Tariff Pass-through into Retail Prices: Measurement, Replacement, and Shrink-flation*

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Abstract

To what extent do import tariffs pass-through into retail prices? Existing estimates for the U.S.-China trade war present a puzzle: pass-through into U.S. border prices was complete with seemingly no effect on retail prices. We combine barcode country-of-origin data with retail scanner data to address this apparent discrepancy in the context of consumer goods. Within barcodes, tariff pass-through into retail prices is 14%, yet pass-through into aggregated price per unit weight is 44%. This discrepancy is attributable to product replacement bias: pass-through occurs predominantly via product turn-over towards barcodes with smaller package size, even within narrow firm-product combinations. Confidence intervals overlap considerably with existing estimates of the foreign cost share of U.S. retail imports, which we validate, such that we cannot reject full tariff pass-through into retail prices.

JEL Categories: E31, F13, F14, F31, L11.

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1 Introduction

Who pays for import tariffs? Basic economic theory suggests that the rate of tariff pass-through - the extent to which the buyer price reflects a changing tariff - is the key metric for quantifying tariff incidence across foreign producers and domestic consumers. Empirical estimates of tariff pass-through, however, are scarce, given the remarkable liberalization of global trade policy in the post-war period.

The U.S.-China trade war of 2018-2019 therefore offers a unique setting in which to study both the outcomes of this particular policy episode, but also the broader incidence of tariffs across importers and exporters, foreign producers and domestic consumers. Almost all research in this vein convincingly points to the same finding: U.S. tariffs applied to Chinese exports in 2018-2019 were passed through completely into prices paid by U.S. importers, such that U.S. buyers bore the brunt of import tariffs applied to Chinese exports (Amiti et al. 2019; Fajgelbaum et al. 2020; Cavallo et al. 2021). And yet there remains remarkably little evidence for any tariff pass-through into prices faced by U.S. households at U.S. stores.[1]

In this paper we use barcode scanner data to estimate the effect of tariffs on final consumer prices. We adopt a broad definition of pass-through that encompasses not only tariff-induced price changes for existing barcodes, but also higher prices for newly introduced products, reflecting pass-through via product replacement. We find that a 10% increase in tariffs increases consumer prices by 4.4%, and we show that product replacement is the predominant mechanism through which pass-through occurs. We argue this tariff elasticity of retail prices is compatible with complete pass-through in price levels, despite appearing to represent incomplete pass-though in terms of percentage changes. Specifically, we show that a large discrepancy exists between border prices and retail prices for products within the same narrowly defined category and origin country, such that we recover a relatively low foreign cost share of U.S. retail imports. When combined with our estimates of the tariff elasticity of retail prices, we argue that pass-through into retail prices was likely complete, and at least as high as 80%, such that U.S. consumers absorbed almost the entire incidence of these

[1] Cavallo et al. (2021) estimate pass-through into U.S. retailer prices of only 3.5%, and this estimate is not disinguishable from zero at standard confidence levels. See Fajgelbaum and Khandelwal (2022) for more discussion.

import tariffs.

A distinguishing feature of the dataset used in this paper is that we observe both price and quantity data for detailed product definitions – barcodes – over time, as well as country of origin information at the same level of observation. The combination of consistent product definitions with price and quantity sales data allow us to compare estimates of pass-through at both the barcode level and at higher levels of aggregation, such as average price per unit weight. Since we observe entry and exit over time, we explicitly highlight the role of product replacement as a mechanism through which pass-through is achieved at U.S. stores, thereby rationalizing the gap between pass-through into unit values and within-barcode pass-through. In turn, we are able to make sense of discrepancies between existing estimates of pass-through at the border (unit values) versus at the store (product specific).[2]

We begin by estimating tariff pass-through into retail unit values aggregated to the firm, category, production country, and retailer level. For example, prices and quantities sold for a specific firm's barcodes of deodorant produced in China and sold at a specific retail chain in the U.S. By implementing a triple-difference design comparing changes in unit values within production origins and within product categories, we recover a headline estimate of 43.5% tariff pass-through into U.S. retail unit values. We confirm a lack of pre-trends, such that we interpret this estimate as the causal effect of import tariffs on retail unit values.

While our estimate is considerably larger in magnitude than existing estimates associated with U.S. retail prices, it still falls well short of the full pass-through consistently recovered using customs data. We argue that this discrepancy is likely due to the cost wedge associated with post-tariff distribution, such as retailing mark-ups, retailing costs and intra-national distribution costs. In the presence of such costs, estimates of pass-through into retail prices must be scaled by the value share of retail imports attributable to pre-tariff activity—the foreign cost share—in order to be comparable to estimates of pass-through at the border.[3]

Despite its important role in determining pass-through, estimates of the foreign cost

[2]Throughout this analysis, we will be focusing exclusively on tariff waves 3 and 4a associated with the U.S.-China trade war. Waves 1 and 2 primarily targeted goods with poor representation in scanner data, such as intermediates and capital goods. Section 2 provides more detail.

[3]For example, if the cost share of domestic economic activity associated with retail goods, such as intra-national distribution costs and retailing costs (land, labor, etc.), is 60%, a tariff is only applied to 40% of the value of the good. Full pass-through at the border would imply 40% pass-through into retail prices. See Sangani (2025) for a similar argument regarding commodity shock pass-through

share are scarce. Existing estimates tend to place the foreign cost share for U.S. retail between 30%-50% (Berger et al. 2012; Flaaen et al. 2025) which overlaps almost perfectly with the confidence interval of our headline unit value pass-through estimate. However, the product categories reported in (Berger et al. 2012) map only imperfectly into a subset of our product categories and are based on older data (1994-2007). We therefore estimate the foreign cost share directly, mapping U.S. customs unit values to unit values from scanner data. We recover an average estimate of approximately 32% for imports of consumer retail goods from China. By interacting our estimates of the foreign cost share with observed tariff changes, we provide qualitative evidence that products with a higher foreign cost share exhibit significantly higher levels of tariff pass-through.[4] Our paper is therefore the first to document the importance of the foreign cost share for pass-through into final consumer prices for a broad set of consumer good categories, and to link the relatively low foreign cost share in U.S. consumer goods imports to the discrepancy in pass-through estimates as recorded at the border and at U.S. stores.

While our headline estimates align with existing estimates of full pass-through into border prices, we show that in the presence of endogenous product turnover, this result is not necessarily incompatible with the null estimate of product-specific tariff pass-through reported by Cavallo et al. (2021). Specifically, we show that the retail unit value tariff elasticity is only 10% when we restrict our sample to continuing barcodes.[5] When we estimate pass-through into barcode-specific prices via a similar triple-difference identification strategy, we recover 14% pass-through for the continuing set of barcodes.[6] This within-barcode pass-through estimate drops to zero once we expand our sample to an unbalanced panel, similar to Cavallo et al. (2021). This suggests that within-barcode price changes are only a relevant margin of adjustment for barcodes that continue to be sold for a sufficiently long time after the tariff change in question.

We therefore argue that the majority of pass-through into retail unit values occurs via

[4] In contemporaneous work, Flaaen et al. (2025) also consider the importance of the foreign cost share for tariff pass-through in their study of EU wine exports to the U.S. They estimate a foreign cost share for EU wine that is strikingly similar to our estimate, at 35%.

[5] We define a continuing barcode as a barcode with non-zero sales throughout the entirety of our sample.

[6] We confirm that our relatively low estimates of within-barcode pass-through are not driven by endogenous price spillover effects to non-tariff goods, tariff "smoothing" by retailers, or the effect of tariff shocks raising all production costs and thereby reducing the effect of product-specific tariffs.

product turnover, such that within-product pass-through differs considerably from unit value pass-through. We decompose unit value pass-through into changes in the numerator—what we call "sticker prices"—and the denominator, or average package size.[7] We recover a tariff elasticity of average package size of -0.287, such that reductions in average package size account for over two thirds of our aggregate unit value pass-through estimate. We refer to this effect as "shrink-flation", and we confirm a lack of pre-trends, suggesting this decrease in size is causally attributable to the tariff change in question.

Our findings suggest that within-product measures of pass-through are potentially subject to product replacement bias (Nakamura and Steinsson 2012), such that within-product estimates may under-state the true pass-through of import tariffs into consumer prices. Still, within-product estimates have the benefit of a clear counterfactual price, whereas entry and exit could lead to compositional shifts in the set of products offered, thereby generating pass-through estimates which are not necessarily relevant for consumer welfare.[8]

We argue that the unit value pass-through estimates we recover are likely welfare relevant. First, we estimate these effects within narrow firm-country-category-retailer observations. In our most rigorous specification, we include firm-category fixed effects in a long difference over time, thereby comparing barcodes within the same category and produced by the same firm but subject to differential tariff levels. Still, we find evidence for tariff-induced reductions in the average package size of barcodes sold. Second, we document both a positive tariff elasticity of barcode exit, which is unsurprising, and a positive tariff elasticity of barcode entry, which is surprising. In particular, barcodes associated with tariff-induced entry do not appear to be lower quality than the average entering barcode. Yet entering barcodes in tariff-affected units are significantly and robustly 18%-20% smaller than barcodes entering non-tariff units.

Finally, we consider the role of buyer and seller power in shaping observed elasticities of tariff pass-through. Specifically, we interact tariff changes with both the share of expenditure

[7] By "sticker price", we refer to the average price per barcode sold, rather than the average price per unit of weight sold, which we refer to as unit values. Section 4 provides an exact decomposition of unit value pass-through into a sticker price component and an average package size component.

[8] As discussed in Metzler (1949) and documented by Ludema and Yu (2016); Chen and Juvenal (2016); Freitag and Lein (2023), tariffs might generate an endogenous exit of low-quality varieties, thereby mechanically increasing unit values even in the absence of any within-variety pass-through.

within a given retailer attributable to a specific firm (the seller share) and the share of expenditure within a given firm attributable to a specific retailer (the buyer share). In line with Alviarez et al. (2023) and notions of monopoly and monopsony power, we find elevated levels of pass-through for above-median seller shares and reduced levels of pass-through for above-median buyer shares for both unit values and barcode-specific prices. Firms with above-median seller shares exhibit a pronounced gap between unit value pass-through and barcode-specific pass-through, suggesting that endogenous product turnover is particularly common when seller power is elevated. Alternatively, when firms exhibit below-median seller power at below-median retailers, barcode and unit value pass-through estimates are effectively identical, at 17%.

Related literature: This paper fits into a growing empirical literature on the economic consequences of the U.S.-China trade war, with a particular focus on the price effects of this event (Amiti et al. 2019; Fajgelbaum et al. 2020; Flaaen et al. 2020; Cavallo et al. 2021).[9] The closest papers to ours are Cavallo et al. (2021) and Flaaen et al. (2025) who study pass-through in the context of, respectively, consumer retail goods and E.U. wine exports. Our null estimate of within-barcode pass-through for an unbalanced panel matches findings in Cavallo et al. (2021), who consider a similar specification. By estimating pass-through into retail unit values, we show that product replacement can align this result with full pass-through at the border. Similar to Flaaen et al. (2025), we show that domestic wedges associated with inter-mediation of imported goods generate muted price effects in retail data that are not necessarily inconsistent with full pass-through at the border.

Our results build on the product replacement bias documented in Nakamura and Steinsson (2012).[10] Producers and/or retailers may perceive product replacement as a mechanism for increasing prices which generates less negative sentiment among consumers (Rotemberg

[9] See Fajgelbaum and Khandelwal (2022) for a full literature review of the first U.S.-China trade war. Key papers include Charbonneau and Landry (2018); Fetzer and Schwarz (2021); Benguria et al. (2022); Blanchard et al. (2024); Handley et al. (2025). See Bown (2021) for a full timeline of the events which constitute the U.S.-China trade war.

[10] "Product replacement bias" is distinct from the endogenous quality response of firms to changes in trade costs, as documented by Ludema and Yu (2016), Chen and Juvenal (2016), and Freitag and Lein (2023). Similarly, while product entry is beneficial to consumers (Feenstra 1994; Broda and Weinstein 2006), product replacement bias suggests not all entry is equal, as product replacement is equivalent to a counterfactual price increase of an otherwise identical product.

2005; Nakamura and Steinsson 2011), and a growing literature suggests that "shrink-flation" may be a particularly common method by which firms achieve higher prices when replacing products (Evangelidis 2024; Chalioti and Serfes 2024). We similarly contribute to the literature quantifying the foreign cost share of domestic retail goods (Berger et al. 2012; Flaaen et al. 2025).[11] Finally, by studying the endogenous response of retailers to tariffs, we also contribute to the literature documenting the relationships between foreign producers, domestic retailers, and trade shocks (Raff and Schmitt 2006, 2009; Eckel 2009; Basker and Van 2010; Basker et al. 2012; Raff and Schmitt 2012, 2016; Cole and Eckel 2018; Jaccard 2023).

Section 2 describes our data. Section 3 provides our headline estimates of pass-through into retail unit values alongside estimates of the foreign cost share. Section 4 decomposes unit value pass-through into components associated with entering, exiting, and continuing barcodes, and Section 5 concludes.

2 Data

We bring together a number of data sources for the empirical analysis of this paper: i) barcode-level price and expenditure from NielsenIQ Retail Scanner Data, ii) barcode-level country-of-origin data purchased from Label Insight, iii) barcode-level country-of-origin data scraped from the website of a large U.S. retailer, iv) tariff data at the eight-digit Harmonized System (HS) level from the U.S. International Trade Commission (USITC), v) firm identifiers from GS1, and vi) a concordance between NielsenIQ product modules and HS-10 digit codes (constructed by the authors).[12]

[11] As noted by Berger et al. (2012), the range of estimates they recover (30%-50%) for the foreign cost share are themselves between 10 and 20 percentage points lower than most existing estimates (Burstein et al. 2003; Devereux et al. 2003; Anderson and Van Wincoop 2004; Goldberg and Campa 2010). Flaaen et al. (2025), however, cite evidence of a 50% foreign cost share in U.S. consumer goods, and document a foreign cost share of approximately 35% for EU wine exports to the U.S., which is their object of study.

[12] This is an extension of the concordance between NielsenIQ product modules and HS-6 digit codes used in Bai and Stumpner (2019).

2.1 Price and Expenditure

For information on prices and expenditures at the barcode-level, we make use of the NielsenIQ Retail Scanner Data, over the period 2015-20. Products from all NielsenIQ categories are included in the data, such as alcoholic beverages, dairy, deli, dry grocery, fresh produce, frozen foods, packaged meat, general merchandise, health and beauty care, and non-food grocery. Depending on the year, data are included from approximately 30,000-50,000 participating grocery, drug, mass merchandiser, and other stores.

The raw data is available at the barcode-store-week level. For the analysis, we build a panel dataset of prices and expenditures at the barcode-retailer-month level. To abstract away from changes in the set of reporting stores over time, we focus on the set of stores that report positive sales in every year of our sample period ($n = 29,054$). To aggregate sales and prices at the retailer level, we make use of the NielsenIQ retail chain identifiers.

2.2 Country of Origin

One limitation of the Retail Scanner Data when used in empirical studies of international trade is the lack of information regarding a product's country of origin. To overcome this, we supplement it with two separate data sources that provide this information at the barcode level. First, we use a proprietary dataset purchased from Label Insight, a private firm specializing in the provision of detailed product attribute data. Second, we scrape data from the website of a large U.S. retailer, which further improves our product coverage. Together, these two sources provide us with country-of-origin data for 332k barcodes from roughly 16k firms sold at 68 retailers over the entire period 2015-2020, corresponding to 24% of the total number of NielsenIQ barcodes during our sample period. However, because Label Insight prioritizes products with the highest volume of sales, these matched barcodes account for 64% of total expenditure in the Retail Scanner data. As shown in Figure A.1, the distribution across NielsenIQ departments (both in terms of number of UPC codes and expenditure) looks similar for the matched and broader samples. In any given year, we have origin data for roughly 220k barcodes on average. In 2017, the year before the first tariff increases, we have data for 216k barcodes, out of which 176k are domestic and 40k are imported goods.

Out of the 40k imported goods, roughly 9k are Chinese.

2.3 Tariff Data

We use data from the official tariff lists published by the United States Trade Representative (USTR) for waves 1-4. Figure 1 shows the weighted average tariff that the U.S. Government has applied on imports from China over time, using 2017 import weights. The tariff increase was substantially lower in HS codes that map into NielsenIQ consumer product modules than in other categories of goods, but was still substantial.[13] The aggregate tariff increase applied to Chinese goods present in the NielsenIQ data from early 2017 to the peak at the end of 2019 was over 7ppt, compared to a pre-2018 baseline average tariff rate of around 3%.

