.91	0.96
Employment share (medium firms)	0.31	0.32
Employment share (small firms)	0.17	0.33
Employment share within importers (medium firms)	0.14	0.15
Employment share within importers (small firms)	0.02	0.05
B.2. Decomposition of Aggregate Tariff Pass-Through		
Aggregate	0.840	0.009
Average continuing	−0.247	−0.002
Between continuing	−0.253	−0.004
Starting	1.821	0.040
Ending	−1.271	−0.025

Notes: The data moments are constructed based on the data procedures described in Appendix C.2. The model moments are derived accordingly.

sources from consumption towards production. In Appendix C.3, we consider an alternative scenario in which the tariff is concentrated on a single country, which speaks more directly to China-U.S. dispute. The results show that the qualitative findings are unchanged.

Role of firm heterogeneity To highlight how firm heterogeneity matters for the welfare effect, the second column of Table 5.3 reports the same decomposition in a counterfactual economy without firm heterogeneity. In the counterfactual, heterogeneous firms collapse into two representative types matched to baseline importers and non-importers.[34] Comparing the

[34]Firms within each type are identical. The representative importer (non-importer) is assigned the productivity-weighted average of baseline importers (non-importers). Importers and non importers represent 5 and 95 percent of firms, respectively, as in the baseline model.

Table 5.3: Decomposing First-order Welfare Effect of Tariff Increase

	Baseline	Without heterogeneity
Import price intensive	−0.022	−0.046
Import price extensive	−0.001	0.000
Importer dom. substitution	+0.009	+0.034
Non-importer dom. substitution	−0.008	0.000
GE allocation	−0.025	−0.003
Sum	−0.048	−0.015
$\Delta \ln(C/L)$	−0.068	−0.028

Notes: "Sum" represents the total first-order welfare effect of a tariff increase, while $\Delta \ln(C/L)$ represents the total welfare effect of the tariff increase, including both first-order and higher-order terms. The "Without heterogeneity" column reports a counterfactual case with two-type representative-firm: a representative importer with productivity equal to the productivity-weighted average of baseline importers, and a representative non-importer with productivity equal to the productivity-weighted average of baseline non-importers.

two columns reveals how heterogeneity reshapes the welfare effect through several channels.[35]

The extensive margin of import price is absent by construction. The intensive margin is larger in magnitude in the counterfactual. Without firm heterogeneity, exporters can no longer adjust their markups based on which buyer they are selling to, and importers have the same sourcing set and cannot substitute across foreign varieties to soften the shock. Tariff pass-through is therefore complete: importers see a sharper rise in their foreign input costs, which translates into a bigger intensive-margin loss.

The same mechanism amplifies the importer substitution channel: because foreign inputs become more expensive, importers switch toward domestic inputs more aggressively, producing a larger welfare gain from that substitution. In the baseline, heterogeneous bargaining and the ability to drop varieties dampen the rise in foreign input prices, so both the intensive-margin loss and the substitution gain are smaller.

The general equilibrium allocation channel differs as well. In the baseline, the tariff redirects demand across firms of different productivities and foreign exposures, pushing it toward firms that charge higher prices, an effect summarized by the aggregate demand shifter D in Proposition 3.1. Because consumers ultimately pay these higher prices, this reallocation generates an aggregate welfare loss. In the counterfactual, firms within-type respond homogeneously and the only across-type reallocation is between importers and non-

[35]Including non-importers is to keep the non-importer domestic variety substitution effect of tariffs. Restricting the counterfactual to one representative firm would produce an even smaller welfare loss and thus a larger heterogeneity effect, though the actual gap between the two variants is small.

importers, so the GE channel collapses to a small residual.

The non-importer substitution channel in the counterfactual is small, because non-importers account for a small share of consumer expenditure and the rise of domestic price from tariffs is indirect and modest.

This decomposition shows that omitting firm heterogeneity overstates the intensive-margin and importer-substitution channels, while understating the extensive margin, non-importer substitution, and the general-equilibrium reallocation. In our calibration, the understated channels dominate, so a model without firm heterogeneity substantially understates the true welfare loss. Overall, the sum of these first-order components for the counterfactual welfare loss is 1.5 percent, about a third of the baseline (4.8 percent).

6 Conclusion

We use confidential firm-linked trade data from the U.S. Census Bureau to investigate a puzzling finding in recent literature: the complete 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 adapted to study other heterogeneous responses to common cost shocks, such as firms' heterogeneous responses to exchange-rate shocks or regions' heterogeneous responses to tariff shocks.

We focus on the short-run effects of tariffs during the U.S.–China trade dispute, since international trade was 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 Robustness for Decomposing Aggregate Tariff Pass-Through

In this section, we demonstrate that the finding of (more than) complete pass-through at the aggregate level and incomplete pass-through at the firm level in Table 2.1 remain robust to alternative tariff measures, different sample selections, and various fixed-effect specifications.

When we narrow the window to January 2017–June 2018, a period during which tariff increases were generally applied to all trading partners rather than targeted specifically at China, we obtain results consistent with Amiti et al. (2019), namely complete tariff pass-through. Aggregating the LFTTD data to the product-country level and using the sample period in Amiti et al. (2019) yields roughly 1,042,000 observations, as reported in Panel B of Table A.1; by comparison, the aggregate data in Amiti et al. (2019) contain about 1,647,617 observations. This difference in sample composition is the main reason why we estimate more than complete pass-through even when using their sample period.

Scheduled Tariff In line with the literature, including our direct counterpart Amiti et al. (2019), 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 E.1 of the Supplementary Material.[36] 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).

[36] 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%.

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. (2019) We restrict the sample period to January 2017 through December 2018, in order to ensure comparability with the analysis of Amiti et al. (2019). Our analysis yields a statistically significant β of around 0.803, as shown in Panel B of Table A.1, indicating more-than-complete pass-through. 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. 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.3 Continuing Pairs: Empirical Findings

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

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

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:

$$\Delta y_{ijct} = \alpha + \beta_1 \Delta \ln(1+\tau_{jct}) + \beta_2 \ln(emp)_{i,2017} + \beta_3 \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017} + \eta_{ct} + \delta_j + \epsilon_{ijct}, \tag{A.2}$$

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 increase, 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:

$$\Delta y_{ijct} = \alpha + \beta_1 \Delta \ln(1+\tau_{jct}) + \beta_2 \ln(emp)_{i,2017} + \beta_3 \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017} + I_{ijct'} + \eta_{ct} + \delta_j + \epsilon_{ijct}, \tag{A.3}$$

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.[37]

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.3), we replace $I_{ijct'}$ with 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:

$$I_3 = \begin{cases} I_w, & \text{if goods traded on an organized exchange,} \\ I_r, & \text{if reference priced,} \\ I_n, & \text{if differentiated products.} \end{cases} \tag{A.4}$$

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.2) and estimate the following:

$$\begin{aligned} \Delta y_{ijct} =& \alpha + \beta_1 \Delta \ln(1+\tau_{jct}) + \beta_2 \ln(emp)_{i,2017} + \beta_3 I_3 \\ &+ \beta_4 \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017} + \beta_5 \Delta \ln(1+\tau_{jct}) \times I_3 + \beta_6 \Delta \ln(emp)_{i,2017} \times I_3 \\ &+ \beta_7 \Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017} \times I_3 + \eta_{ct} + \delta_j + \epsilon_{ijct}. \end{aligned} \tag{A.5}$$

For standardized products within an HS10 category (I_w), we expect limited variety

[37] The heterogeneous effect of s_{ijc} on tariff pass-through to importers, discussed in Section 4, illustrates the underlying mechanism for this concern.

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.2). 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%.

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.

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.

A.4 Starting and Ending Pairs: Empirical Findings

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

$$y_{ijct'} = \alpha + \beta_1 \Delta \ln(1+\tau_{jct}) + \beta_2 \mathbb{1}_{ijct}^{\text{new c-j}} + \beta_3 \Delta \ln(1+\tau_{jct}) \times \mathbb{1}_{ijct}^{\text{new c-j}} + \eta_{ct} + \delta_j + \epsilon_{ijct}, \quad \text{(A.6)}$$

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's 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.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.2) 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.3). 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.

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.3) 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%.

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

	(1) Δln(unit value)	(2) Δimport quantity share	(3) 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.5). 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%.

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 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.4.1, there are fewer starting pairs and more ending pairs after the tariff increase. Second, as detailed in Appendix A.4.2, firms that start new trade relationships after

Table A.7: Comparing Starting and Continuing Pairs

	(1) $ln(\text{unit value})_{ijct'}$	(2) $\text{quantity share}_{ijct'}$	(3) $ln(\text{import price})_{ijct'}$
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.6). 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%.

the tariff increase mainly do so to import existing products from alternative sourcing countries, 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 3.2, 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

	(1) $ln(\text{unit value})_{ijct}$	(2) $\text{quantity share}_{ijct}$	(3) $ln(\text{import price})_{ijct}$
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.6) 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.4.1 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:

$$\mathcal{I}_{ijct} = \alpha + \beta \Delta \ln(1+\tau_{jct}) + \eta_{ct} + \delta_j + \epsilon_{ijct} \tag{A.7}$$

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 dis-

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

	(1) $\mathbb{1}_{ijct}^{\text{new c-j}}$	(2) $\mathbb{1}_{ijct}^{\text{exit c-j}}$
A. Average Effects		
$\Delta \ln(1+\tau_{jct})$	-0.173	0.315
	(15.37)***	(27.40)***
Obs.	26110000	26110000
adjusted R^2	0.1	0.04
B. Heterogeneous Effects		
$\Delta \ln(1+\tau_{jct})$	-0.077	0.691
	(2.73)***	(25.31)***
$\ln(emp)_{i,2017}$	-0.006	-0.006
	(24.98)***	(27.93)***
$\Delta \ln(1+\tau_{jct}) \times \ln(emp)_{i,2017}$	-0.009	-0.057
	(2.71)***	(18.52)***
Obs.	7833000	7833000
adjusted R^2	0.11	0.04

Notes: This table presents the estimation results of estimating equation (A.7). 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%.

solution 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.

We further introduce firm heterogeneity into the linear probability model to study how extensive margin responses depend on firms' size. The estimation strategy is given by:

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

Panel B of Table A.9 shows that the average effects of tariff increases remain significant even after controlling for firm size. Larger firms are less likely to adjust their import profiles during normal times. Moreover, tariff increases reduce starting more strongly for large firms, while they increase exit less strongly for large firms.

A.4.2 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.7) 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 Import Relationships

	Dependent variable			
	(1) New c	(2) New j	(3) New j–c	(4) Old j–c
Panel A. Probability of starting				
$\Delta \ln(1+\tau_{jct})$	-0.007^{**}	-0.137^{***}	-0.046^{***}	0.017^{***}
	(2.55)	(18.59)	(6.05)	(3.83)
Observations	26,110,000	26,110,000	26,110,000	26,110,000
Adjusted R^2	0.03	0.12	0.04	0.03
Panel B. Probability of ending				
$\Delta \ln(1+\tau_{jct})$	0.014^{***}	0.126^{***}	0.091^{***}	0.084^{***}
	(6.07)	(15.15)	(13.93)	(14.37)
Observations	26,110,000	26,110,000	26,110,000	26,110,000
Adjusted R^2	0.03	0.04	0.03	0.03

Notes: This table reports estimates of equation (A.7). Panel A studies the probability that firm i starts importing product j from country c, distinguishing whether the relationship involves a new country, a new product, a new product–country pair, or an existing product–country pair. Panel B reports the corresponding probabilities of ending relationships. The tariff variable is measured as a 12-month log difference. Standard errors are clustered at the HS-8-digit level. Absolute t-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

B Welfare Decomposition Appendix

B.1 Existing Models of Heterogeneous Importers

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. Table B.1 specifies how existing papers deviate from the standard setups.

B.2 Proof of Proposition 3.1

Proof The first-order approximation of the consumption change in response to tariff change is

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

Table B.1: Models of Heterogeneous Importer Behaviors

Setups	Papers
A. Production functions	
nested-CES	All
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. Importer demand	
Not homothetic	Blaum et al. (2019)
E. 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)
F. 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)
G. 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)
H. Importer and exporter matching	
Exogenous or static	Alviarez et al. (2023); Blaum et al. (2023)
Search and matching	Grossman et al. (2024)
I. GE effect in foreign country	
Labor market clearing	Monarch and Schmidt-Eisenlohr (2023)

Notes: This table summarizes existing importer models. The typical setups among these models 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. This table specifies how existing papers deviate from the standard setups.

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

$$d\ln(C) = -\rho \int_i \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'} d\ln(p_i) di + d\ln(P^\rho C). \tag{B.2}$$

Given that $L = \int_i L_i di$, we have

$$d\ln(L) = \int_i \frac{L_i}{\int_{i'} L_{i'} di'} d\ln(L_i) di, \quad d\ln(L_i) = (1-\rho) d\ln(p_i) + d\ln(D), \tag{B.3}$$

where D is the aggregate demand shifter defined in equation (3.9). Also note that $\frac{L_i}{L_{i'}} = \frac{p_i c_i}{p_{i'} c_{i'}}$, so $\frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'} = \frac{L_i}{\int_{i'} L_{i'} di'} \equiv e_i$. Therefore,

$$d\ln(C/L) = -\int_i e_i d\ln(p_i) di + d\ln\left(\frac{P^\rho C}{D}\right) = -d\ln(P) + d\ln\left(\frac{P^\rho C}{D}\right). \tag{B.4}$$

That is, the first-order welfare effect of tariff increase can be decomposed into an inverse price index effect and a general equilibrium effect.

Step 1. Deriving the first-order formula for $-d\ln P$. For the inverse price index effect at the first order, given $d\ln(p_i) = d\ln(\psi_i)$, we have $-d\ln(P) = -\int_i e_i d\ln(\psi_i^{(1)}) di$, where $d\ln\psi_i^{(1)}$ denotes the first-order change of ψ_i.

Step 2. Deriving the first-order change of ψ_i (i.e., $d\ln\psi_i^{(1)}$). Recall $\psi(A_i, b_i^*) = \frac{1}{A_i}\left(\frac{W}{1-\alpha}\right)^{1-\alpha}\left(\frac{p_i^X}{\alpha}\right)^{\alpha}, p_i^X = [(p_i^H)^{1-\sigma} + (p_i^F)^{1-\sigma}]^{\frac{1}{1-\sigma}}, p_i^H = \left(\int_0^1 (p_{ik}^H)^{1-\theta} dk\right)^{\frac{1}{1-\theta}}$, and

$p_i^F = \left[\int_{b_i^*}^{\infty}\left(\frac{\tau_{jc} p_{ijc}}{\hat{b}_{ijc}}\right)^{1-\epsilon} dF(b)\right]^{\frac{1}{1-\epsilon}}$. Given that $W \equiv 1$, we have $d\ln\psi_i = \alpha d\ln p_i^X$ and its first-order part is $d\ln\psi_i^{(1)} = \alpha d\ln p_i^X$.

Step 3. Deriving the first-order change of p_i^X (i.e., $d\ln p_i^X$). The price index for the composite intermediate input of firm i is $p_i^X = [(p_i^H)^{1-\sigma} + (p_i^F)^{1-\sigma}]^{\frac{1}{1-\sigma}}$ Let $Y = (p_i^X)^{1-\sigma} = (p_i^H)^{1-\sigma} + (p_i^F)^{1-\sigma}$. Then $\ln p_i^X = \frac{1}{1-\sigma}\ln Y$. Differentiate: $d\ln p_i^X = \frac{1}{1-\sigma}\frac{dY}{Y}$ Compute dY: $dY = (1-\sigma)(p_i^H)^{1-\sigma} d\ln p_i^H + (1-\sigma)(p_i^F)^{1-\sigma} d\ln p_i^F$ Hence, $d\ln p_i^X = \frac{(p_i^H)^{1-\sigma} d\ln p_i^H + (p_i^F)^{1-\sigma} d\ln p_i^F}{(p_i^H)^{1-\sigma} + (p_i^F)^{1-\sigma}}$. Define the expenditure shares: $s_i^h = \frac{(p_i^H)^{1-\sigma}}{(p_i^H)^{1-\sigma} + (p_i^F)^{1-\sigma}}$. $s_i^f = 1 - s_i^h$ Then $d\ln p_i^X = s_i^h d\ln p_i^H + s_i^f d\ln p_i^F$.

Recall $p_i^H = \left(\int_0^1 (p_{ik}^H)^{1-\theta} dk\right)^{\frac{1}{1-\theta}}$. Taking logs and differentiating: $d\ln p_i^H = \frac{\int_0^1 (p_{ik}^H)^{1-\theta} d\ln p_{ik}^H dk}{\int_0^1 (p_{ik'}^H)^{1-\theta} dk'}$ $= \int_0^1 \omega_{ik}^H d\ln p_{ik}^H dk$, where $\omega_{ik}^H = \frac{(p_{ik}^H)^{1-\theta}}{\int_0^1 (p_{ik'}^H)^{1-\theta} dk'}$.

