The Production Relocation and Price Effects of U.S. Trade Policy: The Case of Washing Machines

Aaron Flaaen Ali Hortaçsu Felix Tintelnot*

February 18, 2020

Abstract

We estimate the price effect of U.S. import restrictions on washers. The 2012 and 2016 antidumping duties against South Korea and China were accompanied by downward or minor price movements along with production relocation to other export platform countries. With the 2018 tariffs, on nearly all source countries, the price of washers increased nearly 12 percent. Interestingly, the price of dryers—not subject to tariffs—increased by an equivalent amount. Factoring in dryer prices and price increases by domestic brands, the 2018 tariffs on washers imply a tariff elasticity of consumer prices of above one.

To an extent not seen in nearly a quarter century, trade policy occupied the forefront of economic policy debates in the United States in 2018. In that year, the United States imposed a series of tariffs on a wide range of goods—largely from China—using a variety of trade policy measures that have little precedent. The economic impacts of these tariffs on trade flows, prices, and production are highly uncertain as the magnitude of these tariff changes is extraordinary for an advanced country integrated with the global economy. On the one hand, tariffs, which are levied on the gross value of an imported good, have become more punitive given the decline in the value-added share of a given country's exports amidst increases in production sharing across global supply chains. On the other hand, given the prominence of multinational firms in global production, it may be easier than ever to relocate production across country borders, undoing the effects of tariffs.

Set against the uncertainties of how trade policy plays out in an integrated global economy are long-standing questions of international trade theory with little or conflicting empirical evidence. One such question is the incidence of tariffs: whether the amount of import taxes is passed on to consumers in the form of higher prices or absorbed by foreign producers by lowering their export price. Irwin (2019) notes that direct evidence on the consumer

*Flaaen: Federal Reserve Board (email: aflaaen@gmail.com); Hortaçsu: University of Chicago and NBER (email: hortacsu@uchicago.edu); Tintelnot: University of Chicago and NBER (email: tintelnot@uchicago.edu). We are grateful to Xianglong Kong, Ari Boyarsky, and Vivi Gregorich for superb research assistance. We thank Christine Edwards for helpful discussions about washing machine and dryer pricing. Suggestions by Jonathan Dingel, Thomas Holmes, and Harry Li, the editor, and four anonymous referees have substantially improved this paper. Ali Hortaçsu and Felix Tintelnot gratefully acknowledge financial support from the Becker Friedman Institute for Economics at the University of Chicago. Any opinions and conclusions expressed herein are those of the authors and do not necessarily represent the views of the Board of Governors or its research staff.

price effect of tariffs is scarce, particularly for a large economy such as the United States with potential monopsony power. Although new tariffs offer many possibilities for study, most are placed on intermediate goods where tracking price effects through the economy is particularly challenging. This paper focuses on a final consumer good, washing machines, and provides evidence of the effects of recent trade policies on trade flows, domestic production, and, most notably, prices.

The study of washing machines offers useful lessons for how trade policies affect the economy for several reasons. First, washing machine imports have been subject to wide-ranging trade policies in recent years. The contrasting effects of these policies offer lessons for how the characteristics of any particular trade policy (specifically, whether it's multilateral or unilateral) will alter their impact. Second, the new tariffs on washing machines in early 2018 were the first of a long string of subsequent trade policy actions enacted by the Trump administration, and therefore the full effect of these tariffs is more readily evident than the effect of those imposed later on, specifically on China. Finally, features of the product in question—relatively simple means of classification, clear channels for complementarities (washers and dryers), and a reasonable concentration of production—make this episode relatively straightforward for detailed study.

The first round of trade policy measures against imported washing machines consisted of country-specific antidumping duties, targeting specific companies producing in particular locations. These antidumping duties, first imposed on Mexican/Korean production in 2012 and later on Chinese production in 2016, resulted in a shift in production to other countries while keeping the overall magnitude of U.S. imports roughly the same. Such "country-hopping" behavior is intuitive from existing theories of tariff avoidance and models with export platform FDI. The second round utilized a little-used area of U.S. trade law, enacting "safeguard" tariffs on virtually all source countries for washing machine imports to the United States. Apart from notable shifts in the timing of imports based on when these tariffs went into effect (i.e., anticipatory increases—or front-running—of imports before the tariffs were first applied), the so-called Section 201 tariffs coincided with new domestic production, as both LG Electronics and Samsung Electronics opened plants in the United States in 2018. To summarize, firms shifted production following each new trade policy—first from Mexico/Korea to China, then to Thailand/Vietnam, and finally to the U.S.—to avoid paying import tariffs.

Coincident with these changes in production and trade flows were significant price movements, as measured by the published Consumer Price Index (CPI). In the 12 months following the Korea/Mexico antidumping duties, the CPI for laundry equipment actually declined by about 5 percent, reversing the previous trend of moderate increases in the years before. The 12 months after the China antidumping duties saw the CPI continuing on its prior trend. Conversely, the index jumped in the months following the Section 201 safeguard tariffs and was up by about 9 percent by February 2019.

To more fully assess the price impacts of these tariffs, we use detailed weekly retail price data on major appliances. A concern with comparing the prices of washing machines before and after trade policy changes is the presence of other shocks that changed the price of washers independently of the trade policy under study. For example, washer prices may respond to changes in the price of steel or general changes in retail markups. We therefore use other appliances as control products for the change in washing machine prices. In addition,

a diverse set of product features in the data allow us to remove non-tariff-related price movements based on the life cycle feature of product pricing and also account for product characteristics and brand- or model-specific differences in pricing. The approach of using non-treated appliance products as controls has been used before by Ashenfelter, Hosken and Weinberg (2013) in their study of the effects of the Maytag-Whirlpool merger in 2006.

The implications of the 2016 antidumping duties on Chinese imports were strikingly different from the safeguard tariffs on many countries in 2018. Although China accounted for a whopping 80 percent of washing machine imports to the United States prior to the application of tariffs, we find little evidence of any meaningful consumer price changes due to the 2016 China-specific tariffs. This difference could be explained by the relative ease with which large foreign brands (Samsung, LG) appeared to subsequently shift production to Vietnam and Thailand, with coinciding increases in washing machine parts exports from Korea to these countries. By contrast, washer prices in the months following the new 2018 global safeguard tariffs notably spiked: about 12 percent more than the corresponding change in our control group. Moreover, prices of a complementary good—clothes dryers—also jumped at the same time by a similar magnitude, even though these products were not subject to any new tariffs during this period.

A key metric for evaluating the effects of tariffs is the degree of tariff pass-through to consumer prices. Yet, data limitations have made it difficult to capture the complicated effects on prices due to production relocation, complementary goods, and the responses by domestic producers. With our available data, we calculate the tariff elasticity of consumer prices, which measures the price changes encompassing the overall bundle of goods available to consumers (both imported and domestically produced) relative to the average change in tax applied to these goods via import tariffs. Although our sample of micro-level prices does not overlap with the Korea/Mexico antidumping duties, we report evidence – a drop in import prices from subsequent production in China, along with declines in the CPI index — pointing to a *negative* pass-through of tariffs and hence increased consumer surplus from these duties. Our estimates of the tariff elasticity of consumer prices for the country-specific antidumping duties on Chinese production, though positive, are small. Production relocation plays a prominent role in the differences in these estimates. Indeed, we show theoretically in Appendix A that the potential for production relocation by multinationals to other export platform countries leads to a non-monotonic response of prices to tariff changes.

We find a much higher tariff elasticity of consumer prices for the global 2018 safeguard tariffs. Due to the price increases by domestic brands, and incorporating the additional effect on dryer prices, our estimates imply a pass-through of the safeguard tariffs to consumer prices of above 100 percent with estimates ranging between 108 and 225 percent. Our estimates indicate that the safeguard tariffs raised the median price of washing machines and clothes dryers by about 86 USD and 92 USD per unit, respectively. Using the level of shipments to construct an aggregate, we calculate that these tariffs resulted in increased consumer costs of just over 1.5 billion USD annually. By comparison, the total amount of tariff revenue collected was relatively small, aggregating to about 82 million USD annually. Absent additional factors, the reports of increases in domestic employment attributed to this policy of roughly 1,800 workers would result in an average annual cost to consumers of over 815,000 USD per job created (after netting out tariff revenues).

Our analysis contributes to the literature on the incidence of tariffs. Irwin (2019) studies

the sugar price response to import tariffs from 1880 to 1930, finding a roughly 40 percent pass-through to consumer prices of import tariff *increases* and a complete pass-through of import tariff *reductions*. Huber (1971) and Bernhofen and Brown (2004) compare 19th-century autarky price levels of several goods in Japan with price levels after trade liberalization. Bai and Stumpner (2019) and Jaravel and Sager (2019) measure the U.S. consumer gains from imports from China using retail price data. Dating back to at least Feenstra (1989), several papers have analyzed the response of import prices to tariff changes (e.g., Winkelmann and Winkelmann 1998; Trefler 2004; Broda and Weinstein 2006; Broda, Limao and Weinstein 2008; Spearot 2012; Ludema and Yu 2016; Fitzgerald and Haller 2018). In an analysis of the 2018 trade policies enacted by the United States, the comprehensive reviews of both Amiti, Redding and Weinstein (2019) and Fajgelbaum et al. (2019) find complete pass-through of tariffs to import prices.

Availability and coverage of retail price data offer a number of advantages in analyzing the economic effects of policy. The U.S. retail prices we study capture the impacts of tariffs on domestic competitors, production relocation, and complementary goods—channels that would be more difficult to assess using import prices alone.[1] For example, we find either flat or increasing import prices of imported washers from Korea in response to the 2012 antidumping duties, but domestic prices in the U.S. fell as foreign production relocated to China.

Our paper also contributes by providing evidence on the response of multinational firms to tariff changes. A large literature on the proximity concentration trade-off documents that the ratio of foreign affiliate sales to exports rises in the import tariff level (e.g., Brainard 1997; Helpman, Melitz and Yeaple 2004). Horstmann and Markusen (1992) show that in response to an import tariff, a foreign multinational may set up a plant in the home country which could lead to lower domestic prices than without the tariff. Blonigen (2002) studies the tariff jumping behavior of foreign firms to U.S. antidumping measures in the 1980s. He finds an economically small increase in the probability that a foreign firm establish U.S. production in response to the antidumping rulings. Consistent with the predictions of models of export platform FDI (e.g., Yeaple 2003; Ekholm, Forslid and Markusen 2007; Tintelnot 2017), our findings illustrate the relocation of production to third markets as export platforms in response to bilateral tariff changes.[2]

I Import Restrictions and Changes in Trade Flows

Throughout the latter half of the 20th century, a series of major domestic brands of washing machines—including Maytag, Whirlpool, G.E., and Kenmore—competed for market share in the United States. In 2006, the Whirlpool Corporation ("Whirlpool") cemented its position as the dominant domestic producer after acquiring Maytag, its main competitor. This merger substantially increased the concentration of both washing machines and clothes dryers: ac-

[1] Using Belgian manufacturing data, Amiti, Itskhoki and Konings (2016) document that large firms respond to competitors' cost changes induced by exchange rate changes. Using the 2015 Swiss Franc appreciation as a natural experiment, Auer, Burstein and Lein (2018) find that prices of Swiss-produced goods fell by more in product categories with larger reductions in border prices.

[2] These findings reflect a third-country effect from trade policy discussed in various works by Bagwell and Staiger (see Bagwell, Bown and Staiger 2016, for a review). Our findings are also related to work by Ruhl (2014), who finds a large aggregate impact of U.S. antidumping policies. For a literature survey on the effects of trade policy, see Goldberg and Pavcnik (2016).

cording to research on the effects of this merger in Ashenfelter, Hosken and Weinberg (2013), Whirlpool and Maytag together (pre-merger) accounted for 60 percent of total revenue for washing machines and 65 percent for clothes dryers.

Imported washing machines occupied a small share—less than 10 percent—of U.S. sales during this time. Around the same time as the Whirlpool/Maytag merger, however, two large South Korean electronics companies, LG Electronics and Samsung, were beginning to enter the U.S. appliance market.[3]

A Antidumping and Global Safeguard Investigations

Following steady gains in U.S. market share by the two Korean companies, in December 2011 Whirlpool filed an antidumping petition (as part of Section 731 of the Tariff Act of 1930) with the U.S. International Trade Commission (USITC), alleging that imports of large residential washers from Mexico and Korea were being sold in the United States at less than fair value and that the U.S. industry was being "materially injured or threatened with material injury as a result." In this form of investigation, the petitioning firm must prove a particular type of unfair pricing behavior as well as actual (or threat of) material injury resulting from that behavior. Any remedial measures—meant to be corrective rather than punitive—are then applied to the U.S. imports of the importing firm, but only on imports from the particular country in question. In February 2012, the USITC issued a ruling recommending antidumping measures; in July, the Commerce Department announced firm-specific import duties ranging from 9.3 to 82.4 percent—see Table B2 for details.[4]

After LG and Samsung maneuvered production around the antidumping duties, in December 2015 Whirlpool filed another antidumping petition with the USITC, this time against the imports of washing machines produced in China. In February 2016, the USITC issued another ruling in favor of antidumping measures; final antidumping duties announced by the Commerce Department ranged from 32.1 percent (LG) to 52.5 percent (Samsung).[5]

Following additional "country-hopping" responses to these localized antidumping duties, in May 2017 Whirlpool petitioned for a global safeguard investigation into large residential washing machines. Known colloquially by its section number of the Trade Act of 1974, a "Section 201" global safeguard investigation is not required to prove unfair trade practices; rather, the USITC simply determines "whether an article is being imported in such increased quantities that it is a substantial cause of serious injury, or threat thereof, to the U.S. industry producing an article like or directly competitive with the imported article" (U.S. Code: Title 19, Code 2252). Moreover, the global safeguard remedy differs from antidumping and countervailing duties in that it is generally applied on a global basis.[6] Use of this trade measure has been rare; Section 201 safeguard tariffs were last implemented in 2002 on steel and steel products.

[3]Indeed, Ashenfelter, Hosken and Weinberg (2013) note that competitive forces from increased foreign entry into this market was a key argument by the U.S. Department of Justice in approving the merger.

[4]Preliminary antidumping duties were first applied in August of 2012 (first dashed line in Figure 1).

[5]The new antidumping duties on Chinese imports began five months later in July 2016 (second dashed line in Figure 1).

[6]There were ultimately a few country exclusions to the section 201 safeguard tariffs. Canada was excluded, as well as imports from a set of developing countries were also excluded from the tariff, provided that the country's share of total imports remains below a certain threshold. The Section 201 safeguard tariffs are imposed in addition to the standard MFN rates under Chapter 84 of the tariff schedule (which, in 2019, were 1 percent for washing machines).

The USITC issued a positive determination in the case in October 2017 and published recommendations for temporary safeguard tariffs in December. The final result, published as a presidential proclamation in January 2018, was a tariff rate quota: a tariff rate of 20 percent on the first 1.2 million imported units (per year) entering the United States, with all subsequent units subject to a 50 percent tariff. Select imported components of washing machines were also subject to a tariff rate quota: in the first year, any imported parts above 50,000 units would be subject to an additional tariff of 50 percent. These tariff rates went into effect in February 2018 (for washing machines and their component parts) and are scheduled to expire after three years. Table B1 provides a summary of the key dates associated with the three rounds of import restrictions against washing machine imports.

B Trade Policy Effects on Production and Trade Flows

Panel A of Figure 1 shows the striking response of U.S. imports to the series of trade restrictions on washing machines. In the two years following the antidumping duties on Korean imports, the quantity of these imports fell by roughly 75 percent (blue line in Panel A). Contemporaneous with the drop in imports from Korea (and to a lesser extent, Mexico) was a substantial increase in imports from China (red line). The results of the later antidumping duties on Chinese imports were nearly identical to the 2012 ruling: imports from China fell from 3 million units per year in 2015 to roughly 300,000 units in 2017. This time, imports of washing machines produced in Thailand and Vietnam (purple and yellow lines) increased sharply, from essentially zero in 2015 to nearly 3.3 million units (combined) in 2017.

As expected, the Section 201 safeguard tariffs in 2018 had differing effects given their global nature. In the midst of the global safeguard investigation of 2017, both Samsung and LG announced plans to begin U.S. production of large residential washing machines. The Samsung factory in Newberry, South Carolina, opened in January 2018 with plans to produce 1 million washing machines that year; Samsung claims the plant will create around 1000 new jobs by 2020 (Samsung (2017)). An LG Electronics factory in Clarksville, Tennessee, opened in May 2019 with an advertised creation of roughly 600 new jobs (LG Electronics (2017)). Similarly, Whirlpool reported adding 200 workers in 2018 explicitly due to the new tariffs.