There were four waves of tariff changes associated with the 2018-2019 trade war, that were implemented at different points in time. Figure 2 plots the tariff rate applied to Chinese goods by tariff wave, as well as the average tariff increase applied to Chinese goods across all imports. The taxed categories accounted for roughly two thirds of all US imports from China in 2017. The remaining third of U.S. imports from China (list 4b) were left as a threat point during the U.S.-China negotiations and were eventually left untaxed after the signing of the Phase One Deal in January 2020.

In the main part of our analysis we focus on the comparison between Wave 3 and the never taxed categories. Waves 1 and 2 focused largely on intermediate goods and have a poor representation in NielsenIQ scanner data. While our scanner data contains a sufficient number of products across waves 3 and 4a to include both in our analysis, we focus our results on those associated with wave 3, with wave 4a results provided as a robustness. We do this for two reasons. First, as shown in Figure 2, the wave 3 tariffs experienced two increases: an increase from 2.5% to 12.5% in September 2018, and a further increase to 27.5% in May 2019. Wave 3 goods then maintained this heightened tariff rate through 2020. Wave 4a categories, on the other hand, experienced a tariff increase from 5% to 20% in August 2019 which was followed by a reduction back to 12.5% in early 2020. The dynamic effects associated with a short-lived, dramatic, increase in tariff rates followed by a mediation

[13] The initial two waves of the U.S.-China trade war focused heavily on intermediates (chemicals and machinery), rather than consumer goods.

Figure 1: Trade War Tariffs by Dataset

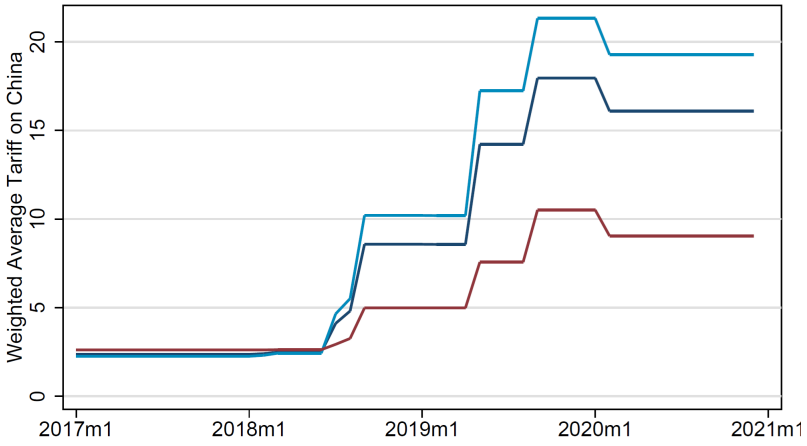
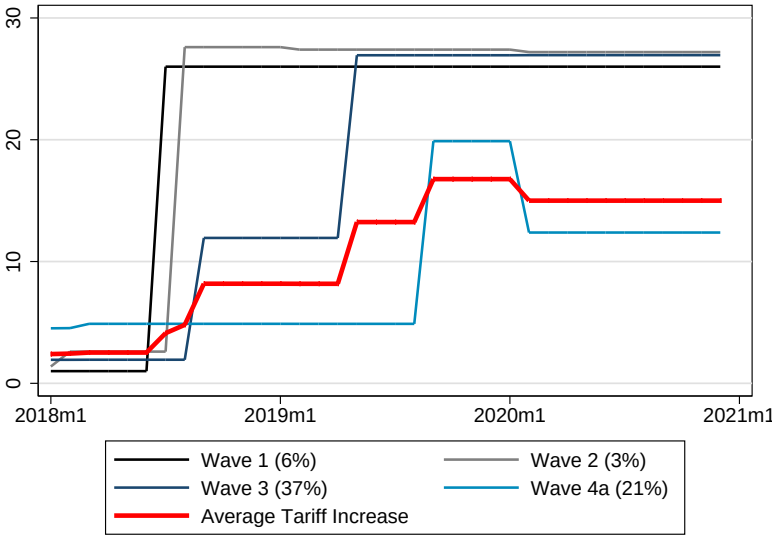


Figure 2: Trade War Tariffs by Wave within NielsenIQ Sample



Notes: Figure 1 provides the average tariff rate applied by the U.S. to imports from China over time. All products are in dark blue, products outside of the NielsenIQ scanner data are in light blue, and products within NielsenIQ scanner data in dark red. Figure 2 provides the average tariff increase over time within NielsenIQ categories, and denotes the total share of categories within the NielsenIQ data subject to the different tariff waves applied to imports from China.

of rates to 12.% complicates interpretation of effects, particularly given the lagged effects of tariffs we document below. Second, since wave 4a tariff rates only stabilize at the start of 2020, there is only a short period prior to the Covid-19 pandemic with which to estimate tariff effects. While we control for country-month and product category-month shocks, as well as seasonality controls specific to tariff-affected goods, it is still possible that the Covid-

19 pandemic induced a distribution of demand and supply shocks that are unobserved, and potentially correlated with treatment, which we cannot account for here. Still, we show below that at least qualitatively, and to a large extent in magnitudes as well, estimates associated with the wave 4a tariffs had similar effects to the wave 3 tariffs.

2.4 Concordance between NielsenIQ and tariff data

Barcode price and expenditure data in NielsenIQ are organized in roughly 1,200 different product modules. In order to apply tariff rates to barcodes we require a mapping between product modules and HS codes. We build on the concordance in Bai and Stumpner (2019) that maps NielseIQ product modules to HS6 codes, forming 359 product categories. The number of product categories is lower than the number of modules due to many cases where several product modules and several HS6 codes have to be combined to form one consistent "category". There are two reasons that make this concordance unsuitable in our setting. First, the original concordance matches product module codes to HS6 codes of the 2002 HS revision, while tariffs are applied using HS codes of the 2017 revision. Second, the concordance links NielsenIQ modules to six-digit HS codes, while tariffs are typically applied at the eight-digit (HS8) or in some cases even ten-digit (HS10) level. To overcome this problem, we translate the concordance in Bai and Stumpner (2019) to the HS2017 revision, and refine it as much as possible to map to 8-digit or 10-digit HS codes. This results in a more granular concordance between modules and HS codes, creating 445 different categories. Since these categories may map to several HS8 codes, it is possible that the underlying HS8 codes may belong to different tariff waves or be left untreated, creating a problem of tariff aggregation. In order to avoid this problem we restrict attention to a set of "clean" categories, i.e. categories for which all underlying HS codes belong to the same tariff wave. Our final sample consists of 303 product categories, of which 40 have been never treated, 162 belong to wave 3, and 101 to wave 4.

3 Tariff Pass-through into Average Prices

We begin by estimating pass-through of U.S. import tariffs during the 2018-2019 U.S.-China trade war into U.S. retail prices. In order to allow for the broadest possible set of mechanisms associated with endogenous retail price changes, while also controlling for endogenous responses across retail chains, we begin by studying pass-through into aggregated unit values at the firm-module-country-retailer-month level. We denote firms as f, product modules as c, origin countries as j, retail chains as r, and periods as t. Throughout, we refer to the firm-category-country triplet fcj as k to ease notation, such that krt will denote our unit of observation in most estimating equations to follow.

3.1 Empirical Model

Equation 1 provides our baseline empirical model. In this case y_{krt} denotes some observed outcome associated with the triplet fcj sold at retailer r in month t. We estimate both the effect of tariffs on unit values u_{krt} and quantities sold q_{krt}, where both measures are adjusted for the underlying size of barcodes which constitute each fcj triplet. That is, we construct $q_{krt} = \sum_{i \in \Omega_{krt}} q_{irt}$ where Ω_{krt} denotes the set of barcodes associated with triplet krt. q_{irt} denotes the quantity volume of sales of barcode i multiplied by the size, or weight, of i such that $q_{irt} = \tilde{q}_{irt} w_i$. In this case $\tilde{q}_{irt}$ denotes the raw count of purchases of barcode i in retailer-month rt, and moving forward all variables with a tilde denote variables which are unadjusted for product size.[14] Average prices, which we refer to as unit values, are simply total expenditure, v_{krt}, divided by the total quantity sold:

$$u_{krt} = \frac{v_{krt}}{q_{krt}} = \frac{\sum\limits_{i \in \Omega_{krt}} p_{irt} q_{irt}}{\sum\limits_{i \in \Omega_{krt}} q_{irt}} = \frac{\sum\limits_{i \in \Omega_{krt}} p_{irt} \tilde{q}_{irt} w_i}{\sum\limits_{i \in \Omega_{krt}} \tilde{q}_{irt} w_i}.$$

[14] Not all barcodes within a given product module exhibit the same unit of measure. When possible, we convert units into a standard benchmark, such as "OZ" to "mL". Still, some recorded units, such as "Counts", cannot be readily converted to comparable units. For each product module, we calculate the most common unit of measure in our pre-tariff period, 2017, and drop all barcodes with units of measure which cannot be readily converted to this predominant unit of measure. In practice, this data restriction maintains over 95% of expenditure in our raw data. A benefit of using barcodes as our definition of a product is that any change to the size of a barcode, and therefore the labeling, must generate a new UPC, and therefore a new barcode, such that w_i is constant across observations of barcode i.

We denote the tariff level common to all barcodes within module c and produced in origin country j in period t as τ_{jct}. By applying OLS to Equation 1, we recover the parameter of interest, β:

$$\ln y_{krt} = \beta \ln(1 + \tau_{j(k)c(k)t}) + \alpha_{krt} + \gamma_{k,q(t)} + \epsilon_{krt}. \tag{1}$$

When the dependent variable represents unit values, β captures the elasticity of retail unit values to import tariffs, which we would expect to be bounded below by zero and above by one, with an estimate of one denoting full pass-through. When the dependent variable represents total quantity sold, β captures the quantity elasticity of tariffs, which we expect to be negative. For the sake of exposition, we collect all fixed effects within the vector α_{krt}, such that α_{krt} represents the following set of fixed effects:

$$\alpha_{krt} = \alpha_{kr} + \alpha_{rt} + \alpha_{c(k)t} + \alpha_{j(k)t}.$$

We include fixed effects at the $fcjr$, or kr, level as this is the unit of analysis in this specification, such that we control for any level differences in prices and quantities across firm-category-country-retailer units of observation. We then include fixed effects which account for shocks at the retailer-month level, category-month level, and origin country-month level. The category-month shocks account for any demand or supply shocks which are common to barcodes within a given product category, such as supply shocks due to other tariffs imposed by either the U.S. or China during this period. Country-period shocks isolate the role specifically of tariffs, by comparing the effect of tariff changes on Chinese goods to other imports from China for which tariffs did not change. Notice that these fixed effects control for exchange rate changes which may be endogenous to the tariff change, as well as any tariff effects which alter perceived future tariff rates associated with all goods produced in China. Finally, we include retailer-period fixed effects to account for potentially differential exposure across retail chains during the trade war.

The vector $\gamma_{k,q(t)}$ constitutes seasonality controls, which we include in order to account for seasonal fluctuations which we observe in the tariff-targeted goods prior to the U.S.-China trade war. These controls constitute a dummy variable for each quarter of the calendar year interacted with the treatment dummy. Such seasonality is not captured by the fixed effects

described above as these shocks are not specific to Chinese exports or specific categories, but the specific interaction of Chinese varieties within tariff-targeted categories. We therefore include a vector of seasonality controls, in which $\Gamma_k = 1$ is a treatment indicator equal to one if the combination of product category $c(k)$ and origin country $j(k)$ are ultimately targeted with a tariff by the U.S. We interact this indicator with indicator variables at the quarter level, such that $q(t) = 1$ denotes that period t is in the first quarter.

$$\gamma_{k,q(t)} = \sum_{q'=1}^{4} \gamma_{q'} \times \Gamma_k \times \mathbf{1}[q(t) = q']$$

The identification strategy employed here is effectively a triple-difference: we compare outcomes between Chinese goods and non-Chinese goods across tariff and non-tariff product categories before and after tariff implementation. As such, we can adjust our specification to an event study so as to check for the presence of pre-trends. To do so, we apply OLS to Equation 2 and plot the estimate vector β_γ.

$$\ln(y_{krt}) = \sum_{\tau=\underline{T}}^{\bar{T}} \beta_\tau \times \Gamma_k \times \mathbf{1}[t = T - \tau] + \alpha_{krt} + \gamma_{k,q(t)} + \epsilon_{krt} \tag{2}$$

T denotes the date of the first tariff change. While our primary focus in this paper are the wave 3 tariffs, we will also generate event study figures for product categories targeted by the wave 4a tariffs. In all cases, the control group is the never-treated set of product categories.

In constructing variables at the firm-category-country-retailer level, we restrict ourselves to the set of firm-category-country-retailer quadruplets present in each period of our sample, such that at the krt level we estimate β using a balanced panel. Crucially, as we discuss in Section 4.2, we construct unit values and aggregate quantities using all underlying barcodes within each krt observation, such that while the estimating sample is balanced at the krt level, the underlying set of barcodes used to construct aggregate variables is unbalanced.

3.2 Tariff Pass-through into Retail Unit Values

Table 1 provides our baseline estimates of pass-through into unit values and tariff substitution associated with the wave 3 tariffs applied to imports to the U.S. from China. Columns (1)

Table 1: Tariff Pass-through into Unit Values and Tariff Substitution

	(1) Log Unit Value	(2) Log Quantity	(3) Log Unit Value	(4) Log Quantity
$\log(1+\tau)$	0.435***	-0.610***	0.312***	-0.479***
	(0.140)	(0.176)	(0.097)	(0.130)
Fixed Effects	✓	✓	✓	✓
Exclude 2020			✓	✓
R^2	1.00	0.98	1.00	0.98
Observations	4,291,413	4,291,413	3,220,846	3,220,846

*Notes: This table provides estimates of β from applying OLS to Equation 1. Data are aggregated to the firm-category-country-retailer level. All models include fixed effects by firm-country-category-retailer, retailer-month, category-month, and country-month. Columns (1) and (2) estimate, respectively, pass-through into unit values and tariff substitution in quantities for the entire sample perios. Columns (2) and (4) restrict the sample to only time periods prior to 2020, such that our time period is from January 1, 2017, to December 31, 2019. Standard errors are clustered three-way at the category, country, and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

and (2) represent our preferred estimates, in which the entire sample from January 1 2017 to December 31 2020 is included in our estimation. Column (1) provides the headline result of this paper: pass-through into unit values at the firm-category-country-retailer level is 0.435 (0.140). Taken at face value, this estimate implies tariff pass-through into retail prices was 43.5%. We also recover significant substitution away from tariff-targeted goods, with a quantity elasticity estimate in Column (2) of -0.610 (0.176). The implied price elasticity of these two estimates is $-(-0.585)/0.403 = 1.40$, which is plausible given the relatively small estimates of price elasticities associated with consumer packaged goods (Faber and Fally 2021) and the relatively short time-horizon we consider here.

Columns (3) and (4) show that these estimates are broadly robust to excluding the Covid-19 pandemic from our sample. As discussed earlier, the onset of the pandemic in early 2020 could plausibly lead to unobserved demand and supply shocks which may be correlated with treatment. At the same time, the lack of sample periods post-tariffs but prior to the onset of the pandemic limits our ability to recover the dynamic effects of tariffs on unit values and quantities sold when 2020 is removed from our sample. Both the price effects and substitution effects of tariffs are dampened slightly, with the unit values pass-through reduced to 0.312 (0.097) and the quantity elasticity reduced to -0.479 (0.130).