Recall $p_i^F = \left[\int_{b_i^*}^{\infty} \left(\frac{\tau_{jc} p_{ijc}}{\hat{b}_{ijc}}\right)^{1-\epsilon} dF(b)\right]^{\frac{1}{1-\epsilon}}$. Set $q(b) = \ln\left(\frac{\tau p}{\hat{b}}\right)$. Then we have $\ln p_i^F = \frac{1}{1-\epsilon} \ln\left(\int_{b_i^*}^{\infty} e^{(1-\epsilon)q(b)} dF(b)\right)$. Differentiating with respect to changes in $q(b)$ and the cutoff b_i^*: $d\ln p_i^F = \frac{\int_{b_i^*}^{\infty} e^{(1-\epsilon)q(b)} dq(b) dF(b)}{\int_{b_i^*}^{\infty} e^{(1-\epsilon)q(b')} dF(b')} - \frac{1}{1-\epsilon} \frac{e^{(1-\epsilon)q(b_i^*)} f(b_i^*)}{\int_{b_i^*}^{\infty} e^{(1-\epsilon)q(b')} dF(b')} db_i^*$.

Define the share functions: $\omega(b) = \frac{e^{(1-\epsilon)q(b)}}{\int_{b_i^*}^{\infty} e^{(1-\epsilon)q(b')} dF(b')}$, $s_i^* = \frac{e^{(1-\epsilon)q(b_i^*)} f(b_i^*)}{\int_{b_i^*}^{\infty} e^{(1-\epsilon)q(b')} dF(b')}$. Then $d\ln p_i^F = \int_{b_i^*}^{\infty} \omega(b) dq(b) dF(b) - \frac{1}{1-\epsilon} s_i^* db_i^*$.

Since $d\ln \psi_i^{(1)} = \alpha d\ln p_i^X$, we have $d\ln \psi_i^{(1)} = \alpha[s_i^h d\ln p_i^H + s_i^f d\ln p_i^F]$, where s_i^h, s_i^f, $d\ln p_i^H$ and $d\ln p_i^F$ are given in the above.

Step 4. Assembling the First-Order Decomposition. Substituting $d\ln \psi_i^{(1)}$ back into the inverse price index effect gives the first-order approximation:

$$\begin{aligned} d\ln(C/L) &= -\int_{i\geq i^*} e_i \alpha[s_i^h d\ln p_i^H + s_i^f d\ln p_i^F] di - \int_{i<i^*} e_i \alpha d\ln p_i^H di + d\ln\left(\frac{P^\rho C}{D}\right) \\ &= -\alpha \int_{i\geq i^*} e_i \left[\int_{b_i^*}^{\infty} \omega(b) dq(b) dF(b)\right] di - \alpha \int_{i\geq i^*} e_i \frac{1}{\epsilon - 1} s_i^* db_i^* di \\ &\quad - \alpha \int_{i\geq i^*} e_i s_i^h (d\ln p_i^H - d\ln p_i^F) di - \alpha \int_{i<i^*} e_i d\ln p_i^H di + d\ln\left(\frac{P^\rho C}{D}\right). \end{aligned}$$ □

B.3 Welfare Decomposition with "Inefficiencies"

The baseline welfare decomposition implies that import share reallocation across heterogeneous firms does not affect the first-order welfare effects of tariffs. In particular, U.S. consumers' expenditure share on U.S. firm i, denoted by e_i, is unchanged. However, firm-level inefficiencies are common in the data and once firm-level inefficiencies are introduced into the general setup, reallocation across firms becomes first-order important.[38] In this section we demonstrate how they can influence the first-order welfare effects of tariffs.

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 into the general setup. Additional distortions could also be considered. 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).

Specifically, U.S. firms produce imperfectly substitutable varieties and charge variable

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

markups for household consumption, whereas the price for intermediate input production is set equal to a constant markup over marginal cost. The consumption goods price of U.S. firms, p_i, is now given by

$$p_i = \frac{\rho_i}{\rho_i - 1}\psi(A_i, b_i^*),\ \rho_i \equiv \rho - (\rho - 1)e_i,\ e_i \equiv \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}, \tag{B.5}$$

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 (First-Order Welfare Decomposition with Inefficiencies) *Under Assumption 3.1, the first order approximation of the welfare change can be decomposed into seven components:*

$$d\ln(\frac{C}{L}) = \underbrace{-\alpha \int_{i^*} e_i \left[\int_{b_i^*}^{\infty} \omega_{ijc}\left(d\ln(\tau_{jc}) + d\ln(p_{ijc})\right) dF(b)\right] di}_{\text{import price index intensive margin}} \quad \underbrace{-\alpha \int_{i^*} e_i \left(\frac{s_i^*}{\epsilon - 1} db_i^*\right) di}_{\text{import price index extensive margin}}$$

$$\underbrace{-\alpha \int_{i^*} e_i s_i^h \left(d\ln(p_i^H) - d\ln(p_i^F)\right) di}_{\text{importer domestic variety substitution}} \quad \underbrace{-\alpha \int^{i^*} e_i d\ln(p_i^H) di}_{\text{non-importer domestic variety substitution}} \quad \underbrace{+d\ln(P^\rho C) - \int_i l_i M_i di}_{\text{new allocation effect}}$$

$$\underbrace{-\rho \int_i e_i \frac{1}{\rho_i(1-\rho_i)} d\rho_i di}_{\text{markup distortion}} \underbrace{-(\rho - 1)[\int_i e_i d\ln(\psi(A_i, b_i^*)) di - \int_i l_i d\ln(\psi(A_i, b_i^*)) di]}_{\text{input distortion}}, \tag{B.6}$$

where $\epsilon > 1, e_i = \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}$, $l_i \equiv \frac{L_i}{\int_{i'} L_{i'} di'}$, $\omega_{ijc} = \frac{\tau_{jc} p_{ijc} m_{ijc}}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b) m_{ijc}(b) f(b) db}$, $s_i^h = \frac{p_i^H h_i}{p_i^H h_i + p_i^F m_i}$, $\omega_i^* = \frac{\tau_{jc} p_{ijc}^* m_{ijc}^*}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b) m_{ijc}(b) f(b) db}$, p_{ijc}^* *is the foreign export price evaluated at the cutoff* b_i^*, $s_i^* = \omega_i^* f(b_i^*)$. i^* *denotes the marginal importer such that firms with productivity no less than* A_{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* $\tilde{D} = \int_0^1 (p_k^H)^\rho \left(\frac{p_k^H}{p_k^X}\right)^{-\sigma} X_k dk$.
Proof: See Appendix F.2.1 of the Supplementary Material.

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.

By computing the model with and without inefficiencies while targeting the same data moments, we can assess how varying degrees of output market power in consumption goods affect the welfare impact of a tariff increase. In particular, this approach allows us to determine whether the post-tariff reallocation of import shares toward large (and potentially more productive) firms results in allocative inefficiency or efficiency.

B.4 Second-Order Welfare Decomposition

Proposition B.2 *Let P be the price of aggregate consumption, C aggregate consumption, L labor supply, and D the general-equilibrium demand shifter defined in (3.9). Let i^* denote the marginal initial importer: firms with $\frac{\hat{b}_{ijc}}{\tau_{jc}p_{ijc}} \geq b_i^*$ import before the tariff increase; firms with lower values do not. Under Assumption 3.1, the second-order approximation to the welfare change from a tariff increase satisfies*

$$\begin{aligned}
\Delta \ln\Big(\frac{C}{L}\Big) \approx\ & \underbrace{-\alpha \int_{i\geq i^*} e_i \left(\int_{b_i^*}^{\infty} \omega_i(b)\, dq_i(b)\, dF_i(b) \right) di}_{\text{importer import price index, intensive margin}} \quad \underbrace{-\alpha \int_{i\geq i^*} e_i \left(\frac{1}{\epsilon-1} s_i^*\, db_i^* \right) di}_{\text{importer import price index, extensive margin}} \\
& \underbrace{-\alpha \int_{i\geq i^*} e_i\, s_i^h \big(d\ln p_i^H - d\ln p_i^F\big)\, di}_{\text{importer domestic–foreign substitution}} \quad \underbrace{-\alpha \int_{i<i^*} e_i\, d\ln p_i^H\, di}_{\text{non-importer domestic variety substitution}} \\
& \underbrace{-\frac{\alpha}{2} \int_{i\geq i^*} e_i\, d^2 \ln p_i^X\, di}_{\text{within-importer second-order effect}} \quad \underbrace{-\frac{\alpha}{2} \int_{i<i^*} e_i\, d^2 \ln p_i^H\, di}_{\text{within-non-importer second-order effect}} \\
& \underbrace{+\frac{\rho-1}{2} Var_e\big(d\ln \psi_i^{(1)}\big)}_{\text{across-firm second-order effect}} + \underbrace{\Delta \ln\Big(\frac{P^\rho C}{D}\Big)}_{\text{GE reallocation effect}},
\end{aligned} \tag{B.7}$$

where, for initial importers $i \geq i^*$,

$$\begin{aligned}
d^2 \ln p_i^X = & \underbrace{(1-\sigma) s_i^h s_i^f \big(d\ln p_i^H - d\ln p_i^F\big)^2}_{\text{substitution between domestic and foreign inputs}} + \underbrace{s_i^h (1-\theta) Var_{\omega_i^H}\big(d\ln p_{ik}^H\big)}_{\text{substitution across domestic varieties}} \\
& + s_i^f \Big[\underbrace{(1-\epsilon) Var_{\omega_i}\big(dq_i(b)\big)}_{\text{substitution across foreign varieties}} + \underbrace{2 s_i^*(M_i - dq_i(b_i^*))\, db_i^*}_{\text{intensive} \times \text{extensive interaction}}
\end{aligned}$$

$$\underbrace{-s_i^* q_i'(b_i^*)(db_i^*)^2 - \frac{s_i^*}{1-\epsilon}\Big(s_i^* + \frac{f_i'(b_i^*)}{f_i(b_i^*)}\Big)(db_i^*)^2\Big]}_{\textit{cutoff curvature and density effects of extensive margin}}, \tag{B.8}$$

and for initial non-importers $i < i^*$,

$$d^2 \ln p_i^X = d^2 \ln p_i^H = (1-\theta) Var_{\omega_i^H}\big(d \ln p_{ik}^H\big). \tag{B.9}$$

The first-order cost change is

$$d \ln \psi_i^{(1)} = \begin{cases} \alpha\big[s_i^h \, d \ln p_i^H + s_i^f \, d \ln p_i^F\big] & \textit{if } i \geq i^*, \\ \alpha \, d \ln p_i^H & \textit{if } i < i^*, \end{cases} \tag{B.10}$$

with

$$0 < \alpha < 1, \qquad \epsilon > 1, \qquad e_i = \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'} = \Big(\frac{p_i}{P}\Big)^{1-\rho}, \tag{B.11}$$

$$s_i^h = \frac{p_i^H h_i}{p_i^H h_i + p_i^F m_i} = \frac{(p_i^H)^{1-\sigma}}{(p_i^H)^{1-\sigma} + (p_i^F)^{1-\sigma}}, \qquad s_i^f = 1 - s_i^h, \tag{B.12}$$

$$\omega_i^H(k) = \frac{(p_{ik}^H)^{1-\theta}}{\int_0^1 (p_{i\ell}^H)^{1-\theta} d\ell}, \qquad p_i^H = \Big(\int_0^1 (p_{ik}^H)^{1-\theta} dk\Big)^{\frac{1}{1-\theta}}, \tag{B.13}$$

$$p_i^F = \Big[\int_{b_i^*}^{\infty} \Big(\frac{\tau_{jc} p_{ijc}}{\hat{b}_{ijc}}\Big)^{1-\epsilon} dF_i(b)\Big]^{\frac{1}{1-\epsilon}}, \qquad q_i(b) = \ln\Big(\frac{\tau_{jc} p_{ijc}}{\hat{b}_{ijc}}\Big), \tag{B.14}$$

$$\omega_i(b) = \frac{\tau_{jc} p_{ijc}(b) m_{ijc}(b)}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b') m_{ijc}(b') f_i(b') db'}, \qquad q_i'(b) = \partial q_i(b)/\partial b, \tag{B.15}$$

$$\omega_i^* = \frac{\tau_{jc} p_{ijc}^* m_{ijc}^*}{\int_{b_i^*}^{\infty} \tau_{jc} p_{ijc}(b') m_{ijc}(b') f_i(b') db'}, \qquad s_i^* = \omega_i^* f_i(b_i^*), \tag{B.16}$$

$$M_i = \int_{b_i^*}^{\infty} \omega_i(b) \, dq_i(b) \, dF_i(b). \tag{B.17}$$

ω_i^* is the share of foreign variety at the cutoff (that is dropped or added after the tariff increase) in determining imported input cost of firm i, and s_i^* is the import cost share of varieties at the cutoff. The variance operators Var_e, $Var_{\omega_i^H}$, and Var_{ω_i} are defined in (F.27)–(F.29) below, and D is given in equation (3.9). All derivatives are evaluated using initial shares.

Proof: See Appendix F.3.2 of the Supplementary Material.

B.5 Proof of Proposition 3.3

Proof The proof proceeds in five steps.

Step 1. Start from the first-order welfare decomposition. From Proposition 3.1, the first-order welfare effect can be written as

$$d\ln\left(\frac{C}{L}\right) = -\alpha\sum_{i\in\mathcal{M}_t} e_i\, d\ln p_i^F - \alpha\sum_{i\in\mathcal{M}_t} e_i s_i^h\left(d\ln p_i^H - d\ln p_i^F\right) - \alpha\sum_{i\notin\mathcal{M}_t} e_i d\ln p_i^H + d\ln\left(\frac{P^\rho C}{D}\right).$$

The key object needed for the sufficient-statistics implementation is $d\ln p_i^F$.

Step 2. Write the firm-level foreign-input price index. For an importing firm i, define the shifter-adjusted after-duty price of imported variety (j,c) as

$$Q_{ijct} \equiv \frac{\tau_{jct}p_{ijct}}{\hat{b}_{ijc}}.$$

The firm's foreign-input price index is the CES index $p_i^F = \left[\sum_{jc\in\Omega_{it}} Q_{ijct}^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$. By Assumption 3.1, $d\ln\hat{b}_{ijc} = 0$. Therefore, for continuing varieties,

$$d\ln Q_{ijct} = d\ln\left(\tau_{jct}p_{ijct}\right) = d\ln\tau_{jct} + d\ln p_{ijct}.$$

Thus, unobserved time-invariant quality or efficiency shifter does not need to be separately estimated for continuing relationships.

Step 3. Apply the Feenstra CES price index. For firm i, the exact Feenstra price index between t and t' is

$$\Delta\ln p_i^F = \sum_{jc\in\Omega_i^{\text{con}}} w_{ijc}^{SV}\Delta\ln Q_{ijc} + \frac{1}{\epsilon-1}\ln\left(\frac{\lambda_{it'}}{\lambda_{it}}\right), \tag{B.18}$$

where w_{ijc}^{SV} are Sato–Vartia weights over continuing varieties, and

$$\lambda_{it} = \frac{\sum_{jc\in\Omega_i^{\text{con}}}\tau_{jct}p_{ijct}m_{ijct}}{\sum_{jc\in\Omega_{it}}\tau_{jct}p_{ijct}m_{ijct}}, \qquad \lambda_{it'} = \frac{\sum_{jc\in\Omega_i^{\text{con}}}\tau_{jct'}p_{ijct'}m_{ijct'}}{\sum_{jc\in\Omega_{it'}}\tau_{jct'}p_{ijct'}m_{ijct'}}.$$

The first term in (B.18) is the intensive-margin price index for continuing varieties. The second term is the Feenstra variety-adjustment term.