As shown in Panel A of Figure 1, imports surged in late 2017 and early 2018 as foreign producers rushed to ship washing machines to the U.S. before the Section 201 tariffs went into effect. Imports subsequently fell sharply in February and March of 2018, rising again through September 2018 just before the quota limit of 1.2 million imported units was reached and subsequent tariffs rose to 50 percent.[7] Imports fell sharply again through the remaining months of 2018.[8]

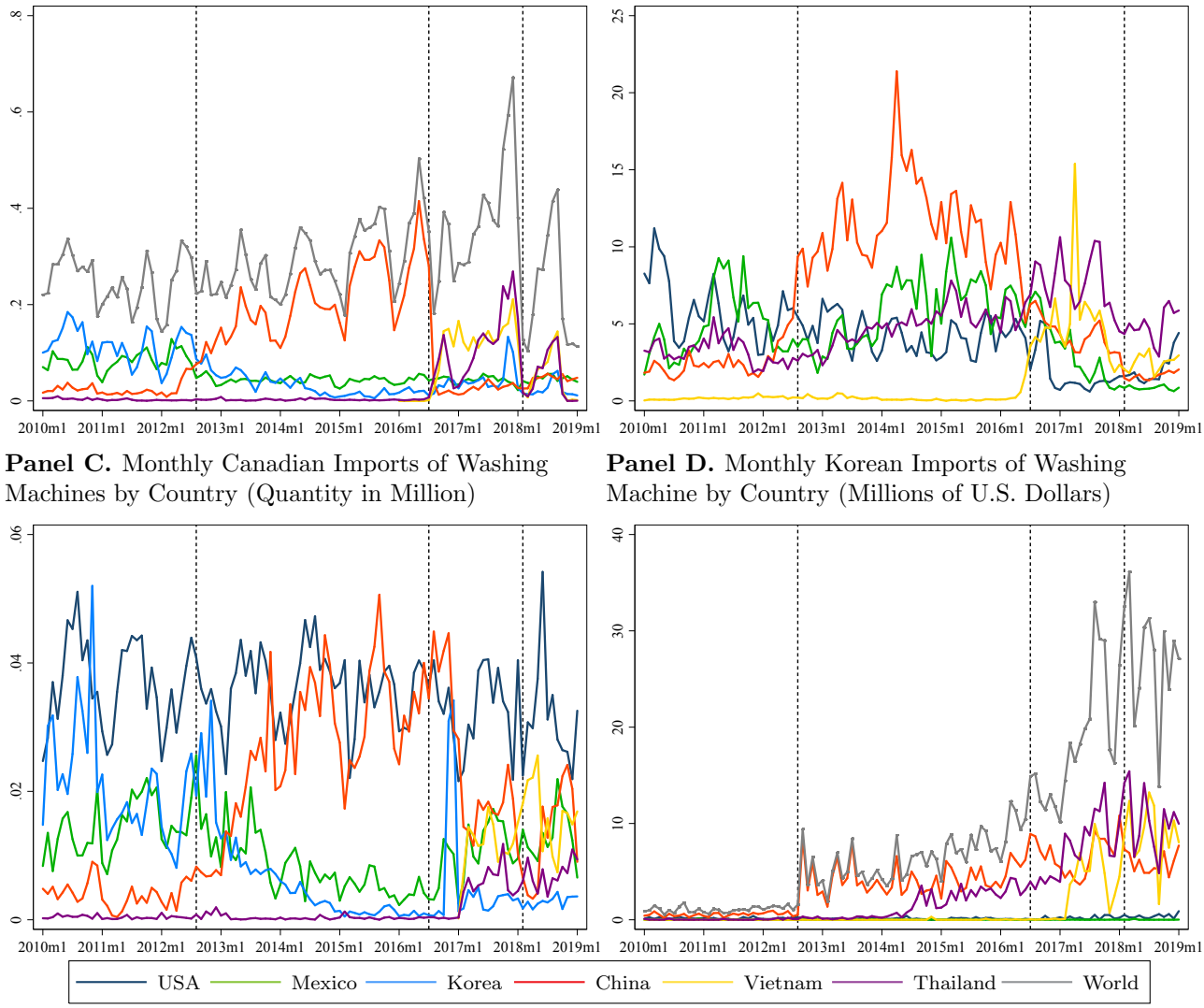
To confirm the country-hopping and front-running patterns in Panel A are the result of adjustments by existing manufacturers in response to the tariff actions, we turn to the PIERS dataset derived from detailed bill of lading documents. From this shipment-level dataset we identify the quantity of imported washing machines and the relevant producer from variables such as the "shipper", "consignee", or "notify" fields. Figure 2 demonstrates

[7] According to Commodity Status Reports published by the U.S. Customs Bureau, the quota limit on washers was reached on October 22, 2018.

[8] Panel A of Figure 1 may understate the responsiveness of import quantities to the Section 201 safeguard tariffs; at Whirlpool's request, not all washers within the selected HS product codes were included as within-scope for the investigation. See Appendix C.2 .

Panel A. Monthly U.S. Imports of Washing Machines by Country (Quantity in Million)

Panel B. Monthly Korean Exports of Washing Machine Parts (Millions of U.S. Dollars)



Panel C. Monthly Canadian Imports of Washing Machines by Country (Quantity in Million)

Panel D. Monthly Korean Imports of Washing Machine by Country (Millions of U.S. Dollars)

Figure 1: Trade Flows of Washing Machines and Washing Machine Parts

Notes: Residential washing machines are classified under HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090. Washing machine parts are classified under HS845090. The seasonally adjusted version of Panel A is shown in Figure D1.
Source: United States International Trade Commission (2010-2019), Korea Customs Service (2010-2019), Canadian International Merchandise Trade Database (2010-2019).

that U.S. imports by LG and Samsung follow the pattern evident in Panel A of Figure 1, with sharp changes in the prevailing country of production.[9]

These changes in sourcing locations can also be viewed through the lens of Korean exports of washing machine parts, given that both Samsung and LG have their global headquarters in Korea. Panel B of Figure 1 plots the value of Korean exports of washing machine parts (under HS845090) to the various countries highlighted above. Panel B shows that exports of parts to China jump in 2013 and 2014 before falling in 2016 and 2017 as exports of parts to Thailand and Vietnam rise. Overall Korean washing machine parts exports (not shown)

[9]The greater lumpiness evident in the PIERS data are likely due to differences in the timing between when the bill of ladings are submitted and the imports are processed by U.S. Customs. Indeed, this lumpiness (and subsequent degree of mis-alignment between PIERS and official statistics)) appears to be greatest when an uncharacteristically large mass of U.S. imports occurs directly before the application of the China antidumping and Section 201 tariffs. See Appendix C.14 for more details.

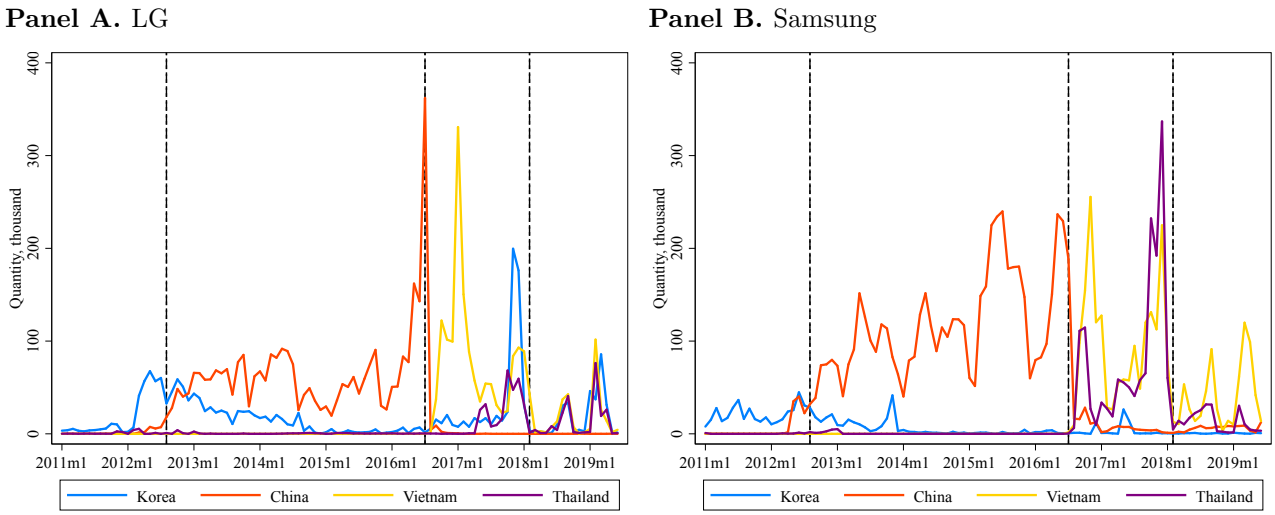


Figure 2: Firm-Level Imports of Washing Machines

Notes: See Appendix C.14 for more details.
Source: PIERS (2012-2019) bill of lading data.

rise nearly 60 percent between 2010 and 2016, consistent with the reduced amount of parts used in Korea for washing machine production for export.[10] Together, Panel A and Panel B of Figure 1 illustrate the changes in supply chains induced by U.S. tariffs.

Beyond supply chain effects, U.S. policy also had notable implications for third country trade flows. Panel C and Panel D of Figure 1 show that Canadian and Korean consumers were affected by U.S. trade policy; the pattern of imports of washers largely follows that of the United States.[11] During the period shown, Korea went from being a net exporter to a net importer of washing machines (see Appendix Figure C6a for Korean washer exports). One might also suspect spillovers in the production location of clothes dryers, but there is little change in the dryer import patterns; the production locations for dryers do not closely align with those of washers (see Appendix Figure C5).

II Effects of Trade Policy Measures on Prices

The overall impact of tariffs depends on the extent to which they are passed on to consumers. In this section, we use detailed, high-frequency microdata from retail stores to study the effect of these tariffs on consumers.

A Evidence Using Import Prices

Figure 3 reports the pattern of import prices for the main trading partners during our sample. Unit values decreased following the Korea/Mexico antidumping duties as production relocated to China; import prices from China (red line) tend to be lower than import prices from Korea (blue line). With the Chinese prices not subject to the tariff, this negative price response to tariff changes is consistent with a *negative* tariff pass-through.[12]

In contrast, import prices tend to be roughly equivalent during the switch from China to Vietnam/Thailand (the purple line). Similarly, no systematic changes in the behavior of

[10] Panel B of Figure 1 highlights that imported components may lower the domestic value-added share of washer exports. For Thailand and Vietnam, imported washing machine parts (HS845090) accounted for 12 to 17 percent of the value of washing machine exports.

[11] These third country effects also allay suspicion that the increase in U.S. imports from Thailand and

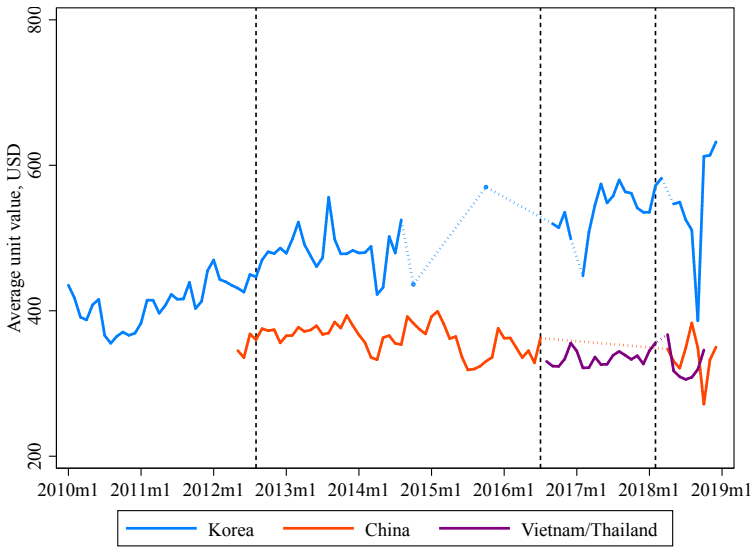


Figure 3: Average Unit Values (Exclusive of Tariffs and Duties) by Production Location

Notes: Includes residential washing machines classified under HS8450200040, HS8450200080 and HS8450200090. Solid lines display country-level unit values with at least 10,000 unit imports in the data. Dotted lines represent periods that did not satisfy a threshold of at least 10,000 unit imports.
Source: United States International Trade Commission (2010-2019).

import prices are evident following the Section 201 safeguard tariffs. Figure 3 illustrates the shortcomings of inferring the tariff elasticity based on a regression evaluating the relationship between changes in import prices and tariff rates at the country-product level. We describe the differences between this approach and our elasticity calculations below using retail prices in greater detail in Appendix C.8.

B Data and Price Trends of Washers and Dryers

Properly identifying the consumer price impact of the U.S. tariffs on washing machines requires data on final point-of-sale prices that are both high frequency and include details on brand, features, and retailer. We obtain data with these features from Gap Intelligence (2013-2018), a market research firm that gathers data across a wide range of products and markets in the U.S. The raw dataset contains weekly data entries of price and product characteristics at the retailer-model level from March 2013 to December 2018.

We have information on five major household appliances: washers, dryers, ranges, dishwashers, and refrigerators. In addition to the posted retail price, we observe the brand, model, date of first appearance in the market, and various other product characteristics such as capacity, color, load type, and energy efficiency rating. The dataset contains records from both brick-and-mortar and online stores (separately for stores with an online and physical presence); the data also contain the number of each retailer's brick-and-mortar stores in a given quarter. Gap Intelligence pays weekly visits to major retailers in 22 metropolitan areas

Vietnam was due to trans-shipments rather than true production relocation. See Appendix C.4.

[12]We demonstrate the theoretical underpinnings of a negative price response to tariff changes (or negative rate of tariff pass-through) in Appendix A, but the evidence from import prices for the Korea/Mexico antidumping case is more suggestive than conclusive. Changing product composition, transfer pricing strategies, and unaccounted for cost information may influence the evidence from reported values and quantities used in this calculation. But as Figure 4 shows, the CPI for laundry equipment declines considerably just after the production relocation from Korea/Mexico to China in mid-2012—consistent with the negative pass-through interpretation of the changes in unit values.

and records the availability and price of each product. The company provides two price variables: the sticker price and the net price after applying promotions or discounts. We work with the net price in our analysis throughout. Some heterogeneity in prices across retail locations may exist, but the provided weekly retailer-product specific price information is what Gap Intelligence considers the nationally representative price.[13] The Gap Intelligence data contain no product-level quantities purchased, so we corroborate our analysis with annual, brand-level market share data by Traqline Market Research (2010-2018), another market research firm.

We apply several sample restrictions to the Gap Intelligence data. To account for the life cycle effects of appliances we calculate each product's age from the initial debut date in our data. The initial debut date is truncated by the first week in which the retail price data was collected. As this introduces large measurement error in products' ages for dates near March 2013 and we find particularly strong price discounts of appliances in the first few months, we start our price analysis from mid-July 2014 onward. We remove laundry machines with both washing and drying functions (All-in-one or Laundry Center) and focus attention on the five major brands of washing machines: LG, Samsung, Whirlpool, Maytag, and G.E. These brands account for more than 80 percent of the total observations on washers and dryers in the raw data. We further concentrate our analysis on the five national retailers in the United States: JC Penney, Best Buy, Lowes, Sears, and Home Depot, which together account for more than 50 percent of the observations in the data. In the Appendix we show results where we include all available brands and retailers.

As a first step to document the trends in prices of washers and dryers, we first filter out changes in price that are accounted for by changes in the product mix, product features, and timeline of the product life-cycle. To do so, we apply the following hedonic regression of log prices of washers and dryers:

$$p_{irt} = \lambda_{C(i)t} + \mathbf{X}_i\beta + b_{B(i)C(i)} + \sum_{a=2}^{25} \alpha^a_{C(i)} \mathbf{1}(\text{age}_{it} = a) + \gamma_r + \epsilon_{irt}. \tag{1}$$

where subscripts i, r, t stand for model, retailer, and time (measured by week) respectively. The notation $C(i)$ refers to the product category (e.g., washer, dryer) whereas $B(i)$ refers to the brand (e.g., Samsung, Whirlpool) of product i. The $\mathbf{X}_i$ term is a vector of specifications for model i, which includes characteristics such as total capacity, energy star, smart appliance, and load type (see Table C8 for a full list of characteristics by product category). The $\lambda_{C(i)t}$ term refers to a product category week fixed effect, and the $b_{B(i)C(i)}$ term captures a brand and product category specific fixed effect.[14] The term γ_r denotes a retailer fixed effect. To account for life cycle effects of product pricing, the age_{it} variable captures the age of a product measured in months. We omit a dummy variable for the first month of the product after initial debut in our dataset and then include dummies for the following 23 months, as well as a dummy for whether the product has debuted more than two years ago.

Figure 4 plots the $\lambda_{C(i)t}$ fixed effects, which depict trends in washer and dryer prices during our sample period. The red line displays the washer-week fixed effect from the log

[13] Nakamura (2008), Hitsch, Hortacsu and Lin (2017) and DellaVigna and Gentzkow (2017) report evidence suggesting chain-level pricing across stores located in different geographic markets.

[14] Note that any linear age effects of washer/dryer models will be captured by the $\lambda_{C(i)t}$ term.