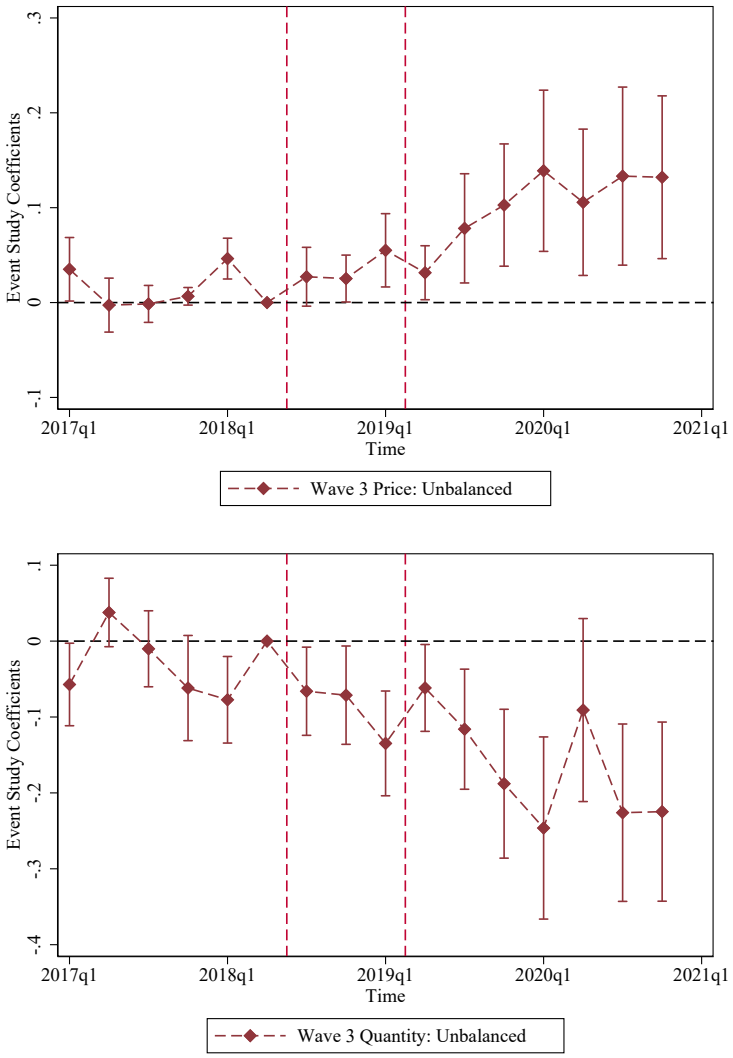
By plotting event study estimates associated with Equation 2, however, we argue that the larger estimates recovered from the full sample are likely not driven by shocks which

occurred during the pandemic. Figure 3 provides these event study estimates for unit values (top) and quantities sold (bottom). Each figure includes two vertical lines which denote the two tariff changes applied to barcodes in tariff wave 3: an initial increase from 2.5% to 12.5% in September 2018 and a further increase to 27.5% tariffs in May 2019. As shown, there are no appreciable pre-trends in either unit values or quantity units sold prior to the first wave 3 tariff change in September 2018. This is reassuring, as earlier tariff waves (1 and 2) had already occurred, which could have led to anticipatory effects on later tariff waves.

For both unit values and quantities, the initial tariff change exhibits modest effects, with the four quarters after the second tariff increase highlighting the dynamic effect of these tariff changes on price and quantities. It is again reassuring that the estimates recovered here actually begin to flatten during the year 2020, suggesting that the pandemic had little effect on the differential trend of prices and quantities for tariff-affected versus unaffected products. For unit values, this relative price differential with non-targeted firm-category-country-retailer quadruplets stabilizes at a roughly 12% increase. For quantities, the relative decrease in tariff-affected quantitites sold stabilizes at -20%. We therefore take the wave 3 estimates in Table 1 associated with the entire sample as our headline estimates, suggesting pass-through into retail unit values was 43.5%.

Robustness across tariff waves. As noted above, the wave 4a tariffs pose a challenge from an identification standpoint, as these tariffs were implemented and then reduced only months prior to the onset of the Covid-19 pandemic. Thus, we focus our analysis in this section on the Wave 3 tariffs, using categories which were never targeted by any wave as control. Still, the results derived here broadly hold for the wave 4a targeted categories as well. Table A.1 confirms that pass-through into unit values associated with the wave 4a tariffs was 0.357 (0.109), such that pass-through estimates associated with wave 3 and wave 4a fall within one standard error of each other. Similarly, the quantity elasticity estimate of -0.460 (0.270), while noisier than the corresponding wave 3 estimate, falls within one standard error of the wave 3 estimate. Figure A.2 provides the event study figures associated with wave 4a unit values and quantities, again confirming a lack of pre-trends in both cases.

Figure 3: Event Study Estimates for Unit Value Pass-through (Wave 3)



Notes: This figure provides estimates associated with the event study design at the aggregated country-category-retailer level outlined in Equation 2. All models include fixed effects by firm-country-category-retailer, retailer-month, category-month, and country-month. 95% confidence intervals included, with standard errors clustered three-way at the category, country, and month level. Only wave 3 and never-treated categories included. Red vertical lines denote tariff changes, from 2.5% to 12.5% in September 2018, and from 12.5% to 27.5% in May 2019.

3.3 Tariff Incidence and the Foreign Cost Share of U.S. Retail

While our pass-through estimate of 43.% is significant in its own right, as it suggests U.S. consumers bore at least some non-trivial share of the incidence associated with these tariffs, our estimate is still well shy of the full pass-through into border prices recorded by numerous papers studying this same tariff episode (Amiti et al. 2019; Fajgelbaum et al. 2020; Cavallo

et al. 2021). This is particularly concerning given that our estimate of pass-through into retail prices also consists of unit values, thereby offering a plausibly consistent comparison between the unit values recorded in customs data and those recorded in retail prices.[15]

As suggested by Cavallo et al. (2021), any differential in pass-through estimates at the border versus at the store could reflect the ability of U.S. intermediaries, such as retailers, to absorb this cost shock. Given estimates of full pass-through into border prices and null pass-through into store prices, it seems natural to assume that retailers simply paid the entire incidence of these import tariffs. However this result can only be inferred, as the distribution of incidence across intermediaries and domestic consumers is not directly observed. In this section, we instead consider the possibility that pass-through into retail prices is unlikely to fully reflect the same percentage change in prices as recorded in customs data, even in the presence of full pass-through into border and retail prices. Simply put, tariffs are only levied on the value share of a given imported good when that good crosses the border. All post-tariff costs associated with intra-national distribution and retailing occur after the tariff is levied, such that even full pass-through into border and retail prices would only manifest as the foreign cost share multiplied by the tariff change, when measured using retail prices.[16]

As a simple exercise to highlight this point, consider a retailer which combines retailing services for a given kr combination, as purchased at the border, with costs associated with post-tariff activity. Ignoring second-order substitution effects and assuming a constant pass-through elasticity across the underlying set of barcodes in each kr unit, the effect of a tariff change $d\ln\tau$ on the final price offered at retailer r is simply

$$\beta = \frac{\partial \ln u_{kr}}{d\ln\tau} = F_{kr}\frac{\partial \ln u_k^f}{d\ln\tau} = F_{kr}\beta^f.$$

That is, the effect of a tariff τ on the unit values associated with product k as observed at the border, u_k^f, is mediated by the cost share of purchasing this foreign good within the total cost of selling this product on the shelves of retailer r. In this case, F_{krt} denotes this

[15] Flaaen et al. (2020), Cavallo et al. (2021), and Flaaen et al. (2025) do not have quantity sales data for U.S. retailers, and are therefore unable to provide a direct comparison between retail unit values and customs data unit values.

[16] See Sangani (2025) for a similar argument in the context of commodity price shocks and Flaaen et al. (2025) for evidence of this effect in wine tariffs.

foreign cost share and is defined as $F_{krt} \equiv u_k^f / u_{kr}$. An implication of this first-order cost shock approximation is that estimates of pass-through into retail prices which are lower than estimates of pass-through into border prices may in fact capture the exact same magnitude of tariff pass-through.[17]

Existing estimates of the foreign cost share of U.S. retail imports suggest a range of 30%-50% (Berger et al. 2012). For E.U. wine exports to the U.S., Flaaen et al. (2025) document a foreign cost share of approximately 38%, and provide evidence from the Bureau of Economic Analysis that across consumer goods, the average foreign cost share is just under 50%. We make use of our correspondence between scanner and customs data to to estimate the foreign cost share directly at the country-category level in the year 2017, prior to any tariff changes. That is, we impose the restriction $F_{kr} \equiv F_{cj}$, and calculate unit values, or total import value by unit size, at the country-by-HS8 level using U.S. customs data. We then map these unit values into country-by-product module average import unit values, thereby calculating u_{cj}^f: the unit values associated with module c and country j as measured at the border. By calculating the same unit values with retail data, u_{cj}, we then construct an estimate of the foreign cost share: $\hat{F}_{cj} = u_{cj}^f / u_{cj}$.[18]

We recover an average estimate of $\hat{F}_{cj} = 0.30$, with imports from China exhibiting an average of 0.32. We manually link our product categories to those studied in Berger et al. (2012) and find that for categories consistent across the two datasets, Berger et al. (2012) recover foreign cost share estimates in the range of 30%-40%, suggesting that our lower estimates may be partly due to the composition of goods we study. We provide qualitative support for the relevance of our foreign cost share estimates by estimating Equation 1 using import tariffs scaled by the foreign cost share as our regressor of interest. Table A.2 provides these estimates. We document a unit value elasticity of 0.813 (0.318) for this re-scaled measure of tariffs, suggesting that for a foreign cost share equal to one, pass-through would be 81.3% into retail unit values and statistically indistinguishable from zero. In sum, our

[17] If the underlying production function of retailing services is Cobb-Douglas in both the product being purchased and the retailing costs associated with providing this product to consumers, then this result is no long a first-order approximation, but holds exactly for a Cobb-Douglas cost parameter F_{kr} associated with the imported good as input.

[18] Further details regarding construction of our measure and descriptions of our findings can be found in Appendix B.1.

own estimates of the foreign cost share, the estimate range recovered by Berger et al. (2012), and the BEA estimates reported in Flaaen et al. (2025), all suggest that we cannot reject full pass-through into U.S. retail unit values.

Still, our estimates of pass-through into retail unit values are considerably larger than the within-product estimates associated with Cavallo et al. (2021), who document zero pass-through for this same tariff wave. Equipped with a unique combination of prices, quantities, and well-defined products, we dedicate the remainder of this paper to understanding this discrepancy. Ultimately, we provide evidence that the composition effect of tariffs on the set of products sold at U.S. retailers is responsible for the majority of tariff pass-through into unit values. We also provide evidence that these compositional effects are welfare relevant, in that they reflect product replacement bias, as in Nakamura and Steinsson (2012), via "shrink-flation": producers and retailers passed through tariffs to U.S. consumers primarily by reducing the average package size of barcodes offered. We therefore provide evidence that both the null estimates documented by Cavallo et al. (2021) and the complete pass-through estimates associated with unit values at the border (Amiti et al. 2019; Fajgelbaum et al. 2020; Cavallo et al. 2021) are not necessarily inconsistent.

4 Margins of Adjustment

This section provides a decomposition of the unit value pass-through estimates described above into various margins of adjustment. By incorporating price, quantity, and entry and exit data across barcode-retailer pairs, we decompose unit value pass-through into components associated with the continuing and unbalanced panel of barcodes, product replacement within the unbalanced panel, and pass-through heterogeneity at the barcode level.

4.1 Decomposing Unit Value Pass-through

In order to fully leverage the detailed price and sales data at our disposal, we begin by providing a decomposition of the tariff elasticity of unit values—total expenditure divided by total quantities sold—as observed at the firm-retailer-category-country-time level. We decompose the aggregate unit value elasticity into two components: unit values associated

with continuing barcodes and unit values which allow for the possibility of entry and exit:

$$u_{krt} = u^c_{krt} \times \frac{v_{krt}/q_{krt}}{v^c_{krt}/q^c_{krt}}.$$

We use the superscript "c" to denote variables associated with this continuing set of barcodes, which we also refer to as the "balanced" panel of barcodes. In Section 4.2 below, we provide estimates of $d\ln u^c_{krt}/d\ln\tau$ and show that pass-through into unit values associated with the balanced panel of barcodes is only 10%, thereby explaining less than a quarter of the aggregate unit value pass-through described in Section 3. We also provide evidence in Section 4.4 that at the barcode level, pass-through for the unbalanced panel of barcodes is zero, such that the bulk of pass-through into unit values is driven by product turn-over.

Product replacement may affect the unit value through changes in both the numerator of the unit value and the denominator. That is, in order to pass-through tariffs into higher normalized prices, retailers can either shift the product mix to those products with higher price per unit weight or to products with identical sticker price but smaller packaging. In the derivations below, we define $\tilde{u}_{krt}$ as the sticker price and $\tilde{q}_{krt}$ the total number of sales, rather than the total quantity-adjusted volume of sales. We therefore calculate the average sticker price as

$$\tilde{u}_{krt} = \frac{v_{krt}}{\tilde{q}_{krt}} = \sum_i \frac{\tilde{q}_{irt}}{\tilde{q}_{krt}} \frac{q_{irt}}{\tilde{q}_{irt}} p_{irt}.$$

Notice that the ratio $q_{irt}/\tilde{q}_{irt}$ is simply the package size of barcode i: the total quantity-adjusted volume of sales divided by the number of raw sales counts. We therefore define the average package size $w_{krt} = \sum_i \frac{\tilde{q}_{irt}}{\tilde{q}_{krt}} w_i$. Unit values can then be expressed as

$$\begin{aligned} u_{krt} &= u^c_{krt} \times \frac{v_{krt}/\tilde{q}_{krt}}{v^c_{krt}/\tilde{q}^c_{krt}} \times \frac{\tilde{q}_{krt}/q_{krt}}{\tilde{q}^c_{krt}/q^c_{krt}} \\ &= u^c_{krt} \times \frac{\tilde{u}_{krt}}{\tilde{u}^c_{krt}} \times \frac{w^c_{krt}}{w_{krt}}. \end{aligned}$$

When differentiated with respect to some tariff change $d\ln\tau$, we derive the following decom-

position:

$$\frac{\partial \ln u_{krt}}{\partial \ln \tau} = \frac{\partial \ln u^c_{krt}}{\partial \ln \tau} + \left(\frac{\partial \ln \tilde{u}_{krt}}{\partial \ln \tau} - \frac{\partial \ln \tilde{u}^c_{krt}}{\partial \ln \tau} \right) + \left(\frac{\partial \ln w^c_{krt}}{\partial \ln \tau} - \frac{\partial \ln w_{krt}}{\partial \ln \tau} \right)$$

This decomposition highlights the myriad possible discrepancies between estimates of pass-through into unit values and estimates of pass-through that are product-specific. Within-product estimates of pass-through have the benefit of capturing a clear counterfactual price change within the same good by comparing an identical product before and after the tariff change. Estimates of pass-through into unit values, however, implicitly assume that the underlying products associated with this aggregated price are comparable before and after the tariff change.

Thus, product-specific pass-through estimates are unable to account for the possibility of product replacement bias: the explicit use of product replacement by producers/retailers as a means of raising prices while mitigating the salience of this price change in the eyes of consumers (Nakamura and Steinsson 2012). To the extent that product replacement reflects a genuine change in the price of an otherwise comparable product, this change in price should be seen as relevant for welfare and therefore pass-through. By combining product characteristics with detailed price and sales data, we estimate each component of the decomposition derived above in Section 4.3. We find that that a decrease in average product size within the unbalanced panel of barcodes accounts for two thirds of the aggregate unit value pass-through, such that $\partial \ln w_{krt} / \partial \ln \tau < 0$.[19]

Even within the set of continuing barcodes, however, an unweighted average estimate of tariff pass-through does not necessarily capture the relevant measure of how prices change in response to a tariff, as pass-through estimates at the barcode level should be weighted by expenditure shares. We show this by deriving the tariff elasticity of continuing barcode unit values:

$$\frac{d \ln u^c_{krt}}{d \ln \tau} = \sum_i \left(\frac{v_{irt}}{v^c_{krt}} \right) \left(\beta^p_{ir} + \beta^q_{ir} [1 - u^c_{krt} / p_{irt}] \right).$$

[19] A potential complication in interpreting unit value pass-through is the possibility that tariffs lead to an endogenous shift in quality towards higher priced goods: those goods that are able to maintain profitability when tariffs are present (Metzler 1949; Ludema and Yu 2016; Chen and Juvenal 2016; Freitag and Lein 2023). We provide a number of robustness checks in Section 4.3 to argue that our empirical findings regarding exit, entry, and product turn-over are inconsistent with this mechanism within the setting considered here.