At the first order, the Sato–Vartia weight equals the initial expenditure share up to

second-order terms:

$$w_{ijc}^{SV} = \omega_{ijct} + o(1).$$

Since the price change itself is first order, replacing w_{ijc}^{SV} with ω_{ijct} affects $\Delta \ln p_i^F$ only at the second order. Therefore,

$$\sum_{jc \in \Omega_i^{\text{con}}} w_{ijc}^{SV} \Delta \ln Q_{ijc} = \sum_{jc \in \Omega_i^{\text{con}}} \omega_{ijct} \Delta \ln(\tau_{jct} p_{ijct}) + o(\|d\|). \tag{B.19}$$

Step 4. Convert the Feenstra variety adjustment into exit and new-variety shares. By definition,

$$\lambda_{it} = 1 - \frac{\sum_{jc \in \Omega_i^{\text{exit}}} \tau_{jct} p_{ijct} m_{ijct}}{\sum_{jc \in \Omega_{it}} \tau_{jct} p_{ijct} m_{ijct}} = 1 - x_{it}^{\text{exit}}, \tag{B.20}$$

$$\lambda_{it'} = 1 - \frac{\sum_{jc \in \Omega_i^{\text{new}}} \tau_{jct'} p_{ijct'} m_{ijct'}}{\sum_{jc \in \Omega_{it'}} \tau_{jct'} p_{ijct'} m_{ijct'}} = 1 - x_{it'}^{\text{new}}, \tag{B.21}$$

where

$$x_{it}^{\text{exit}} = \sum_{jc \in \Omega_{it}} \omega_{ijct} \mathbb{I}_{ijct}^{\text{exit}}, \tag{B.22}$$

$$x_{it'}^{\text{new}} = \sum_{jc \in \Omega_{it'}} \omega_{ijct'} \mathbb{I}_{ijct'}^{\text{new}}. \tag{B.23}$$

Therefore,

$$\frac{1}{\epsilon - 1} \ln\left(\frac{\lambda_{it'}}{\lambda_{it}}\right) = \frac{1}{\epsilon - 1} \left[\ln(1 - x_{it'}^{\text{new}}) - \ln(1 - x_{it}^{\text{exit}})\right]. \tag{B.24}$$

Using the first-order approximation $\ln(1 - x) \approx -x$, we obtain

$$\frac{1}{\epsilon - 1} \ln\left(\frac{\lambda_{it'}}{\lambda_{it}}\right) \approx \frac{1}{\epsilon - 1} \left(x_{it}^{\text{exit}} - x_{it'}^{\text{new}}\right) = \frac{1}{\epsilon - 1} \left[\sum_{jc \in \Omega_{it}} \omega_{ijct} \mathbb{I}_{ijct}^{\text{exit}} - \sum_{jc \in \Omega_{it'}} \omega_{ijct'} \mathbb{I}_{ijct'}^{\text{new}}\right]. \tag{B.25}$$

The sign is economically important. Exit raises the foreign-input price index because it removes varieties, whereas new varieties lower the foreign-input price index. Hence the extensive-margin term is proportional to $x_{it}^{\text{exit}} - x_{it'}^{\text{new}}$. When tariff reduces the number of new foreign varieties compared to the normal time, $\omega_{ijct'} \mathbb{I}_{ijct'}^{\text{new}}$ exhibits a negative sign and therefore contributes to the welfare loss.

Step 5. Substitute the firm-level import price index into welfare. Combining (B.19) and (B.25) yields

$$\Delta \ln p_i^F = d \ln p_i^F + o(\|d\|), \qquad \square$$

where $d \ln p_i^F$ is defined in (3.12).

Finally, by the linearity of the first-order approximation, the tariff-induced component of the import-price effect is obtained by replacing the realized continuing-price changes and entry/exit indicators with their fitted tariff components. This gives (B.26) and the directly estimable welfare component (B.28).

B.6 Estimating Import Price Index Effect Directly from Data

In this section, we propose a sufficient statistics approach of estimating the import price index effect of tariffs using the observable data moments, bypassing the need to structurally estimate unobserved variety distributions and firm heterogeneous responses.

At the first order, equations (B.33) and (B.30) summarize the moments and parameter values needed to estimate the effect of tariffs on the import price index: α, ϵ, e_i, ω_{ijct}, $\hat{\mathbb{I}}ijct^{exit}\big|Tariff$, and $\hat{\mathbb{I}}ijct^{new}\big|Tariff$. Note that we still need to take a stand on the values of α and ϵ. We therefore should use different values of α and ϵ to provide a range of estimates for the first-order effect of tariffs on the import price index.[39]

We are not able to precisely estimate the second-order effect directly using the data, due to the lack of information on s_i^f, an individual firm's foreign input share. However, the analysis in Appendix F.5.1 of the Supplementary Material demonstrates how estimates of the welfare effects of tariffs can be biased if only the first-order import price index effect is considered. Our methodology can be useful for future research using data that contain both import information and foreign input shares.

Additionally, this sufficient-statistics approach can only estimate the effect of tariff increases on the import price index. To estimate other effects, we still need a structural model, given that we do not have input data for non-importers.

[39] Additionally, as shown in Proposition B.3, the effect of tariffs on the import price index can still be estimated in the presence of firm-level inefficiencies.

B.6.1 First-Order Import Price Index Effect of Tariffs

In this section, we show that for each firm i, the tariff-induced firm-level import-price-index change is

$$\widehat{d\ln p_{it}^F} \equiv \sum_{jc\in\Omega_i^{\text{con}}} \omega_{ijct}\widehat{dq}_{ijct}\Big|_{Tariff} + \frac{1}{\epsilon-1}\left[\sum_{jc\in\Omega_{it}} \omega_{ijct}\hat{\mathbb{I}}_{ijct}^{exit}\Big|_{Tariff} - \sum_{jc\in\Omega_{it'}} \omega_{ijct'}\hat{\mathbb{I}}_{ijct'}^{new}\Big|_{Tariff}\right]. \tag{B.26}$$

Then the average tariff-induced firm-level import-price-index change for a firm in our panel data is

$$\widehat{d\ln p_i^F} = \frac{\sum_{t\in \mathrm{T_i}} \widehat{d\ln p_{it}^F}}{T_i}. \tag{B.27}$$

Consequently, the directly estimable first-order import-price index component of welfare is

$$\widehat{\mathcal{W}}_T^F \equiv -\alpha \sum_{i\in\mathcal{M}_t} e_i \widehat{d\ln p_i^F}. \tag{B.28}$$

The detailed analysis is as follows.

First-Order Intensive Margin Import Price Index Effect of Tariffs From our empirical specification for continuing pairs (equation (A.2)), we construct the predicted, tariff-induced after-duty price change:

$$\widehat{dq}_{ijct}\Big|_{Tariff} \equiv \Delta\ln\left[\widehat{p_{ijct}(1+\tau_{jct})}\right]\Big|_{Tariff} = \left(\hat{\beta}_1^{cont} + \hat{\beta}_3^{cont}\ln(emp)_i\right)\Delta\ln(1+\tau_{jct}), \tag{B.29}$$

where τ_{jct} is defined as net tariff rate, instead of gross tariff rate.

By the linearity of the first-order approximation, substituting this fitted tariff-related price change into our discrete formula yields the intensive margin import price effect of tariff shocks for firm $i \in \mathcal{M}_t$:

$$IM_{it}^{Tariff} = -\alpha \sum_{jc\in\Omega_{it}^{con}} \omega_{ijct}\widehat{dq}_{ijct}\Big|_{Tariff}. \tag{B.30}$$

Using the computed IM_{it}^{Tariff} and observable e_i, we derive the intensive margin of import price effect.

First-Order Extensive Margin Import Price Index Effect of Tariffs Using our empirical specification (equation (A.8)), we isolate the fitted tariff-related component of the extensive margin response. We keep only the terms involving tariff changes, including their interaction with firm size, and hold the remaining components fixed.[40] This gives:

$$\hat{\mathbb{I}}_{ijct}^{exit}\Big|_{Tariff} = \left(\hat{\beta}_1^{exit} + \hat{\beta}_3^{exit} \ln(emp)_i\right) \Delta \ln(1+\tau_{jct}), \tag{B.31}$$

$$\hat{\mathbb{I}}_{ijct'}^{new}\Big|_{Tariff} = \left(\hat{\beta}_1^{new} + \hat{\beta}_3^{new} \ln(emp)_i\right) \Delta \ln(1+\tau_{jct}). \tag{B.32}$$

Replacing the raw binary indicators with these predicted probabilities yields the empirical counterpart to the extensive margin import price index effect for firm $i \in \mathcal{M}_t$:

$$EM_{it}^{Tariff} = -\alpha \frac{1}{\epsilon - 1} \left[\sum_{jc \in \Omega_{it}} \omega_{ijct} \hat{\mathbb{I}}_{ijct}^{exit}\Big|_{Tariff} - \sum_{jc \in \Omega_{it'}} \omega_{ijct'} \hat{\mathbb{I}}_{ijct'}^{new}\Big|_{Tariff} \right]. \tag{B.33}$$

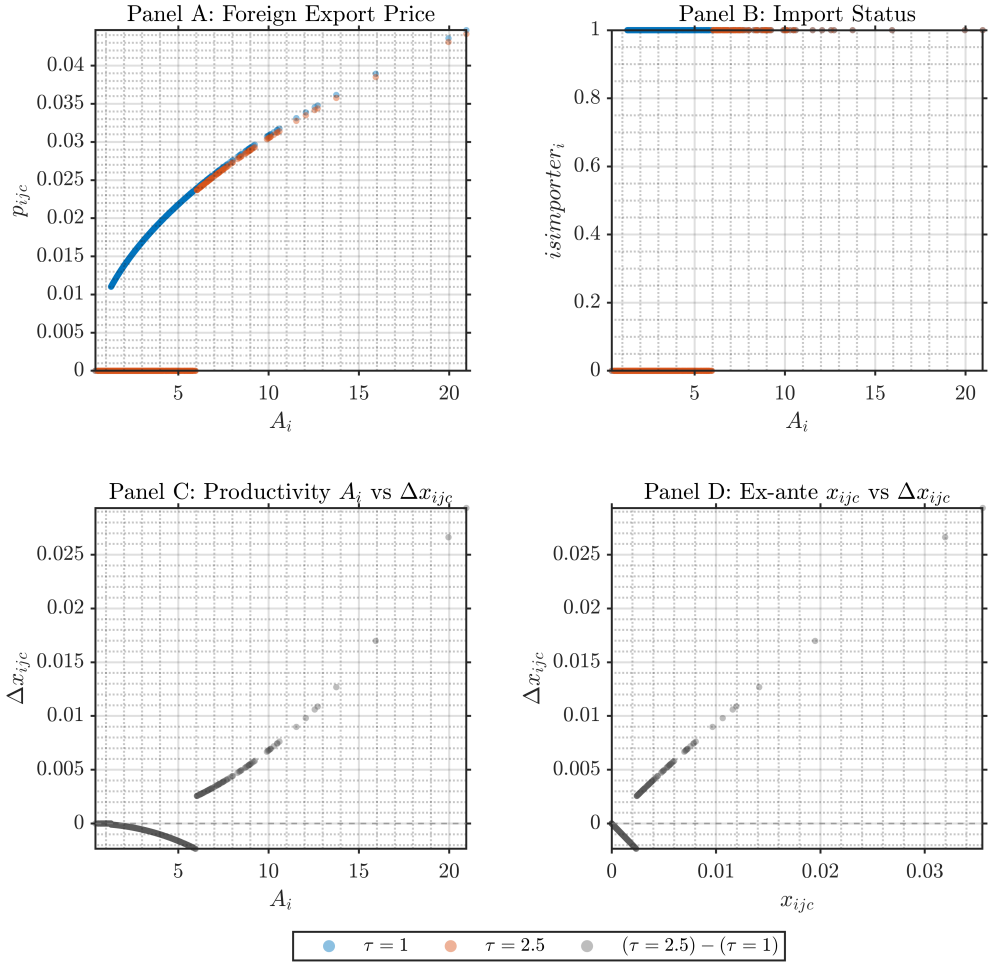
Using the computed EM_{it}^{Tariff} and observable e_i, we derive the extensive margin of import price effect.

C Full Quantitative Model Appendix

C.1 Model Mechanism on Tariff Pass-Through

In this section, we show in detail how the model maps tariff shocks into firm- and aggregate-level pass-through through changes in import prices, import shares, and trade relationships. We first characterize how tariff increases reshape trade relationships, then examine their implications for firm-level unit values. We show that $\frac{\partial c_{ijc}(A_i)}{\partial A_i} > 0$ and $\frac{\partial f(\Theta_{ijc})}{\partial \Theta_{ijc}} > 0$ are essential 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 high importer bargaining power, a high ι_i, limits firms' ability to lower unit values after tariff hikes, despite pass-through is incomplete.

Figure C.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.

C.1.1 Tariff Pass-Through through Relationship Adjustment

Figure C.1 illustrates how firms with different productivity levels adjust trade relationships within a product–country market after a tariff increase, and how these adjustments shape foreign export prices, import status, and import shares. Panel A shows that more productive firms pay higher foreign export prices because exporter marginal costs increase with importer productivity, $\partial c_{ijc}(A_i)/\partial A_i > 0$. After the tariff hike, exporters lower prices in response to weaker demand. Panel B shows that fixed import costs restrict importing to sufficiently productive firms. A tariff increase raises the productivity cutoff and thus reduces the mass of importers. Panel C shows that imports become more concentrated among productive firms after the tariff hike, as these firms are better able to retain access to foreign varieties. Panel D shows a similar reallocation by initial import share x_{ijc}: firms with larger pre-shock import shares are more likely to remain active, so import shares shift toward larger importers. Because larger firms tend to source higher-cost varieties, these extensive-margin adjustments contribute to complete aggregate pass-through at the product–country level.

Similarly, tariff hikes increase relationship exit, so newly formed relationships account for a larger share of imports. If new relationships carry higher prices because they have less accumulated relationship capital, $f'(\Theta_{ijc}) > 0$, this reallocation raises product–country unit values and contributes to complete aggregate pass-through.complete tariff pass-through at the product–country level. [41]

C.1.2 Tariff Pass-Through within Continuing Relationships

Conditional on fixed trade relationships before and after the tariff increase, we discuss the mechanisms driving firm-level tariff pass-through using Propositions C.1 and C.2.

Proposition C.1 *Under the assumption of competitors' non-responsiveness and sufficiently low values of each pass-through components, the import price pass-through elasticity is*

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

[40] By the Frisch-Waugh-Lovell theorem, the tariff coefficients are estimated after partializing out the included controls and fixed effects. The fitted decomposition then follows from the linearity of the model.

[41] Figure G.3 illustrates sourcing adjustment across product–country markets. More productive firms are more likely to import, source more varieties, and purchase higher-cost intermediates. A tariff increase makes these costly varieties less attractive, inducing firms to drop varieties from their sourcing portfolios and pushing marginal importers out of foreign sourcing.

where

$$\Gamma^{s}_{ijc} = (1-\iota_i)\frac{\mu^{oligopoly}_{ijc}}{\mu_{ijc}}\frac{1}{\varepsilon_{ijc}-1}\frac{\epsilon-\varepsilon_{ijc}}{\varepsilon_{ijc}}; \tag{C.2}$$

$$\Gamma^{x}_{ijc} = \iota_i\frac{\mu^{oligopsony}_{ijc}}{\mu_{ijc}}\left[\frac{x_{ijc}(1-x_{ijc})^{\frac{1}{\kappa}-1}}{\kappa(1-(1-x_{ijc})^{\frac{1}{\kappa}})}-1\right]. \tag{C.3}$$

Proof. See Appendix G.2.2 of the Supplementary Material.

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.[42] Moreover, 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 G.2.4 in Supplementary Material discusses the detailed mechanisms of firm-level tariff pass-through.

Proposition C.2 *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 $\partial_\iota\left[\partial\ln(\tau_{jc}p_{ijc})/\partial\ln\tau_{jc}\right] \geq 0$, with $\iota \in [0,1]$, all else being equal.*
Proof. See Appendix G.2.3 of the Supplementary Material.

Proposition C.2 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, so a larger share of the tariff burden is borne by importers. This mechanism helps rationalize the higher pass-through faced by larger importers and motivates allowing bargaining power to increase with importer size, namely $\frac{\partial\iota_i(A_i)}{\partial A_i} > 0$.

C.2 Constructing Targeted and Untargeted Moments

This section describes the procedure we take to compute moments from data.

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–

[42] If $\iota_i = \iota$, equation (C.1) 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}.

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. **Sales share of importers among all U.S. firms before tariff increase**: Using LBD merged with LFTTD, we calculate total sales for U.S. importers and for all U.S. firms in 2017. The ratio of these totals yields the sales share of importers among all U.S. firms.

5. **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).

6. **Price gap: continuing pairs vs starting pairs and continuing pairs vs ending pairs**: The first regression coefficient in the first column of Tables A.7 and A.8.

7. **Firm pass-through and its interaction with size**: First column of Table A.2.

8. **Decomposition of aggregate tariff pass-through**: Table 2.1.

Table C.1: Decomposing Welfare Effect: China Case

	Benchmark	Without heterogeneity
Import price intensive	−0.005	−0.006
Import price extensive	−0.001	0.000
Importer dom. substitution	+0.004	+0.005
Non-importer dom. substitution	−0.002	0.000
GE allocation	−0.004	0.000
Sum	−0.008	−0.002
$\Delta \ln(C/L)$	−0.012	−0.004

Notes. The tariff is concentrated on one source country. The counterfactual "Without heterogeneity" column reports a two-type representative-firm economy. All other model features are identical to those in Section 5.2.

C.3 Welfare Decomposition: China Case

In this appendix, we report the welfare decomposition under an alternative tariff scenario in which only one of the sourcing countries is hit by the tariff increase. This one country accounts for 20-percent share of total foreign imports, which is roughly China's share of U.S. goods imports during the trade dispute. The gross tariff on this country rises from 1.04 to 1.15, reflecting the trade-weighted average rate the U.S. imposed on Chinese imports during the dispute. The tariffs on the other countries remain at the pre-dispute level of 1.04 throughout. All other model features are identical to those in the baseline reported in Section 5.2.