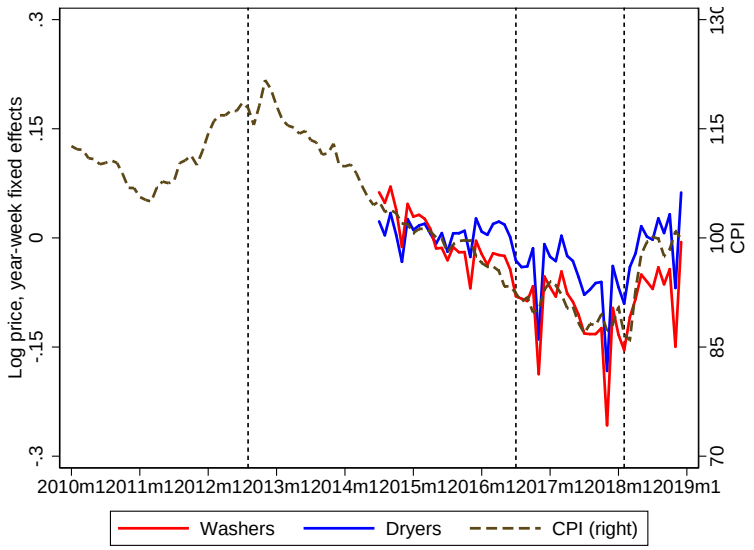


Figure 4: Time Fixed Effects from Log Price Regression, CPI for Laundry Equipment

Notes: We plot the year-week fixed effects for washers or dryers, averaged over each month, obtained from estimating equation (1). We omit the week dummy for the week of April 1, 2015. In that month, the CPI for laundry equipment was close to 100 points and therefore the left and right axes are simple to compare. The dates of the three vertical lines are August 2012, July 2016, and February 2018, discussed in the text.

price regression in equation (1) (averaged by month), the blue line the dryer-week fixed effect (again averaged to its monthly level). These fixed effects summarize the average (log) price level in those periods after controlling for life-cycle factors and product/brand characteristics. The dashed line represents the CPI for laundry equipment from the the Bureau of Labor Statistics (2010-2019). The residualized price series patterns align well with the CPI during our sample. For example, from July 2014 to January 2018 (shortly before the introduction of the safeguard tariffs in February 2018), the Gap Intelligence data suggests a decline in washer prices of about 20 percent and a decline in dryer prices of about 7 percent. The CPI for laundry equipment (a price index for washers and dryers combined) declined by about 15 percent during this period. One noticeable difference is that our series contains more seasonality, whereas the CPI for laundry equipment is seasonally adjusted. However, we find similar seasonal patterns for all five household appliances, so seasonality will not drive our estimates of the tariff effects discussed below. The product-category-time fixed effects for all five appliances are shown in Figure D2 in the appendix.

Figure 4 demonstrates that prices of washing machines jump shortly after the safeguard tariffs were applied. A more striking feature of Figure 4, however—and one that would not be evident without the more disaggregated data at our disposal—is that the price of dryers jumps by a similar magnitude as washers, despite not being directly affected by tariffs during this period. We explore this feature of the data in greater detail below.

C Estimating the Price Effects of Washing Machine Import Restrictions

We now turn our attention to estimating the price effects of U.S. trade policy. Although our sample is not long enough to evaluate the first antidumping duties (on Mexican/Korean imports), we can separately assess the effects of the 2016 China antidumping duties and the 2018 safeguard tariffs.

By leveraging the additional appliances in our data, we can account for other factors influencing costs and demand conditions in the overall appliance market in the United States.

One important factor during this time period was new import restrictions affecting steel and aluminum. Using the rarely invoked "Section 232" trade remedy based on national security considerations, in March of 2018 the United States imposed tariffs of 25 percent on steel and 10 percent on aluminum. The result of these measures, however, was a jump in the domestic prices of steel and aluminum—which together represent a significant input cost in U.S. production of washing machines. Our strategy allows us to isolate the particular effects of washing machine tariffs given that all appliances were similarly affected by these changes in input costs. The product category closest to washers and dryers with respect to steel content is ranges; therefore we choose it as the control product group. This appliance also has the most similar import share (see Appendix C.5 for a discussion of the metals content and import share of appliances).

To estimate the price effect of the antidumping duties against China (effective from July 2016) and the safeguard tariffs (effective from February 2018), we regress the log price on product and brand controls, a retailer fixed effect, year-week fixed effects, and the interaction of each product category with weekly fixed effects. As ranges are the omitted product category, all estimates of the interaction terms are relative to the average log price of ranges before and after the event:

$$p_{irt} = \lambda^{d}_{C(i)t} + \mathbf{X}_i\beta + b_{B(i)C(i)} + \sum_{a=2}^{25} \alpha^{a}_{C(i)} \mathbf{1}(\text{age}_{it} = a) + \gamma_r + \ell_t + \epsilon_{irt}. \tag{2}$$

Most of the coefficients in equation (2) are the same as in equation (1), the difference being that $\lambda^{d}_{C(i)t}$ measures the product category week fixed effect relative to the week fixed effect from ranges.[15] To better illustrate our results, we estimate equation (2) twice, once with the week effect of the antidumping duties against China (week of July 17, 2016) normalized to zero and again with the week fixed effect of the safeguard tariffs ($t = -1$ of January 28, 2018) set to zero. The term ℓ_t absorbs price shocks that commonly affect all household appliances, such as changes in the price of steel.

Panel A of Figure 5 reports the estimates of $\lambda^{d}_{C(i)t}$ for the categories of washers, dryers, refrigerators, and dishwashers before and after the 2016 China antidumping duties. Panel B reports equivalent estimates for the Section 201 safeguard tariffs. We include refrigerators and dishwashers in the analysis as placebo effects—a check for the plausibility of our estimates. Though the patterns for both washers and dryers are striking in Panel B in particular, we report 48 weeks of estimates before the policy dates to illustrate the effects of any pre-trends in the estimates. For example, refrigerator prices (Panel A) appear to be growing differentially from ranges before and after July 2016. As we know from Figure 4, over a long horizon, the prices of washers have fallen more than the prices of dryers or other appliances (see Figure D2 for price changes in all five appliances). Hence, though the patterns evident in Figure 5 are informative, we must factor in the different trends (see, e.g., Finkelstein (2007)) to arrive at the true effect of tariff changes on prices. To do this, we calculate the estimated change in prices after the introduction of import restrictions relative to the change in prices prior to the import restrictions. Specifically, we calculate the four-month effect of a tariff/

[15] Additional details on the other covariates in regression 2 are available in Table C8. Standard errors are clustered by model.

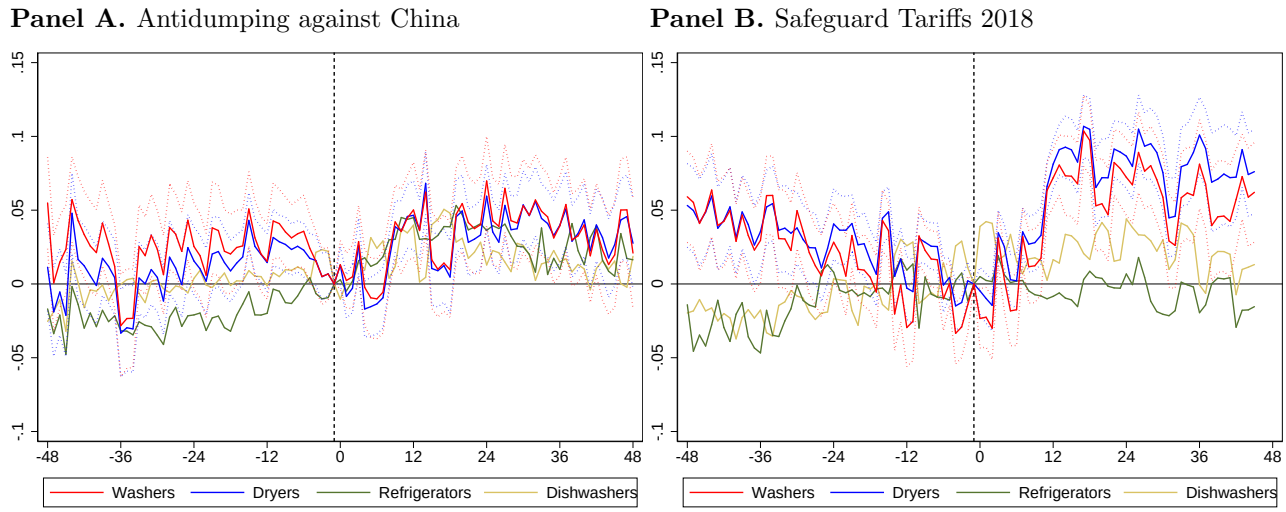


Figure 5: Price Effects of Safeguard Tariffs and Antidumping Duties against China

Notes: These figures report the regression coefficients $\lambda_{C(i)t}$ from equation (2). In Panel A the estimates are relative to the week of July 17, 2016, and in Panel B the estimates are relative to the week of January 28, 2018. The dotted lines denote 95 percent confidence intervals for the coefficient estimates for washers and dryers, based on standard errors clustered by model.

antidumping event as

$$\begin{aligned}\Delta^{\text{4m}}_{\text{event}}\bar{p}_C = &\left(\bar{\lambda}^d_{\text{C, -28to-20 weeks from event}} - \bar{\lambda}^d_{\text{C, -8to0 weeks from event}}\right) \\ &- \left(\bar{\lambda}^d_{\text{C, -8to0 weeks from event}} - \bar{\lambda}^d_{\text{C, +12to+20 weeks from event}}\right)\end{aligned} \tag{3}$$

and an eight-month effect analogously, where we define the end points using periods -44 to -36 weeks and +28 to +36 weeks relative to the policy date.

Table 1: Difference-in-Difference Estimates: Price Effects of Washing Machine Tariffs

	Antidumping against China				**Safeguard tariffs 2018**			
	4-month	8-month	4-month	8-month	4-month	8-month	4-month	8-month
Washers	0.026	0.034	0.046	0.058	0.109	0.115	0.110	0.119
	(0.015)	(0.017)	(0.012)	(0.013)	(0.014)	(0.018)	(0.011)	(0.012)
Dryers	0.016	0.023	0.033	0.047	0.111	0.114	0.112	0.119
	(0.012)	(0.014)	(0.009)	(0.010)	(0.013)	(0.017)	(0.009)	(0.009)
Refrigerators	0.025	0.008	0.039	0.028	0.001	-0.035	-0.002	-0.018
	(0.010)	(0.013)	(0.007)	(0.007)	(0.010)	(0.015)	(0.006)	(0.007)
Dishwashers	0.012	-0.006	0.035	0.024	-0.010	-0.021	-0.012	-0.017
	(0.013)	(0.014)	(0.008)	(0.008)	(0.012)	(0.018)	(0.007)	(0.009)
Model characteristics	✓	✓			✓	✓		
Model fixed effects			✓	✓			✓	✓
N	1,637,298		1,637,298		1,637,298		1,637,298	

Notes: The table reports estimates for $\Delta^{\text{4m}}_{\text{event}}\bar{p}_C$ and $\Delta^{\text{8m}}_{\text{event}}\bar{p}_C$ defined in equation (3) and the text below it. The right hand side of equation (3) is a linear combination of the estimates from equation (2). Standard errors in parentheses.

Our baseline specification includes controls for product characteristics and an interaction of brand and product category fixed effects. We also present results with model fixed effects. In that specification the estimated policy effect is identified from the price changes of the products existing both before and after the policy change, whereas the baseline specification estimates price effects including price level changes for new products.

As shown in Table 1, after accounting for differential pre-trends, we find only modest price changes caused by the antidumping case against China. Our baseline estimates in

columns 1 and 2 suggest a price increase of only 1.5 to 3.5 percent for washers and dryers in the 4 and 8 months periods. Columns 3 and 4 show the specification using model fixed effects, which show slightly higher estimates – though the price estimates of the two placebo appliances suggest that not all of this increase was due to tariffs.[16]

By contrast, and consistent with the preliminary evidence from Panel B of Figure 5, the estimated price effects of the Section 201 safeguard tariffs are much more striking. We find that the price of washers jumps by around 11 percent in the period four to eight months following the application of these tariffs. As noted above, equally dramatic is the relative price estimate for dryers which rises by an equivalent amount. In this case the estimates pertaining to the alternative specification are essentially unchanged.

The price effects on dryers are initially puzzling as these appliances were not subject to any new tariffs during this time. Residential washing machines are typically sold jointly (often, as paired models) with clothes dryers. Indeed, a prominent counter-argument from respondents to the Section 201 investigation was that paired washer and dryer units are often sold at essentially identical prices; dryers are substantially less costly to produce, so considering profits on washers alone would understate the overall margins these companies expect to make on the laundry equipment market as a whole (see United States International Trade Commission 2017*a*).

To explore this point further, we identify the set of matched washer-dryer models within each brand, as discussed in Appendix C.9. Roughly three-quarters of the washers in our data have a matched dryer model (often with either gas or electric versions). Focusing solely on the electric models, we find that in over 85 percent of our weekly observations, these matched models report the *exact same dollar price*. Hence, the price correlation between these matched models is very high—over 0.95—while the correlation of price changes is 0.82.[17] These facts are consistent across all major brands in our data.

For another perspective, we scrape major online retailer websites and capture the "Best Selling" sales rank for both washers and dryers, in addition to the model name and number. We use these data to calculate the correlations of sales rank for washers and dryers for the major brands we study. The correlation of sales ranks for a brand's washers and dryers at a given retailer is quite high, 0.9 to 0.95, and typically lower, 0.3 to 0.9, for other appliance pairs (Appendix C.10 and Appendix Figure C10). As a whole, our data offer clear evidence of complementarities between washers and dryers. As such, the firms in our sample may have chosen to split the effects of new tariffs on prices between washers and dryers, maintaining the convention of identical prices. Nevertheless, this behavior raises significant questions. If dryers are indeed significantly less costly to produce, why doesn't competition drive down the price? One possibility is that consumers might be more informed about, and thus have a more elastic demand, for the washer unit while treating the dryer as an "add-on" good, for which demand is less elastic, as in Ellison (2005) and Gabaix and Laibson (2006). In addition, the aesthetics of similar design and style features of matched washer-dryer pairs is likely an important component of consumer behavior as well.

[16] In columns 3 and 4, when compared with dishwashers and refrigerators, the price increases for washers and dryers are comparable to columns 1 and 2. See Tables C6 and C7 in the appendix for analogous tables when refrigerators or dishwashers are used as the control group; the coefficients are identical to the difference between the washer or dryer coefficients and the other appliance category from Table 1.

[17] The correlation of average prices across all models within a brand/merchant is 0.87. The washer-dryer correlation of average price changes across all models within a brand/merchant is 0.74.

Reassuringly, in Table 1 we find little evidence of any differential price effects for refrigerators and dishwashers for the results pertaining to the 2018 safeguard tariffs. It is worth pointing out that some of the other appliances used in our analysis were subsequently subject to new tariffs later in 2018. A third round of tariffs imposed on Chinese imports included refrigerators and electric/gas ranges; household dishwashers were not subject to new tariffs. These tariffs went into effect in September (roughly $t = 28$ in Panel B of Figure 5) at a rate of 10 percent. Although one might wonder whether these Section 301 tariffs may affect our results, the scope of impact of these China-specific tariffs on refrigerators and ranges was quite small by comparison. Prior to these tariffs, the Chinese import share for refrigerators was around 15 percent, leading to an increase in the trade-weighted tariff rate of less than two percentage points. For ranges, the Chinese import share was about 10 percent, and hence the increase in the effective tariff rate was less than one percentage point. See Appendix C.5 for more details.

The evidence in Table 1 demonstrates that, as a whole, washers and dryers experienced notable price increases following the safeguard tariffs of 2018. Multiplying these estimates by the median pre-period price of washers (749 USD per unit) and dryers (809 USD per unit) yields that the dollar price increase attributable to these tariffs on washers and dryers was 86 USD per unit and 92 USD per unit, respectively.

Because the tariffs under consideration were not evenly applied across all models in the data, these estimates could mask much larger price changes by foreign producers (primarily LG and Samsung) with little to no price changes by domestic producers. To explore this heterogeneity, we rerun specification (2) but allow for separate coefficients for each brand. Specifically, we estimate

$$p_{irt} = \lambda'_{C(i)B(i)t} + \mathbf{X}_i\beta' + \sum_{a=2}^{25} \alpha'^{a}_{C(i)}\mathbf{1}(\text{age}_{it} = a) + \gamma'_r + \ell'_{B(i)t} + \epsilon'_{irt}, \tag{4}$$

where now $\lambda'_{C(i)B(i)t}$ denotes a product category $\times$ brand-week fixed effect and $\ell'_{B(i)t}$ denotes the brand-specific week fixed effect applied to all product categories. The product category of ranges does not have a separate product category $\times$ brand-week fixed effect. We then apply a suitably modified equation (3) to arrive at price change estimates that vary by both appliance and brand.