We define $\beta^p_{irt} = d\ln p_{irt}/d\ln\tau$ as the within-barcode tariff price elasticity and $\beta^q_{irt} = d\ln q_{irt}/d\ln\tau$ the within-barcode tariff quantity elasticity. Consider first the role of the weights v_{irt}/v^c_{krt} in shaping tariff pass-through. To the extent that tariff pass-through is negatively or positively correlated with expenditure shares, a simple unweighted mean estimate of β^p could exhibit bias in either a positive or negative direction. That is, an unweighted estimate of tariff pass-through at the barcode level implicitly assumes zero covariance between market shares and tariff pass-through across barcodes within narrow product categories. This assumption is worrisome given an extensive literature documenting—and theoretically motivating—the possibility of heterogeneous pass-through by market share (Atkeson and Burstein 2008; Amiti et al. 2016; Alviarez et al. 2023).

In addition, tariffs may shift sales towards more or less expensive barcodes, which is captured by the quantity tariff elasticity β^q_{ir} multiplied by the relative price of a given barcode when compared to the average unit values within that kr pair. In practice, we do not find much evidence for this second channel. The key takeaway from this simple exercise, however, is that even within the set of continuing barcodes, in the absence of quantity sales data the unit value tariff elasticity is equivalent to the barcode-specific price elasticity only when pass-through is uncorrelated with market shares $cov[v_{irt}, \beta^p_{ir}] = 0$ and the quantity elasticity of tariffs are uncorrelated with initial prices $cov[p_{irt}, \beta^q_{ir}] = 0$.[20] We provide evidence below that this first assumption does not hold and is empirically relevant for understanding tariff pass-through into retail prices.

We turn now to providing these various decompositions of the unit value tariff elasticity of 43.5% documented in Section 3.

4.2 Pass-through Heterogeneity by Barcode Tenure

This section provides unit value pass-through estimates associated with the balanced and unbalanced panel of underlying barcodes. The balanced panel is constructed using only those barcode-retailer pairs which exhibit non-zero sales in all months of 2016-2020. When estimating tariff pass-through and quantity elasticities for the aggregate unbalanced panel, we

[20] In this case, it is easy to show that $d\ln u^c_{krt}/d\ln\tau = \bar{\beta}^p$, where $\bar{\beta}^p$ is the constant pass-through value associated with all barcodes.

again restrict our observations to only those $fcjr$ quadruplets with non-zero balanced panel expenditure, such that the observations recorded below are identical for the "unbalanced" and "balanced" panel estimates. The terms "balanced" and "unbalanced" instead refer to the underlying set of barcodes used to construct these aggregated measures.

Table 2 provides these estimates for the wave 3 tariffs, with columns (2) and (4) simply repeating the aggregate unit value pass-through estimates documented in Table 1. Columns (1) and (3) provide estimates associated with the balanced panel, which are considerably smaller in magnitude, although similar in direction and significance, as the unbalanced panel estimates. Specifically, we recover unit value pass-through within the continuing set of barcodes of 0.106 (0.025) with a quantity tariff elasticity of -0.262 (0.098). When compared to the unbalanced panel estimates of, respectively, 0.435 (0.140) and -0.610 (0.176), it is clear that pass-through into continuing barcode unit values do not capture the majority of the associated change in unit values across all barcodes. Indeed, the aggregate pass-through elasticity is not only over four times larger than the pass-through into continuing product unit value, these estimates are statistically distinguishable from each other at 99% confidence levels. Figure A.3 provides event study figures and confirms that this discrepancy is not due to differential pre-trends. Similarly, Figure A.4 finds a significant discrepancy between event study estimates for the unbalanced and balanced panel for categories associated with the wave 4a tariffs, with the same pattern emerging: continuing product unit values exhibit considerably smaller pass-through estimates when compared to the aggregate unit values, which incorporate product entry and exit.

4.3 Product Replacement and "Shrink-flation"

This section further decomposes tariff-induced price changes in unit values by barcode tenure into changes in the "sticker price", or unadjusted price per barcode purchased, and a change in the average size of barcodes within a given firm-category-country-retailer quadruplet. That is, we replace the dependent variable in our triple-difference estimating equation—Equation 1—with the "sticker price" unit value $\ln \tilde{u}_{krt}$ and the average package size $\ln w_{krt}$. We then compare estimates of β across the these two variables for the continuing set of barcodes and the unbalanced set of barcodes. As always, we also estimate this triple-difference identifica-

Table 2: Tariff Pass-through into Unit Values by Barcode Tenure

	(1)	(2)	(3)	(4)
	Log Unit Value		Log Quantity	
$\log(1+\tau)$	0.106***	0.435***	-0.262**	-0.610***
	(0.025)	(0.140)	(0.098)	(0.176)
Balanced	✓		✓	
Unbalanced		✓		✓
Fixed Effects	✓	✓	✓	✓
R^2	1.00	1.00	0.98	0.98
Observations	4,291,413	4,291,413	4,291,413	4,291,413

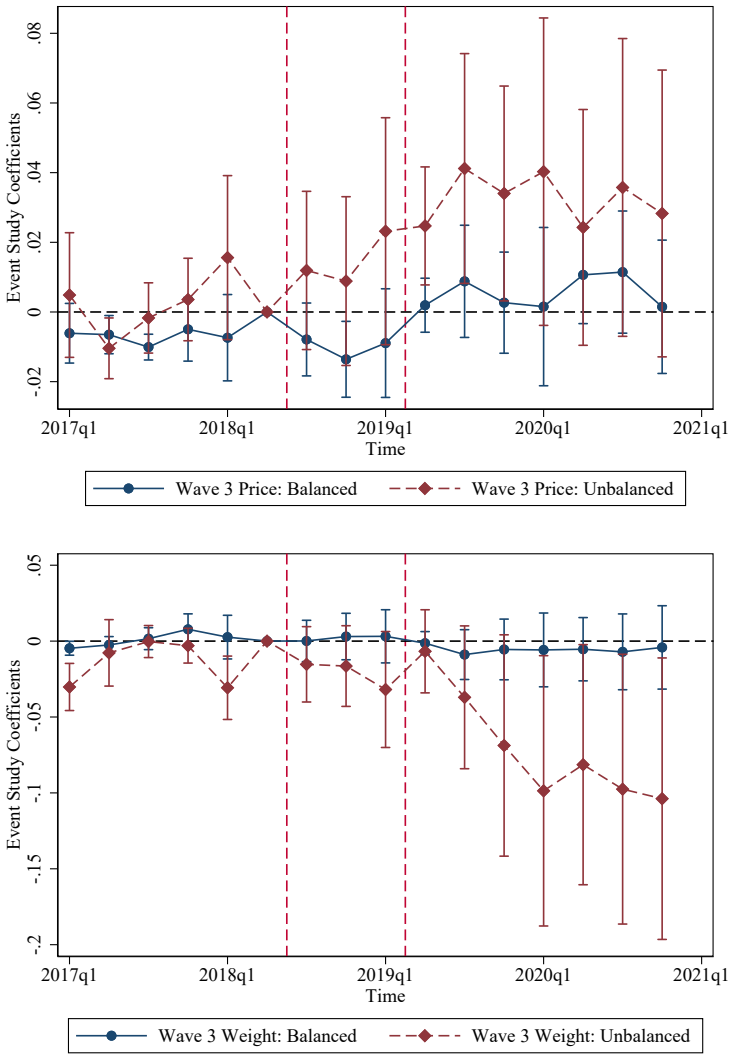
*Notes: This table provides estimates of β from applying OLS to Equation 1. Data are aggregated to the firm-category-country-retailer level. All models include fixed effects by firm-country-category-retailer, retailer-month, category-month, and country-month. Columns (1) and (3) construct unit values and quantities sold using a balanced panel of underlying barcodes with non-zero expenditure in all periods between 2017 and 2020 for each $fcjr$ quadruplet. Columns (2) and (4) construct measures using the raw unbalanced panel of all barcodes recording any sales in a given period. Only $fcjr$ quadruplets with a non-empty set of continuing barcodes are included in estimation, such that both samples have the same observations. Standard errors are clustered three-way at the category, country, and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

tion strategy as an event study design, as outlined in Equation 2. Figure 4 provides these event study figures, with the blue circle series denoting estimates associated with the continuing set of barcodes, and the red diamond series denoting estimates associated with the unbalanced set of barcodes. The upper panel provides "sticker price" unit values, whereas the lower panel provides average weight estimates.

As shown in the upper panel of Figure 4, average sticker prices increased for the continuing set of barcodes, but only after the additional tariff change to 27.5% in May, 2019, and only by a modest amount. The tariff-induced increase in average sticker prices associated with the unbalanced panel of barcodes exhibits a clear positive response to both tariff changes, with relative prices stabilizing between three and four percentage points higher than the control group after the second tariff change. When placed within the context of the decomposition provided earlier, we therefore have evidence of a modest positive magnitude associated with $\partial \ln \tilde{u}_{krt} / \partial \ln \tau$ and a smaller, albeit positive, magnitude associated with $\partial \ln \tilde{u}^c_{krt} / \partial \ln \tau$. Recall from Figure 3, however, that aggregated unit values in the unbalanced panel increased by as much as 12 percentage points after the second tariff change.

The bottom panel of Figure 4 highlights the role of changes in the denominator of unit

Figure 4: Event Study Estimates for Unit Value Pass-through Decomposition



Notes: This figure provides estimates associated with an event study design at the aggregated firm-country-category-retailer level. All models include fixed effects by firm-country-category-retailer, retailer-month, category-month, and country-month. The dependent variable in the upper panel is $\tilde{u}_{krt}$, expenditure per barcode purchase counts, and in the lower panel the dependent variable is w_{krt}, the average package size of barcodes purchased. All estimates are associated with wave 3 categories as treated and never-tariff categories as control. Red diamonds denote estimates using the entire sample of underlying barcodes; blue circles denote estimates associated with the continuing set of barcodes. Vertical lines denote tariff changes. 95% confidence intervals included, with standard errors are clustered three-way at the category, country, and month level..

values, or average weight, in shaping the increase in unit values for the unbalanced panel illustrated in Section 3. As expected, the continuing set of barcodes show no appreciable change in the average size of barcodes sold post-tariff change, as the set of barcodes is unable

to change and a given barcode's weight is fixed.[21] However the unbalanced panel provides a striking negative trend which begins immediately following the first change in tariffs in September 2018, but intensifies considerably after the second tariff increase in May 2019. By the first quarter of 2020, the average package size of barcodes sold in the unbalanced panel had decreased by ten percentage points when compared to Chinese barcodes in non-tariff categories. In all cases, and in particular for the estimates of average package size, pre-trends are remarkably flat, suggesting that these outcomes are attributable specifically to the import tariffs applied to these goods.

Table 3 then provides the triple-difference estimates associated with these event studies. Columns (1) and (2) simply re-iterate the unit value pass-through estimates associated with, respectively, the balanced and unbalanced panels, as in Table 2. Columns (3) and (4) provide equivalent estimates but for the average sticker price, or price per barcode purchased, with the balanced panel exhibiting a sticker price tariff elasticity of 0.069 (0.034) and the unbalanced panel exhibiting a sticker price elasticity of 0.151 (0.061). Compared to the aggregate unit value elasticities, changes in the average price per barcode purchase account for approximately two thirds of the continuing barcode unit value tariff elasticity, and one third of the unbalanced barcode unit value tariff elasticity.

Columns (5) and (6) provide the first clear evidence to date that a remarkable share of tariff pass-through into unit values was in fact achieved by an endogenous decrease in the average package size of goods sold in tariff-affected categories of imports. Specifically, the tariff elasticity of average package size for the continuing set of barcodes is indistinguishable from zero at -0.037 (0.032) while the tariff elasticity of average package size for the unbalanced set of barcodes is -0.284 (0.151), and distinguishable from zero at 90% confidence levels. To put these estimates in context, a 10% tariff increase generates a 2.84% decrease in average package size. This decrease in package size contributed over two thirds of the aggregate effect of these tariffs on average unit values.

The null estimate associated with the continuing set of barcodes suggests that this effect is not attributable to consumer substitution in the face of increasing prices, but rather the

[21] We confirm via the barcode provider GS1 that any change (increase or decrease) to the legally-required declared net content that is printed on the pack, requires assignment of a new GTIN, or barcode, such that there could not be changes in average size occurring within the continuing set of barcodes.

Table 3: Decomposition of Unit Value Pass-through by Barcode Tenure

	(1)	(2)	(3)	(4)	(5)	(6)
	Log Unit Value		Log Sticker Price		Log Average Size	
$\log(1+\tau)$	0.106***	0.435***	0.069**	0.151**	-0.037	-0.284*
	(0.025)	(0.140)	(0.034)	(0.061)	(0.032)	(0.151)
Balanced	✓		✓		✓	
Unbalanced		✓		✓		✓
Fixed Effects	✓	✓	✓	✓	✓	✓
R^2	1.00	1.00	0.99	0.98	1.00	1.00
Observations	4,291,413	4,291,413	4,291,413	4,291,413	4,291,413	4,291,413

*Notes: This table provides estimates of β from applying OLS to Equation 1. Data are aggregated to the firm-category-country-retailer level. All models include fixed effects by firm-country-category-retailer, retailer-month, category-month, and country-month. Columns (1), (3), and (5) construct unit values and quantities sold using a balanced panel of underlying barcodes with non-zero expenditure in all periods between 2017 and 2020 for each $fcjr$ quadruplet. Columns (2), (4) and (6) construct measures using the raw unbalanced panel of all barcodes recording any sales in a given period. Only $fcjr$ quadruplets with a non-empty set of continuing barcodes are included in estimation, such that both samples have the same observations. Columns (1) and (2) estimate pass-through into unit values. Columns (3) and (4) estimate pass-through into "sticker prices", which is total expenditure divided by the un-adjusted number of units sold: $\tilde{u}_{krt} = v_{krt}/\tilde{q}_{krt}$. Columns (5) and (6) estimate tariff elasticities of average package size. Standard errors are clustered three-way at the category, country, and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

endogenous change in varieties offered, due to exit and/or entry.

Replacement bias versus endogenous quality changes. The previous results provide evidence that even within narrow definitions of product—specific firms selling narrow product modules from a given country and at a specific retail chain—produce turnover led to a significant increase in the unit values associated with tariff-affected goods, primarily via a decrease in average package size. Indeed, we find that two thirds of all unit value increases associated with this tariff change are attributable to this mechanism. These results are in line with the produce replacement bias described in Nakamura and Steinsson (2011), who find that firms tend to replace products with new, more expensive, alternatives, rather than increasing prices within a continuing product.

Whether or not this observation should be considered welfare-relevant for understanding tariff pass-through remains a first-order concern in this setting. A clear benefit to measuring tariff pass-through within continuing products—as in Flaaen et al. (2020) and Cavallo et al. (2021)—is that the researcher can clearly observe some counterfactual pre-tariff price

associated with each barcode. The fact that for entering barcodes we have no clear pre-tariff counterfactual price is therefore worrisome, as we may be conflating endogenous changes in the set of products sold with genuine tariff pass-through via product replacement.[22] This observation is particularly salient within the literature on tariff pass-through as a number of papers have highlighted the role of endogenous quality changes in generating unit value pass-through purely via composition effects (Metzler 1949; Ludema and Yu 2016; Chen and Juvenal 2016; Freitag and Lein 2023). Specifically, if tariffs leads to an endogenous exit of low-quality, or low-price, products, then the measured unit value may endogenously increase for a given category of goods even in the absence of any true tariff pass-through.

Measuring the characteristics of entering and exiting goods over time within the context of Equation 1 is challenging, as entry and exit often do not occur within a given unit of observation for a given period. We therefore transition to a long-difference estimation strategy in which we take the set of firm-module-country-retailer observations present in Q4 of 2017, prior to any tariff change, and Q4 of 2019, prior to the onset of the covid-19 pandemic, and calculate a long difference $\Delta \ln y_{kr}$ across a number of measures y_{kr}. We then regress this long-difference on a simple indicator for whether or not this kr observation was targeted by wave 3 tariffs alongside category, country, and retailer fixed effects. Equation 3 provides our empirical specification, to which we apply OLS:

$$\Delta \ln y_{kr} = \beta^{LD} \mathbf{1}[\Gamma_k = 1] + \alpha_c + \alpha_j + \alpha_r + \epsilon_{kr}^{LD}. \tag{3}$$

Notice that this specification mimics the triple-difference identification strategy from Equation 1 but with the level fixed effects removed via the first-difference over time. As in Equation 2, Γ_k denotes an indicator for whether a given firm-country-category pair is treated by a wave 3 tariff.