Table C.1 reports the welfare decomposition for this case. The qualitative patterns mirror those of the uniform tariff. The intensive margin and the importer domestic substitution channel are both larger in the counterfactual without firm heterogeneity. The extensive margin is absent in the counterfactual by construction, and the non-importer substitution channel is quantitatively negligible. Quantitatively, all channels are roughly one-fifth the size of those in the uniform-tariff scenario. The conclusion that omitting firm heterogeneity substantially understates the welfare loss continues to hold.

D Link to the Supplementary Material

The Supplementary Material can be found via this link.

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

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E Data Appendix

E.1 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 $Month < M_{2018}^{E}$, $\tau^{Scheduled} = \tau_{2018}^{Initial} + \tau^{201801}$. If $M_{2018}^{E} \leq Month <$ 201901, $\tau^{Scheduled} = \tau_{2018}^{Max} + \tau^{201801}$. If 201901 $\leq Month < M_{2019}^{E}$, $\tau^{Scheduled} = \tau_{2018}^{Max} + \tau^{201801}$. If $Month \geq M_{2019}^{E}$, $\tau^{Scheduled} = \tau_{2019}^{Max} + \tau^{201801}$. There are two special cases. The first case is that M_{2018}^{E} does not exist. This means there is no tariff change in 2018. In this case, $\tau^{Scheduled} = \tau_{2018}^{Max} + \tau^{201801} = \tau_{2018}^{Initial} + \tau^{201801}$ for all months in 2018. The second case is that M_{2019}^{E} does not exist. This means there is no tariff change in 2019. In this case, $\tau^{Scheduled} = \tau_{2018}^{Max} + \tau^{201801}$ for all months in 2019.

E.2 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 could 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

$$\underbrace{\frac{p_{jct'}-p_{jct}}{p_{jct}}}_{\approx\Delta\ln(p_{jct})}=\underbrace{\frac{\sum_G\frac{(p^{S^G}_{jct'}-p^{S^G}_{jct})}{n^G}}{p_{jct}}}_{\text{Average Continuing}}+\underbrace{\frac{\sum_G(\tilde{x}^{S^G}_{jct'}-\bar{x}^{S^G}_{jct'})(p^{S^G}_{jct'}-\bar{p}^{S^G}_{jct'})-\sum_G(\tilde{x}^{S^G}_{jct}-\bar{x}^{S^G}_{jct})(p^{S^G}_{jct}-\bar{p}^{S^G}_{jct})}{p_{jct}}}_{\text{Between Continuing}}$$
$$+\underbrace{\frac{\sum_G x^{E^G}_{jct'}(p^{E^G}_{jct'}-p^{S}_{jct'})}{p_{jct}}}_{\text{Starting}}+\underbrace{\frac{\sum_G x^{X^G}_{jct}(p^{S}_{jct}-p^{X^G}_{jct})}{p_{jct}}}_{\text{Ending}}, \tag{E.1}$$

where $G\in\{\text{large firm},\text{small firm}\}$, $\tilde{x}^{S^G}_{jct}\equiv\frac{x^{S^G}_{jct}}{x^{S}_{jct}}$ is the import quantity share of group G among continuing pairs, $\bar{x}^{S^G}_{jct}\equiv\frac{\sum_G\tilde{x}^{S^G}_{jct}}{n^G}$ is the unweighted average of $\tilde{x}^{S^G}_{jct}$ across G for continuing pairs, $p^{S^G}_{jct}$ denotes the unit value of continuing pairs in group G, $\bar{p}^{S^G}_{jct}\equiv\frac{\sum_G p^{S^G}_{jct}}{n^G}$ is the unweighted average of $p^{S^G}_{jct}$ 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 E.2.1. The explanation for each component can be specified as follows.

Continuing. Equation (E.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 (E.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 (E.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, $x^{E^G}_{jct'}$, can be further decomposed as $x^{E^G}_{jct'}=n^{E^G}_{jct'}\times\bar{x}^{E^G}_{ijct'}$, where $n^{E^G}_{jct'}$ denotes the number of starting pairs in group $G\in\{\text{large},\text{small}\}$

in product-market (j,c) at period t', and $\bar{x}^{E^G}_{jct'} \equiv \frac{\sum_{i\in E^G_{jct'}} x_{ijct'}}{n^{E^G}_{jct'}}$ 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 $n^{E^G}_{jct'}$ but higher $\bar{x}^{E^G}_{ijct'}$ after tariff increase would suggest either fewer but larger starting importers, or fewer importers per product–country pair, which leads to a higher $\bar{x}^{E^G}_{ijct'}$. The analysis for ending pairs follows analogously.

We could reestimate equation (2.5) by replacing the left-hand side, $\Delta \ln p_{jct}$, with the decomposed components in equation (E.1). This generates a more detailed decomposition of aggregate tariff pass-through with richer firm heterogeneity. Due to page limits, we only present this method in the Appendix and leave its application to future research.

E.2.1 Derivation Details

In this section, we derive equation (E.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

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

where $G \in \{\text{large}, \text{small}\}$, and M^G_{jc} 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 (E.1). Specifically, we derive in two steps.

Step 1. It is easy to show that

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

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

$$p_{jct} \equiv \sum_M \sum_{i \in M_{jc}} x_{ijct} p_{ijct} = \sum_M \sum_{i \in M_{jc}} \frac{m_{ijct}}{\sum_{i \in \Omega_{jct}} m_{ijct}} p_{ijct} = \sum_M \frac{\sum_{i \in M_{jc}} m_{ijct}}{\sum_{i \in \Omega_{jct}} m_{ijct}} \sum_{i \in M_{jc}} \frac{m_{ijct}}{\sum_{i \in M_{jc}} m_{ijct}} p_{ijct}$$
$$= \sum_M \sum_{i \in M_{jc}} x_{ijct} \sum_{i \in M_{jc}} \frac{x_{ijct}}{\sum_{i \in M_{jc}} x_{ijct}} p_{ijct} \equiv \sum_M x^M_{jct} p^M_{jct},$$

where $x^M_{jct} \equiv \sum_{i \in M_{jc}} x_{ijct}$, $p^M_{jct} \equiv \sum_{i \in M_{jc}} \frac{x_{ijct}}{x^M_{jct}} p_{ijct}$, 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,

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

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

$$\begin{aligned} p_{jct'} - p_{jct} &= p^S_{jct'} - p^S_{jct} + x^E_{jct'}(p^E_{jct'} - p^S_{jct'}) + x^X_{jct}(p^S_{jct} - p^X_{jct}) \\ &= \frac{1}{x^S_{jct'}} \sum_G x^{S^G}_{jct'} p^{S^G}_{jct'} - \frac{1}{x^S_{jct}} \sum_G x^{S^G}_{jct} p^{S^G}_{jct} + (\sum_G x^{E^G}_{jct'})(\frac{1}{x^E_{jct'}} \sum_G x^{E^G}_{jct'} p^{E^G}_{jct'} - p^S_{jct'}) \\ &+ (\sum_G x^{X^G}_{jct})(p^S_{jct} - \frac{1}{x^X_{jct}} \sum_G x^{X^G}_{jct}\, p^{X^G}_{jct}). \end{aligned} \tag{E.2}$$

Note that

$$p^S_{jct} = \sum_G \frac{x^{S^G}_{jct}}{x^S_{jct}} p^{S^G}_{jct} = \bar{p}^{S^G}_{jct} + \sum_G (\tilde{x}^{S^G}_{jct} - \bar{x}^{S^G}_{jct})(p^{S^G}_{jct} - \bar{p}^{S^G}_{jct}), \tag{E.3}$$

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

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

The starting component can be further written as

$$x^E_{jct'}(p^E_{jct'} - p^S_{jct'}) = (\sum_G x^{E^G}_{jct'})(\frac{1}{x^E_{jct'}}\sum_G x^{E^G}_{jct'}p^{E^G}_{jct'} - p^S_{jct'}) = x^E_{jct'}(\sum_G \frac{x^{E^G}_{jct'}}{x^E_{jct'}}p^{E^G}_{jct'} - p^S_{jct'})$$
$$= x^E_{jct'}(\sum_G \frac{x^{E^G}_{jct'}}{x^E_{jct'}}p^{E^G}_{jct'} - p^S_{jct'}\sum_G \frac{x^{E^G}_{jct'}}{x^E_{jct'}}) = \sum_G x^{E^G}_{jct'}(p^{E^G}_{jct'} - p^S_{jct'}). \tag{E.5}$$

Similarly, the ending component can be rewritten. Therefore, we have

$$p_{jct'} - p_{jct} = \sum_G \frac{(p^{S^G}_{jct'} - p^{S^G}_{jct})}{n^G} + \sum_G (\tilde{x}^{S^G}_{jct'} - \bar{x}^{S^G}_{jct'})(p^{S^G}_{jct'} - \bar{p}^{S^G}_{jct'}) - \sum_G (\tilde{x}^{S^G}_{jct} - \bar{x}^{S^G}_{jct})(p^{S^G}_{jct} - \bar{p}^{S^G}_{jct})$$
$$+ \sum_G x^{E^G}_{jct'}(p^{E^G}_{jct'} - p^S_{jct'}) + \sum_G x^{X^G}_{jct}(p^S_{jct} - p^{X^G}_{jct}). \tag{E.6}$$

F Welfare Decomposition Appendix

F.1 Solving the General Importer Model

In this section, we solve the import price index and import demand based on the general setups for the importer models in Section 3.

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

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

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

Firms' Problem: As shown in equation (4.11), 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

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

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

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

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

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

where

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

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

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

and p_{ijc}^* is foreign export price evaluated at the cutoff.

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

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

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

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

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**

$$\min_{L_i, X_i}\left\{W L_i + p_i^X X_i\right\} \qquad \text{s.t.} \quad y_i = A_i L_i^{1-\alpha} X_i^{\alpha}.$$

The first order conditions yield

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

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

where

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

The intermediate composite input aggregation is formulated as follows

$$\min_{h_i,m_i} \left\{ p_i^H h_i + p_i^F m_i \right\} \qquad \text{s.t.} \quad X_i = \left(h_i^{\frac{\sigma-1}{\sigma}} + m_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}.$$

The first order conditions yield

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

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

where

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

The domestic intermediates aggregation is formulated as follows

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

The first order condition leads to

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

where

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

The foreign input variety aggregation is formulated as follows

$$\min_{m_{ijc}} \left\{ \int_{b_i^*}^{\infty} \tau_{jc} p_{ijc} m_{ijc} dF(b) \right\} \qquad \text{s.t.} \quad m_i = \left[\int_{b_i^*}^{\infty} \left(\hat{b}_{ijc} m_{ijc} \right)^{\frac{\epsilon-1}{\epsilon}} dF(b) \right]^{\frac{\epsilon}{\epsilon-1}}.$$

The first order condition yields

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

where

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

F.2 Welfare Decomposition with "Inefficiencies"

F.2.1 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 a constant markup over marginal cost. The labor input for consumption goods production and intermediate goods production is revised separately:

$$L_i^{\mathrm{C}} = \frac{\psi(A_i, b_i^*)(1-\alpha)}{W} c_i, \;\; c_i = p_i^{-\rho} P^{\rho} C; \tag{F.19}$$

$$L_i^{\mathrm{I}} = \frac{\psi(A_i, b_i^*)(1-\alpha)}{W} y_i^{\mathrm{I}}, \;\; y_i^{\mathrm{I}} = \int_0^1 h_{ki} dk = (\frac{\rho}{\rho-1}\psi(A_i, b_i^*))^{-\rho} \int_0^1 (p_k^H)^{\rho} \left(\frac{p_k^H}{p_k^X}\right)^{-\sigma} X_k dk. \tag{F.20}$$

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

$$d\ln(\frac{C}{L}) = d\ln(C) - d\ln(L) \tag{F.21}$$

$$= -\rho \int_i e_i \frac{1}{\rho_i(1-\rho_i)} d\rho_i di - \rho \int_i e_i d\ln(\psi(A_i, b_i^*)) di + d\ln(P^{\rho} C) \tag{F.22}$$

$$- (1-\rho) \int_i l_i d\ln(\psi(A_i, b_i^*)) di - \int_i l_i M_i di \tag{F.23}$$

$$- (1-\rho) \int_i e_i d\ln(\psi(A_i, b_i^*)) di + (1-\rho) \int_i e_i d\ln(\psi(A_i, b_i^*)) di \tag{F.24}$$

$$= - \int_i e_i d\ln(\psi(A_i, b_i^*)) di + \underbrace{d\ln(P^{\rho} C) - \int_i l_i M_i di}_{\text{new allocation effect}} \tag{F.25}$$

$$\underbrace{- \rho \int_i e_i \frac{1}{\rho_i(1-\rho_i)} d\rho_i di}_{\text{markup distortion}} \underbrace{- (\rho-1)[\int_i e_i d\ln(\psi(A_i, b_i^*)) di - \int_i l_i d\ln(\psi(A_i, b_i^*)) di]}_{\text{input distortion}}, \tag{F.26}$$

where $e_i = \frac{p_i c_i}{\int_{i'} p_{i'} c_{i'} di'}$ 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, $s_i^h = \frac{p_i^H h_i}{p_i^H h_i + p_i^F m_i}$ is the share of domestic intermediate inputs in firm i's total intermediate input use, p_{ijc}^* is the foreign export price evaluated at the cutoff b_i^*, $s_i^* = \omega_i^* f(b_i^*)$ is the import expenditure

density at the sourcing cutoff, 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 normalized expenditure weight at the sourcing cutoff. 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.

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

where

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

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.

F.3 Second-Order Welfare Decomposition

F.3.1 Variance Operators

For any firm-level scalar x_i,

$$Var_e(x_i) \equiv \int_i e_i \big(x_i - \bar{x}\big)^2 di, \qquad \bar{x} \equiv \int_i e_i x_i \, di. \tag{F.27}$$

For any domestic-variety scalar h_{ik},

$$Var_{\omega_i^H}(h_{ik}) \equiv \int_0^1 \omega_i^H(k)\big(h_{ik} - \bar{h}_i^H\big)^2 dk, \qquad \bar{h}_i^H \equiv \int_0^1 \omega_i^H(k) h_{ik} \, dk. \tag{F.28}$$

For any foreign-variety scalar $y_i(b)$,

$$Var_{\omega_i}(y_i(b)) \equiv \int_{b_i^*}^{\infty} \omega_i(b)\big(y_i(b) - \bar{y}_i\big)^2 dF_i(b), \qquad \bar{y}_i \equiv \int_{b_i^*}^{\infty} \omega_i(b) y_i(b) \, dF_i(b). \tag{F.29}$$

With these definitions,

$$Var_{\omega_i^H}\big(d\ln p_{ik}^H\big) = \int_0^1 \omega_i^H(k)\big(d\ln p_{ik}^H\big)^2 dk - \big(d\ln p_i^H\big)^2, \tag{F.30}$$

$$Var_{\omega_i}\big(dq_i(b)\big) = \int_{b_i^*}^{\infty} \omega_i(b)\big(dq_i(b)\big)^2 dF_i(b) - M_i^2. \tag{F.31}$$

F.3.2 Proof of Proposition B.2

Step 1. Deriving the second-order formula for $-\Delta \ln P$. For the inverse price index effect, we are interested in having a second-order decomposition instead of a first-order decomposition. Note that given $d\ln(p_i) = d\ln(\psi_i)$, we have $-d\ln(P) = -\int_i e_i d\ln(\psi_i)di$. So $-d^2\ln(P) = -\int_i e_i d^2\ln(\psi_i)di - \int_i de_i d\ln(\psi_i)di$, where $d^2\ln(\cdot) = d(d\ln(\cdot))$ and $de_i = (1-\rho)e_i(d\ln p_i - d\ln P) = (1-\rho)e_i\left(d\ln p_i - \int_{i'} e_{i'} d\ln p_{i'} di'\right)$. Therefore, $-\int_i de_i d\ln(\psi_i)di = -(1-\rho)\int_i e_i(d\ln\psi_i - d\ln P)d\ln\psi_i di = -(1-\rho)\left[\int_i e_i(d\ln\psi_i)^2 di - (d\ln P)^2\right] \equiv -(1-\rho)Var_e(d\ln\psi_i)$.

Assuming $d^2\ln(\psi_i) \approx 0$ (small, order $O(\epsilon)$), we have $-d^2\ln(P) = (\rho-1)Var_e(d\ln\psi_i)$. So at the second-order approximation, $-\Delta\ln(P) \approx -d\ln(P) - \frac{1}{2}d^2\ln(P) = -\int_i e_i d\ln(\psi_i)di + \frac{\rho-1}{2}Var_e(d\ln\psi_i)$, where $\Delta\ln(P)$ denotes the exact change of price index P.

Define the first-order firm-level input cost change as derived in the proof: $d\ln\psi_i^{(1)} \equiv x_i^{IM} + x_i^{EM} + x_i^{IDS} + x_i^{NDS}$ where these are the linear (first-order, fixed-share) components. Define the within-firm second-order term z_i such that $d\ln\psi_i = d\ln\psi_i^{(1)} + z_i$. Then $-\Delta\ln(P) \approx -\int_i e_i(d\ln\psi_i^{(1)} + z_i)di + \frac{\rho-1}{2}Var_e(d\ln\psi_i^{(1)} + z_i)$.