Our estimates, reported in Table 2, show that all major brands increased prices following the safeguard tariffs. There is no clear distinction between domestic and foreign brands in these results, all within a range of 5 and 17 percent. Depending on the time horizon, Whirlpool increased washer prices between 13 and 17 percent; dryer prices increased at least as much. Maytag raised washer prices by about 14 percent, dryer prices between 17 and 20 percent. G.E. had lower price increases: around 5 and 11 percent for washers and dryers, respectively. LG raised prices over four months by 8 percent and over eight months by about 13 percent for both washers and dryers. Samsung increased prices by 15 to 17 percent for washers and about 10 percent for dryers.

Why did the price of domestic brands increase in line with foreign brands, despite being excluded from the additional costs of tariffs? One possibility is that the domestic brands are expanding their market shares and have rising marginal costs (the standard argument in most

Table 2: Difference-in-Difference Estimates: Brand-Specific Price Effects of Washing Machine Tariffs

	Washers		Dryers		Refrigerators		Dishwashers	
	4-month	8-month	4-month	8-month	4-month	8-month	4-month	8-month
Antidumping against China								
Whirlpool	-0.031	-0.034	-0.034	-0.003	0.007	-0.012	-0.030	-0.046
	(0.028)	(0.036)	(0.025)	(0.034)	(0.017)	(0.024)	(0.021)	(0.028)
Maytag	0.142	0.190	0.114	0.148	0.031	-0.014	0.012	-0.011
	(0.044)	(0.053)	(0.037)	(0.046)	(0.049)	(0.053)	(0.043)	(0.048)
LG	0.010	-0.011	-0.008	-0.036	0.042	0.036	0.012	-0.024
	(0.039)	(0.049)	(0.029)	(0.042)	(0.028)	(0.042)	(0.058)	(0.069)
Samsung	0.083	0.057	0.093	0.060	0.116	0.030	0.026	-0.054
	(0.041)	(0.050)	(0.036)	(0.041)	(0.037)	(0.044)	(0.061)	(0.070)
G.E.	-0.002	0.024	-0.017	-0.018	-0.015	-0.008	0.012	0.011
	(0.018)	(0.024)	(0.017)	(0.023)	(0.016)	(0.022)	(0.015)	(0.018)
Safeguard tariffs 2018								
Whirlpool	0.174	0.129	0.175	0.142	0.008	-0.029	0.041	-0.001
	(0.033)	(0.037)	(0.028)	(0.033)	(0.023)	(0.029)	(0.024)	(0.032)
Maytag	0.146	0.137	0.169	0.201	0.030	0.148	0.018	0.009
	(0.035)	(0.050)	(0.031)	(0.047)	(0.028)	(0.048)	(0.029)	(0.058)
LG	0.081	0.131	0.082	0.125	0.040	0.022	0.136	0.158
	(0.022)	(0.031)	(0.020)	(0.028)	(0.021)	(0.030)	(0.036)	(0.072)
Samsung	0.153	0.175	0.104	0.099	0.008	-0.071	-0.016	0.054
	(0.031)	(0.039)	(0.028)	(0.035)	(0.021)	(0.028)	(0.024)	(0.050)
G.E.	0.072	0.051	0.123	0.108	-0.035	-0.064	-0.052	-0.066
	(0.023)	(0.031)	(0.023)	(0.030)	(0.017)	(0.026)	(0.017)	(0.029)

Notes: The table reports results analogous to Table 1—based on separate estimates for each brand. Specifically, first equation (4) is estimated (with model characteristics as controls) and then a linear combination of these estimates is used to compute the left hand side of equation (3)—separately for each brand and product category. Figure D3 in the appendix displays the corresponding weekly price estimates by brand. Standard errors are in parentheses.

undergraduate textbook treatments of tariff analysis). To consider this possibility, we utilize data on annual brand-level market shares from Traqline. Following the China antidumping and safeguard tariffs, brand market shares were roughly stable and even declined slightly in 2017 and 2018 for Whirlpool and Maytag. Moreover, the observed differences in market shares between 2017 and 2018 align well with the estimated changes in relative prices reported in Table 2. The firm with the lowest price increase (G.E.) experienced the largest gain in market share between 2017 and 2018. Annual shipment data from the Association of Home Appliance Manufacturers (AHAM) indicate that total sales of both washers and dryers declined by 3 percent during this period.

The Section 201 safeguard investigation also included new tariffs on washing machine parts. This could have raised the cost of domestic production, with subsequent pass-through to retail prices of washing machines. Further inspection reveals that the effective tariff rate on parts hardly changed following the Section 201 tariffs, consistent with this provision being a targeted measure to prevent foreign firms from importing semi-assembled pieces to get around the tariffs on fully assembled machines. Further details on washing machine parts is available in Appendix C.6. The effect of the increase in steel prices is differenced out, as it also applies to ranges (the control group) and the other appliances. In light of these results, a more plausible explanation is that the domestic brands are using their market power to raise prices. Indeed, as shown by Pierce (2011) for a broader set of industries, domestic

plants protected from antidumping duties tend to exhibit increased prices and markups.

Finally, we explore whether the increase in prices following the Section 201 safeguard tariffs reflected increased prices by wholesalers or changes in margins by retailers. We turn to proprietary data from AHAM, which includes monthly aggregate value and quantity (and, hence, a calculated average unit value) for shipments of broad categories of appliances (e.g., top-load washers and side-by-side refrigerators). Replicating the analysis above on this data, we find similar wholesale price changes for washers and dryers: an increase of roughly 10 percent in both washers and dryers following the Section 201 safeguard tariffs. Further details are available in Appendix C.7.

D Robustness

Appendix D contains additional results indicating that our findings from Section C are robust to alternative assumptions. We modify the sample to include all available stores and brands and to restrict to only brick-and-mortar stores. We have tried alternative specifications for how we treat the age of a model in our specification and run versions that remove the life cycle effects completely. We also run a specification using weights based on the number of brick-and-mortar stores for each retailer.

Our results are robust to these alternative assumptions. Focusing on our results pertaining to the safeguard tariffs, we see that the smallest estimate of price changes comes from the sample including all brands and retailers, with eight-month price increase estimates for washers and dryers of 8 percent. Our largest estimate of price changes comes from the weighted sample restricted to only brick-and-mortar stores, with eight-month price increase estimates for washers and dryers of 13 percent.

E The Tariff Elasticity of Consumer Prices

The tariff elasticity of prices (or tariff pass-through) is a useful metric for policymakers attempting to understand the likely consequences of increased tariffs on economic activity. In an environment pertaining to worldwide tariffs on a homogeneous goods market with a competitive retail sector, this elasticity would follow directly from the changes in import prices following a tariff change. A number of features, however, such as imperfect competition, changes in wholesaler/retailer margins, production relocation (including to the domestic market), and complementary goods, complicate the calculation of this metric.

We construct a measure of the tariff elasticity of *consumer* prices that can accommodate these complications. Formally, let $\Delta_t \ln P_C(\Delta\tau)$ denote the log change in the consumer price index of product category C *in response to a tariff change*. The measure is meant to capture the change in expenditure required to obtain the same utility as under pre-tariff prices (i.e., $\frac{e(p_1,u_0)-e(p_0,u_0)}{e(p_0,u_0)}$). Then, we define the tariff elasticity of consumer prices (TECP) as

$$\text{TECP}_{C,t} = \frac{\Delta_t \ln P_C(\Delta\tau)}{\left[\frac{M_{C,t-1}}{D_{C,t-1}}\right] \sum_K s^k_{C,t-1} \Delta\tau^k_{C,t}}, \tag{5}$$

where $M_{C,t-1}$ and $D_{C,t-1}$ are aggregate imports and consumption of product category C, measured in period $t-1$ before tariffs are applied. The term $s^k_{C,t-1}$ denotes lagged import shares of country k to apply to the country-specific tariff rate changes ($\Delta_t \tau^k_C$). Equation (5)

more accurately captures the indirect price effects of tariffs by measuring the aggregate price and tariff changes separately while using lagged import weights to reflect the effective tariff burden facing firms and therefore applicable to the initial price level. The focus on the overall consumer prices—made possible by our data—and an adjustment for the share of domestic production facing no tariff changes (the $\frac{M_{C,t-1}}{D_{C,t-1}}$ term in the denominator) ensure that the measure reflects an overall elasticity for products consumed.[18] Finally, the measure allows one to identify the product category C to assess whether broader categories of products experience price changes.

The TECP measure has intuitive properties. If import prices on the selected countries subject to tariffs rise proportionally with the tariff change and prices of goods from other countries do not change, the TECP measure takes a value of one, indicating a full pass-through of tariffs to consumers.[19] If firms substitute their import locations to other countries and increase prices by less than the tariff change, and domestic competitors do not change their prices, the TECP measure will be less than one. Finally, if competitors not subject to tariffs themselves increase their prices as well, the TECP measure can be larger than one.

To implement equation (5) in our data, we require two adjustments. First, as a measure of the price index, we are effectively taking the average log change of prices from our data. While this may insufficiently capture the substitution possibilities of consumers across brands, our brand-level analysis demonstrates similar price changes and stable market shares during the periods we study.[20] And, as shown in Figure 4, our estimates mirror the CPI quite well. Second, to capture the causal impact on prices (defined as $\Delta_t \ln P_C(\Delta\tau)$ above), we follow our approach from Section C and utilize our estimates $\widehat{\Delta_t^{8m}\bar{p}_C}$ in equation (3), which uses a set of control group (J) products. This is to difference out factors apart from tariffs that could be influencing consumer prices for product category C during this time period. This leads to the modified expression

$$\widehat{\text{TECP}}_{C,t} = \frac{\widehat{\Delta_t^{8m}\bar{p}_C}}{\left[\frac{M_{C,t-1}}{D_{C,t-1}}\right]\sum_{K_C} s^k_{C,t-1}\Delta_t\tau^k_C - \left[\frac{M_{J,t-1}}{D_{J,t-1}}\right]\sum_{K_J} s^k_{J,t-1}\Delta_t\tau^k_J} \tag{6}$$

Implementing equation (6) in our data presents a number of complications. First, calculating the statutory tariff rate change is complicated. For the two antidumping cases in which the application of antidumping duties is firm specific, there is the question of how to aggregate. In order to best approximate the aggregate change in duties we utilize the firm-level bill of lading data (see Appendix C.14) to construct pre-period firm-level shares to use as weights. For the Section 201 safeguard case, the complication comes from a number of product-level exclusions (within HS-10 codes) which we are unable to identify in the retail price data (see Appendix C.2). Appendix Figure C3 demonstrates that imports iden-

[18] For washing machines, we measure aggregate consumption using shipments data from AHAM.

[19] To see this, consider a first-order approximation of the expenditure function. Applying Shephard's lemma, one obtains $\frac{e(p_1,u_0)-e(p_0,u_0)}{e(p_0,u_0)} \approx \sum_k s_0^k \frac{p_1^k - p_0^k}{p_0^k}$. Hence, under these conditions, the numerator and denominator of the TECP formula will be the same.

[20] One would ideally estimate a structural model of demand across washers and dryers to estimate substitution parameters, and to calculate the consumer welfare effect of the policy induced prices changes. Although we lack the quantity data for this exercise, we will use the observed decline in the aggregate consumption of washers for our quantification of the consumer cost increases due to the 2018 safeguard tariffs on washers in Section III.

tified under the Section 201 rate provision code display an applied tariff rate that matches those specified in the statute, while the average effective tariff rate across all washer imports is significantly lower. Because it is unclear which washers were excluded, and to what brands/models they belong, we adopt the conservative convention and simply apply the statutory rate in our calculations in equation (6).

In addition, the Section 201 safeguard measure is a tariff-rate quota and therefore exhibits multiple tariff rates during the sample period we study. As mentioned, the quota of 1.2 million units subject to the lower (20 percent) additional tariff rate was reached in October 2018, and all relevant units thereafter paid a higher rate of 50 percent. In our results below we report two estimates based on whether we use the trade-weighted average of these two rates or the maximum rate. The maximum rate may be appropriate if companies perceive the opportunity cost of selling a washer imported under the lower rate to be importing it at the higher rate in the future.

Finally, a third issue is how to account for the price changes of dryers, which had no tariff change during this period. We found that prices of dryers rose in line with washers, consistent with evidence for broader complementarities between these products. Firms likely spread out the increase in prices across both washers and dryers to keep the retail prices similar between matching models sold as pairs. To add the dryer effect to equation (6), we modify the product category C to include both washers and dryers. Because we estimate the price change to be nearly identical (the numerator), the main difference arises in a smaller average tariff rate change (a smaller denominator, reflecting a zero tariff rate change for dryers).

Table 3: Calculation of the Tariff Elasticity of Consumer Prices

	Antidumping		**Safeguard Tariffs**[a]	
	Korea & Mexico	China	Trade-Weighted Average	Maximum
	(1)	(2)	(3)	(4)
A: Average Consumer Price Change[b]				
Washers Only	N/A	3.40%	11.50%	11.50%
Washers and Dryers	-8.55%	2.85%	11.45%	11.45%
B: Pre-Period Trade-Weighted Average Statutory Tariff Rate Change				
Washers Only	9.57%	16.32%	9.18%	19.94%
Washers and Dryers	5.27%	9.15%	5.09%	10.64%
C: Tariff Elasticity of Consumer Prices				
Washers Only	N/A	0.21	1.25	0.58
Washers and Dryers	-1.62	0.31	2.25	1.08

Notes: Panels A and B follow the numerator and denominator of equation (6), respectively. The denominator calculates import shares in a pre-period defined as Jul-Dec 2011, Jul-Dec 2015, and Feb-Aug 2017 for the Korea/Mexico antidumping, China antidumping, and safeguard tariffs, respectively. Statutory tariff rate changes for antidumping duties use firm-level weights from PIERS Bill of Lading data (see Table B2).

[a] The two columns pertaining to the Section 201 safeguard tariffs correspond to the method of accounting for the heterogeneity in tariff rates over time. The "Trade-Weighted Average" uses import shares as weights during the period of study, and the "Maximum" column uses the maximum (50 percent) rate.

[b] Columns (2), (3), and (4) in panel A are calculated based on estimates presented in column (2) of Table 1, where the estimates for washers and dryers are the simple average of the two coefficients. Column (1) is calculated using changes in the CPI for "laundry equipment" relative to "other appliances" during the relevant period (following equation (3)).

Panel C of Table 3 presents the estimates of the tariff elasticity of consumer prices for the three tariff changes we study. (We separate out the numerator and denominator components

in panels A and B, respectively, and report estimates for both washers and washers including dryers.) Although we lack detailed micro-level retail prices for the first Korea/Mexico antidumping duties, we provide an estimate of price changes using the published CPI for laundry equipment relative to the CPI for "other appliances." For the Section 201 safeguard tariffs, we report estimates separately based on whether we use the trade-weighted average or the maximum value of the tariff rate applied during the 12-month period following tariffs being implemented.

Evident in Table 3 is a wide range of the consumer elasticity of tariffs. Our suggestive estimate for the 2012 antidumping duties against Korea and Mexico indicates a *decline* in prices and hence a *negative* elasticity. (See Appendix A for a theoretical discussion.) Consistent with this estimate, the brand-level market share data in Appendix Table C12 indicate that both LG and Samsung gained market share in 2013 and 2014 (whereas their combined market shares were flat in the two years prior to the Korea antidumping case). However, the small price increase we estimate for the 2016 antidumping duties against China results in a modest elasticity of 0.21 (washers only) to 0.31 (washers and dryers combined). Finally, the estimates for the Section 201 safeguard tariffs are considerably higher: 1.25 to 2.26 using the trade-weighted average tariff increase or 0.58 to 1.08 using the maximum tariff rate. Our results demonstrate markedly different consumer price effects between single- and multi-country tariffs. They further highlight that price increases by domestic competitors and for complementary goods can push this elasticity well above one.

III Discussion and Conclusions

A common summary measure for evaluating the effects of a policy combines the impact on consumer prices with the added domestic employment into an estimate of the consumer cost per domestic job created in that industry. In the period following the 2018 safeguard tariffs, U.S. employment rose as existing producers claimed an additional 200 jobs and foreign producers added 1,600 jobs from new U.S. production.[21] As shown, these job gains were accompanied by substantially higher consumer prices. To arrive at an overall cost increase to consumers, we multiply the dollar value increases in washer/dryer prices by the annual level of washer/dryer shipments. We use the average level of shipments between 2017 and 2018, based on AHAM numbers indicating that washing machine sales fell in 2018. These numbers are roughly 10 million washing machines and 7.7 million clothes dryers, indicating an annual cost to consumers of 1.55 billion USD.[22]

Tariff revenues offset these costs to a small extent. According to USITC records, calculated duties from February 2018 to January 2019 amounted to just under 82 million USD for washing machines and about 355,000 USD for washing machine parts. After netting out the tariff revenue from the annual costs to consumers, the consumer cost per job for the 2018 safeguard tariffs amounts to roughly 817,000 USD annually. This number is of the same order of magnitude as in other similar exercises. Hufbauer and Lowry (2012) calculate

[21] Of course, the effect on overall employment from these policies depends in large degree on the extent of slack in the economy. In February 2018, the unemployment rates in Newberry County, SC (Samsung plant), Montgomery County, TN (LG plant), and Sandusky County, OH (main Whirlpool plant) were 3.7, 3.8, and 5.1 percent, respectively.