Table 4 provides estimates associated with this regression across a number of different dependent variables. First, we consider the share of all barcodes which exit and enter. That is, if N_{kr} denotes the initial count of barcodes present in Q4 of 2017, and N_{kr}^{EX} the count of

[22] It should be noted that firms may rely on product replacement bias as a means of increasing prices for the very same reason: it is difficult for consumers to compare the new, more expensive, product directly to the cheaper products which were offered prior to the tariff change and subsequently dropped from store shelves.

Table 4: Entry and Exit Composition as a Long Difference

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\Delta \ln N_{kr}$		$\Delta \ln v_{kr}$		$\Delta \ln q_{kr}$		$\Delta \ln w_{kr}$	
Wave 3	0.168***	0.413***	0.292***	0.098	0.296***	-0.046	0.028	-0.203***
	(0.032)	(0.068)	(0.107)	(0.193)	(0.104)	(0.189)	(0.020)	(0.049)
Constant	-0.606***	-0.886***	-1.547***	-1.939***	-1.516***	-1.969***	-0.043***	-0.030***
	(0.002)	(0.004)	(0.007)	(0.012)	(0.007)	(0.012)	(0.001)	(0.003)
Exit	✓		✓		✓		✓	
Enter		✓		✓		✓		✓
Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.14	0.14	0.11	0.10	0.11	0.10	0.05	0.08
Observations	105,849	54,250	105,849	54,250	105,849	54,250	105,849	54,250

*Notes: This table provides estimates of the long-difference change in product entry and exit characteristics. Data are aggregated to the firm-retailer-category-country level, and estimated as a cross-section with each observation a within firm-retailer-category-country long difference between Q4 of 2019 and Q4 of 2017. Columns (1), (3), and (5) provide estimates of the relative difference in the exiting share of barcodes for tariff-affected products versus control products. Column (1) is the raw exiting barcode count share, column (3) the expenditure share of exiting barcodes, and column (5) the raw sales quantity share of exiting barcodes. Columns (2), (4), and (6) provide equivalent estimates but for barcodes which entered during the long difference. Column (7) provides the average weight of exiting barcodes, relative to the initial average weight in Q4 2017, and Column (8) the average weight of entering barcodes, again relative to the initial baseline. All models include category, country, and retailer fixed effects. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

barcodes which are present in Q4 of 2017 but not in Q4 of 2019, we define $y_{kr} = N_{kr}^{EX}/N_{kr}$ as the share of exiting barcodes within a given firm-category-country-retailer observation. We provide the same measure but for entering barcodes, again normalizing by the initial number of barcodes within kr. Columns (1) and (2) of Table 4 provide these estimates for, respectively, exiting and entering barcodes.

We find, perhaps unsurprisingly, that the exiting share of barcodes in tariff-affected units is 17% greater than for non-tariff units. This is in line with an extensive literature documenting the extensive margins of international trade. Surprisingly, however, we also find that tariff-affected units exhibit considerably higher entry than non-tariff units, with entry shares that are on average, 41% greater in tariff-affected units versus non-tariff units. When we replace the variety count share with expenditure or quantity shares, we again find that tariff-affected units exhibit elevated exit when compared to non-tariff units (columns (3) and (5)). For entry, however, we find no effect of tariffs on the expenditure share of entering goods or the quantity sales share of entering goods (columns (4) and (6)). Thus, entry is elevated in tariff-affected units but consists of varieties with lower expenditure per

barcode than non-tariff units, whereas exit in tariff-affected units is higher than non-tariff units and is biased towards varieties with higher expenditure than in non-tariff units.

Crucially, in columns (7) and (8) we find no evidence that exiting varieties for tariff-affected categories exhibit differential average product size than non-tariff units, whereas entering barcodes in tariff-affected units are, on average, 20% smaller than the varieties which enter into non-tariff units. Taken together, Table 4 provides evidence that while exit rates are elevated by tariffs, these tariff-specific exit rates do not appear to be particularly correlated with product size. If anything, exiting varieties in tariff-affected categories are higher quality than in non-tariff units, as the expenditure per barcode associated with exiting varieties is higher when tariffs are applied. Entry, however, is substantially higher in tariff-affected units and this entry is specifically associated with barcodes which are smaller than the entering barcodes into non-tariff units. This decomposition is crucial for arguing that the average package size effects documented here, and therefore the bulk of pass-through into unit values, is difficult to attribute to endogenous changes in quality, as it suggests that exit was not particularly driven by product size while entry was both elevated and concentrated in smaller products.

The differential sample size for entering and exiting varieties exhibited in Table 4 reflects the fact that not all kr units of observation exhibited both entry and exit. As a robustness check, Table A.3 re-estimates all elements of Table 4 but for the set of kr units with both entry and exit. Sample size is reduced to approximately 35 thousand, but the same story emerges: tariffs are associated with elevated entry (+19.6%) of low-expenditure barcodes with much smaller size (−30.5%) than in non-tariff units, whereas exit is uncorrelated with product size (+1.9%). Table A.4 maintains this balanced entry and exit estimating sample while further imposing fixed effects at the firm-category level. We again find elevated entry (+81.8%) associated with smaller products (−18.2%). In this specification, the effect of tariffs on exit are positive but muted, and concentrated in products of larger size. Thus, even within narrow firm-category pairs, differential tariff changes led to differential shifts in the size of products offered, with entry effects driving the overal downward shift in product size of tariff-affected products.

4.4 Barcode-Level Pass-through

Finally, we make use of our barcode-level data to estimate tariff pass-through within barcodes, thereby providing a comparison to the existing retail pass-through literature (Flaaen et al. 2020; Cavallo et al. 2021) and providing a means of comparison with the retail unit value elasticities discussed thus far. The unit of observation throughout is a barcode-retailer pair, such that estimates of pass-through are measured within this same unit of observation.

Empirical Model: We again implement a triple-difference identification strategy reminiscent of the aggregated triple-difference strategy in Equation 1, except now at the barcode-retailer level. That is, we compare barcodes produced in China to non-Chinese goods within the same product category and compare this difference across targeted and non-targeted categories before and after tariffs were implemented, all within the same retail chain. Consider some outcome associated with barcode i at retail chain r in month t, y_{irt}. Equation 4 provides our triple-difference estimating equation at this level of disaggregation, with β capturing the effect of changes in tariffs on outcome y_{irt} at the barcode-retailer level.

$$\ln(y_{irt}) = \beta \ln(1 + \tau_{j(i)c(i)t}) + \alpha_{irt} + \gamma_{i,q(t)} + \epsilon_{irt} \tag{4}$$

α_{irt} denotes a vector of fixed effects, such that:

$$\alpha_{irt} = \alpha_{ir} + \alpha_{rt} + \alpha_{m(i),t} + \alpha_{j(i),t}$$

This specification replicates the triple-difference identification strategy outlined in Section 3, with the vector $\gamma_{i,q(t)}$ again capturing seasonality controls, as defined earlier. We focus on two primary outcomes of interest at the barcode-retailer pair level: price and total quantity of units sold. We also employ an event study design similar to Equation 2, but at the ir level of observation.

Results: We first provide estimates of barcode-level pass-through for a balanced panel of barcodes. That is, we omit all barcodes which enter or exit the sample during the tariff period, and we restrict our analysis to the continuing set of barcodes. Table 5 provides these

Table 5: Estimates of Tariff Pass-through and Substitution at the Barcode Level

	(1) Log Price	(2) Log Quantity	(3) Log Price	(4) Log Quantity
$\log(1+\tau)$	0.136***	-0.235***	0.112***	-0.361***
	(0.034)	(0.081)	(0.040)	(0.043)
Sample			<2020	<2020
Fixed Effects	✓	✓	✓	✓
R^2	1.00	0.97	1.00	0.98
Observations	1.54e+07	1.54e+07	1.16e+07	1.16e+07

*Notes: This table provides estimates of β from applying OLS to Equation 4. Columns (1) and (2) use the entire sample of observations, with column (1) documenting price pass-through and column (2) the tariff substitution elasticity within barcodes. Columns (3) and (4) provide the same estimates, respectively, but with 2020 excluded from the sample. All estimates are associatd with the continuing panel of balanced barcodes. Standard errors are clustered three-way at the category, country, and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

estimates.

Table 5 is organized identically to Table 1, except estimates are now interpreted as within-barcode. Columns (1) and (2) provide estimates of tariff pass-through and substitution for the entire estimating sample, and columns (3) and (4) provide the same respective estimates but with 2020 excluded. We maintain columns (1) and (2) as our preferred estimates, although the pass-through estimates we recover are indistinguishable between the two estimating samples.

Our estimate in column (1) of $\beta = 0.136$ (0.034) implies pass-through of tariffs into retail prices of 13.6%. When 2020 is excluded, this estimate decreases to 0.112 (0.040). We therefore recover barcode-specific average pass-through rates of 13.6% for the balanced panel of barcodes, which is reassuringly similar to our earlier estimate of 10% associated with the unit values of continuing barcodes (Table 2).

Reassuringly, we find no evidence of pre-trends associated with the price pass-through estimates described in Table 5. Figure A.5 and Figure A.6 in Appendix A.2 illustrate these event study plots for prices and quantities and across both tariff waves. Quantity tariff elasticities at the barcode level are -0.235 (0.081) for our entire sample period amd -0.361 (0.043) when excluding 2020. For estimates associated with the entire sample, we therefore recover an implied price elasticity of 1.73, which is larger than the implied price elasticity of unit values: 1.40.

Table 6: Estimates of Tariff Pass-through and Substitution at the Barcode Level by Tenure

	(1)	(2)	(3)	(4)
	Log Price		Log Quantity	
$\log(1+\tau)$	0.136***	0.001	-0.235***	-0.689***
	(0.034)	(0.045)	(0.081)	(0.184)
Balanced	✓		✓	
Unbalanced		✓		✓
Fixed Effects	✓	✓	✓	✓
R^2	1.00	1.00	1.00	1.00
Observations	15393284	43819632	15393284	43819632

*Notes: This table provides estimates of β from applying OLS to Equation 4. Columns (1) and (2) provide estimates of, within-barcode pass-through for respectively, the balanced and unbalanced panel of barcodes. Columns (3) and (4) provide the same respective estimates but for the the within-barcode quantity tariff elasticity. Standard errors are clustered three-way at the category, country, and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

Table 6 provides barcode-level estimates by product tenure, similar to Table 2 when discussing unit value pass-through. When compared to the balanced panel of barcodes, the unbalanced panel exhibits pass-through estimates that are almost exactly zero, and precisely estimated. Specifically, we recover within-barcode pass-through estimates for the unbalanced panel of 0.001 (0.045). The within-barcode quantity tariff elasticity, however, represents the largest magnitude of substitution throughout our results, at −0.689 (0.184). The implied price elasticity of these unbalanced within-barcode estimates is implausibly large, suggesting that retailers purposefully kept prices low for barcodes that eventually exited the market, while managing to reduce inventory by increasing sales dramatically.[23]

This result is reassuring in that it confirms the role of product turnover in shaping the larger pass-through estimate for the unbalanced panel documented in Section 4.2: this discrepancy is not due to the unbalanced panel of barcodes simply exhibiting larger within-barcode pass-through than the balanced panel. Indeed the opposite is true: the unbalanced panel of barcodes exhibit precisely zero pass-through. Incorporating all estimates of pass-through recorded up to this point, we recover a striking image of how the typical U.S. consumer would interact with tariff-induced price changes. If a consumer had selected a

[23]Our null pass-through results in the unbalanced panel draws an interesting parallel with the null estimate found by Cavallo et al. (2021) who, to the best of our knowledge, similarly estimate pass-through within products using an unbalanced panel of barcode-retailer pairs. Our empirical specification differs from Cavallo et al. (2021), which we describe in greater detail in Appendix B.3.

random unbalanced panel of barcodes and recorded within-barcode price changes throughout this tariff episode, they would recover exactly zero tariff pass-through. If they instead focused their efforts on a continuing panel of barcodes, they would recover pass-through of 14%. If they recovered the sales-weighted average price per barcode, such that they interpreted sticker prices as the object of interest, they would recover pass-through of 15%. Finally, if they recorded the average price per unit weight of barcodes sold they would recover pass-through estimates of 44%.

To ensure that the relatively low barcode-level estimates recorded here are credible, we consider a number of robustness checks, including accounting for the possibility of endogenous spillover effects to prices of non-targeted barcodes, tariff "smoothing" by retailers across products, and the effect of tariffs on intermediate goods leading to cost shocks for domestically produced goods. Section B.2 in Appendix B provides detailed descriptions and results for these various robustness exercises: we find no evidence of effects which would suggest that low barcode-level estimates described here are the result of downward bias.

4.5 Heterogeneity in Tariff Pass-through

We now move on to study heterogeneity in pass-through across product and retailer characteristics. In particular, we evaluate the extent to which heterogeneous pass-through by product or retailer market share might lead to a gap between estimates of pass-through within barcodes and estimates of pass-through into average unit values, even in the absence of composition effects.

The key motivation for this exercise is the substantial literature both theoretically grounding, and empirically documenting, heterogeneous pass-through according to market structure and product-specific market power (Atkeson and Burstein 2008; Amiti et al. 2016; Alviarez et al. 2023). In general, these papers either confirm or predict that pass-through should be decreasing in market power, as these firms can reduce mark-ups in order to gain a greater share of the market, whereas small firms are constrained to charging a fixed mark-up over marginal costs. Alviarez et al. (2023), however, suggest that nuance is also needed when mapping pass-through across bilateral buyer-seller relationships, such that both buyer and seller power play a role in shaping the pass-through which occurs when the seller faces a cost

shock.

In constructing market shares, we can consider three separate definitions of buyer/seller power. In all cases, we use expenditure shares in 2017 to define each measure. First, we define barcode market shares as the within-category expenditure share of a given barcode. Second, we define the seller share, or firm share, of a given firm within a given retail chain as the share of revenue accruing to retailer r generated by sales associated with firm f. Finally, we consider the buyer share, of retailer share, of a given retailer within a given firm, which we define as the share of all revenue accruing to a given firm which is generated within a given retail chain.

While Chinese barcodes are more concentrated in the lower market share bins, the distributions overlap considerably. 87% of all expenditure on Chinese barcodes is concentrated in the lowest quintile of market share, which hosts 30% of all Chinese barcodes. At the high end of the distribution, 1.6% of all Chinese barcodes are in the highest market share quintile, but these barcodes account for 14% of all expenditure on Chinese barcodes.

Table A.5 provides estimates of tariff pass-through and substitution by barcode market share. We estimate pass-through elasticities which are increasing in market share, with each MS_i denoting elasticity estimates associated with barcodes in the i tercile of 2017 market share. From low to high market share, we recover pass-through estimates of 10.4%, 20.8%, and 23.2%, respectively. Interestingly, tariff quantity elasticities exhibit the reverse pattern, with tariff substitution largest for barcodes in the lowest market share tercile, despite these barcodes exhibiting the lowest level of tariff pass-through.

While tariff pass-through into prices depends on the superelasticity of the demand system, the substitution effect on quantities depends largely on the initial level of the demand elasticity. The results therefore suggest that a larger substitution effect for low market share goods is the result of a very high initial demand elasticity of low market share barcodes – so high that it overcompensates the smaller increase in prices. Taking our results on prices and quantities together, our results are therefore consistent with Atkeson and Burstein (2008) in the ranking of demand elasticities across market shares (low market share goods have higher elasticities), but inconsistent in the ranking of superelasticities, as our price results suggest that the demand elasticity of high market share products is less elastic, leading to higher

pass-through.

We then turn to understanding how pass-through varies by firm and retailer bargaining power via the buyer and seller shares described earlier. For example, Alviarez et al. (2023) build a model of two-sided bargaining according to which pass-through should be increasing in the firm share of retailer sales, and decreasing in the retailer's share of firm sales. Figure A.7 plots the distribution of these two bilateral variables in the data in 2017. The blue bars highlight that the vast majority of firms are small relative to retailers: In roughly 80% of all firm-retailer relationships, the firm accounts for less than 0.1% of total retailer sales, and in almost all firm-retailer relationships the firm accounts for less than 1% of retailer sales. This illustrates that there is not much variation in the data to estimate the effect of different firm shares in retailer sales. In contrast, many retailers account for a sizable share of firm sales: In roughly half of all firm-retailer relationships, the retailer accounts for more than 1% of firm sales, and in almost 15% of cases for more than 10%.