Because $z_i = O(\epsilon^2)$, the variance term simplifies: $Var_e(d\ln\psi_i^{(1)} + z_i) = Var_e(d\ln\psi_i^{(1)}) + 2Cov_e(d\ln\psi_i^{(1)}, z_i) + Var_e(z_i)$. But $d\ln\psi_i^{(1)} = O(\epsilon)$ and $z_i = O(\epsilon^2)$, so $Cov(d\ln\psi_i^{(1)}, z_i) = O(\epsilon^3)$, $Var(z_i) = O(\epsilon^4)$ Hence, up to second order, $Var_e(d\ln\psi_i^{(1)} + z_i) = Var_e(d\ln\psi_i^{(1)}) + O(\epsilon^3)$. Therefore (to $O(\epsilon^2)$):

$$-\Delta\ln P \approx \underbrace{-\int_i e_i d\ln\psi_i^{(1)} di}_{\text{first-order effect}} \quad \underbrace{-\int_i e_i z_i di}_{\text{within-firm second-order effect}} \quad \underbrace{+\frac{\rho-1}{2}Var_e(d\ln\psi_i^{(1)})}_{\text{across-firm second-order effect}}.$$

Step 2. Deriving the second-order change of ψ_i (i.e., z_i). From the definition of z_i and noting that $\Delta\ln\psi_i = \alpha\Delta\ln p_i^X$: $z_i = \alpha(\Delta\ln p_i^X - d\ln p_i^X)$, where $\Delta\ln p_i^X$ is the exact change and $d\ln p_i^X$ is its first-order part. To second order, $\Delta\ln p_i^X = d\ln p_i^{X(1)} + \frac{1}{2}d^2\ln p_i^X$, so $z_i = \frac{\alpha}{2}d^2\ln p_i^X$. We compute $d^2\ln p_i^X$ by differentiating the first-order expression.

Step 3. Deriving the second-order change of p_i^X (i.e., $d^2\ln p_i^X$). Recall we have $d\ln p_i^X = \frac{1}{1-\sigma}\frac{dY}{Y}$. Then $d^2\ln p_i^X = \frac{1}{1-\sigma}\left(\frac{d^2Y}{Y} - \frac{(dY)^2}{Y^2}\right)$

1. Compute d^2Y. Let $A = (p_i^H)^{1-\sigma}$, $B = (p_i^F)^{1-\sigma}$ Then $dA = (1-\sigma)Ad\ln p_i^H$, $dB = (1-\sigma)Bd\ln p_i^F$. Differentiate again: $d(dA) = (1-\sigma)[dAd\ln p_i^H + Ad^2\ln p_i^H] = (1-\sigma)A[(1-\sigma)(d\ln p_i^H)^2 + d^2\ln p_i^H]$. Similarly, $d(dB) = (1-\sigma)B[(1-\sigma)(d\ln p_i^F)^2 + d^2\ln p_i^F]$. Since $d^2Y = d(dA) + d(dB)$, $d^2Y = (1-\sigma)\{A[(1-\sigma)(d\ln p_i^H)^2 + d^2\ln p_i^H] + B[(1-\sigma)(d\ln p_i^F)^2 + d^2\ln p_i^F]\}$. But $\frac{A}{Y} = s_i^h$, $\frac{B}{Y} = s_i^f$. Hence $\frac{d^2Y}{Y} = (1-\sigma)[s_i^h((1-\sigma)(d\ln p_i^H)^2 + d^2\ln p_i^H) + s_i^f((1-\sigma)(d\ln p_i^F)^2 + d^2\ln p_i^F)]$.

2. Compute $\frac{(dY)^2}{Y^2}$ We have $\frac{dY}{Y} = (1-\sigma)d\ln p_i^X$. Thus $\frac{(dY)^2}{Y^2} = (1-\sigma)^2(d\ln p_i^X)^2$.

3. Compute the formula for $d^2\ln p_i^X$. Therefore, $d^2\ln p_i^X = s_i^h((1-\sigma)(d\ln p_i^H)^2 + d^2\ln p_i^H) + s_i^f((1-\sigma)(d\ln p_i^F)^2 + d^2\ln p_i^F) - (1-\sigma)(d\ln p_i^X)^2$. Group terms: $d^2\ln p_i^X = (1-\sigma)[s_i^h(d\ln p_i^H)^2 + s_i^f(d\ln p_i^F)^2 - (d\ln p_i^X)^2] + s_i^h d^2\ln p_i^H + s_i^f d^2\ln p_i^F$ Using $d\ln p_i^X = s_i^h d\ln p_i^H + s_i^f d\ln p_i^F$, we have $s_i^h(d\ln p_i^H)^2 + s_i^f(d\ln p_i^F)^2 - (s_i^h d\ln p_i^H + s_i^f d\ln p_i^F)^2 = s_i^h s_i^f(d\ln p_i^H - d\ln p_i^F)^2$. Thus $d^2\ln p_i^X = (1-\sigma)s_i^h s_i^f(d\ln p_i^H - d\ln p_i^F)^2 + s_i^h d^2\ln p_i^H + s_i^f d^2\ln p_i^F$.

4. Compute $d^2\ln p_i^H$. Assuming no second-order changes in domestic input prices ($d^2\ln p_{ik}^H \approx 0$) $d^2\ln p_i^H = (1-\theta)\left[\int_0^1 \omega_{ik}^H (d\ln p_{ik}^H)^2 dk - (d\ln p_i^H)^2\right] = (1-\theta)Var_{\omega^H}(d\ln p_{ik}^H)$.

5. Compute $d^2\ln p_i^F$. Recall that $d\ln p_i^F = \int_a^\infty \omega(b)dq(b)dF(b) - \frac{1}{1-\epsilon}s_i^* da$, where $a = b_i^*$, $\omega(b) = \frac{e^{(1-\epsilon)q(b)}}{\int_a^\infty e^{(1-\epsilon)q(b')}dF(b')}$, $s_i^* = \omega(a)f(a)$, and $dq(b)$ denotes the change in $q(b)$ at a fixed b due to tariff changes. We assume $d^2q(b) \approx 0$ and $d^2a \approx 0$. So we have $d^2\ln p_i^F = d\left(\int_a^\infty \omega(b)dq(b)dF(b)\right) - \frac{1}{1-\epsilon}d(s_i^* da)$.

(i). Compute $d\left(\int_a^\infty \omega(b)dq(b)dF(b)\right)$. Let $T = \int_a^\infty \omega(b)dq(b)dF(b)$. By Leibniz's rule, $dT = \int_a^\infty d[\omega(b)dq(b)]dF(b) - \omega(a)dq(a)f(a)da$. Since $d(dq) = 0$, $d[\omega dq] = (d\omega)dq$. Hence $dT = \int_a^\infty d\omega(b)dq(b)dF(b) - s_i^* dq(a)da$. Now $\omega(b) = e^{(1-\epsilon)q(b)}/I$ with $I = \int_a^\infty e^{(1-\epsilon)q(b)}dF(b)$. Differentiating, $d\omega(b) = \omega(b)[(1-\epsilon)dq(b) - d\ln I]$. mFrom the definition of I, $dI = (1-\epsilon)\int_a^\infty e^{(1-\epsilon)q(b)}dq(b)dF(b) - e^{(1-\epsilon)q(a)}f(a)da = (1-\epsilon)IM - Is_i^* da$, where $M = \int_a^\infty \omega(b)dq(b)dF(b)$. Therefore, $d\ln I = (1-\epsilon)M - s_i^* da$. Substituting back, $d\omega(b) = (1-\epsilon)\omega(b)(dq(b) - M) + \omega(b)s_i^* da$. Therefore,

$$\begin{aligned}\int_a^\infty d\omega(b)dq(b)dF(b) &= (1-\epsilon)\int_a^\infty \omega(b)(dq(b) - M)dq(b)dF(b) + s_i^* da\int_a^\infty \omega(b)dq(b)dF(b) \\ &= (1-\epsilon)\left[\int_a^\infty \omega(b)(dq(b))^2 dF(b) - M^2\right] + s_i^* M da. \qquad \text{(F.32)}\end{aligned}$$

Thus, $dT = (1-\epsilon)\left[\int_a^\infty \omega(b)(dq(b))^2 dF(b) - M^2\right] + s_i^* M da - s_i^* dq(a)da$.

(ii). Compute $d(s_i^* da)$. We have $d(s_i^* da) = d(s_i^*)da + s_i^* d^2 a$. With $d^2a \approx 0$, $d(s_i^* da) = d(s_i^*)da$. Now $d(s_i^*)$ with $s_i^* = \omega(a)f(a)$ must account for the moving point a: $d(s_i^*) = f(a)d\omega(a) + \omega(a)f'(a)da$. To find $d\omega(a)$ we use $d\omega(b)$ evaluated at the variable point a, but

we must also include the change due to the shift in the argument. For a fixed b, $d\omega(b)$ in the above gives the differential of ω as a function of the shocks and the cutoff. At the moving point a, we add the partial derivative with respect to b: $d\omega(a) = \frac{\partial \omega}{\partial b}\Big|_{b=a} da + [(1-\epsilon)\omega(a)(dq(a) - M) + \omega(a)s_i^* da]$. Since $\frac{\partial \omega}{\partial b} = (1-\epsilon)\omega(b)q'(b)$ (with $q'(b) = \partial q/\partial b$, taking I as given), we obtain $d\omega(a) = (1-\epsilon)\omega(a)q'(a)da + (1-\epsilon)\omega(a)(dq(a) - M) + \omega(a)s_i^* da$. Hence $d(s_i^*) = f(a)\omega(a)[(1-\epsilon)(dq(a)-M)+((1-\epsilon)q'(a)+s_i^*)da]+\omega(a)f'(a)da = s_i^*[(1-\epsilon)(dq(a)-M)+((1-\epsilon)q'(a)+s_i^*)da]+s_i^*\frac{f'(a)}{f(a)}da = s_i^*(1-\epsilon)(dq(a)-M)+s_i^*\left[(1-\epsilon)q'(a)+s_i^*+\frac{f'(a)}{f(a)}\right]da$.

(iii). Compute $d^2 \ln p_i^F$. Therefore, we have $d^2 \ln p_i^F = (1-\epsilon)\left[\int_a^\infty \omega(b)(dq(b))^2 dF(b) - M^2\right] + s_i^* M da - s_i^* dq(a)da - \frac{1}{1-\epsilon}\left\{s_i^*(1-\epsilon)(dq(a)-M)da + s_i^*\left[(1-\epsilon)q'(a)+s_i^*+\frac{f'(a)}{f(a)}\right](da)^2\right\}$.

The terms linear in da combine as $s_i^*(M-dq(a))da - s_i^*(dq(a)-M)da = 2s_i^*(M-dq(a))da$. The quadratic term becomes

$$-\frac{1}{1-\epsilon}s_i^*\left[(1-\epsilon)q'(a)+s_i^*+\frac{f'(a)}{f(a)}\right](da)^2 = -s_i^* q'(a)(da)^2 - \frac{s_i^*}{1-\epsilon}\left(s_i^*+\frac{f'(a)}{f(a)}\right)(da)^2. \tag{F.33}$$

Therefore $d^2 \ln p_i^F = (1-\epsilon)\left[\int_a^\infty \omega(b)(dq(b))^2 dF(b) - M^2\right] + 2s_i^*(M-dq(a))da - s_i^* q'(a)(da)^2 - \frac{s_i^*}{1-\epsilon}\left(s_i^*+\frac{f'(a)}{f(a)}\right)(da)^2$. Note that $\left[\int_a^\infty \omega(b)(dq(b))^2 dF(b) - M^2\right] = Var_\omega(dq(b))$ so we have $d^2 \ln p_i^F = (1-\epsilon)Var_\omega(dq(b)) + 2s_i^*(M-dq(a))da - s_i^* q'(a)(da)^2 - \frac{s_i^*}{1-\epsilon}\left(s_i^*+\frac{f'(a)}{f(a)}\right)(da)^2$.

6. Compute $d^2 \ln p_i^X$. For importers that import before and after tariff increase ($i \geq i^*$),

$$d^2 \ln p_i^X = (1-\sigma)s_i^h s_i^f (d\ln p_i^H - d\ln p_i^F)^2 + s_i^h(1-\theta)Var_{\omega^H}(d\ln p_{ik}^H)$$
$$+s_i^f\left[(1-\epsilon)Var_\omega(dq(b)) + 2s_i^*(M-dq(b_i^*))db_i^* - s_i^* q'(b_i^*)(db_i^*)^2 - \frac{s_i^*}{1-\epsilon}\left(s_i^*+\frac{f'(b_i^*)}{f(b_i^*)}\right)(db_i^*)^2\right]. \tag{F.34}$$

For non-importers that do not import before and after tariff increase ($i < i^*$), $d^2 \ln p_i^X = d^2 \ln p_i^H$.

For switchers that import before tariff increase but stop importing after tariff increase, the expressions for $d\ln p_i^X$ and $d^2 \ln p_i^X$ are the same as continuous importers as only initial shares are used (foreign input share is non-zero). For switchers that do not import before tariff increase but start importing after tariff increase, the expressions for $d\ln p_i^X$ and $d^2 \ln p_i^X$ are the same as continuous non-importers as only initial shares are used (foreign input share is zero). Therefore, we only need to identify if the firm is an importer or not before the tariff increase.

Step 4. Deriving $-\Delta \ln P$. For firms that import before the tariff increase ($i \geq i^*$), from the proof of first-order decomposition, $d\ln\psi_i^{(1)} = \alpha[s_i^h d\ln p_i^H + s_i^f d\ln p_i^F]$, where $s_i^h = \frac{(p_i^H)^{1-\sigma}}{(p_i^H)^{1-\sigma}+(p_i^F)^{1-\sigma}}$, $s_i^f = 1 - s_i^h$ $d\ln p_i^H = \int_0^1 \omega_{ik}^H d\ln p_{ik}^H dk$, $d\ln p_i^F = \int_{b_i^*}^\infty \omega(b) dq(b) dF(b) - \frac{1}{1-\epsilon} s_i^* db_i^*$. and $\omega_{ik}^H = \frac{(p_{ik}^H)^{1-\theta}}{\int_0^1 (p_{ik'}^H)^{1-\theta} dk'}$, $q(b) = \ln\left(\frac{\tau p}{b}\right)$, $\omega(b) = \frac{e^{(1-\epsilon)q(b)}}{\int_{b_i^*}^\infty e^{(1-\epsilon)q(b')} dF(b')}$, $s_i^* = \frac{e^{(1-\epsilon)q(b_i^*)} f(b_i^*)}{\int_{b_i^*}^\infty e^{(1-\epsilon)q(b')} dF(b')}$.

and the second-order components are:

$$z_i = \frac{\alpha}{2} d^2 \ln p_i^X = \frac{\alpha}{2}\{(1-\sigma) s_i^h s_i^f (d\ln p_i^H - d\ln p_i^F)^2 + s_i^h (1-\theta) Var_{\omega^H}(d\ln p_{ik}^H)$$
$$+ s_i^f \left[(1-\epsilon) Var_\omega(dq(b)) + 2 s_i^* (M - dq(b_i^*)) db_i^* - s_i^* q'(b_i^*)(db_i^*)^2 - \frac{s_i^*}{1-\epsilon}\left(s_i^* + \frac{f'(b_i^*)}{f(b_i^*)}\right)(db_i^*)^2\right]. \tag{F.35}$$

For firms that do not import before the tariff increase ($i < i^*$), $d\ln\psi_i^{(1)} = \alpha d\ln p_i^H$, Therefore, $z_i = \frac{\alpha}{2} d^2 \ln p_i^X = \frac{\alpha}{2} d^2 \ln p_i^H$.