[22] Hence, 86 USD $\times$ 9.78 million $\approx$ 841 million USD plus 92 USD $\times$ 7.72 million $\approx$ 710 million USD. Together, they equal 1.552 billion USD.

such a metric from the Section 421 tariffs on Chinese tire imports, finding a cost of roughly 900,000 USD per job. These calculations are made in partial equilibrium and focus only on the direct effects of these policies on the washing machine sector. Upstream linkages to domestic suppliers could create a multiplier effect on the number of domestic jobs created from this policy. But higher prices of appliances at retail stores may reduce available income for expenditures on other goods, leading to job losses in other industries.

Three broader lessons regarding firm behavior following new import tariffs emerge from our study. First, we find that complementary goods complicate the measurement of the tariff elasticity of prices, as dryer prices rose markedly in 2018 despite not being subject to new tariffs. Spillovers from complementarities across goods could operate more broadly, as complementary goods (mattresses and box springs, tables and chairs, ink printers and cartridges, and video game consoles, accessories, and games) are common and widespread. Firms being increasingly sophisticated in their models of pricing such goods (e.g., bundling, subscription plans), so tariff policies for a particular good may lead to unexpected price changes in other products unaffected by tariffs.

Second, production relocation plays a large role in the extent of tariff pass-through to prices. The large shifts in production and trade following the two sets of antidumping duties imply that duties were ultimately not applied to a significant share of imports. Retail prices rose only modestly after the 2016 China antidumping duties; more strikingly, import prices even *declined* following the 2012 Korea/Mexico antidumping duties (see Figure 3). But what conditions govern whether production will relocate in response to a change in trade policy? Any response will necessarily rely on idiosyncratic features of the particular firms and policies, but the experience of washing machines offers several useful lessons. First, the product specificity of capital and the structure of existing production networks appear to play important roles. During the transitions from Korea to China and China to Thailand/Vietnam, both LG and Samsung utilized existing plants used previously for other products in the destination countries to adjust production of washing machines while keeping overall trade flows to their large markets roughly unchanged. In contrast, the shift of production to the United States following safeguard tariffs took comparatively longer as both firms opened new facilities (Appendix C.12.) Whether and when relocation occurs may also depend on the magnitude of import duties, the timing of when they are implemented, and the expectations for how long they will last.[23]

Finally, domestic producers increase prices following the global safeguard tariff by a similar margin to importers. Price increases by domestic brands are consistent with a model of oligopoly in which prices are strategic complements (see Amiti, Itskhoki and Konings 2016). The extent of competition is a key determinant for how domestic producers will respond following an increase in import tariffs. Using the Traqline data to calculate the Herfindahl-Hirschmann index (HHI), we find the washing machine industry would be classified as "Moderately Concentrated" (an HHI between 1500 and 2500). Similar calculations for industries subject to new tariffs would be a useful exercise to better understand the overall impact of changes in trade policy on consumer prices.

[23] As shown in Table B1, there were effectively five months in between the USITC initial report and preliminary duties for the two antidumping cases and a slightly shorter lead time (four months) for the safeguard duties. Antidumping duties are subject to sunset reviews after five years, whereas safeguard tariffs are typically granted for a period of four years or less.

References

Amiti, Mary, Oleg Itskhoki, and Jozef Konings. 2016. "International Shocks and Domestic Prices: How Large Are Strategic Complementarities?" National Bureau of Economic Research Working Paper 22119.

Amiti, Mary, Stephen J. Redding, and David Weinstein. 2019. "The Impact of the 2018 Trade War on U.S. Price and Welfare." Center for Economic Policy Research Working Paper DP-13564.

Ashenfelter, Orley C., Daniel S. Hosken, and Matthew C. Weinberg. 2013. "The Price Effects of a Large Merger of Manufacturers: A Case Study of Maytag-Whirlpool." *American Economic Journal: Economic Policy*, 5(1): 239–261.

Association of Home Appliance Manufacturers. 2013-2019. "Factory Shipments Database." Confidential dataset.

Auer, Raphael, Ariel T. Burstein, and Sarah M. Lein. 2018. "Exchange Rates and Prices: Evidence from the 2015 Swiss Franc Appreciation." BIS Working Paper No. 751.

Bagwell, Kyle, Chad P. Bown, and Robert W. Staiger. 2016. "Is the WTO Passé?" *Journal of Economic Literature*, 54(4): 1125–1231.

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

Bernhofen, Daniel M., and John C. Brown. 2004. "A Direct Test of the Theory of Comparative Advantage: The Case of Japan." *Journal of Political Economy*, 112(1): 48–67.

Blonigen, Bruce A. 2002. "Tariff-jumping Antidumping Duties." *Journal of International Economics*, 57(1): 31–49.

Brainard, S Lael. 1997. "An Empirical Assessment of the Proximity-Concentration Tradeoff between Multinational Sales and Trade." *American Economic Review*, 87(4): 520–544.

Broda, Christian, and David E. Weinstein. 2006. "Globalization and the Gains From Variety." *Quarterly Journal of Economics*, 121(2): 541–585.

Broda, Christian, Nuno Limao, and David E. Weinstein. 2008. "Optimal Tariffs and Market Power: The Evidence." *American Economic Review*, 98(5): 2032–2065.

Bureau of Labor Statistics. 2010-2019. "Consumer Price Index." https://www.bls.gov/cpi/, accessed May 20, 2019.

Canadian International Merchandise Trade Database. 2010-2019. https://www5.statcan.gc.ca/cimt-cicm/home-accueil?lang=eng, accssed July 19, 2019.

DellaVigna, Stefano, and Matthew Gentzkow. 2017. "Uniform Pricing in US Retail Chains." National Bureau of Economic Research Working Paper 23996.

Ekholm, Karolina, Rikard Forslid, and James R. Markusen. 2007. "Export-Platform Foreign Direct Investment." *Journal of the European Economic Association*, 5(4): 776–795.

Ellison, Glenn. 2005. "A Model of Add-On Pricing." *The Quarterly Journal of Economics*, 120(2): 585–637.

Fajgelbaum, Pablo D., Pinelopi K. Goldberg, Patrick J. Kennedy, and Amit K. Khandelwal. 2019. "The Return to Protectionism." National Bureau of Economic Research Working Paper 25638.

Feenstra, Robert C. 1989. "Symmetric Pass-through of Tariffs and Exchange Rates under Imperfect Competition: An Empirical Test." *Journal of International Economics*, 27(1): 25 – 45.

Finkelstein, Amy. 2007. "The Aggregate Effects of Health Insurance: Evidence from the Introduction of Medicare." *Quarterly Journal of Economics*, 122(1): 1–37.

Fitzgerald, Doireann, and Stefanie Haller. 2018. "Exporters and shocks." *Journal of International Economics*, 113: 154 – 171.

Gabaix, Xavier, and David Laibson. 2006. "Shrouded Attributes, Consumer Myopia, and Information Suppression in Competitive Markets." *The Quarterly Journal of Economics*, 121(2): 505–540.

Gap Intelligence. 2013-2018. "Weekly Consumer Appliance Retail Price Series." Confidential dataset.

Goldberg, Pinelopi, and Nina Pavcnik. 2016. "Chapter 3 - The Effects of Trade Policy." In . Vol. 1 of *Handbook of Commercial Policy*, , ed. Kyle Bagwell and Robert W. Staiger, 161 – 206. North-Holland.

Grant, Matthew. 2017. "Why Special Economic Zones? Using Trade Policy to Discriminate Across Importers." Working Paper.

Helpman, Elhanan, Marc J Melitz, and Stephen R Yeaple. 2004. "Export Versus FDI with Heterogeneous Firms." *American Economic Review*, 94(1): 300–316.

Hitsch, Guenter, Ali Hortacsu, and Xiliang Lin. 2017. "Pricing in US Retail Chains." Chicago Booth Working Paper 17-18.

Horstmann, Ignatius J., and James R. Markusen. 1992. "Endogenous Market Structures in International Trade (Natura Facit Saltum)." *Journal of International Economics*, 32(1): 109 – 129.

Huber, J. Richard. 1971. "Effect on Prices of Japan's Entry into World Commerce after 1858." *Journal of Political Economy*, 79(3): 614–628.

Hufbauer, Gary, and Sean Lowry. 2012. "US Tire Tariffs: Saving Few Jobs at High Cost." Peterson Institute for International Economics.

Irwin, Douglas A. 2019. "Tariff Incidence: Evidence from U.S. Sugar Duties, 1890-1930." *National Tax Journal*, 72(3): 599–616.

Jaravel, Xavier, and Erick Sager. 2019. "What are the price effects of trade? Evidence from the US and implications for quantitative trade models." Center for Economic Policy Research DP-13902.

Korea Customs Service. 2010-2019. "Trade Statistics." http://www.customs.go.kr/english/cm/cntnts/cntntsView.do?mi=8042&cntntsId=2724, accssed July 12, 2019.

LG Electronics. 2017. "LG Electronics to Build U.S. Factory for Home Appliances in Tennessee." *Press Release*, https://www.lg.com/us/press-release/lg-electronics-to-build-us-factory-for-home-appliances-in-tennessee.

Ludema, Rodney D., and Zhi Yu. 2016. "Tariff Pass-through, Firm Heterogeneity and Product Quality." *Journal of International Economics*, 103(1): 234–249.

Nakamura, Emi. 2008. "Pass-Through in Retail and Wholesale." *American Economic Review*, 98(2): 430–37.

Pierce, Justin R. 2011. "Plant-level Responses to Antidumping Duties: Evidence from U.S. Manufacturers." *Journal of International Economics*, 85(1): 222–233.

PIERS. 2012-2019. "Bill of Lading Database." Confidential dataset.

Ruhl, Kim J. 2014. "The Aggregate Impact of Antidumping Policies." 25.

Sales Rank Dataset. 2019. "Online Sales Rank by Retailer." Compiled from http://www.bestbuy.com, http://www.homedepot.com, and http://www.jcpenney.com; accessed on January 30, 2019, and February 1, 2019.

Samsung. 2017. "Samsung to Expand U.S. Operations, Open $380 Million Home Appliance Manufacturing Plant in South Carolina." *Press Release*, https://news.samsung.com/us/samsung-south-carolina-home-appliance-manufacturing-plant-investment-newberry/.

Spearot, Alan C. 2012. "Firm Heterogeneity, New Investment and Acquisitions." *Journal of Industrial Economics*, 60(1): 1–45.

Tintelnot, Felix. 2017. "Global Production with Export Platforms." *Quarterly Journal of Economics*, 132(1): 157–209.

Traqline Market Research. 2010-2018. "Brand-level Retail Market Share Series." Confidential dataset.

Trefler, Daniel. 2004. "The Long and Short of the Canada-U. S. Free Trade Agreement." *American Economic Review*, 94(4): 870–895.

United Nations. 2010-2019. "Comtrade Database." https://comtrade.un.org/, accessed July 15, 2019.

United States Census Bureau. 2000-2019. "Related Party Trade Database." https://relatedparty.ftd.census.gov/, accessed December 15, 2018.

United States International Trade Commission. 2010-2019. "DataWeb." https://dataweb.usitc.gov/, accessed April 20, 2019.

United States International Trade Commission. 2017*a*. "Large Residential Washers." USITC, Investigation No: TA-201-076 Report 4745.

United States International Trade Commission. 2017*b*. "Large Residential Washers: Pre-hearing Report." USITC, Investigation No: TA-201-076 Report Doc ID: 621175.

Winkelmann, Liliana, and Rainer Winkelmann. 1998. "Tariffs, Quotas and Terms-of-trade: the Case of New Zealand." *Journal of International Economics*, 46(2): 313–332.

Yeaple, Stephen Ross. 2003. "The Complex Integration Strategies of Multinationals and Cross Country Dependencies in the Structure of Foreign Direct Investment." *Journal of International Economics*, 60(2): 293–314.

The Production Relocation and Price Effects of U.S. Trade Policy: The Case of Washing Machines

Aaron Flaaen Ali Hortaçsu Felix Tintelnot

Online Appendix

A A Simple Model of Production Relocation, Prices, and Tariffs

We describe a simple model of a firm's production relocation and pricing decisions and how these decisions respond to tariffs. The goal of this section is to illustrate theoretically that under imperfect competition the price effect of tariffs may be non-monotone when production relocation to third countries is taken into account.

Suppose consumers have CES preferences over a continuum of sectors.[24] We focus on one of these sectors—the washing machine sector. We assume that there is a foreign monopolist that supplies washers to the United States. We further assume that the foreign supplier has constant marginal cost in each of the available production locations. Regardless of the production location, washing machines are made with the same blueprint owned and supplied by the foreign monopolist, and are considered perfect substitutes by consumers. Note that for simplicity we assume away any domestic producers of washing machines, since for the foreign production relocation the existence of domestic producers is not essential, and the graphical analysis below is easier to convey without them. Tariffs are of the ad-valorem type. Our assumptions on demand and production cost imply that the monopolist charges a constant mark-up over marginal cost times one plus the tariff.

Consider first the textbook case without production relocation by the foreign monopolist. This case is depicted in Figure A1a. If the U.S. government charges an ad-valorem tariff on washing machine imports of t, the U.S. consumers pay the foreign monopolist price times one plus the tariff rate, $(1+t)$. The loss in consumer surplus is $a+b$, the government revenue collected is equal to region a, and the overall welfare loss for the United States is b.

Next, let us consider the case of Figure A1b, in which the foreign monopolist has the option to produce in country C or in country V. If the fixed cost to establish production in these countries is the same, and there are no import restrictions, the foreign monopolist chooses the production location with the lower marginal cost—here, country C. However, under sufficiently high import tariffs against country C, the producer obtains higher profits from producing in country V instead. This leads to an increase in the domestic price by $p_V - p_C \leq tp_C$. The consumer surplus falls by a_1 and b_1, and no government revenue is being collected. Note, however, that under the option of production relocation the decline in U.S. consumer surplus from tariff is smaller than in the example of Figure A1a.[25] The

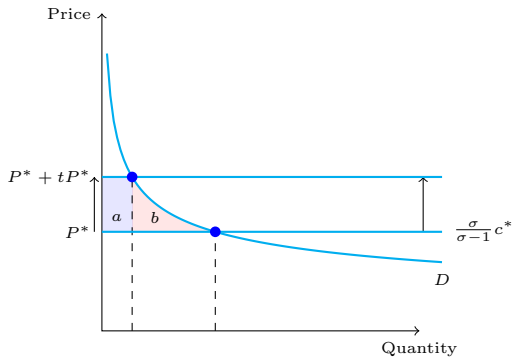
[24] Specifically, consumers have a utility function $U = \left(\int_0^1 q(j)^{(\sigma-1)/\sigma} dj\right)^{(\sigma/(\sigma-1)}$, where j denotes a sector.

[25] While under production relocation from C to V the consumer surplus declines less than in the textbook case (Figure A1a), the U.S. welfare loss may be higher as no tariff revenue is collected.

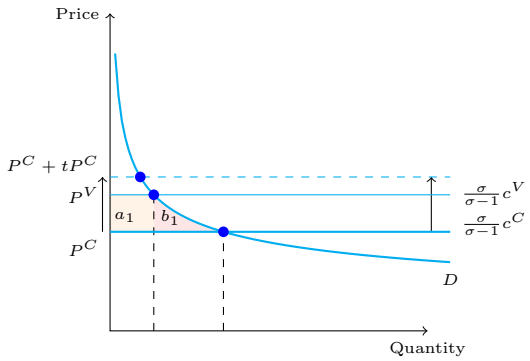
case presented in Figure A1b is an example of trade diversion due to asymmetric tariffs across countries.[26] Note that a similar response to the tariff would arise also under perfect competition if there are multiple foreign countries in which the good can be produced.