We then test for this mechanism in Table 7. Column (1) uses a linear interaction with the log tariff and the bilateral sales shares, while column (2) defines this interaction using dummy variables for whether or not a given share is higher than the median. While the linear interaction estimates are noisy and likely biased by large outliers, the dummy variable estimates in column (2) provide a clear interpretation for the role of buyer and seller power in shaping tariff pass-through within barcodes.

Consistent with existing evidence, we document a positive effect of firm seller power on barcode-level pass-through estimates (Atkeson and Burstein 2008; Amiti et al. 2016; Alviarez et al. 2023). Specifically, for a barcode sold by a below-median firm at a below-median retailer, pass-through is 16.7%. For an above-median firm at a below-median retailer, pass-through is 25.0%. However we also document a strong dampening effect of buyer power on barcode-level pass-through, with a below-median firm pass-through that is effectively null when sold at an above-median retailer. When both the firm and retailer are above-median, pass-through is only 8.7%. We therefore match the intuition described in Alviarez et al. (2023): monopoly power exercised by relatively large sellers leads to greater pass-through into barcode-level prices whereas monopsony power exercised by relatively large buyers leads to lower pass-through.

Table 7: Bilateral Sales Shares and Tariff Pass-Through

	(1)	(2)
	Log Price	
$\log(1+\tau)$	0.166***	0.167***
	(0.037)	(0.033)
$\log(1+\tau)\times$ Firm Share in Retailer	0.407	
	(0.824)	
$\log(1+\tau)\times$ Retailer Share in Firm	-0.226***	
	(0.039)	
$\log(1+\tau)\times$ High firm share in retailer sales		0.083***
		(0.018)
$\log(1+\tau)\times$ High retailer share in firm sales		-0.163***
		(0.004)
Fixed Effects	✓	✓
R^2	0.998	0.998
Observations	15083496	15083496

*Notes: This table provides estimates associated with interactions between the tariff rate and two measures of market power: a firm's expenditure share within a given retail chain, and a retailer's share of expenditure within a given firm. Column (1) interacts these two market shares linearly, whereas column (2) interacts tariff changes with dummy variables for these respective shares being above median. Standard errors are clustered three-way at the category, country, and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

Finally, in Table A.6 we estimate the same relationship between pass-through, firm, and retailer shares, using the aggregated unit value estimates of pass-through, as in Section 3. We document the same general pattern, with above-median firms able to generate higher levels of tariff pass-through and larger retailers able to dampen aggregate tariff pass-through. Interestingly, we find that for below-median firms selling products at below-median retailers, the barcode-level estimates and unit values estimates of tariff pass-through are identical at approximately 17%. The effect of product turn-over in shaping pass-through is particularly pronounced for above-median firms, for which pass-through into unit values is 44 percentage points higher than below-median firms, conditional on retailer size. We therefore provide evidence that while the magnitudes vary, both within-product pass-through and pass-through into unit values are increasing in firm seller power and decreasing in retailer buyer power.

5 Conclusion

This paper provides novel evidence regarding the pass-through and substitution effects of U.S. import tariffs applied to Chinese consumer goods exports during the 2018-2019 U.S.-China trade war. While existing evidence suggests a puzzle, in that tariffs were fully passed through into border prices with little effect on retail prices, we show that in fact such a discrepancy in estimates does not necessarily imply zero pass-through to U.S. consumers. We show that product replacement bias—the replacement of products with higher price per unit weight alternatives—was the predominant mechanism whereby these import tariffs were passed through to U.S. consumers, such that pass-through estimates within a given barcode might be zero while pass-through into unit values was 43.5%. We provide evidence, building on Berger et al. (2012), Sangani (2025), and Flaaen et al. (2025), that post-tariff margins associated with mark-ups and/or intra-national distribution and retailing costs suggest that 43.5% pass-through into retail prices is entirely consistent with full pass-through into border prices. Thus, we conclude that U.S. consumers bore the entirety of tariff incidence associated with these import tariffs.

Finally, we shed light on the heterogeneous effects of tariffs across barcodes, firms, and retailers, according to buyer and seller power within these producer-retailer relationships. We document increasing pass-through for higher market share barcodes and higher pass-through for firms which constitute a relatively large share of expenditure within a given retailer. Retailers which constitute a relatively large share of expenditure within a given firm, however, dampen the level of pass-through, and we confirm both buyer and seller effects in the barcode-level estimates of pass-through and unit value estimates of pass-through.

We therefore provide evidence that considerable nuance is needed when comparing estimates of pass-through across differing levels of product aggregation. Changes in the composition of underlying barcodes lead to endogenous changes in unit values which are not captured when estimating within-product pass-through. Whether or not unit values elasticities reflect price changes that are relevant to welfare will depend on the context in question, but future work must take seriously this consideration.

References

Alviarez, Vanessa I, Michele Fioretti, Ken Kikkawa, and Monica Morlacco, "Two-sided market power in firm-to-firm trade," Technical Report, National Bureau of Economic Research 2023.

Amiti, Mary, Oleg Itskhoki, and Jozef Konings, "International Shocks, Variable Markups, and Domestic Prices," *The Review of Economic Studies*, 2016, *86* (6), 2356–2402.

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

Anderson, James E and Eric Van Wincoop, "Trade costs," *Journal of Economic literature*, 2004, *42* (3), 691–751.

Atkeson, Andrew and Ariel Burstein, "Pricing-to-market, trade costs, and international relative prices," *American Economic Review*, 2008, *98* (5), 1998–2031.

Bai, Liang and Sebastian Stumpner, "Estimating US consumer gains from Chinese imports," *American Economic Review: Insights*, 2019, *1* (2), 209–24.

Basker, Emek and Pham Hoang Van, "Imports "R" Us: Retail Chains as Platforms for Developing-Country Imports," *American Economic Review*, 2010, *100* (2), 414–18.

_ , Shawn Klimek, and Pham Hoang Van, "Supersize it: The growth of retail chains and the rise of the "Big-Box" store," *Journal of Economics & Management Strategy*, 2012, *21* (3), 541–582.

Benguria, Felipe, Jaerim Choi, Deborah L Swenson, and Mingzhi Jimmy Xu, "Anxiety or pain? The impact of tariffs and uncertainty on Chinese firms in the trade war," *Journal of International Economics*, 2022, *137*, 103608.

Berger, David, Jon Faust, John H Rogers, and Kai Steverson, "Border prices and retail prices," *Journal of international Economics*, 2012, *88* (1), 62–73.

Blanchard, Emily J, Chad P Bown, and Davin Chor, "Did Trump's Trade War Impact the 2018 Election?," *Journal of International Economics*, 2024, *148*, 103891.

Bown, Chad P, "The US–China trade war and Phase One agreement," *Journal of Policy Modeling*, 2021, *43* (4), 805–843.

Broda, Christian and David E Weinstein, "Globalization and the Gains from Variety," *The Quarterly journal of economics*, 2006, *121* (2), 541–585.

Burstein, Ariel T, Joao C Neves, and Sergio Rebelo, "Distribution costs and real exchange rate dynamics during exchange-rate-based stabilizations," *Journal of monetary Economics*, 2003, *50* (6), 1189–1214.

Cavallo, Alberto, Gita Gopinath, Brent Neiman, and Jenny Tang, "Tariff pass-through at the border and at the store: Evidence from us trade policy," *American Economic Review: Insights*, 2021, *3* (1), 19–34.

Chalioti, Evangelia and Konstantinos Serfes, "Shrinkflation," *Economics Letters*, 2024, *244*, 111959.

Charbonneau, Karyne B and Anthony Landry, "The trade war in numbers," Technical Report, Bank of Canada 2018.

Chen, Natalie and Luciana Juvenal, "Quality, trade, and exchange rate pass-through," *Journal of International Economics*, 2016, *100*, 61–80.

Cole, Matthew T and Carsten Eckel, "Tariffs and markups in retailing," *Journal of International Economics*, 2018, *113*, 139–153.

Devereux, Michael B, Charles Engel, and Cédric Tille, "Exchange rate Pass-Through and the welfare effects of the euro," *International Economic Review*, 2003, *44* (1), 223–242.

Eckel, Carsten, "International trade and retailing," 2009.

Evangelidis, Ioannis, "Frontiers: Shrinkflation aversion: When and why product size decreases are seen as more unfair than equivalent price increases," *Marketing Science*, 2024, *43* (2), 280–288.

Faber, Benjamin and Thibault Fally, "Firm heterogeneity in consumption baskets: Evidence from home and store scanner data," *Review of Economic Studies*, 2021.

Fajgelbaum, Pablo D and Amit K Khandelwal, "The economic impacts of the US–China trade war," *Annual Review of Economics*, 2022, *14* (1), 205–228.

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

Feenstra, Robert C, "New product varieties and the measurement of international prices," *The American Economic Review*, 1994, pp. 157–177.

Fetzer, Thiemo and Carlo Schwarz, "Tariffs and politics: Evidence from Trump's trade wars," *The Economic Journal*, 2021, *131* (636), 1717–1741.

Flaaen, Aaron, Ali Hortaçsu, and Felix Tintelnot, "The production relocation and price effects of US trade policy: the case of washing machines," *American Economic Review*, 2020, *110* (7), 2103–27.

Flaaen, Aaron B, Ali Hortaçsu, Felix Tintelnot, Nicolás Urdaneta, and Daniel Xu, "Who Pays for Tariffs Along the Supply Chain? Evidence from European Wine Tariffs," Technical Report, National Bureau of Economic Research 2025.

Freitag, Andreas and Sarah M Lein, "Endogenous product adjustment and exchange rate pass-through," *Journal of International Economics*, 2023, *140*, 103706.

Goldberg, Linda S and José Manuel Campa, "The sensitivity of the CPI to exchange rates: Distribution margins, imported inputs, and trade exposure," *The Review of Economics and Statistics*, 2010, *92* (2), 392–407.

Handley, Kyle, Fariha Kamal, and Ryan Monarch, "Rising import tariffs, falling exports: When modern supply chains meet old-style protectionism," *American Economic Journal: Applied Economics*, 2025, *17* (1), 208–238.

Jaccard, Torsten, "Retailers and Import Penetration: Evidence from US Dollar Stores," 2023.

Ludema, Rodney D and Zhi Yu, "Tariff pass-through, firm heterogeneity and product quality," *Journal of International Economics*, 2016, *103*, 234–249.

Metzler, Lloyd A, "Tariffs, the terms of trade, and the distribution of national income," *Journal of Political Economy*, 1949, *57* (1), 1–29.

Nakamura, Emi and Jón Steinsson, "Price setting in forward-looking customer markets," *Journal of Monetary Economics*, 2011, *58* (3), 220–233.

_ **and** _ , "Lost in transit: product replacement bias and pricing to market," *American Economic Review*, 2012, *102* (7), 3277–3316.

Raff, Horst and Nicolas Schmitt, "Exclusive dealing and common agency in international markets," *Journal of International Economics*, 2006, *68* (2), 485–503.

_ **and** _ , "Buyer power in international markets," *Journal of International Economics*, 2009, *79* (2), 222–229.

_ **and** _ , "Imports and the structure of retail markets," *Canadian Journal of Economics/Revue canadienne d'économique*, 2012, *45* (4), 1431–1455.

_ **and** _ , "Retailing and international trade," *Handbook on the Economics of Retailing and Distribution. Edwar Elgar Publishers, Cheltenham*, 2016, pp. 157–179.

Rotemberg, Julio J, "Customer anger at price increases, changes in the frequency of price adjustment and monetary policy," *Journal of monetary economics*, 2005, *52* (4), 829–852.

Sangani, Kunal, "Complete Pass-Through in Levels," 2025.

A Appendix: Additional Tables and Figures

This section provides additional tables and figures, as described in the main text.

A.1 Additional Tables

Table A.1: Tariff Pass-through and Substitution by Wave

	(1) Log Unit Value	(2) Log Quantity	(3) Log Unit Value	(4) Log Quantity
$\log(1+\tau)$	0.435***	-0.610***	0.357***	-0.460*
	(0.140)	(0.176)	(0.109)	(0.270)
Wave 3	✓		✓	
Wave 4a		✓		✓
Fixed Effects	✓	✓	✓	✓
R^2	1.00	0.98	1.00	0.98
Observations	4,291,413	4,291,413	3,935,998	3,935,998

*Notes: This table provides estimates of β from applying OLS to Equation 1. Data are aggregated to the firm-category-country-retailer level. All models include fixed effects by firm-country-category-retailer, retailer-month, category-month, and country-month. All columns provide results estimated using the unbalanced panel of underlying barcodes. Columns (1) and (2) estimate the effect of Wave 3 tariffs on unit values and quantities, with all Wave 4a categories omitted. Columns (3) and (4) estimate the effect of Wave 4a tariffs on unit values and quantities with all Wave 3 categories omitted. Standard errors are clustered three-way at the category, country, and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Return to Section 3.2.*

Table A.2: Tariff Pass-through into Unit Values Scaled by the Foreign Cost Share

	(1)	(2)	(3)
		Log Price	
$\log(1+\tau)$	0.435***	-0.149	-0.172*
	(0.140)	(0.100)	(0.095)
$\log(1+\tau) \times FCS$		0.813**	
		(0.318)	
$\log(1+\tau) \times FCS$			0.829**
			(0.321)
Fixed Effects	✓	✓	✓
R^2	0.996	0.996	0.996
Observations	4,291,413	3,902,851	3,875,426

*Notes: This table provides estimates of β from applying OLS to Equation 1. Data are aggregated to the firm-category-country-retailer level. All models include fixed effects by firm-country-category-retailer, retailer-month, category-month, and country-month. All columns provide results estimated using the unbalanced panel of underlying barcodes, and only wave 3 and never-treated categories are included. Column (1) provides our baseline estimates. Column (2) interacts the tariff change with the country-category foreign cost share and column (3) interacts the tariff change with the average foreign cost share within a given category. Standard errors are clustered three-way at the category, country, and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Return to Section 3.3.*

Table A.3: Entry and Exit Composition as a Long Difference

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\Delta \ln N_{kr}$		$\Delta \ln v_{kr}$		$\Delta \ln q_{kr}$		$\Delta \ln w_{kr}$	
Wave 3	-0.115*	0.196**	-0.542**	0.006	-0.435**	-0.239	0.019	-0.305***
	(0.067)	(0.090)	(0.216)	(0.253)	(0.210)	(0.245)	(0.048)	(0.063)
Constant	-1.003***	-1.112***	-2.300***	-2.010***	-2.272***	-2.045***	-0.068***	-0.032***
	(0.004)	(0.005)	(0.012)	(0.014)	(0.012)	(0.014)	(0.003)	(0.004)
Exit	✓		✓		✓		✓	
Enter		✓		✓		✓		✓
Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Balance	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.20	0.17	0.21	0.13	0.21	0.13	0.10	0.09
Observations	35,479	35,479	35,479	35,479	35,479	35,479	35,479	35,479

*Notes: This table provides estimates of the long-difference change in product entry and exit characteristics. Data are aggregated to the firm-retailer-category-country level, and estimated as a cross-section with each observation a within firm-retailer-category-country long difference between Q4 of 2019 and Q4 of 2017. Columns (1), (3), and (5) provide estimates of the relative difference in the exiting share of barcodes for tariff-affected products versus control products. Column (1) is the raw exiting barcode count share, column (3) the expenditure share of exiting barcodes, and column (5) the raw sales quantity share of exiting barcodes. Columns (2), (4), and (6) provide equivalent estimates but for barcodes which entered during the long difference. Column (7) provides the average weight of exiting barcodes, relative to the initial average weight in Q4 2017, and Column (8) the average weight of entering barcodes, again relative to the initial baseline. Only kr pairs with both non-zero entry and exit are included. All models include category, country, and retailer fixed effects. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Back to Section 4.3.*

Table A.4: Entry and Exit Composition as a Long Difference with Firm-Module Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\Delta \ln N_{kr}$		$\Delta \ln v_{kr}$		$\Delta \ln q_{kr}$		$\Delta \ln w_{kr}$	
Wave 3	0.150*	0.818***	0.354	1.915***	0.325	1.680***	0.209***	-0.182**
	(0.082)	(0.111)	(0.290)	(0.337)	(0.280)	(0.326)	(0.069)	(0.086)
Constant	-1.025***	-1.143***	-2.348***	-2.074***	-2.317***	-2.112***	-0.073***	-0.035***
	(0.003)	(0.005)	(0.012)	(0.014)	(0.011)	(0.013)	(0.003)	(0.003)
Exit	✓		✓		✓		✓	
Enter		✓		✓		✓		✓
Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Balance	✓	✓	✓	✓	✓	✓	✓	✓
Firm-Module FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.55	0.53	0.47	0.42	0.48	0.42	0.33	0.37
Observations	34,485	34,485	34,485	34,485	34,485	34,485	34,485	34,485