Therefore,

$$-\Delta \ln P \approx -\int_{i^*} e_i \alpha \left[s_i^h d\ln p_i^H + s_i^f \left(\int_{b_i^*}^\infty \omega(b) dq(b) dF(b) - \frac{1}{1-\epsilon} s_i^* db_i^*\right)\right] di$$
$$- \int^{i^*} e_i \alpha d\ln p_i^H di - \int_{i^*} e_i \frac{\alpha}{2} d^2 \ln p_i^X di - \int^{i^*} e_i \frac{\alpha}{2} d^2 \ln p_i^H di + \frac{\rho-1}{2} Var_e(d\ln\psi_i^{(1)}). \tag{F.36}$$

Rearranging, we have

$$-\Delta \ln P \approx \underbrace{-\int_{i^*} e_i \alpha \left[\int_{b_i^*}^\infty \omega(b) dq(b) dF(b)\right] di}_{\text{importer import price index intensive margin}} \quad \underbrace{-\int_{i^*} e_i \alpha \left[-\frac{1}{1-\epsilon} s_i^* db_i^*\right] di}_{\text{importer import price index extensive margin}}$$
$$\underbrace{-\int_{i^*} e_i \alpha \left[s_i^h (d\ln p_i^H - d\ln p_i^F)\right] di}_{\text{importer domestic variety substitution}} \quad \underbrace{-\int^{i^*} e_i \alpha d\ln p_i^H di}_{\text{non-importer domestic variety substitution}}$$
$$\underbrace{-\int_{i^*} e_i \frac{\alpha}{2} d^2 \ln p_i^X di}_{\text{within importer second-order effect}} \quad \underbrace{-\int^{i^*} e_i \frac{\alpha}{2} d^2 \ln p_i^H di}_{\text{within non-importer second-order effect}} \quad \underbrace{+\frac{\rho-1}{2} Var_e(d\ln\psi_i^{(1)})}_{\text{across-firm second-order effect}}, \tag{F.37}$$

where

$$\int_{i^*} e_i \frac{\alpha}{2} d^2 \ln p_i^X di = \int_{i^*} e_i \frac{\alpha}{2}\{s_i^h (1-\theta) Var_{\omega^H}(d\ln p_{ik}^H) + (1-\sigma) s_i^h s_i^f (d\ln p_i^H - d\ln p_i^F)^2 +$$

$$s_i^f \left[(1-\epsilon) Var_\omega(dq(b)) + 2s_i^*(M - dq(b_i^*))db_i^* - s_i^* q'(b_i^*)(db_i^*)^2 - \frac{s_i^*}{1-\epsilon}\left(s_i^* + \frac{f'(b_i^*)}{f(b_i^*)}\right)(db_i^*)^2 \right] \} di, \tag{F.38}$$

$$\int^{i^*} e_i \frac{\alpha}{2} d^2 \ln p_i^H di = \int^{i^*} e_i \frac{\alpha}{2} (1-\theta) Var_{\omega^H}(d \ln p_{ik}^H) di. \tag{F.39}$$

Therefore, higher elasticity of substitutions (ρ, θ, σ) contribute to larger across-firm second-order effect or within-firm second-order effect (which therefore mitigate the welfare loss of tariff increase). Higher ϵ weakens the first-order and second-order effects of importer import price index extensive margin.

F.3.3 Summary of How Firm Heterogeneity Matters

The decomposition in Proposition B.2 shows that the total welfare effect is a sum of firm-level effects, weighted by their consumption share (e_i), and includes terms that are inherently non-linear and distribution-dependent. In particular, the welfare effects depend not only on weighted *average* price changes, but also on the *distribution* of cost and price changes across firms and across varieties within firms.

Heterogeneous first-order exposure The first-order term $-\int_i e_i \, d \ln \psi_i^{(1)} di$ is already heterogeneous:

- **Importers vs. non-importers.** For non-importers ($i < i^*$), $d \ln \psi_i^{(1)} = \alpha d \ln p_i^H$; their exposure is purely through domestic input prices. For importers ($i \geq i^*$), $d \ln \psi_i^{(1)}$ combines domestic and foreign shocks:

$$d \ln \psi_i^{(1)} = \alpha \left[s_i^h d \ln p_i^H + s_i^f d \ln p_i^F \right],$$

  and $d \ln p_i^F$ itself includes both intensive and extensive margin terms $\omega_i(b) dq_i(b) dF_i(b)$ and $s_i^* db_i^*$.

- **Intensive vs. extensive margins.** The importer import price index terms decompose into:

  - Intensive margin: $\int \omega_i(b) \, dq_i(b) \, dF_i(b)$, which depends on firm-specific weights $\omega_i(b)$ and variety-specific price changes $dq_i(b)$.

– Extensive margin: $\frac{1}{\epsilon-1} s_i^* db_i^*$, which depends on the firm's cost share of its variety at the cutoff s_i^* and its change in the cutoff db_i^* itself.

Even with the same aggregate import price index, two firms with different $e_i, \omega_i(b), s_i^*$ and db_i^*) generate different welfare contributions.

- **Domestic–foreign substitution.** The term $-\alpha \int_{i \geq i^*} e_i \, s_i^h \big(d \ln p_i^H - d \ln p_i^F\big) di$ shows that the ability of importers to substitute between domestic and foreign inputs depends on firm-specific shares s_i^h and the firm-specific gap $d \ln p_i^H - d \ln p_i^F$. Two firms with the same average foreign price change but different s_i^h or different domestic price changes will contribute differently to welfare.

Across-firm second-order effect The term $\frac{\rho-1}{2} Var_e\big(d \ln \psi_i^{(1)}\big)$ is an inherently distributional, second-order effect. It captures the idea that consumers substitute across firms:

- If every firm had the same $d \ln \psi_i^{(1)}$, then $Var_e\big(d \ln \psi_i^{(1)}\big) = 0$ and this term would vanish.
- With heterogeneity in $d \ln \psi_i^{(1)}$, consumers benefit from being able to substitute away from high-cost firms toward low-cost firms; this is reflected in the variance term.[43]
- The amplification factor $\rho - 1$ shows that higher elasticity of substitution across firms reduces the welfare cost of a given dispersion in cost changes, because substitution is easier.

Thus, cross-firm heterogeneity in exposure to tariffs and in substitution possibilities generates second-order welfare gains that a first-order (average) approximation misses.

Within-firm second-order effects Within-firm second-order terms are captured by $-\frac{\alpha}{2} \int_i e_i \, d^2 \ln p_i^X di$ (or $d^2 \ln p_i^H$ for non-importers), and are decomposed in equation (B.8). They reflect how much each firm can mitigate cost shocks by substituting *within* its input bundle:

- **Across domestic varieties:** $s_i^h (1-\theta) Var_{\omega_i^H}\big(d \ln p_{ik}^H\big)$. Heterogeneous domestic variety changes $d \ln p_{ik}^H$ allow firms to reallocate toward relatively cheaper domestic inputs. The strength of this cushioning depends on the dispersion $Var_{\omega_i^H}$, domestic input share s_i^h and the elasticity of substitution across domestic varieties θ.

[43] As shown in the proof, $Var_e\big(d \ln \psi_i^{(1)}\big) = -\int_i de_i d \ln \psi_i^{(1)} di$.

- **Between domestic and foreign inputs:** $(1-\sigma)s_i^h s_i^f \left(d\ln p_i^H - d\ln p_i^F\right)^2$. This term depends on:
  - the squared domestic–foreign price change gap,
  - the product $s_i^h s_i^f$ (high when the firm uses both sources significantly),
  - the elasticity of substitution between domestic input and foreign input σ.

  This shows that firms with more balanced use of domestic and foreign inputs and higher σ have more scope to offset tariff shocks via substitution.

- **Across foreign varieties and cutoff dynamics:** $s_i^f \Big[(1-\epsilon)Var_{\omega_i}\big(dq_i(b)\big) + 2s_i^*(M_i - dq_i(b_i^*))db_i^* - s_i^* q_i'(b_i^*)(db_i^*)^2 - \frac{s_i^*}{1-\epsilon}\Big(s_i^* + \frac{f_i'(b_i^*)}{f_i(b_i^*)}\Big)(db_i^*)^2\Big]$. Here:
  - $Var_{\omega_i}(dq_i(b))$ captures dispersion of price changes across foreign varieties, and hence scope for within-foreign substitution that mitigates cost shocks.
  - The interaction term $2s_i^*(M_i - dq_i(b_i^*))db_i^*$ shows that when varieties at the sourcing boundary have a below-average price increase ($dq_i(b_i^*) < M_i$), dropping varieties ($db_i^* > 0$) is particularly costly (contribute to a negative welfare effect, as firms do not drop varieties that are extremely expensive).
  - The quadratic terms $(db_i^*)^2$ depend on $q_i'(b_i^*)$ and on the shape of the density $f_i(b)$ near b_i^*: they capture how the cost of dropping additional varieties depends on the local distribution of varieties.

  Specifically, the term $-s_i^* q_i'(b_i^*)(db_i^*)^2$ captures the curvature of the effective price schedule as one moves along the shifter b. Given $q_i(b) = \ln\Big(\frac{\tau_{jc}p_{ijc}}{\hat{b}_{ijc}}\Big)$, and treating τ_{jc} and p_{ijc} as independent of $\hat{b}$, we have $q_i'(b) = \frac{\partial}{\partial b}\ln\Big(\frac{\tau_{jc}p_{ijc}}{\hat{b}}\Big) = \frac{\partial}{\partial b}\ln\Big(\frac{1}{b}\Big) = -\frac{1}{b} < 0$. Thus $q_i'(b_i^*) < 0$, and since $(db_i^*)^2 \geq 0$, we obtain $-s_i^* q_i'(b_i^*)(db_i^*)^2 > 0$. This term is therefore always *amplifying the welfare loss of tariff increase*: this term makes the true increase in the imported input price index larger than its first-order approximation. In the welfare decomposition this term is multiplied by $-\frac{\alpha}{2}$, so it amplifies the welfare loss of the tariff increase. Intuitively, This term reflects the convexity of the imported-input price index in the cutoff: as the firm raises b_i^* in response to tariff increase, it successively drops the worst remaining imported varieties, which are progressively more valuable (higher b, lower price) than those dropped before. This makes the total cost increase grow faster than linearly in db_i^*.

The last quadratic term, $-\frac{s_i^*}{1-\epsilon}\left(s_i^* + \frac{f_i'(b_i^*)}{f_i(b_i^*)}\right)(db_i^*)^2 = \frac{s_i^*}{\epsilon-1}\left(s_i^* + \frac{f_i'(b_i^*)}{f_i(b_i^*)}\right)(db_i^*)^2$, links the cost of adjusting the cutoff to the *shape* of the distribution of varieties near the cutoff. Since $\epsilon > 1$, the prefactor $s_i^*/(\epsilon - 1)$ is positive, so the sign of this term is determined by $s_i^* + \frac{f_i'(b_i^*)}{f_i(b_i^*)}$.

To interpret this, note that $\frac{f_i'(b_i^*)}{f_i(b_i^*)}$ is the derivative of the log density at the cutoff, i.e. it captures whether the density of varieties is rising or falling as we move along b.

- If the density is roughly flat around b_i^* (so $f_i'(b_i^*)/f_i(b_i^*) \approx 0$), the term is essentially proportional to $s_i^{*2}(db_i^*)^2 > 0$. In this case, increasing the cutoff has an increasingly costly impact: as the firm moves the cutoff, the varieties near the new sourcing boundary become more important in the remaining import bundle, so each additional step in b_i^* removes a variety with a growing cost share. This convexity in the cost of dropping varieties shows up as a positive quadratic term, contributing to a negative welfare effect.
- If the density is sharply *decreasing* around b_i^* (so $f_i'(b_i^*)/f_i(b_i^*) \ll 0$), then $s_i^* + f_i'(b_i^*)/f_i(b_i^*)$ can become small or even negative. Intuitively, there are fewer and fewer varieties as one moves to higher b, so raising the cutoff eliminates varieties from a very thin part of the distribution. In that case, the cost of further raising the cutoff grows slowly, and this quadratic term becomes smaller, potentially negative. A negative term would mitigate the welfare loss.
- Conversely, if the density is *increasing* around b_i^* (so $f_i'(b_i^*)/f_i(b_i^*) > 0$), then $s_i^* + f_i'(b_i^*)/f_i(b_i^*)$ is larger; raising the cutoff moves into a region with many varieties, so further increases in b_i^* remove a lot of varieties at once and the cost of doing so rises quickly. This makes the quadratic term larger and positive, indicating strong curvature in the cost of adjusting the extensive margin, and hence a strong negative welfare effect.

In all cases, this term tells us that the welfare loss of dropping varieties depends not only on the cost share of these varieties s_i^*, but also on how densely varieties are packed near the cutoff and how this density changes as we move along b.

F.4 Connecting Welfare Decomposition with Feenstra (1994)

Equation (3.12) is the first-order log version of the Feenstra (1994) CES import price index at the firm level. The intensive term corresponds to the Sato–Vartia price index over continuing

varieties. The extensive term corresponds to the Feenstra variety adjustment:

$$\frac{1}{\epsilon-1}\ln\left(\frac{\lambda_{it'}}{\lambda_{it}}\right)\approx\frac{1}{\epsilon-1}\left(x_{it}^{\text{exit}}-x_{it'}^{\text{new}}\right).$$

Thus, the direct import-price component of the welfare decomposition is an e_i-weighted average of firm-level Feenstra import price indices, scaled by the intermediate-input share parameter α. This is why aggregate product–country pass-through is not a sufficient statistic for welfare: welfare depends on which firms face the import price-index changes, how important those firms are in final expenditure, and which continuing, exiting, and newly added relationships account for each firm's foreign-input bundle. The remaining terms in Proposition (3.3) require additional equilibrium structure because they depend on domestic input prices, substitution between domestic and foreign inputs, non-importers' exposure to domestic price changes, and aggregate demand reallocation.

F.5 Estimating Import Price Index Effect Directly from Data

F.5.1 Second-Order Import Price Index Effect of Tariffs

We map our empirical estimates into the set of second-order mechanisms identified in Proposition B.2 for importers $i \in \mathcal{M}$. As detailed below, s_i^f is unobservable in the data, so we are not able to precisely estimate the second-order effect directly. Therefore, the second-order import price index effects of tariffs are used to illustrate how estimates of the welfare effects of tariffs can be biased if only the first-order import price index effect is considered.

Within-importer second-order effect: substitution across foreign varieties Firms substitute quantities away from varieties experiencing the largest price hikes, which is reflected by the term

$$-\frac{\alpha}{2}\int_{i\in\mathcal{M}} e_i s_i^f(1-\epsilon)Var_{\omega_i}\big(dq_i(b)\big)di$$

in Proposition B.2. Using our predicted tariff-induced price changes $\widehat{dq}_{ijct}$ derived above, we compute this variance directly from the empirical cross-section of continuing varieties for each firm $i \in \mathcal{M}$:

$$\widehat{Var}_{\omega_i}^{Data}=\sum_{jc\in\Omega_{i,cont}}\omega_{ijct}\left(\widehat{dq}_{ijct}\Big|_{Tariff}-\overline{dq}_i\Big|_{Tariff}\right)^2, \tag{F.40}$$

where $\overline{dq_i}|_{Tariff} = \sum_{jc\in\Omega_{i,cont}} \omega_{ijct}\widehat{dq}_{ijct}|_{Tariff}$ is the firm's cost-weighted average predicted price change. Because $\epsilon > 1$, multiplying by $-\frac{\alpha}{2}e_i s_i^f(1-\epsilon)$ makes this term strictly positive, mitigating the welfare loss of tariffs.

Within-importer second-order effect: cutoff curvature and density effects of extensive margin In Proposition B.2, the term

$$-\frac{\alpha}{2}\int_{i\in\mathcal{M}} e_i s_i^f[-s_i^* q_i'(b_i^*)(db_i^*)^2 - \frac{s_i^*}{1-\epsilon}\left(s_i^* + \frac{f_i'(b_i^*)}{f_i(b_i^*)}\right)(db_i^*)^2]di \equiv -\frac{\alpha}{2}\int_{i\in\mathcal{M}} e_i s_i^f EM_Convexity_i di$$

captures the convexity of dropping varieties. Expanding the Feenstra ratio to second order using $\ln(1-x) \approx -x - x^2/2$ yields the empirical equivalent to this curvature. Let $\hat{x}_{i,exit} = \sum_{jc\in\Omega_{it}} \omega_{ijct}\hat{\mathbb{I}}^{exit}_{ijct}|_{Tariff}$ and $\hat{x}_{i,new} = \sum_{jc\in\Omega_{it'}} \omega_{ijct'}\hat{\mathbb{I}}^{new}_{ijct'}|_{Tariff}$. The second-order convexity term for firm i is:

$$EM_Convexity_i^{Data} = -\frac{1}{2(\epsilon-1)}\left(\hat{x}^2_{i,exit} - \hat{x}^2_{i,new}\right) \tag{F.41}$$

In the data, $\hat{x}_{i,exit} > \hat{x}_{i,new}$ (net dropping), making this term strictly negative, amplifying the welfare loss of tariffs. This empirically captures the accelerating welfare loss of severing a large mass of trade relationships.

The detailed derivation is as follows.

1. From Proposition B.2, the structural second-order terms governing the curvature of the extensive margin for dropped varieties inside $d^2 \ln p_i^F$ are:

$$-s_i^* q_i'(b_i^*)(db_i^*)^2 - \frac{s_i^*}{1-\epsilon}\left(s_i^* + \frac{f_i'(b_i^*)}{f_i(b_i^*)}\right)(db_i^*)^2$$

   This expression captures the local curvature of the price schedule q_i' and the variety density f_i'.