Figure A1: A Simple Model of Production Response to Tariffs

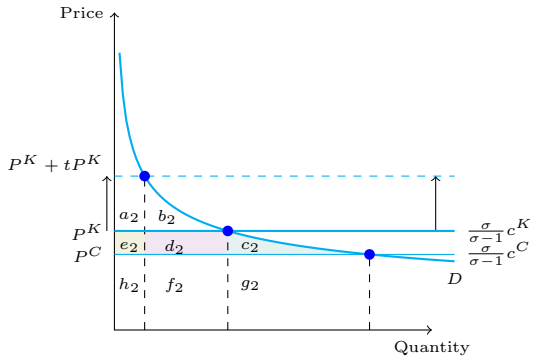
(a) Textbook Example



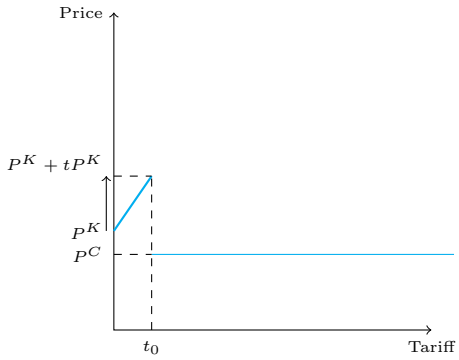
(b) Relocation Dampens the Consumer Price Increase



(c) Relocation Reduces the Consumer Price



(d) Price Change in (c)



Finally, consider the case depicted in Figure A1c. Here, in addition to producing in country K, the foreign monopolist has also the option of producing in country C, in which the marginal cost of producing the good is lower than in country K. Suppose the monopolist faces additional fixed cost F to establish production in C. If the foreign monopolist is headquartered in country K, the assumption of higher fixed cost of foreign production is common in the literature on multinational firms (e.g., Brainard (1997), Helpman, Melitz and Yeaple (2004)). In the depicted figure, $R_K = e_2 + d_2 + f_2 + h_2$ denotes the firm's revenue when producing in K, while the firm makes revenues of $R_C = h_2 + f_2 + g_2$ when producing in country C. As the monopolist charges a constant mark-up that depends on the demand elasticity, the monopolist's variable profits are proportional to revenue, and therefore in the absence of any tariffs, the firm produces washing machines in country K if $\frac{1}{\sigma}(R_C - R_K) \leq F$, where σ denotes the elasticity of demand. As long as the fixed costs of opening a plant in C are sufficiently large, or tariffs on imports from K are sufficiently small, this inequality will

[26] Trade diversion is often discussed in context of regional free trade agreements. The main idea being that in response to a tariff reduction for only selected countries, one may forgo tariff revenue and purchase the good from a producer within the regional free trade area, even though the cheapest producer (without tariffs) would be outside the free trade area. Of course, the same logic also applies to tariff increases against specific countries.

still hold resulting in full pass-through of the tariffs to the prices faced by U.S. consumers. If the tariff increase is so large, however, that the revenues under import tariffs on K, depicted in the graph by $e_2 + h_2$ have fallen sufficiently compared to the revenues the firm would make when producing in C, the foreign monopolist switches the production location in response to the tariff and produces in C instead. Quite interestingly, as a consequence, the prices U.S. consumers would pay for washing machines would *fall* in response to the import restrictions on K. While no tariff revenue is being collected, the increase in the U.S. consumer surplus is equal to $e_2 + d_2 + c_2$.[27]

Hence, as depicted in Figure A1d, the presence of fixed costs and production relocation imply that the effect of tariffs on U.S. prices is non-monotone. It is important to point out, that the example depicted in Figure A1c would not occur in a competitive market. Under perfect competition, production would occur in the lower cost place (country C) in the absence of tariffs. Given the presence of patents on washer technology and strong market power associated with branding, the washing machine market is best characterized as non-competitive.

[27] In this example, overall U.S. welfare increases due to the tariff and equals the change in the U.S. consumer surplus.

B Extended Detail on Timeline

Table B1: Important Event Dates Relative to Three Cases of Tariff

Date	Event
Antidumping against Korea and Mexico	
Dec 2011	Whirlpool files antidumping petition
Feb 2012	USITC issues initial report
Jul 2012	Department of Commerce announces affirmative preliminary determination of AD/CvD duties
Aug 2012	Firms are required to post cash bonds for imports of affected washers
Dec 2012	Department of Commerce announces final determinations of AD/CvD duties
Feb 2013	Final duties go into effect (Perhaps this is when the posted cash bonds (from August 2012 forward) are now taken as duties, and duties are taken immediately on others going forward.)
Antidumping against China	
Dec 2015	Whirlpool files antidumping petition
Feb 2016	USITC issues preliminary report
Jul 2016	Department of Commerce announces AD/CvD import duties
Jul 2016	Duties first applied
Dec 2016	Department of Commerce released its final antidumping determination
Jan 2017	USITC released its final determination
Feb 2017	Department of Commerce issued the final order
Safeguard tariffs 2018	
May 2017	Whirlpool files petition for global safeguard investigation
Oct 2017	USITC issues preliminary report (link)
Jan 2018	Executive office issues new import duties (link)
Feb 2018	Tariffs first applied
Oct 2018	Quota limit reached, second tier of tariffs applied
HS codes	
Washers	8450200040, 8450200080, 8450200090, 8450110040, 8450110080
Washer parts	8450902000, 8450906000
Chapter 99	99034501 (washers within quota), 99034502 (washers beyond quota) 99034505 (washer parts within quota) and 99034506 (washer parts beyond quota)

Table B2: Extensive Detail on Antidumpings

	Rate(%)	Effective date	Period of review	Note
Antidumping against Korea				
Daewoo	79.11	08/03/2012	10/01/2010 to 09/30/2011	Preliminary determination
	82.41	12/26/2012	10/01/2010 to 09/30/2011	Final determination
	79.11	02/14/2013	10/01/2010 to 09/30/2011	Order issurance
	79.11	09/16/2015	08/03/2012 to 01/31/2014	Deposit rate change
LG	12.15	08/03/2012	10/01/2010 to 09/30/2011	Preliminary determination
	13.02	12/26/2012	10/01/2010 to 09/30/2011	Final determination
	13.02	02/14/2013	10/01/2010 to 09/30/2011	Order issurance
	1.38	09/16/2015	08/03/2012 to 01/31/2014	Deposit rate change
	1.62	09/12/2016	02/01/2014 to 01/31/2015	Deposit rate change
	0	09/12/2017	02/01/2015 to 01/31/2016	Deposit rate change
	0.64	01/31/2018	02/01/2016 to 01/31/2017	Deposit rate change
Samsung	9.62	08/03/2012	10/01/2010 to 09/30/2011	Preliminary determination
	9.29	12/26/2012	10/01/2010 to 09/30/2011	Final determination
	9.23	02/14/2013	10/01/2010 to 09/30/2011	Order issurance
	82.35	09/16/2015	08/03/2012 to 01/31/2014	Deposit rate change
All others	11.36	08/03/2012	10/01/2010 to 09/30/2011	Preliminary determination
	11.86	12/26/2012	10/01/2010 to 09/30/2011	Final determination
	11.8	02/14/2013	10/01/2010 to 09/30/2011	Order issurance
Antidumping against Mexico				
Electrolux	33.3	08/03/2012	10/01/2010 to 09/30/2011	Preliminary determination
	36.52	12/27/2012	10/01/2010 to 09/30/2011	Final determination
	36.52	02/14/2013	10/01/2010 to 09/30/2011	Order issurance
	6.22	09/15/2015	08/03/2012 to 01/31/2014	Deposit rate change
	2.47	09/12/2016	02/01/2014 to 01/31/2015	Deposit rate change
	3.67	07/12/2017	02/01/2015 to 01/31/2016	Deposit rate change
	72.41	03/19/2018	02/01/2016 to 01/31/2017	Deposit rate change
Samsung	72.41	08/03/2012	10/01/2010 to 09/30/2011	Preliminary determination
	72.41	12/27/2012	10/01/2010 to 09/30/2011	Final determination
	72.41	02/14/2013	10/01/2010 to 09/30/2011	Order issurance
Whirlpool	72.41	08/03/2012	10/01/2010 to 09/30/2011	Preliminary determination
	72.41	12/27/2012	10/01/2010 to 09/30/2011	Final determination
	72.41	02/14/2013	10/01/2010 to 09/30/2011	Order issurance
All others	33.3	08/03/2012	10/01/2010 to 09/30/2011	Preliminary determination
	36.52	12/27/2012	10/01/2010 to 09/30/2011	Final determination
	36.52	02/14/2013	10/01/2010 to 09/30/2011	Order issurance
Antidumping against China				
LG	49.88	07/26/2016	04/01/2015 to 09/30/2015	Preliminary determination
	32.12	12/15/2016	04/01/2015 to 09/30/2015	Final determination
	32.12	12/15/2016	04/01/2015 to 09/30/2015	Deposit rate change
	38.43	02/03/2017	04/01/2015 to 09/30/2015	Order issurance
Samsung	111.09	07/26/2016	04/01/2015 to 09/30/2015	Preliminary determination; amendment.
	52.51	12/15/2016	04/01/2015 to 09/30/2015	Final determination
	57.37	02/03/2017	04/01/2015 to 09/30/2015	Order issurance
All others	80.49	07/26/2016	04/01/2015 to 09/30/2015	Preliminary determination; amendment.
	44.28	12/15/2016	04/01/2015 to 09/30/2015	Final determination
	49.72	02/03/2017	04/01/2015 to 09/30/2015	Order issuance

Table B3: Extensive Detail on Averaging of Firm Antidumping Rates

Firm Name	Firm Specific Antidumping Rate	Firm-Specific Shares	Firm Name	Firm Specific Antidumping Rate
Korea			**Mexico**	
Daewoo	82.41%	0.011	Electrolux	36.52%
LG	13.02%	0.202	Samsung	72.41%
Samsung	9.29%	0.685	Whirlpool	72.41%
Others	11.86%	0.102	Others	33.30%
Weighted Avg	**11.11%**		**Simple Avg**	**53.66%**
China				
LG	32.12%	0.240		
Samsung	52.51%	0.727		
Others	44.28%	0.033		
Weighted Avg	**47.35%**			

Notes: The antidumping rates come from the USITC, and the firm-specific shares are calculated from the PIERS bill of lading data. See Section C.14 for further details on PIERS data. The period over which the firm-specific quantity shares are taken is July-December 2011 for Korea, and July-December 2015 for China. Note that there is no PIERS data for Mexico as the data only covers bills of lading from U.S. sea ports.
Source: United States International Trade Commission (2010-2019) and PIERS (2012-2019) bill of lading data.

Table B4: Extensive Detail on Antidumping Duties Calculations

	Korea	**Mexico**	**China**
(1) Avg AD Tariff Change	11.11%	53.66%	47.35%
(2) Country Import Share	0.45	0.40	0.80
Washers Only			
(3a) Import Share of Consumption	0.36		0.43
Avg Tariff Change ((1) × (2) × (3a))	**9.57%**		**16.32%**
Washers and Dryers			
(3b) Import Share of Consumption	0.34		0.40
(4) Washer Share of Washer/Dryer Imports	0.59		0.60
Avg Tariff Change ((1) × (2) × (3b) × (4))	**5.27%**		**9.15%**

Notes: The calculations of average AD tariff change come from Table B3 above. The time periods over which calculations are made are July-December 2011 for the Korea/Mexico antidumping duties, and July-December 2015 for the China antidumping duties.
[a] Country import shares are quantity shares taken from the USITC for the periods specified above.
[b] Import Share of Consumption is calculated using both import quantities from USITC and shipments data from AHAM.
Source: United States International Trade Commission (2010-2019) and Association of Home Appliance Manufacturers (2013-2019).

Table B5: Extensive Detail on Countervailing Duties against Korea

	Rates	Effective date	Period of review	Notes
Daewoo	70.58	06/05/2012	01/01/2011 to 12/31/2011	Preliminary determination
	72.3	02/14/2013	10/01/2010 to 09/30/2011	Order issurance
	81.91	09/16/2015	08/03/2012 to 01/31/2014	Deposit rate change
Samsung	1.2	06/05/2012	01/01/2011 to 12/31/2011	Preliminary determination
	1.85	02/14/2013	10/01/2010 to 09/30/2011	Order issurance
	34.77	09/16/2015	08/03/2012 to 01/31/2014	Deposit rate change
All others	1.2	06/05/2012	01/01/2011 to 12/31/2011	Preliminary determination
	1.85	02/14/2013	10/01/2010 to 09/30/2011	Order issuance

Table B6: Extensive Detail on Global Safeguard Tariffs

	Year 1	Year 2	Year 3
First 1.2 million units of imported finished washers	20%	18%	16%
All subsequent imports of finished washers	50%	45%	40%
Tariff of covered parts	50%	45%	40%
Covered parts excluded from tariff	50,000 units	70,000 units	90,000 units

C Additional Results

C.1 Intra-Firm vs Arms-length Imports

Firms are required to report whether a particular import transaction is at arms-length or between related parties. An import transaction is defined as between related parties if "any person, directly or indirectly owns, controls, or holds power to vote 5 percent or more of the outstanding voting stock or shares" of the other party. See Section 402(e) of the Tariff Act of 1930. This distinction matters for our calculations of tariff pass-through, as the decision to adjust prices in response to tariffs may involve how the firm decides to change the allocation of profits across subsidiaries. The U.S. Census Bureau publishes aggregates of trade according to this split; the most disaggregated data available for our purposes is NAICS 335224: "all household laundry equipment."

As shown in Table C1, a very large share of U.S. imports of this category occurs between related parties. Figure C1 shows these related-party shares by country and year; the patterns evident in this figure align with the shifts in production by these major firms shown in other figures.

Table C1: Related-Party Share of 2016 U.S. Imports by Country, NAICS 335224: Household Laundry Equipment

Country	Related Party Share	Import Share
Mexico	0.99	0.37
China	0.76	0.36
South Korea	0.90	0.07
Thailand	0.79	0.06
Vietnam	0.99	0.06
World	0.85	1.00

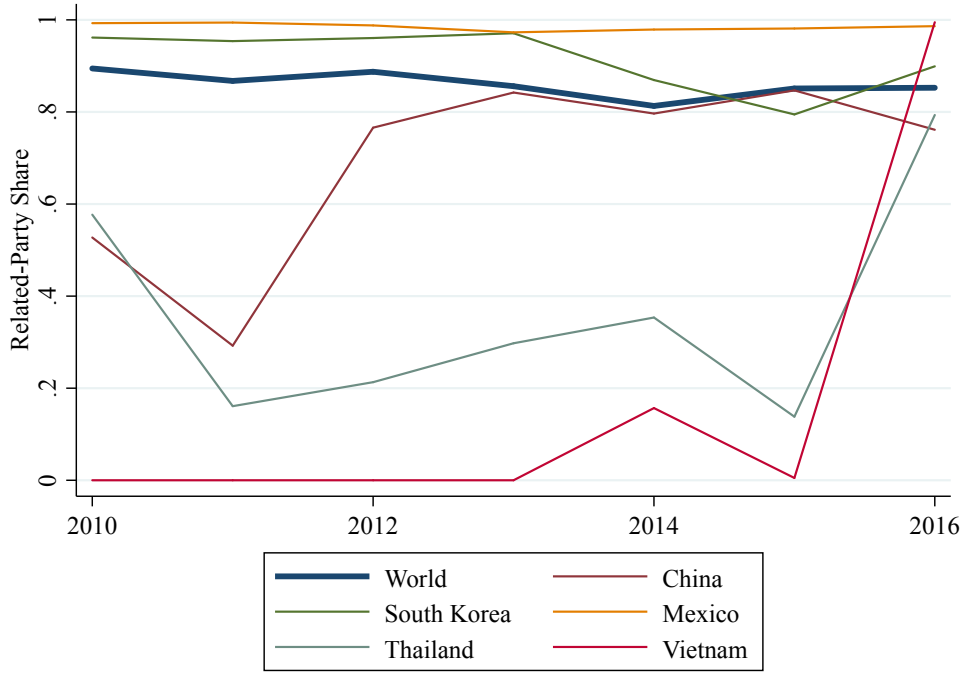
Notes: Imports are defined as related-party if "any person, directly or indirectly owns, controls, or holds power to vote 5 percent or more of the outstanding voting stock or shares" of the other party. See Section 402(e) of the Tariff Act of 1930. The most disaggregated data available split out by related-party includes all household laundry equipment; thus, the import shares are not directly comparable to other tables/figures in this paper.
Source: United States Census Bureau (2000-2019).

C.2 Application of Section 201 Tariffs

As shown in Figure C2, the calculated duties before the global safeguard tariffs in 2018 were negligible. Interestingly, the figure shows that duties didn't jump until roughly May of 2018, despite the fact that announcements indicated duties would be collected beginning in February.

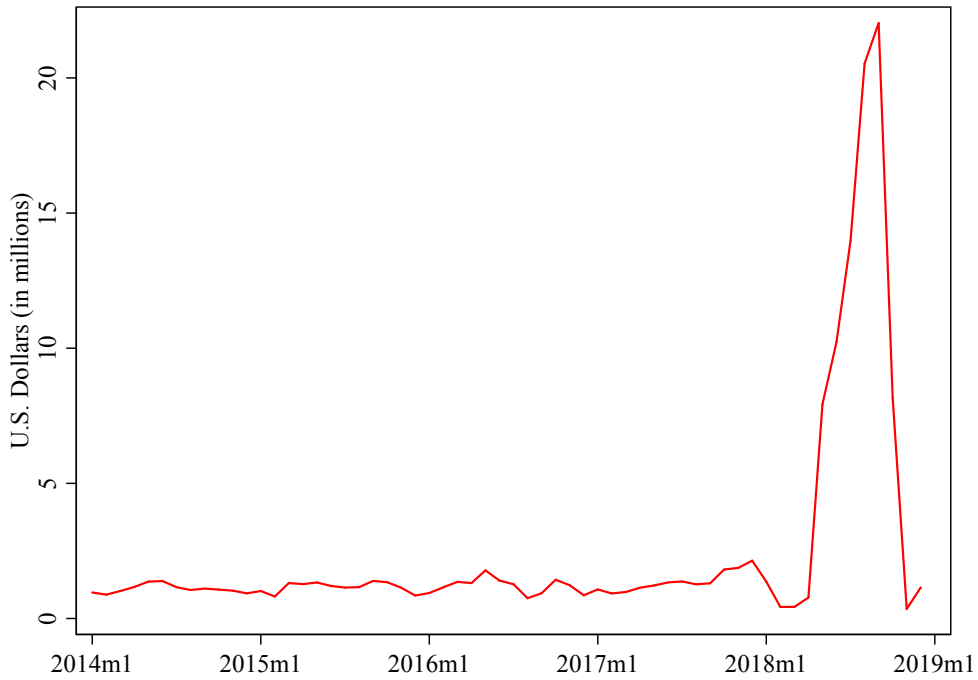
The Section 201 Import Safeguard tariff included a number of exclusions, such that not all imports of the relevant HS product codes were subject to new tariffs in early 2018. In addition to excluding washing machine imports from Canada and a number of developing countries, the initial petition identified a number of products to be out of the scope of

Figure C1: Related Party Share of Household Laundry Equipment Imports to U.S., Selected Countries 2010-2016



Notes: Imports are defined as related-party if "any person, directly or indirectly owns, controls, or holds power to vote 5 percent or more of the outstanding voting stock or shares" of the other party. See Section 402(e) of the Tariff Act of 1930. The most disaggregated data available split out by related-party includes all household laundry equipment; thus, the import shares are not directly comparable to other tables/figures in this paper.
Source: United States Census Bureau (2000-2019).