*Notes: This table provides estimates of the long-difference change in product entry and exit characteristics. Data are aggregated to the firm-retailer-category-country level, and estimated as a cross-section with each observation a within firm-retailer-category-country long difference between Q4 of 2019 and Q4 of 2017. Columns (1), (3), and (5) provide estimates of the relative difference in the exiting share of barcodes for tariff-affected products versus control products. Column (1) is the raw exiting barcode count share, column (3) the expenditure share of exiting barcodes, and column (5) the raw sales quantity share of exiting barcodes. Columns (2), (4), and (6) provide equivalent estimates but for barcodes which entered during the long difference. Column (7) provides the average weight of exiting barcodes, relative to the initial average weight in Q4 2017, and Column (8) the average weight of entering barcodes, again relative to the initial baseline. Only kr pairs with both non-zero entry and exit are included. All models include firm-by-category, country, and retailer fixed effects. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Back to Section 4.3.*

Table A.5: Pass-through and Substitution by Market Share Bins

	(1)	(2)	(3)	(4)
	Log Price		Log Quantity	
$\log(1+\tau) \times MS_1$	0.104**	0.081*	-0.282	-0.397**
	(0.039)	(0.044)	(0.219)	(0.191)
$\log(1+\tau) \times MS_2$	0.208***	0.174***	-0.090	-0.280
	(0.050)	(0.054)	(0.214)	(0.196)
$\log(1+\tau) \times MS_3$	0.232***	0.217***	-0.197	-0.253
	(0.065)	(0.058)	(0.310)	(0.256)
Sample		<2020		<2020
Fixed Effects	✓	✓	✓	✓
R^2	1.00	1.00	0.97	0.98
Observations	15393284	11556925	15393284	11556925

*Notes: Tariff pass-through by barcode market share, from low market share (s_1) to high market share (s_3). Market shares are computed within product modules based on 2017 sales volume. Columns (1) and (3) estimate price and quantity elasticities for the entire sample, with columns (2) and (4) providing the same respective estimates with 2020 excluded. Standard errors are clustered three-way at the category, country, and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Back to Section 4.5.*

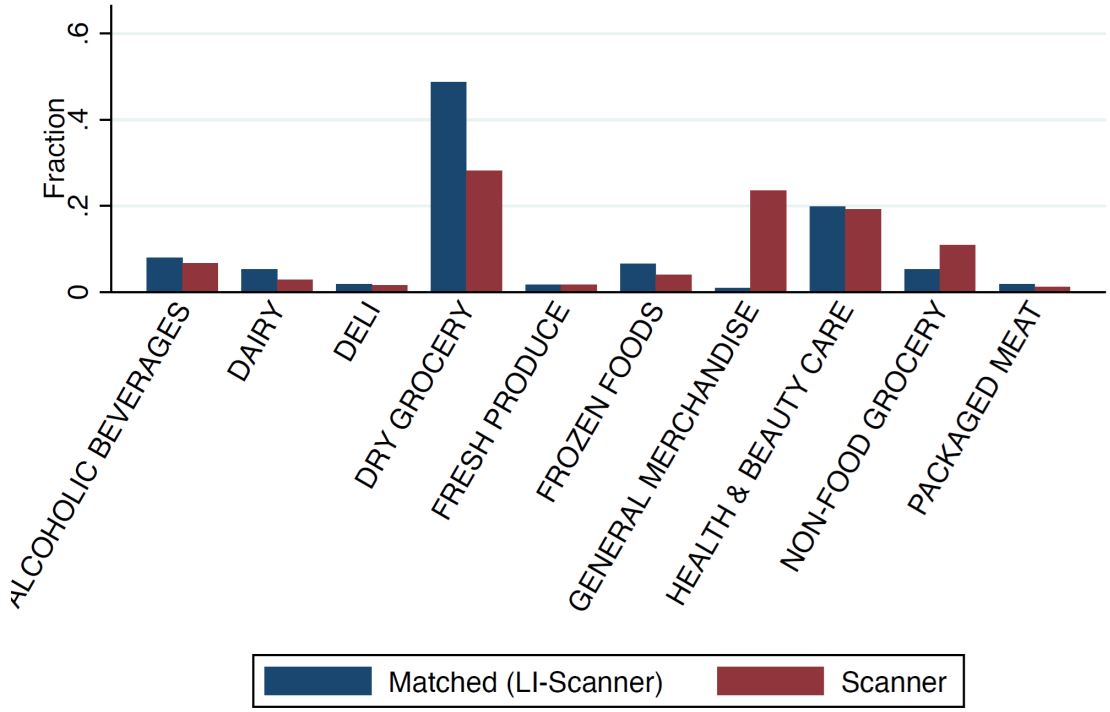
Table A.6: Bilateral Sales Shares and Tariff Pass-Through into Unit Values

	(1)	(2)
	Log Price	
$\log(1+\tau)$	0.482***	0.176
	(0.156)	(0.109)
$\log(1+\tau)\times$ Firm Share in Retailer	-12.215**	
	(5.999)	
$\log(1+\tau)\times$ Retailer Share in Firm	-0.427**	
	(0.162)	
$\log(1+\tau)\times$ High firm share in retailer sales		0.443***
		(0.080)
$\log(1+\tau)\times$ High retailer share in firm sales		-0.295***
		(0.086)
Fixed Effects	✓	✓
R^2	0.996	0.996
Observations	4,291,413	4,291,413

*Notes: Notes: This table provides estimates associated with interactions between the tariff rate and two measures of market power: a firm's expenditure share within a given retail chain, and a retailer's share of expenditure within a given firm. Column (1) interacts these two market shares linearly, whereas column (2) interacts tariff changes with dummy variables for these respective shares being above median. All prices are measured as unit values and all observations are at the firm-category-country-retailer-month level. Standard errors are clustered three-way at the category, country, and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Back to Section 4.5.*

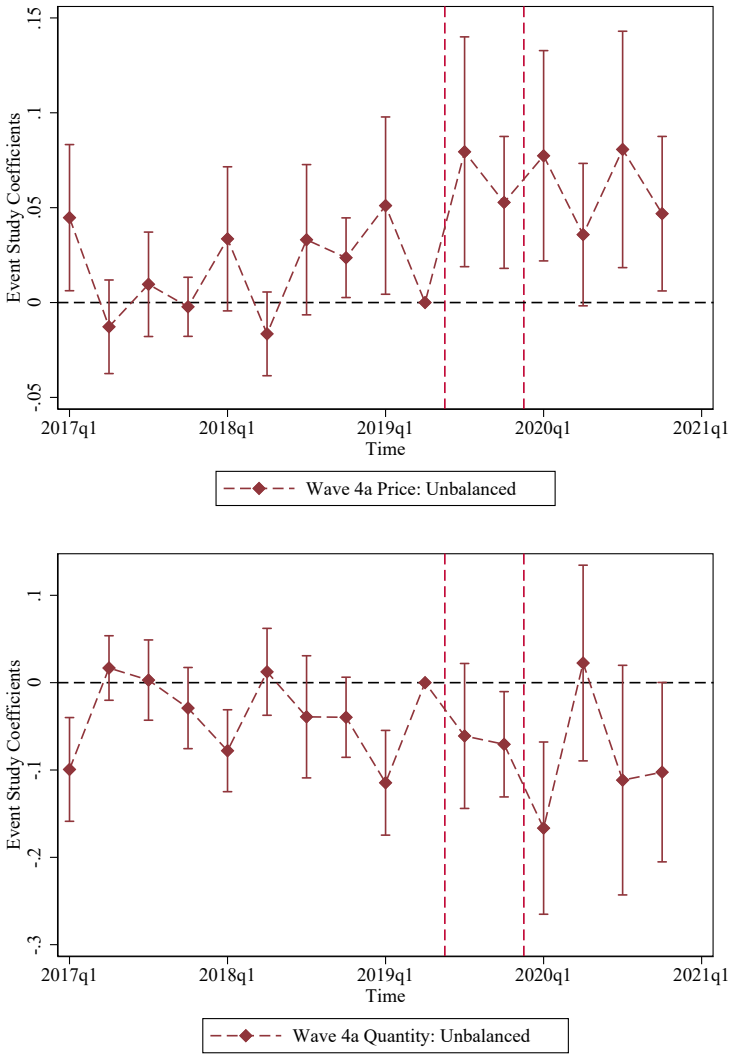
A.2 Additional Figures

Figure A.1: Distribution of Barcodes by Department



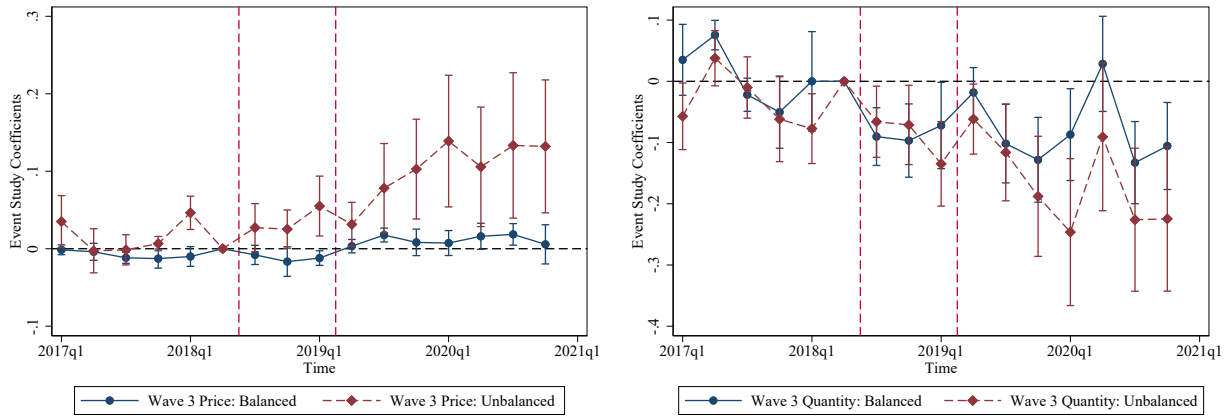
Notes: Figure 1 provides the distribution of barcodes across NielsenIQ product departments according to the raw scanner data (red) and the merged Label Insight-NielsenIQ dataset used in this paper (blue).

Figure A.2: Event Study Estimates for Unit Value Pass-through (Wave 4a)



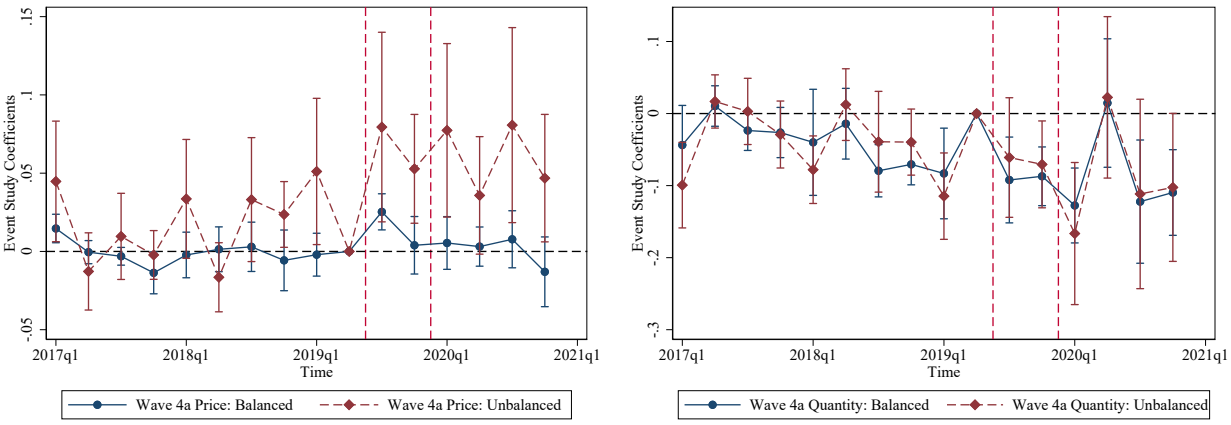
Notes: This figure provides estimates associated with the event study design at the aggregated country-category-retailer level outlined in Equation 2. All models include fixed effects by firm-country-category-retailer, retailer-month, category-month, and country-month. 95% confidence intervals included, with standard errors clustered three-way at the category, country, and month level. Only wave 4a and never-treated categories included. Red vertical lines denote tariff changes, from 5.0% to 20.0% in August 2019, and from 20.0% to 12.5% in January 2020. Back to Section 3.2.

Figure A.3: Event Study Estimates for Unit Value Pass-through by Barcode Tenure



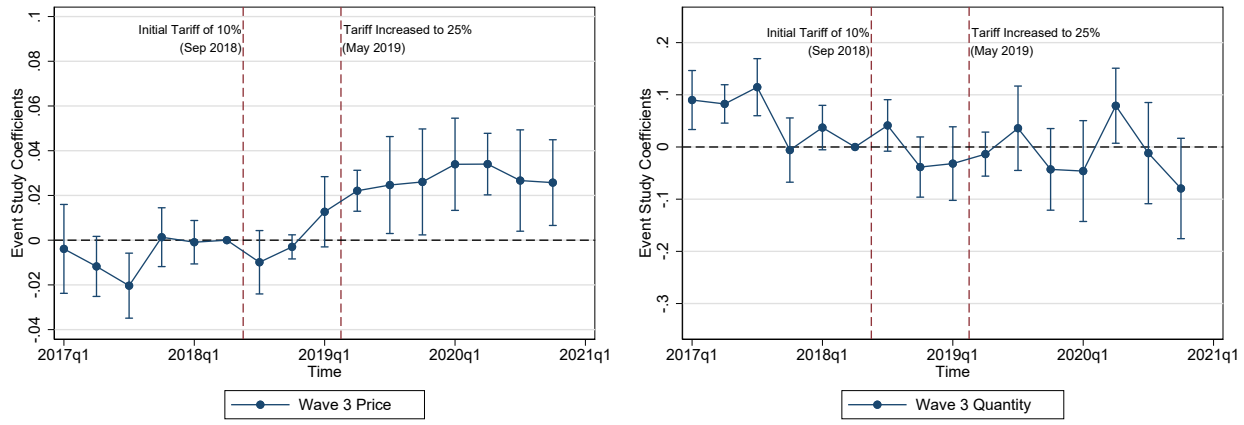
Notes: This figure provides estimates associated with the event study design at the aggregated country-category-retailer level outlined in Equation 2. All models include fixed effects by country-category-retailer, retailer-month, category-month, and country-month. 95% confidence intervals included, with Standard errors clustered three-way at the category, country, and month level.

Figure A.4: Event Study Estimates for Unit Value Pass-through by Barcode Tenure (Wave 4a)



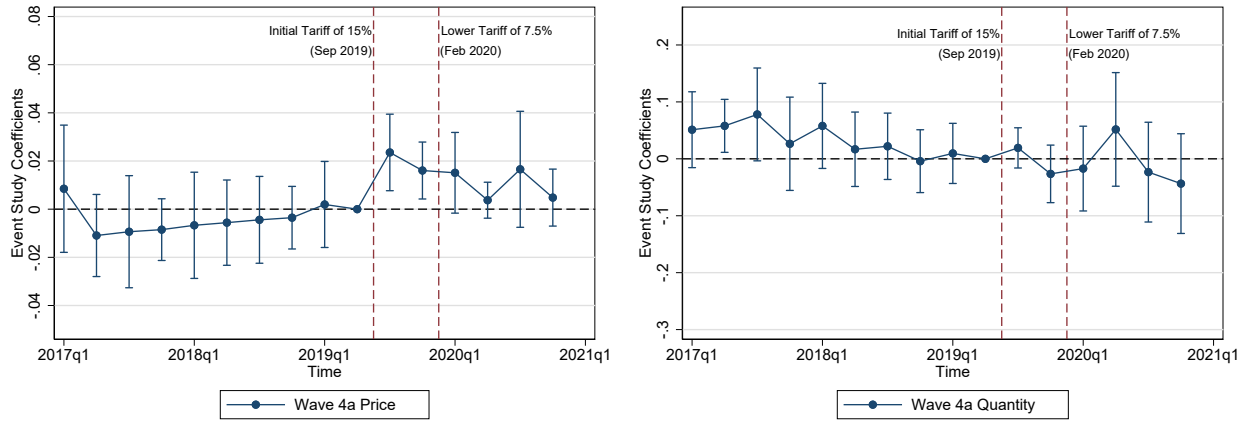
Notes: This figure provides estimates associated with the event study design at the aggregated country-category-retailer level outlined in Equation 2. All models include fixed effects by country-category-retailer, retailer-month, category-month, and country-month. 95% confidence intervals included, with Standard errors clustered three-way at the category, country, and month level.