2. Let $x_{i,exit}$ be the expenditure share of dropped varieties. In the model, this is the integral of the cost-share density over the dropped interval. Using Leibniz's rule and taking a second-order Taylor expansion around b_i^*:

$$x_{i,exit} = \int_{b_i^*}^{b_i^*+db_i^*} \omega_i(b)dF_i(b) \approx \omega_i(b_i^*)f_i(b_i^*)db_i^* + \frac{1}{2}\frac{\partial}{\partial b}\Big[\omega_i(b)f_i(b)\Big]\Big|_{b=b_i^*}(db_i^*)^2$$

   Recalling that the pre-shock weight is $\omega_i(b) = e^{(1-\epsilon)q_i(b)}/\int e^{(1-\epsilon)q_i}dF_i$, its derivative

evaluated at b_i^* is $\omega_i'(b_i^*) = (1-\epsilon)q_i'(b_i^*)\omega_i(b_i^*)$. Letting $s_i^* = \omega_i(b_i^*)f_i(b_i^*)$ and applying the product rule yields:

$$x_{i,exit} \approx s_i^* db_i^* + \frac{1}{2}\left[(1-\epsilon)s_i^* q_i'(b_i^*) + s_i^* \frac{f_i'(b_i^*)}{f_i(b_i^*)}\right](db_i^*)^2$$

Notice that the unobservable derivatives q_i' and f_i' are inherently embedded in the observable share $x_{i,exit}$.

3. The exact Feenstra price index adjustment for dropped varieties is $\frac{-1}{\epsilon-1}\ln(1-x_{i,exit})$. Using the approximation $\ln(1-x) \approx -x - x^2/2$, the second-order expansion is:

$$\frac{-1}{\epsilon-1}\ln(1-x_{i,exit}) \approx \frac{x_{i,exit}}{\epsilon-1} + \frac{x_{i,exit}^2}{2(\epsilon-1)}$$

4. Substitute the continuous expansion of $x_{i,exit}$ into this formula and retain terms up to $(db_i^*)^2$:

$$\begin{aligned}
&\frac{1}{\epsilon-1}\left(s_i^* db_i^* + \frac{1}{2}\left[(1-\epsilon)s_i^* q_i'(b_i^*) + s_i^* \frac{f_i'(b_i^*)}{f_i(b_i^*)}\right](db_i^*)^2\right) + \frac{1}{2(\epsilon-1)}(s_i^* db_i^*)^2 \\
&= \underbrace{\frac{s_i^*}{\epsilon-1} db_i^*}_{\text{1st-Order EM}} + \underbrace{\frac{1}{2}\left[-s_i^* q_i'(b_i^*) + \frac{s_i^*}{\epsilon-1}\frac{f_i'(b_i^*)}{f_i(b_i^*)} + \frac{(s_i^*)^2}{\epsilon-1}\right](db_i^*)^2}_{\text{Exact theoretical terms from Prop B.2}}
\end{aligned}$$

This perfectly matches the exact structural second-order terms from Proposition B.2.

5. Therefore, the discrete second-order expansion of the exact Feenstra ratio precisely encapsulates the complex unobservable structural derivatives, proving the validity of $EM_Convexity_i^{Data}$.

Within-importer second-order effect: intensive and extensive interaction In Proposition B.2, the term

$$2s_i^*(M_i - dq_i(b_i^*))\, db_i^*$$

captures the covariance between the average price change of all initial varieties and the price change of dropped/added varieties, scaled by the mass of these extensive margin adjustments. Empirically, this maps to the interaction between the expenditure share of exiting/entering varieties and the gap between the average continuing price changes and the average exit-

ing/entering price changes:

$$Interaction_i^{Data} = \hat{x}_{i,exit}\left(\overline{dq}_{i,cont}\Big|_{Tariff} - \overline{dq}_{i,exit}\Big|_{Tariff}\right) - \hat{x}_{i,new}\left(\overline{dq}_{i,cont}\Big|_{Tariff} - \overline{dq}_{i,new}\Big|_{Tariff}\right) \tag{F.42}$$

In the final aggregate welfare formula, this term is multiplied by $\alpha e_i s_i^f$.

A natural empirical challenge is that we do not observe post-shock prices for dropped varieties, nor do we observe pre-shock prices for newly added varieties. How do we compute their tariff-induced price changes?

We solve this by leveraging our empirical specification in equation (A.2). The model parameterizes the tariff-induced price change as a function of only two observables: the tariff shock $\Delta \ln(1+\tau_{jct})$ and the firm's employment size $\ln(emp)_i$. Because these parameters ($\hat{\beta}_1^{after}$ and $\hat{\beta}_3^{after}$) are structurally identified from continuing varieties, we can use them to generate *out-of-sample counterfactual predictions* for the exiting and entering varieties.

Even if a firm drops a variety jc, we still observe the tariff change $\Delta \ln(1+\tau_{jct})$ that occurred in that specific product–country market. For any variety jc, regardless of its entry/exit status, the predicted tariff-induced price change is:

$$\widehat{dq}_{ijct}\Big|_{Tariff} = \left(\hat{\beta}_1^{cont} + \hat{\beta}_3^{cont}\ln(emp)_i\right)\Delta \ln(1+\tau_{jct}) \tag{F.43}$$

Using this universal prediction equation, we construct the conditionally expected average price changes for the continuing, exiting, and new bundles by weighting them by their respective empirical cost shares:

$$\overline{dq}_{i,cont}\Big|_{Tariff} = \frac{1}{1-\hat{x}_{i,exit}} \sum_{jc\in\Omega_{i,cont}} \omega_{ijct}\widehat{dq}_{ijct}\Big|_{Tariff} \tag{F.44}$$

$$\overline{dq}_{i,exit}\Big|_{Tariff} = \frac{1}{\hat{x}_{i,exit}} \sum_{jc\in\Omega_{i,exit}} \omega_{ijct}\widehat{dq}_{ijct}\Big|_{Tariff} \tag{F.45}$$

$$\overline{dq}_{i,new}\Big|_{Tariff} = \frac{1}{\hat{x}_{i,new}} \sum_{jc\in\Omega_{i,new}} \omega_{ijct'}\widehat{dq}_{ijct}\Big|_{Tariff} \tag{F.46}$$

where $\hat{x}_{i,exit} = \sum_{jc\in\Omega_{i,exit}} \omega_{ijct}$ and $\hat{x}_{i,new} = \sum_{jc\in\Omega_{i,new}} \omega_{ijct'}$. This approach evaluates exactly what the price changes *would have been* for dropped varieties had they continued, and what the price changes *are* for new varieties relative to an imputed pre-shock baseline.

The detailed derivation is as follows.

1. **Exit component in the model:** In Proposition B.2, the theoretical cross-partial interaction term inside $d^2 \ln p_i^F$ arises from Leibniz's rule when taking the differential of the average intensive margin cost change $M_i = \int \omega_i(b) dq_i(b) dF_i(b)$ with respect to a change in the boundary cutoff. For dropped varieties, this theoretical term is $2s^*_{i,exit}(M_i - dq_i(b^*_{i,exit}))db^*_{i,exit}$.

2. When substituted into the total welfare formula, this term is multiplied by the second-order Taylor weight $-\frac{\alpha}{2} e_i s_i^f$. The 2 cancels out, yielding a welfare contribution of:

$$-\alpha e_i s_i^f \left[s^*_{i,exit} db^*_{i,exit} \big(M_i - dq_i(b^*_{i,exit}) \big) \right].$$

3. **Mapping model to data:**

   - The mass of dropped varieties $s^*_{i,exit} db^*_{i,exit}$ maps empirically to the predicted expenditure share of exiting varieties, $\hat{x}_{i,exit}$.
   - $M_i = \int \omega_i(b) dq_i(b) dF_i(b)$ is the pre-shock cost-weighted average price change of *all* initial varieties.
   - $dq_i(b^*_{i,exit})$ is the price change of the dropped varieties. This maps to the counterfactual predicted price change, $\overline{dq}_{i,exit}|_{Tariff}$.

4. **Decomposing the average:** We mathematically decompose the all-variety average price change M_i into the weighted average of continuing and exiting varieties:

$$M_i = (1 - \hat{x}_{i,exit}) \overline{dq}_{i,cont} \Big|_{Tariff} + \hat{x}_{i,exit} \overline{dq}_{i,exit} \Big|_{Tariff}.$$

5. **Forming the interaction bracket:** Substitute M_i into the theoretical bracket $(M_i - \overline{dq}_{i,exit}|_{Tariff})$:

$$\begin{aligned} M_i - \overline{dq}_{i,exit} \Big|_{Tariff} &= \left[(1 - \hat{x}_{i,exit}) \overline{dq}_{i,cont} \Big|_{Tariff} + \hat{x}_{i,exit} \overline{dq}_{i,exit} \Big|_{Tariff} \right] - \overline{dq}_{i,exit} \Big|_{Tariff} \\ &= (1 - \hat{x}_{i,exit}) \left(\overline{dq}_{i,cont} \Big|_{Tariff} - \overline{dq}_{i,exit} \Big|_{Tariff} \right). \end{aligned}$$

6. Since $\hat{x}_{i,exit}$ is a first-order small term (the share of dropped varieties is small), the multiplier $(1 - \hat{x}_{i,exit}) \approx 1$ to the leading second-order expansion. Multiplying by the

extensive margin share ($\hat{x}_{i,exit}$) gives the final exit interaction term:

$$s^*_{i,exit} db^*_{i,exit}\big(M_i - dq_i(b^*_{i,exit})\big) \approx \hat{x}_{i,exit}\left(\overline{dq}_{i,cont}\Big|_{Tariff} - \overline{dq}_{i,exit}\Big|_{Tariff}\right).$$

7. **Entry component in the model:** Symmetrically, for newly added varieties, the extensive margin boundary moves in the opposite direction (increasing the choice set). The exact same Leibniz expansion applied to the post-shock distribution yields the theoretical term with a negative sign (as $da_{new} = -db^*_{i,new} < 0$):

$$-\alpha e_i s_i^f\Big[-s^*_{i,new} db^*_{i,new}\big(M'_i - dq_i(b^*_{i,new})\big)\Big],$$

where M'_i is the post-shock cost-weighted average price change of all available varieties at t'.

8. **Mapping model to data:**

- The mass of added varieties $s^*_{i,new} db^*_{i,new}$ maps empirically to $\hat{x}_{i,new}$.
- $dq_i(b^*_{i,new})$ maps to the counterfactual predicted price change of the new varieties, $\overline{dq}_{i,new}|_{Tariff}$.

9. **Decomposing the average:** We decompose the total post-shock average price change M'_i into continuing and new varieties:

$$M'_i = (1-\hat{x}_{i,new})\overline{dq}_{i,cont}\Big|_{Tariff} + \hat{x}_{i,new}\overline{dq}_{i,new}\Big|_{Tariff}.$$

10. **Forming the interaction bracket:** Substitute M'_i into $(M'_i - \overline{dq}_{i,new}|_{Tariff})$:

$$\begin{aligned} M'_i - \overline{dq}_{i,new}\Big|_{Tariff} &= \left[(1-\hat{x}_{i,new})\overline{dq}_{i,cont}\Big|_{Tariff} + \hat{x}_{i,new}\overline{dq}_{i,new}\Big|_{Tariff}\right] - \overline{dq}_{i,new}\Big|_{Tariff} \\ &= (1-\hat{x}_{i,new})\left(\overline{dq}_{i,cont}\Big|_{Tariff} - \overline{dq}_{i,new}\Big|_{Tariff}\right). \end{aligned}$$

Again, approximating $(1-\hat{x}_{i,new}) \approx 1$ to the leading order yields:

$$s^*_{i,new} db^*_{i,new}\big(M'_i - dq_i(b^*_{i,new})\big) \approx \hat{x}_{i,new}\left(\overline{dq}_{i,cont}\Big|_{Tariff} - \overline{dq}_{i,new}\Big|_{Tariff}\right).$$

11. **Combining exit and new varieties:** Subtracting the "new" interaction term from

the "exit" interaction term (as dictated by the theoretical opposite signs), we arrive at the complete empirical interaction bracket:

$$Interaction_i^{Data} = \hat{x}_{i,exit}\left(\overline{dq}_{i,cont}\Big|_{Tariff} - \overline{dq}_{i,exit}\Big|_{Tariff}\right) - \hat{x}_{i,new}\left(\overline{dq}_{i,cont}\Big|_{Tariff} - \overline{dq}_{i,new}\Big|_{Tariff}\right).$$

This establishes the empirical match to the theoretical Intensive × Extensive interaction. Whether this term amplifies or mitigates the welfare loss of tariffs depends on whether the counterfactual price change of the dropped/added varieties is strictly higher than that of the varieties firms keep.

Within-importer second-order effect: substitution between domestic and foreign inputs In Proposition B.2, the term

$$(1-\sigma)s_i^h s_i^f \left(d\ln p_i^H - d\ln p_i^F\right)^2$$

is non-positive given $\sigma > 1$, which mitigates the welfare loss of tariffs.

Non-importers For non-importers ($i \notin \mathcal{M}$), $s_i^f = 0$ and $s_i^h = 1$. According to our model, their welfare effect operates entirely through general equilibrium changes in domestic input prices $d\ln p_i^H$ and their variance $\frac{1}{2}(\theta-1)Var_{\omega_i^H}(d\ln p_{ik}^H)$. Because our empirical methodology isolates partial equilibrium responses to the tariff shock, we hold $d\ln p_i^H \approx 0$ for the direct effect. Thus, the direct partial-equilibrium contribution of non-importers is zero; their welfare is primarily affected through macroeconomic reallocation (see below).

Across-firm second-order effect Consumers substitute final demand toward U.S. firms that experience the smallest overall tariff shocks. We calculate the total first-order tariff effect for each firm i:

$$\widehat{d\ln\psi}_i^{(1)} = \begin{cases} -\left(IM_i^{Tariff} + EM_i^{Tariff}\right) & \text{if } i \in \mathcal{M}, \\ 0 & \text{if } i \notin \mathcal{M}. \end{cases} \tag{F.47}$$

We compute the expenditure-weighted variance across *all* U.S. firms (including non-importers):

$$\widehat{Var}_e^{Data} = \sum_i e_i \left(\widehat{d\ln\psi}_i^{(1)} - \overline{d\ln\psi}^{(1)}\right)^2 \quad \text{where} \quad \overline{d\ln\psi}^{(1)} = \sum_i e_i \widehat{d\ln\psi}_i^{(1)}. \tag{F.48}$$

Because $\rho > 1$, the macro-reallocation term $\frac{\rho-1}{2}\widehat{Var}_e^{Data}$ mitigates the aggregate welfare loss, rewarding the economy for reallocating demand toward insulated non-importers.

G Full Quantitative Model Appendix

G.1 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 shifter $\hat{b}_{ijc}$. The adjusted shifter is $b_{ijc} = \hat{b}_{ijc}/(\tau_{jc}p_{ijc})$. We set U.S. wage W as the numeraire.

3. Atomistic importer assumption in computation. Although aggregate buyer shares and seller shares are endogenous equilibrium objects and therefore depend on firms' extensive-margin sourcing decisions in the cross section, each individual importer is assumed to be atomistic relative to the market. Accordingly, when solving its cutoff rule b_i^* and intensive-margin choices, firm i takes as given the aggregate market-share objects that enter the bilateral pricing formula and does not internalize the effect of its own sourcing decision on those aggregates. The algorithm therefore solves each firm's problem conditional on a current guess of aggregate objects, and then updates those aggregate objects after aggregating across firms.

4. Inner loop: Guess the firm-specific cutoff threshold b_i^* for shifter. Firms will only import intermediates that are above this threshold, namely $b_{ijc} \geq b_i^*$. Conditional on the current guess of aggregate market-share objects, each firm solves its intensive-margin problem 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. Because the importer is atomistic, these aggregate objects are taken as given by the firm within the inner loop. The criterion function is measured as the sum of absolute values 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 than $1e$-6.

5. Outer loop: Given the solved prices and quantities in the inner loop, update the firm-specific cutoff b_i^* so that the left-hand side of equation (4.18) converges to a value lower than $1e$-3. We use a binary search algorithm to clear the extensive-margin condition. When the left-hand side of equation (4.18) is larger than 0, the marginal gain of including one more foreign intermediate outweighs the marginal import cost, and we adjust b_i^* downward. When the left-hand side of equation (4.18) is smaller than 0, we update b_i^* upward. After solving firms' cutoff rules, we aggregate across firms to update the equilibrium market-share objects implied by the extensive margin, and these updated aggregates are then fed back into the next iteration of the inner loop.

6. Going back to Step 3 (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:

$$\text{isimporter}_{ijc} = \mathbb{1}\{b_{ijc} > b_i^{\star}\}.$$

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 $b_i^{\star}$. 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:

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

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.

It is important to distinguish between the individual firm's optimization problem and the equilibrium aggregation step. At the firm level, importer i takes the aggregate buyer-share and seller-share objects entering the pricing formula as given when solving for $b_i^\star$ and does not internalize the effect of its own sourcing decision on those aggregates. At the equilibrium level, however, these aggregate share objects are updated using the cross-sectional distribution of import decisions. Hence, the extensive margin still affects market shares in equilibrium, but only through aggregation across atomistic firms rather than through strategic internalization by any single importer.