Figure C2: Calculated Duties on U.S. Imports of Washing Machines 2010-2018



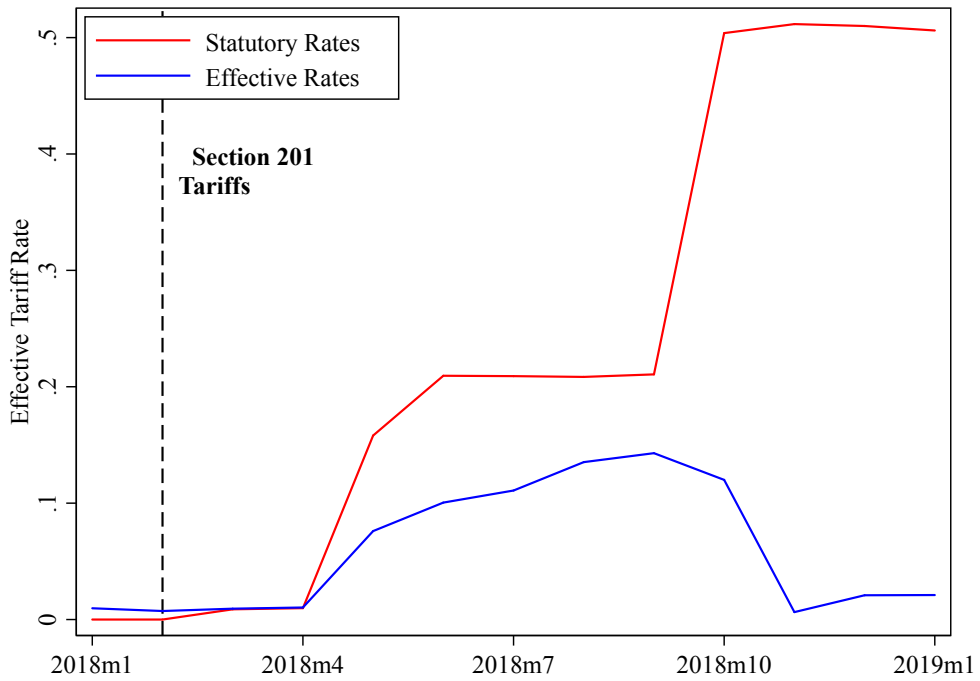
Notes: Includes HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090.
Source: United States International Trade Commission (2010-2019).

the investigation. Among these excluded products were stacked washer-dryers, commercial washers, and the following presumably specialty washers:

- Front loading washers with a permanent split capacitor and belt drive train;
- Top loading washers with a controlled induction motor and belt drive train;
- Front loading washers with a cabinet width greater than 28.5 inches.

It is unclear why these specialty washers were excluded from the scope. From the investigation documents, we learn that the respondents (LG and Samsung) requested these excluded articles be included within the scope of the investigation, whereas Whirlpool and G.E. urged against amending the scope (see USITC 2017, page 9). We can see the effects of these exclusions by splitting the publicly available import quantities by the applicable rate provision code. Section 201 rates are classified under "69 –Chapter 99" of the Harmonized Tariff Schedule of the United States; other rate provisions include "61 – Dutiable HS Chapters 1-87" (MFN rates) and others associated with preferential trade agreements. Figure C3 illustrates the differences between the statutory tariff rates and the average effective tariff rate – defined as the actual tariffs applied to the relevant HS codes divided by overall value.

Figure C3: Effective Tariff Rates of Washing Machines: by Rate Provision Code

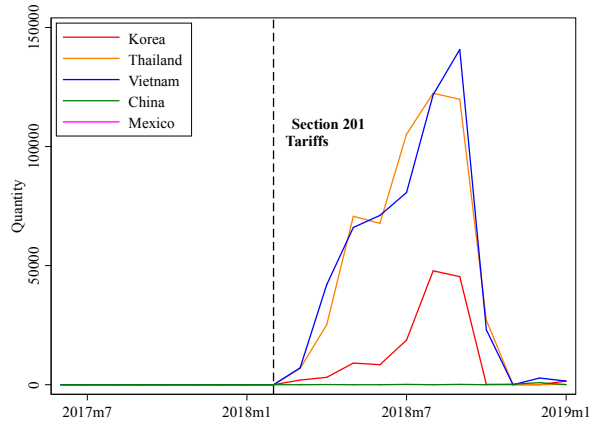


Notes: Includes residential washing machines classified under HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090. Section 201 safeguard tariffs are classified under rate provision code "69 – Dutiable HS chapter 99." The average effective tariff rate is defined as the actual tariffs applied to these imports divided by the tariff-exclusive import value.
Source: United States International Trade Commission (2010-2019).

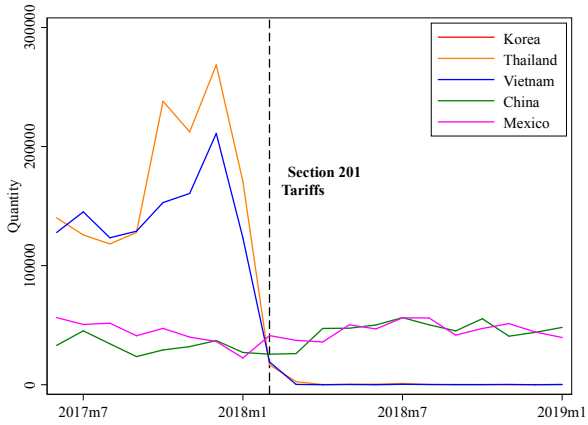
Further detail on the timing and shifts of imports can be seen by also splitting out country-level detail of the rate provision codes. Figure C4 illustrates a number of other patterns in the data.

Figure C4: Imports and Responses to Section 201 Tariffs, Washing Machines

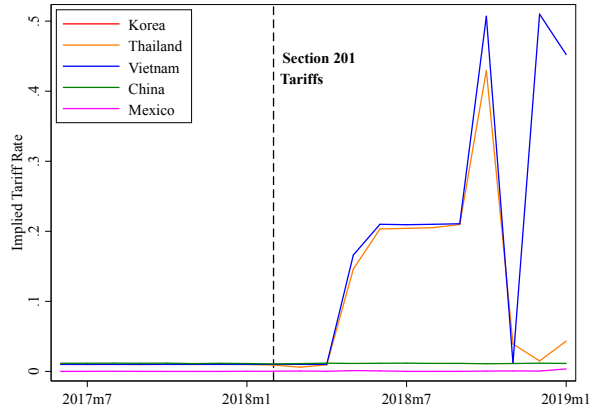
(a) Quantity Washer Imports Subject to Section 201



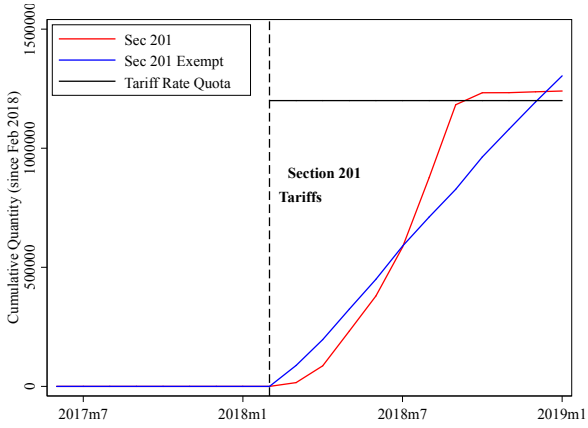
(b) Quantity Washer Imports Excluded from Section 201



(c) Effective Tariff Rate by Country



(d) Cumulative Import Quantities since Feb 2018



Notes: Includes HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090. Section 201 tariffs are classified under rate provision code "69 – Dutiable HS chapter 99."
Source: United States International Trade Commission (2010-2019).

Figures C4b and C4a split the quantity of imported washers by whether or not Section 201 duties applied. The figures demonstrate that the Section 201 tariffs were not applied uniformly across origin countries. Nearly all imports from Vietnam and Thailand were subject to these duties, whereas imports from Korea were only partially affected. In contrast, as shown in Figure C4b, washers from China and Mexico were unaffected. Given that the section 201 ruling did not provide for country-level exclusions for these cases, the most likely explanation is that the composition of products imported from these countries (entirely) fell under the set of excluded products identified above.

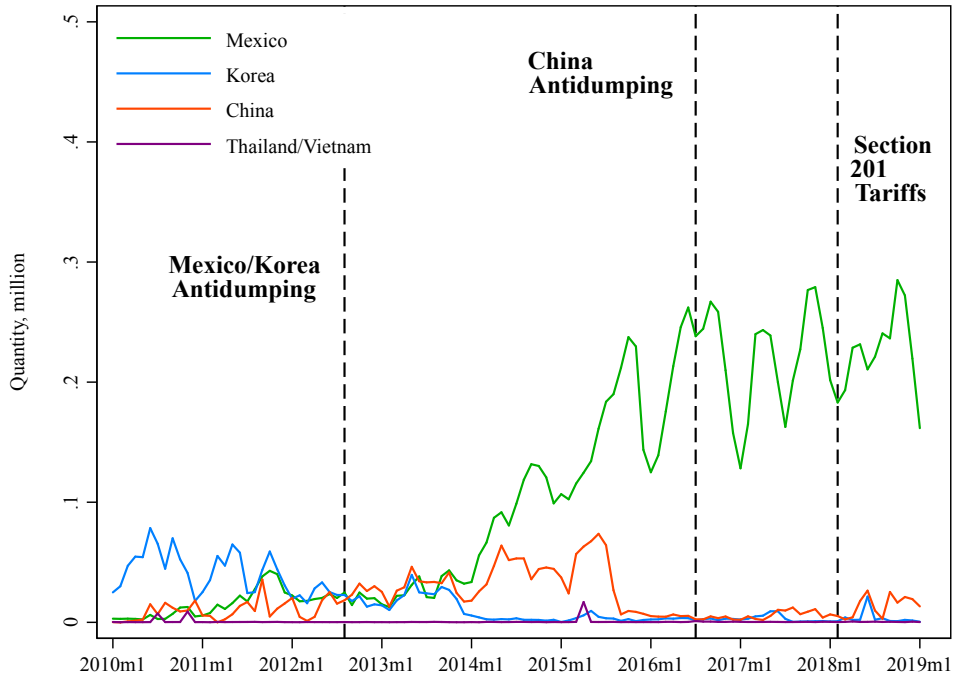
Another way of seeing the differential application of the tariffs across countries is to calculate the average effective tariff rate paid on imported washers. Figure C4c does this by dividing the calculated duties of these imports by the value of imports. Consistent with the fact that all imports from Thailand and Vietnam were subject to the safeguard duties, the average effective rate for these countries aligns with the statutory rates announced by the U.S. Department of Commerce (20 percent, increasing to 50 percent). The average effective rate paid by Korean imports reflects the fact that only some portion were subject to the new

duties. The timing of the rate jump to 50 percent for Thailand/Vietnam in October 2018 is consistent with that shown in Figure C4d showing the cumulative amounts of imports for the period subject to Section 201 duties. While Figure C4d confirms that Section 201 imports reached the 1.2 million-unit quota in October of 2018, it also demonstrates that the quantity of imports excluded from the scope is still substantial.

C.3 Source Locations of Dryer Imports

One might wonder whether the production relocations documented above for washing machines would be similar for dryers, given the fact that the washer-dryer are often matched with similar aesthetics and outward appearance. In Figure C5 we show the major source countries for clothes dryers do not, in fact, match the patterns for clothes washers documented in Panel A of Figure 1. Mexico is the major source location for dryers destined for the U.S. market.

Figure C5: Major Import Source Countries for Dryers



Notes: Includes clothes dryers classified under HS8451210090 and HS8451290010.
Source: United States International Trade Commission (2010-2019).

C.4 Third-Country Effects of U.S. Trade Policy

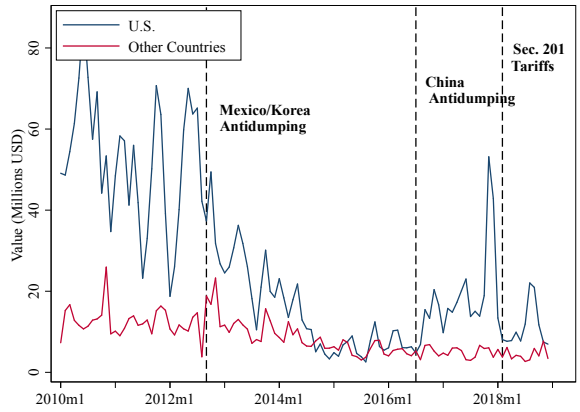
The production relocations that followed U.S. trade policy impacted trade patterns of other countries as well. When production shifted location to avoid country-specific tariffs by the United States, firms then exported their products to other countries in addition to the U.S. These patterns are shown most visibly in Panel C and Panel D of Figure 1 in the main text. Interestingly, we do not see these visible third-country effects for countries in the European Union, or Japan. Figure C6 below shows the broader pattern across the

main foreign countries of production for large residential washers. We plot the U.S and other countries with monthly trade data for comparison. Following the 2012 Korea/Mexico antidumping duties, Korean exports to other countries slow – with a lag – similar to exports to the U.S. (Figure C6a). In Figure C6b Chinese exports to other countries rises and falls (again, with a lag) with exports to the U.S. Finally, in Figure C6c shows third-country exports from Thailand and Vietnam also rise when production shifts from China to these countries.

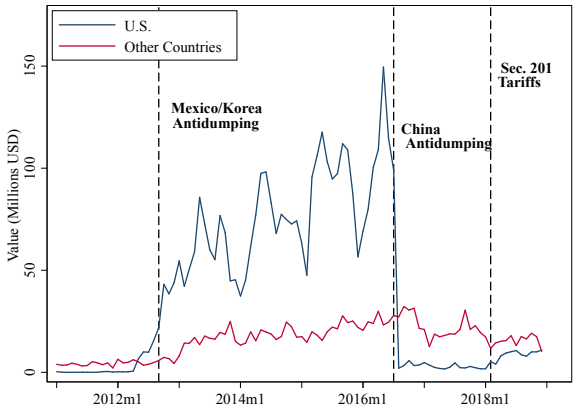
As a whole, this evidence demonstrates sizable effects of U.S. trade policies on third-countries— those not directly impacted by the policies themselves.

Figure C6: Exports of Large Washing Machines to U.S. and Other Countries

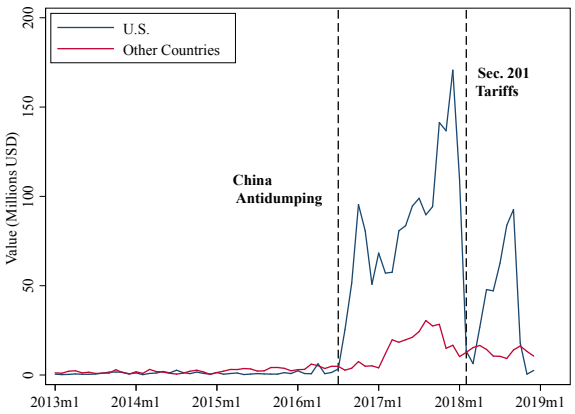
(a) Korea Exports



(b) China Exports



(c) Thailand/Vietnam Exports



Notes: Includes codes under HS845020. Other countries includes those major trading partners that report monthly trade statistics. These include: Australia, Canada, EU-28, Korea, Japan and Mexico.
Source: United Nations (2010-2019).

C.5 Other Relevant Features of Appliances

The inclusion of other appliances in our analysis of price changes following the Section 201 Safeguard tariffs serves to account for any price changes attributed to higher input costs coming from the Section 232 "national security" tariffs on steel and aluminum. Although we do not have a detailed breakdown of the various cost components of appliance production,

Table C2 summarizes the average steel content (in pounds) in individual appliances, according to a recent study performed by the Steel Recycling Institute and the Association of Home Appliance Manufacturers. As is clear in the table, the steel content of washing machines is indeed quite close to the appliance used as our control: electric/gas ranges (average of 90 lbs vs 127.5 lbs). The other appliances—refrigerators and dishwashers—have steel content that is slightly higher and lower, respectively.