Figure A.5: Event Study Estimates at Barcode Level (wave 3)



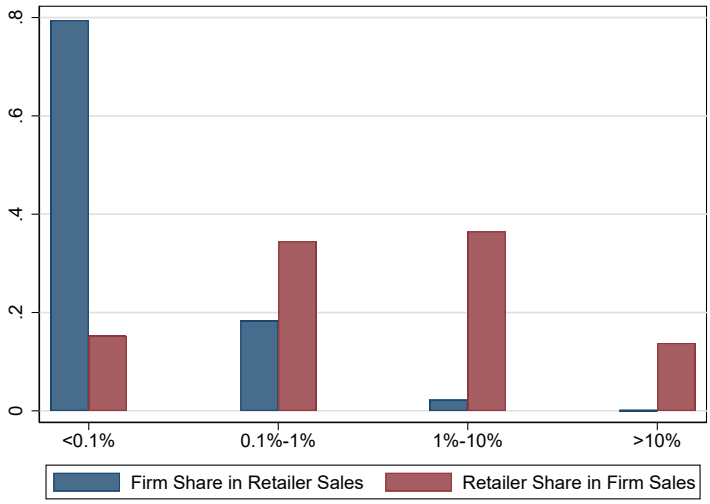
Notes: This figure provides estimates associated with a barcode-retailer-level event study. The dependent variable is p_{irt} (left) and q_{irt} (right). All never-tariff categories are included as the control group, whereas the only treated group included are those categories targeted by tariff wave 3. Barcode-retailer, retailer-month, category-month, and country-month fixed effects included. 95% confidence intervals included, with Standard errors clustered three-way at the category, country, and month level.

Figure A.6: Event Study Estimates at Barcode Level (wave 4a)



Notes: This figure provides estimates associated with estimating Equation 2. The dependent variable is p_{irt} (left) and q_{irt} (right). All never-tariff categories are included as the control group, whereas the only treated group included are those categories targeted by tariff wave 4a. Barcode-retailer, retailer-month, category-month, and country-month fixed effects included. 95% confidence intervals included, with Standard errors clustered three-way at the category, country, and month level.

Figure A.7: Firm and Retailer Bilateral Dependence



Notes: Distribution of the firm share in retailer sales and the retailer share in firm sales in 2017. Both variables are computed for 2017 data. Firm share in retailer sales is the total sales by products of firm f in retailer r, divided by total sales by retailer r. Retailer share in firm sales is the total sales by products of firm f in retailer r, divided by total sales by firm f.

B Empirical Appendix

This section provides further detail regarding data construction, empirical methodology, and results.

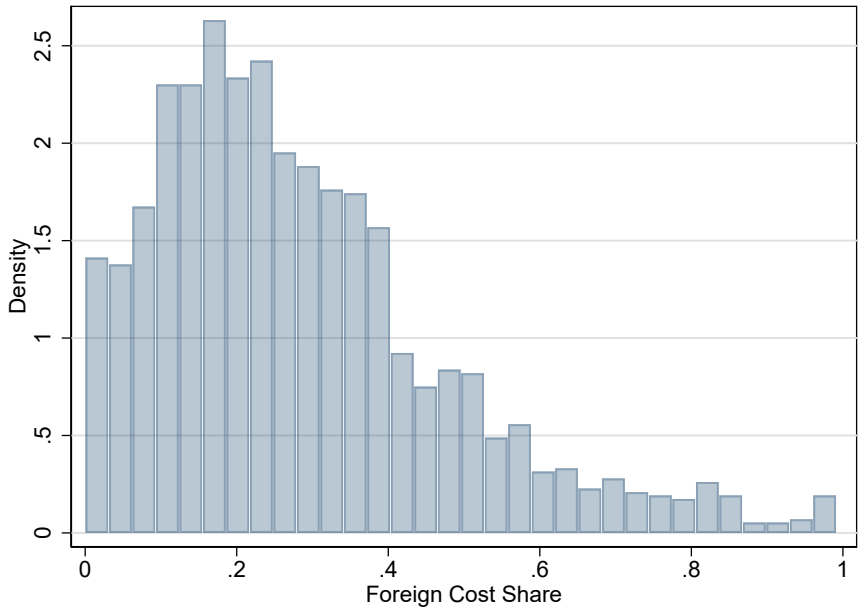
B.1 Constructing Foreign Cost Share Estimates

While we do not have data on the border prices of individual barcodes, we make progress by comparing category-by-origin unit values between retail and customs data. Since the U.S. computes tariff duties using free-on-board (FOB) prices, we use the HS10 customs valuation unit values by country of origin, as opposed to cost-in-freight (CIF) unit values which include international transport and insurance. We drop observations with invalid or missing quantity units and aggregate the import data to the level of product category-by-origin-by-unit of measurement, and compute unit values at that level.

We then try to harmonize as much as possible quantity units of measurement in both the scanner and the customs data. Some unit values cannot be compared across the two datasets, for instance if the unit in the scanner data is simply a "count", but it is measured in kilograms in the customs data. For the pairs for which we can identify a common quantity unit, we compute the foreign cost share as the ratio of the customs unit value and the scanner unit value. In rare cases, there are multiple quantity units of measurement in a given category-by-origin country cell. In all of these cases, one of the units is a product count while the other one is a more cleanly defined unit, such as volume or weight. In these cases we prefer the unit value measured from the non-count data. This procedure is arguably imperfect, since we cannot be sure that we compare the same barcodes in the customs and scanner data. Still, within the roughly two thousand country-category pairs we merge between datasets, 95% of all recovered estimates of the foreign cost share are less than one, which is reassuring as the theoretical upper bound of the FCS is one. Reassuringly, we recover an unweighted correlation between unit values in scanner data and customs data of 0.70. Figure B.1 provides a histogram of the foreign cost share estimates we recover across all imported country-category pairs.

We find no clear relationship with the foreign cost share estimates we recover and import

Figure B.1: Distribution of Barcodes by Department



Notes: This figure provides a histogram of our foreign cost share estimates for all estimates which we reliably link between customs data and scanner data. $N = 1852$.

origin characteristics, such as distance to to the U.S. or GDP per capita, conditional on the product category in question. We do find some evidence that foreign cost shares associated with specifically with imports from China may have within-category foreign cost shares which are, on average, 3.6 percentage points lower than average. Still, this evidence remains qualitative at best, given the limited number of observations.

B.2 Robustness of Barcode-Level Estimates

This section describes a number of robustness checks associated with spillover effects of tariffs to non-treated barcodes. First, any model of strategic pricing would suggest that tariffs on Chinese varieties might induce an increase in markups for competing varieties from other origin countries. We test this effect directly using a differences-in-differences identification strategy, and comparing the effect of tariffs on the price of non-targeted products within tariff categories to products in non-tariff categories. Specifically, we estimate the following

Table B.1: Mark-ups of Non-Tariff Goods

	(1)	(2)	(3)	(4)
	log Price			
$\log(1+\tau_{CN})$	0.001	-0.001	0.019	0.011
	(0.021)	(0.019)	(0.026)	(0.023)
$\log(1+\tau_{CN}) \times (Share_{CN} > 0)$			-0.032	-0.020
			(0.025)	(0.022)
Sample		<2020		<2020
Fixed Effects	✓	✓	✓	✓
R^2	1.00	1.00	1.00	1.00
Observations	1.51e+07	1.13e+07	1.51e+07	1.13e+07

*Notes: This table provides estimates of β from applying OLS to Equation B.1. In columns (1) and (3) we estimate our specification on the whole sample, while in columns (2) and (4) we restrict attention to the comparison between wave 3 and the never treated, and stop the sample pre-Covid. Standard errors are clustered two-way at the category-country and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

empirical model:

$$\ln(p_{irt}) = \beta \ln(1+\tau^{cn}_{c(i)t}) + \alpha_{ir} + \alpha_{rt} + \alpha_{j(i)t} + \alpha_{g(i)t} + \gamma_{w(i)q(t)} + \epsilon_{irt} \tag{B.1}$$

where $\tau^{cn}_{c(i)t}$ denotes the tariff applied to Chinese varieties within category c, which is now the explanatory variable for all non-Chinese varieties within that same category. All other fixed effects remain the same, other than the module-time fixed effects. Since we now exclude Chinese products from the estimation, these fixed effects would entirely absorb the tariff variation across categories. To still control for differential sector-level price trends we include fixed effects at a higher level of category classification, $\alpha_{g(c)t}$, where $g(c)$ denotes roughly 100 NielsenIQ product groups. Results are in Table B.1 and do not provide evidence for an endogenous mark-up response of non-tariff-affected goods. Estimated coefficients are all close to zero with relatively tight confidence intervals. It should be noted that in a similar exercise, Cavallo et al. (2021) also find little evidence for anti-competitive behavior within consumer goods. However, within consumer packaged goods, China's expenditure share in the U.S. is smaller than in many other export markets, with shares that are typically less than 5% of all sales. Thus, it is not immediately clear that the combination of low market shares and (relatively) small tariff changes would lead to observable anti-competitive behavior.

Second, we consider the possibility that firms or retailers may choose to spread price increases across many goods instead of concentrating them on the taxed items. While there is some anecdotal evidence for this type of strategy, particularly by retailers, we are not aware of any study testing whether this is a common pattern.[24] We test this mechanism as follows: do retailers (or firms) more exposed to a particular tariff wave tend to increase their prices of non-taxed goods by more than other retailers? To avoid retailers (or firms) being treated multiple times through different waves, we again restrict attention to the treatment through wave 3, and stop the sample in December 2019. We then define a set of treated firms and retailers using information on the firm and retailer product portfolio in 2017. Among the roughly 4,200 firms in our sample, we define a firm as treated if in 2017 it sold some Chinese products that were later taxed through Wave 3. This applies to 188 firms. Since all 67 retailers have some level of exposure to Chinese Wave 3 goods, we divide retailers by the median 2017 exposure. We then estimate the following specification on only non-Chinese barcodes,

$$\ln(p_{irt}) = \beta \text{Treated Retailer}_r \times \text{Post}_t + \alpha_{irt} + \epsilon_{irt}, \tag{B.2}$$

where $textPost_t$ is a dummy that equals one after the implementation of the initial Wave 3 tariffs in September 2018.

Since we want to identify the effect using variation across retailers, we now need to suppress the retailer-by-time FE. In column (1) of Table B.3 we estimate equation B.2 using barcode-by-retailer, country-by-time, and module-by-time effects, and we do the same in column (2) when we look at the firm effect. Column (3) adds both effects in the same specification. Column (4) then implements a more demanding specification to estimate the firm effect, where we suppress all cross-retailer variation. Finally, specification (5) implements a more demanding specification to estimate the smoothing effect for retailers, using only variation for the same barcode sold at the same point in time, across different retailers, which we do by adding a barcode-by-time effect.[25]

[24] As an example: https://www.oliverwyman.com/our-expertise/insights/2025/jan/retail-strategies-to-adapt-to-new-us-tariffs.html

[25] Notice that a barcode-by-time effect wipes out the firm smoothing effect, since a barcode always remains in the same firm.

Table B.2: Smoothing of Price Increases

	(1)	(2)	(3)	(4)
	Log Price			
Treated Retailer × Post	0.004**		0.004**	
	(0.002)		(0.002)	
Treated Firm × Post		0.003	0.003	0.002
		(0.004)	(0.004)	(0.004)
Sample	<2020	<2020	<2020	<2020
Fixed Effects	ir,mt,jt	ir,mt,jt	ir,mt,jt	ir,mt,rt,jt
R^2	1.00	1.00	1.00	1.00
Observations	1.51e+07	1.51e+07	1.51e+07	1.51e+07

*Notes: In column (1) we estimate equation B.2 using barcode-by-retailer, country-by-time, and module-by-time effects, and we do the same in column (2) when we look at the firm effect. Column (3) adds both effects in the same specification. In column (4) we estimate a more demanding specificaiton with retailer-by-time FEs. Standard errors are clustered two-way at the category-country and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

Table B.3 provides some evidence that, among non-taxed goods only, retailers that were initially more exposed to tariffs raised their prices by more, suggesting that retailers did smooth tariff increases. However, the magnitude is quite small, with prices of unaffected goods increasing by only 0.8-0.9% after implementation of Wave 3. While this channel is of interest *per se*, it is certainly not strong enough to explain the relatively low barcode-level pass-through estimates we recover of 10%.

Finally, while many consumer goods were taxed in waves 3 and 4 of the 2018/19 trade war, earlier waves (1 and 2) focused on intermediate goods. This might lead to price increases of domestically produced consumer goods to the extent that those goods use taxed imported intermediates as inputs in production. Since we cannot directly observe imported intermediates at the firm-level in our data, we instead use the fact that this concern only applies to U.S.-produced goods in the control group, but not to foreign-produced goods. In Table B.3, we re-estimate Equation 4, excluding U.S.-produced goods entirely. The coefficients stay very close in magnitude to our main estimates, suggesting that imported intermediates are not a first-order concern and do not bring us closer to estimates of pass-through in the range of 40%, which we recovered in Section 3.

Table B.3: Comparison to other Imported Products

	(1)	(2)
	Log Price	
$\log(1+\tau)$	0.101**	0.093**
	(0.044)	(0.042)
Sample		<2020
Fixed Effects	✓	✓
R^2	1.00	1.00
Observations	2.76e+06	2.07e+06

*Notes: This table provides estimates of β when applying OLS to equation 4, excluding US-made goods from the estimation. Standard errors are clustered two-way at the category-country and month level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.*

B.3 Comparison with Cavallo et al. (2021)

This section provides a brief description of how our estimating equation differs from the estimating equation used in Cavallo et al. (2021). Although we find evidence of null pass-through within barcodes and for an unbalanced panel, which we believe is the closest comparison to the estimating sample of Cavallo et al. (2021), and therefore can match their results, our estimating equations differ. First, recall that our main estimating equation is effectively a triple-difference, with category-period, country-period, and retailer-period level fixed effects. Cavallo et al. (2021) take a slightly different approach, although the unit of observation remains a product-retailer combination. Mapping their estimating equation into our notation, we derive the following estimating equation:[26]

$$\Delta \ln p_{irt} = \alpha_{c(i)} + \phi^{w}_{CN} + \sum_{\ell=0}^{11} \beta^{\tau}_{\ell} \Delta \ln \tau_{c(i)j(i),t-\ell} + \sum_{\ell=0}^{11} \beta^{ex}_{\ell} \Delta \ln EX_{j(i),t-\ell} + \sum_{\ell=0}^{11} \beta^{ppi}_{\ell} \Delta \ln PPI_{j(i),t-\ell} + \epsilon_{irt}$$

where the Δ operator denotes a first-difference over time periods, which are at the month level. $\alpha_{c(i)}$ denotes category-specific trends in price, while ϕ^{w}_{CN} denote trends that are specific to Chinese barcodes and specific to each wave. τ_{cjt} is the tariff rate, as in our main estimating equation, such that $\sum_{\ell=0}^{11} \hat{\beta}^{\tau}_{\ell}$ denotes tariff pass-through one year after tariff implementation.

[26] Note that product categories in our setting are explicitly HS8 categories, whereas those used in Cavallo et al. (2021) are defined by the BLS as "primary stratum lower", which is somewhere between HS4 and HS6, in terms of disaggregation.

While Cavallo et al. (2021) control for the exchange rate of country $j(i)$ and the producer price index in country $j(i)$ in their headline estimates, these controls are dropped when estimated at the barcode-level (see Table 1 in Cavallo et al. (2021)). Therefore the relevant comparison is the following estimating equation:

$$\Delta \ln p_{irt} = \alpha_{c(i)} + \phi^{w}_{CN} + \sum_{\ell=0}^{11} \beta^{\tau}_{\ell} \Delta \ln \tau_{c(i)j(i),t-\ell} + \epsilon_{irt}$$