Implementation Details:

- The threshold condition isimporter_{ijc} is replaced with the smoothed probability P_{ijc}^{import}.
- All computations involving extensive margin aggregates—such as foreign price indices, expected import shares, and the entry condition—are updated to use P_{ijc}^{import} in place of the binary import indicator.
- We set $\sigma_\varepsilon = 1$ 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.

G.2 Model Mechanism on Tariff Pass-Through

G.2.1 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 implies 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 $\frac{d\ln x_{ijc}}{d\ln \tau_{jc}}$.

G.2.2 Proof of Proposition C.1

Proof A full log-differential of the pricing equation (4.3) yields the log change in post-tariff import price, which is specified as follows:

$$d\ln(\tau_{jc}p_{ijc}) = d\ln \mu_{ijc} + d\ln \tilde{c}_{ijc} + d\ln \tau_{jc}, \tag{G.1}$$

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

$$d\ln \mu_{ijc} = \Gamma^s_{ijc} d\ln s_{ijc} + \Gamma^x_{ijc} d\ln x_{ijc}, \quad \Gamma^s_{ijc} \equiv \frac{\partial \ln \mu_{ijc}}{\partial \ln s_{ijc}}, \quad \Gamma^x_{ijc} \equiv \frac{\partial \ln \mu_{ijc}}{\partial \ln x_{ijc}}. \tag{G.2}$$

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

$$\Phi_{ijc} \equiv \frac{d\ln(\tau_{jc}p_{ijc})}{d\ln \tau_{jc}} = \Gamma^s_{ijc}\frac{d\ln s_{ijc}}{d\ln \tau_{jc}} + \Gamma^x_{ijc}\frac{d\ln x_{ijc}}{d\ln \tau_{jc}} + \frac{d\ln \tilde{c}_{ijc}}{d\ln \tau_{jc}} + 1. \tag{G.3}$$

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:

$$\frac{d\ln s_{ijc}}{d\ln \tau_{jc}} = (1-\epsilon)(1-s_{ijc})\left[\frac{d\ln \tau_{jc}p_{ijc}}{d\ln \tau_{jc}} + \frac{d\ln \tau_{j'c'}\tilde{p}_{ij'c'}}{d\ln \tau_{jc}}\right], \tag{G.4}$$

$$\frac{d\ln x_{ijc}}{d\ln \tau_{jc}} = -(1-x_{ijc})\left[\varepsilon_{ijc}\frac{d\ln \tau_{jc}p_{ijc}}{d\ln \tau_{jc}} + \frac{d\ln \tilde{m}_{i'jc}}{d\ln \tau_{jc}}\right], \tag{G.5}$$

$$\frac{d\ln \tilde{c}_{ijc}}{d\ln \tau_{jc}} = \frac{1-\kappa}{\kappa}\left(-\varepsilon_{ijc}x_{ijc}\frac{d\ln \tau_{jc}p_{ijc}}{d\ln \tau_{jc}} + (1-x_{ijc})\frac{d\ln \tilde{m}_{i'jc}}{d\ln \tau_{jc}}\right), \tag{G.6}$$

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 G.2.1 of the Supplementary Material.

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:

$$\frac{d\ln(\tau_{jc}p_{ijc})}{d\ln \tau_{jc}} \approx \frac{1}{1+\Gamma^s_{ijc}(\epsilon-1)(1-s_{ijc})}\frac{1}{1+\Gamma^x_{ijc}\varepsilon_{ijc}(1-x_{ijc})}\frac{1}{1+\frac{1-\kappa}{\kappa}x_{ijc}\varepsilon_{ijc}}, \tag{G.7}$$

where

$$\Gamma^s_{ijc} = (1-\iota_i)\frac{\mu^{oligopoly}_{ijc}}{\mu_{ijc}}\frac{1}{\varepsilon_{ijc}-1}\frac{\epsilon-\varepsilon_{ijc}}{\varepsilon_{ijc}}; \tag{G.8}$$

$$\Gamma^x_{ijc} = \iota_i\frac{\mu^{oligopsony}_{ijc}}{\mu_{ijc}}\left[\frac{x_{ijc}(1-x_{ijc})^{\frac{1}{\kappa}-1}}{\kappa(1-(1-x_{ijc})^{\frac{1}{\kappa}})}-1\right]. \tag{G.9}$$

□

G.2.3 Proof of Proposition C.2

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, $\mu^{\text{oligopoly}}_{ijc} = \frac{\varepsilon_{ijc}}{\varepsilon_{ijc}-1}$ becomes a constant. We prove in two steps.

First, we prove in the case of $\kappa = 1$. In this case, $\mu^{\text{oligopsony}}_{ijc} = 1$. Based on equation (C.1), we have $\Phi^{SS}_{ijc} = \phi^{TT}_{ijc} = 1$. Then we have $\frac{1-\iota}{\mu_{ijc}} = \frac{1-\iota}{(1-\iota)\mu^{\text{oligopoly}}_{ijc}+\iota}$. It is easy to see that $\frac{d(\frac{1-\iota}{\mu_{ijc}})}{d\iota} < 0$, and hence $\frac{d\Gamma^s_{ijc}}{d\iota} < 0$, $\frac{d\Phi^{SC}_{ijc}}{d\iota} \geq 0$. 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, $\mu^{\text{oligopsony}}_{ijc} = \kappa\frac{1-(1-x_{ijc})^{\frac{1}{\kappa}}}{x_{ijc}}$ is a constant. It is easy to show that $\frac{d(\frac{1-\iota}{\mu_{ijc}})}{d\iota} < 0$,and hence $\frac{d\Gamma^s_{ijc}}{d\iota} < 0$, $\frac{d\Phi^{SC}_{ijc}}{d\iota} \geq 0$. 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 $\frac{d\Gamma^x_{ijc}}{d\iota} < 0$, $\frac{d\Phi^{SS}_{ijc}}{d\iota} \geq 0$.

It is obvious that $\frac{d\Phi^{TT}_{ijc}}{d\iota} = 0$. Therefore, we have $\frac{d\left(\frac{d\ln(\tau_{jc}p_{ijc})}{d\ln\tau_{jc}}\right)}{d\iota} \geq 0$.

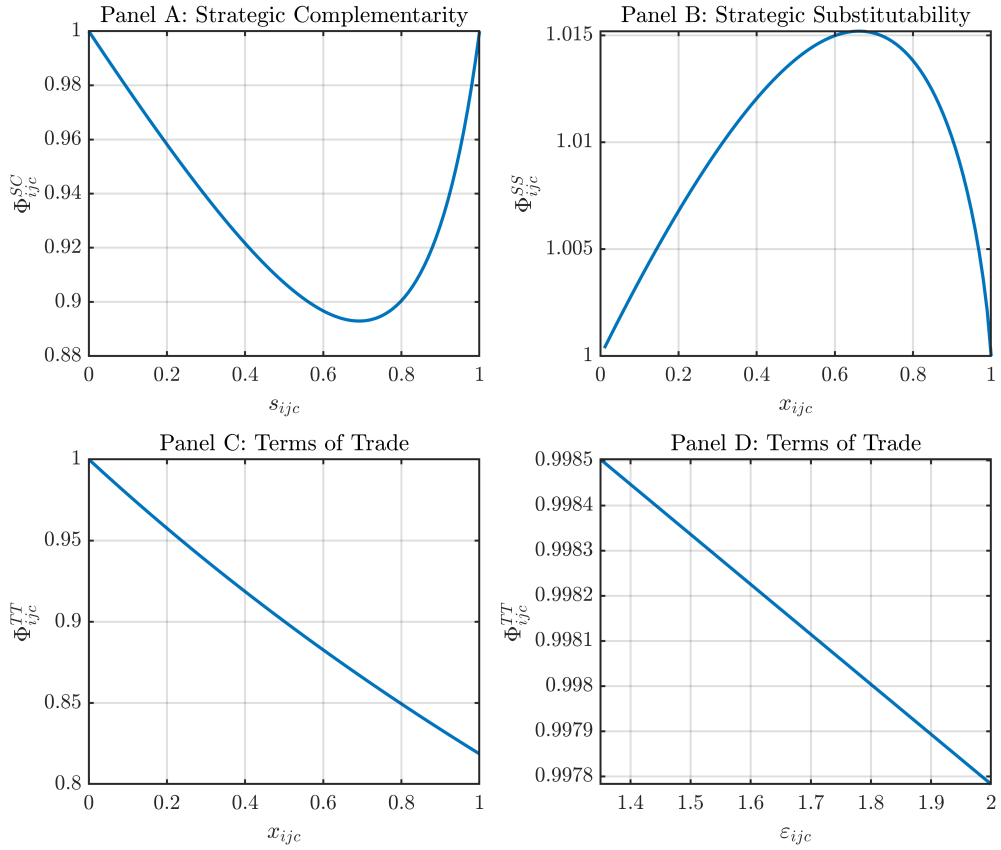
G.2.4 Understanding Tariff Pass-Through to Continuing Trade Relationship

Given $\iota_i = \iota$, $\forall i$, and κ, the mechanisms underlying the three components in equation (C.1) 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 G.1 panel A indicates that Φ^{SC}_{ijc} 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.

Figure G.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 exporters' return to scale $\kappa = 0.9$. 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.

The second component (SS) $\Phi^{SS}_{ijc} \geq 1$ reflects strategic substitutability among importers, highlighting that importers raise import price by reducing markdowns following tariff in-

creases. Figure G.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 G.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 G.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 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 G.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.

G.2.5 Understanding Tariff Increase and Trade Relationship Adjustment

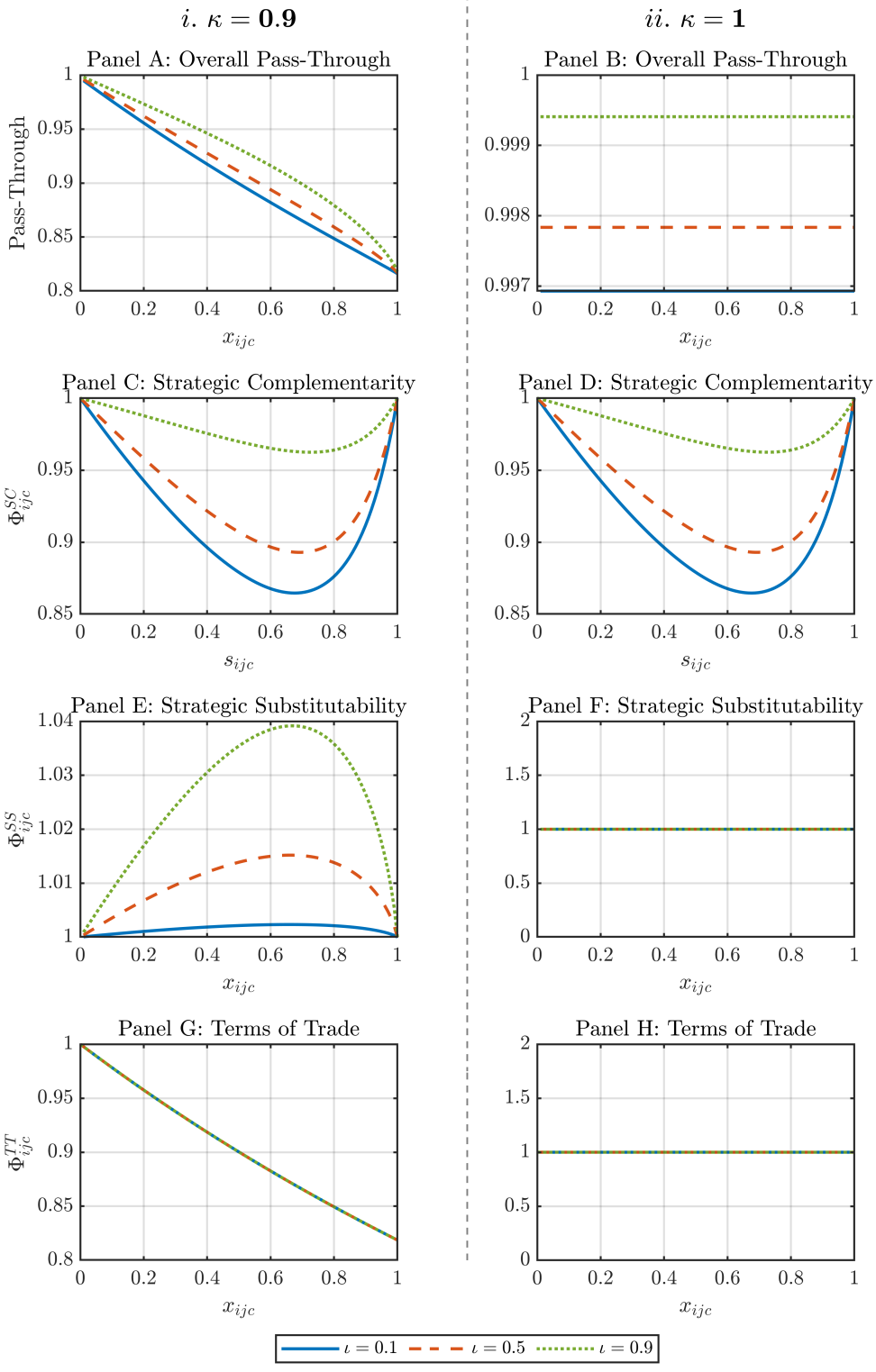
Trading relationship adjustment across product–country markets after a tariff increase. Figure G.3 provides a detailed illustration of how firms adjust their trade relationships across product–country markets in response to a tariff increase, shedding light on the impact of tariffs on foreign export 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. 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 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.

References

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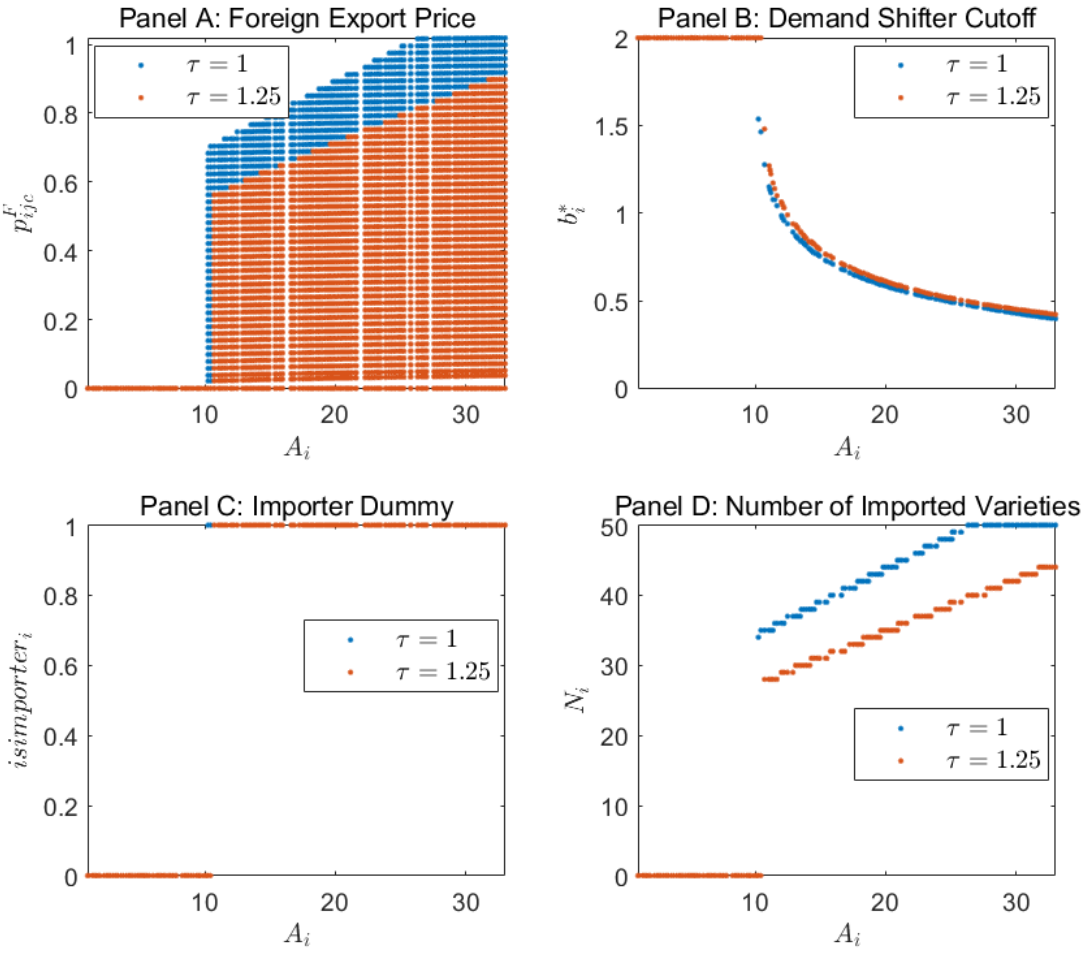
Feenstra, R. C. (1994). New product varieties and the measurement of international prices. *The American Economic Review*, 84(1):157–177.

Figure G.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 G.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}, price-adjusted sourcing-shifter cutoff 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.