Similar steel content would not adequately control for the increased costs associated with higher steel prices if the appliances had vastly different shares of domestic production. If all electric/gas ranges were imported, then they would not be subject to any of the higher costs from higher steel prices in the United States. To check on whether the import shares are similar across appliance categories, we combine import quantities for each appliance to the proprietary data on shipments (imports plus domestic production less exports) available from the Association of Home Appliance Manufacturers (AHAM). Indeed, electric/gas ranges has the closest import share to washing machines – within 15 percentage points – among the appliance categories we considered (dishwashers and refrigerators). See Table C3.

Another concern with our interpretation of evidence using other appliances in the context of washing machines is that subsequent tariffs on Chinese imports—part of the Section 301 provision of enforcing U.S. trade agreements—affected a range of other appliances. Among the set of products included under the third round of Section 301 tariffs against Chinese goods put into place in September 2018 were household refrigerators and gas/electric stoves and ranges. Household dishwashers, the other major appliance in our data, were not subject to additional tariffs during the period we study. The additional rates applied to these goods during this time was substantially smaller (only 10 percent) than other trade provisions put into place in 2018. Apart from differences in the rate and timing of these tariffs, the other obvious difference with the Section 201 tariffs was that these tariffs were targeted at China alone. Prior to the Section 301 tariffs, the Chinese share of total imports for refrigerators, ranges, and dishwashers was 18, 10, and 30 percent, respectively.

As shown in Figure C7 the average effective tariff rate against all imported refrigerators and ranges (the blue lines) moved up only slightly beginning in October of 2018. Dishwashers were unaffected by any new tariffs.

Table C2: Steel Content of Appliance Production

Appliance Description	Steel Weight
Side by side refrigerator	152.5 lb
Ranges (gas)	149.4 lb
Ranges (electric)	106.8 lb
Clothes dryers (gas)	100.4 lb
Clothes dryers (electric)	107 lb
Clothes washers, top load	94.5 lb
Clothes washers, front load	84.2 lb
Top/bottom refrigerator	79.0 lb
Room air conditioners	35.6 lb
Microwave ovens	28.8 lb
Dishwashers (steel interior)	26.7 lb
Dishwashers (plastic interior)	27.6 lb

Source: Steel Recycling Institute and Association of Home Appliance Manufacturers (2013-2019).

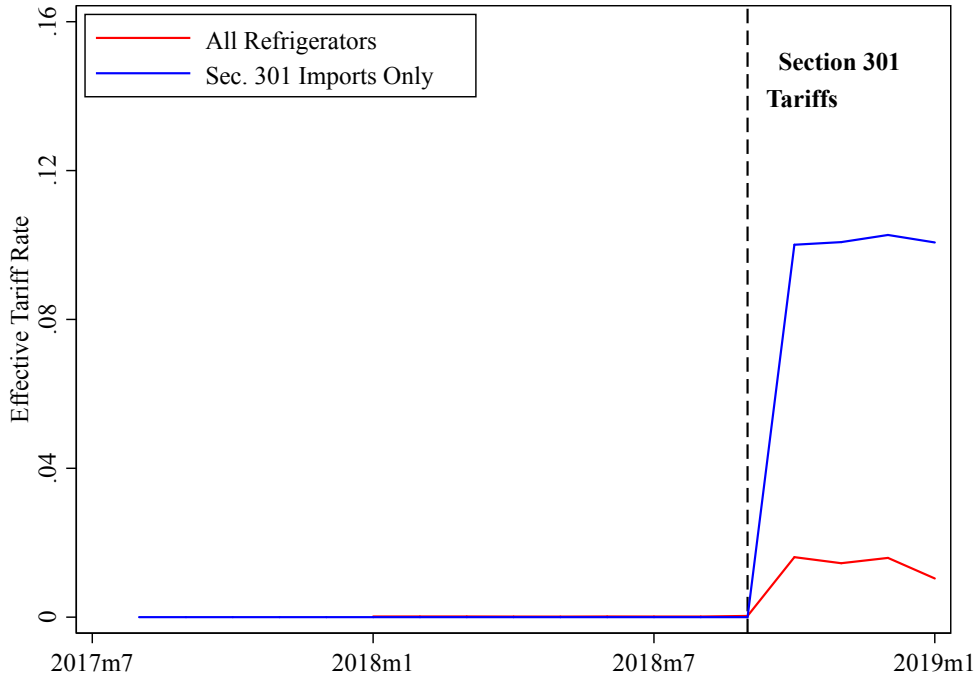
Table C3: Import Share of Consumption: Major Appliances

Imports (USITC) divided by Shipments (AHAM)				
Washers	Dryers	Dishwashers	Ranges	Refrigerators
49.53%	36.67%	16.80%	61.15%	89.62%

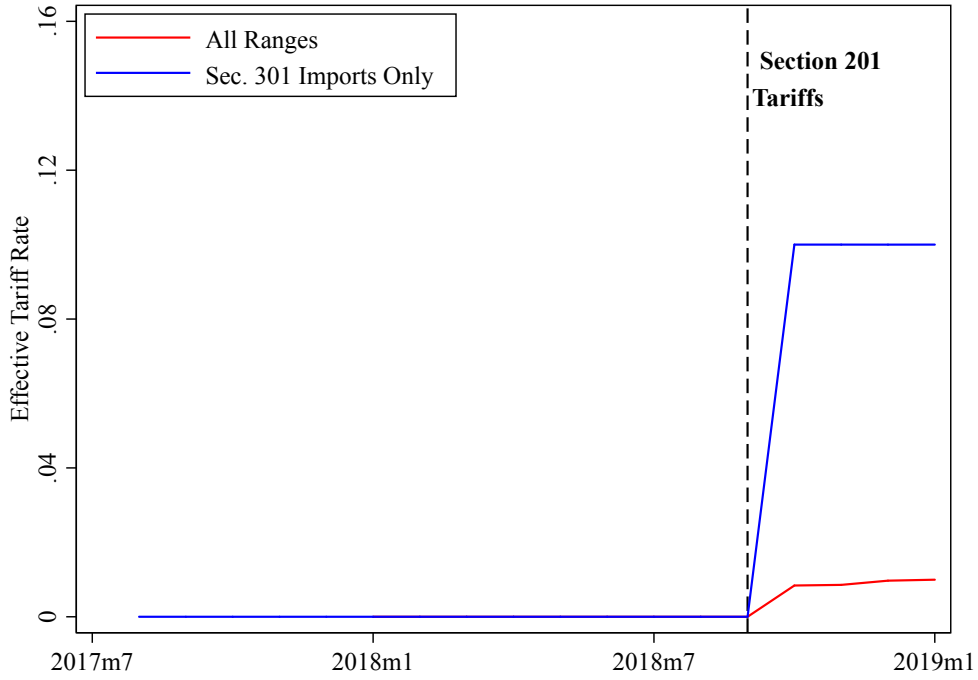
Notes: See Figure C7 for a list of HS codes associated with other appliances.
Source: United States International Trade Commission (2010-2019) and Association of Home Appliance Manufacturers (2013-2019) for 2017.

Figure C7: Effective Tariff Rate of Refrigerators and Ranges: All Imports vs Section 301 Imports

(a) Refrigerators



(b) Ranges



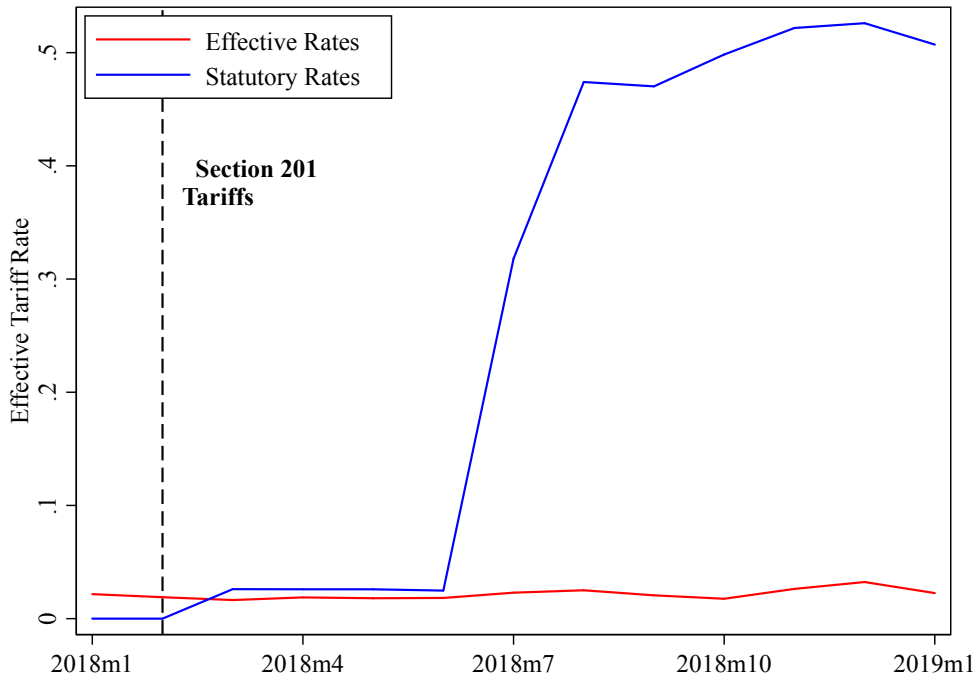
Notes: Refrigerators include products listed in HS8418100020, HS8418100030, HS8418100040, HS8418100045, HS8418100055, HS8418100065, HS8418100075, HS8418100090, HS8418210020, HS8418210030, HS8418210090, HS8418220000, HS8418290000, HS8418291000, HS8418292000, HS8418300000, HS8418400000. Ranges include products listed in HS7321113000, HS7321113010, HS7321113020, HS7321113050, HS8516604074, HS8516604078, HS8516604080, HS8516604082, HS8516604086.
Source: United States International Trade Commission (2010-2019).

C.6 Tariffs on Washing Machine Parts

In addition to large residential washers, the Section 201 Safeguard investigation included certain washer parts, including "(i) all cabinets, or portions thereof, designed for use in washers; (ii) all assembled tubs designed for use in washers which incorporate, at a minimum, a tub and a seal; (iii) all assembled baskets designed for use in washers which incorporate, at a minimum, a side wrapper, a base, and a drive hub; and (iv) any combination of the foregoing parts or subassemblies." (USITC 2017) This description makes clear that these additional inclusions are better described as sub-assemblies of washers than indivisible parts.

To determine whether these additional tariffs could have played a role in the price changes of washers—particularly those domestic brands—we split the publicly available trade data for the relevant product groups (HS84509020 and HS84509060) based on the assigned rate provision code of imports. The evidence, shown in Figure C8 demonstrates that although the tariff rate of washer parts imports subject to Section 201 tariffs (the blue line) did indeed jump in mid-2018, the average tariff rate across all washer parts (shown in the red line) was essentially unchanged. Hence, the share of washer parts affected by these Section 201 tariffs was trivial—less than 1 percent of the total—and therefore this provision of the section 201 investigation was more likely put into place as a preventative measure to guard against the avoidance of the washer tariffs themselves.

Figure C8: Effective Tariff Rate of Washer Parts: Statutory vs Effective Rates



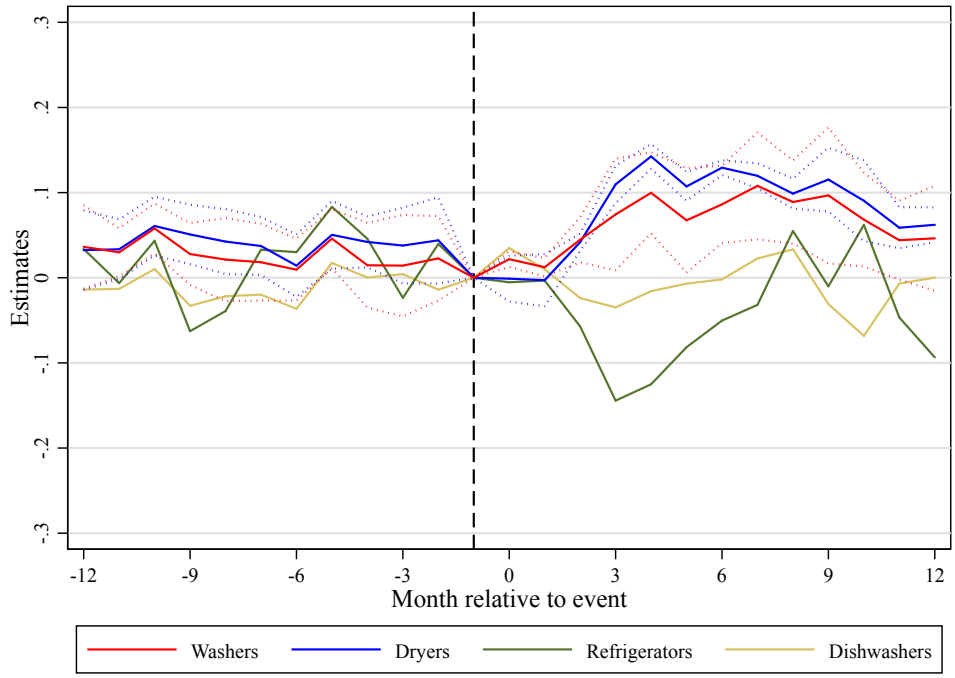
Notes: Includes HS codes listed under HS8450902000 and HS8450906000. Section 201 tariffs are classified under rate provision code "69 – Dutiable HS chapter 99."
Source: United States International Trade Commission (2010-2019).

C.7 Evidence using Wholesale Prices

We use data from the Association of Home Appliance Manufacturers – the main industry organization for appliance manufacturers in the United States – to assess the stage of the supply chain where prices increased following the section 201 safeguard tariffs. AHAM collects the dollar value and quantity for 13 appliance categories from its members at a monthly frequency. The universe of this data corresponds to U.S. industry "shipments", defined to include domestic production plus imports less exports. Hence, this provides a clean mapping to the set of products that are included in our main data from Gap Intelligence.

We apply the same procedure as in section C to estimate the price effects for washers and dryers relative to ranges (gas and electric). The results are in Figure C9. As shown in the Figure, the prices of both washers and dryers rise by amounts similar to Panel B of Figure 5. These results rule out that the price increases were a result of retailer decisions, rather than further up the supply chain.

Figure C9: Price Effects of Safeguard Tariffs: Wholesale Prices



Notes: Excluded category is ranges (gas and electric).
Source: Authors calculations based on Association of Home Appliance Manufacturers (2013-2019).

C.8 Pass-Through Regressions Using Import Prices

A systematic approach for estimating the price effects from tariff changes in prior papers (dating back to at least Feenstra 1989) is to follow the literature examining the effects of exchange rate changes and utilize a regression of changes in import prices (from trade data) on changes in tariff rates. Specifically, the typical estimated regression is given by:

$$\Delta \ln p_{igt}^{border} = \alpha_0 + \alpha_1 \Delta(1 + \tau_{igt}) + \gamma_i + \omega_g + \beta_t + \varepsilon_{igt}, \tag{C1}$$

where g indicates an HS-10 level product code, i indicates an export country, and t indicates month. As the left-hand side variable p_{igt}^{border} is usually measured exclusive of tariffs, an estimate of α_1 close to zero indicates that tariff-inclusive import prices rise by as much as the tariff – hence a 100 percent pass-through to import prices.

Below we estimate equation (C1) separately for each of the tariff changes affecting washing machines. We first construct a dataset for all relevant HS-codes from the appliance categories in section B (washing machines, dryers, ranges, refrigerators, and dishwashers). Then, following Amiti, Redding and Weinstein (2019), we use 12-month log changes and sample periods that include the 12 months before and 12 months after each tariff episode.[28] We also follow the convention of Amiti, Redding and Weinstein (2019) and drop observations with a ratio of unit values in t relative to t-12 of greater than 3 or less than 1/3. Table C4 summarizes the results, where we also include country fixed effects, hs-product fixed effects, and month fixed effects. The implied elasticities are always around 1 and stand in stark contrast to the results we obtain using our data on retail prices that cover both imported and domestically-produced products.

Table C4: Country-Product Level Tariff Pass-Through Regressions on Import Prices (Exclusive of Tariffs)

	Kor/Mex AD	China AD	Sec. 201 Safeguard	
			20% rate	50% rate
	$\Delta \log p_{igt}$	$\Delta \log p_{igt}$	$\Delta \log p_{igt}$	$\Delta \log p_{igt}$
Variables	(1)	(2)	(3)	(4)
$\Delta(1+\tilde{\tau}_{igt})$	-0.00	0.35	-0.02	-0.04
	(0.10)	(0.60)	(0.29)	(0.07)
Constant	0.04	-0.03	0.03	0.03
	(0.02)	(0.04)	(0.05)	(0.05)
Implied Elasticity	1.00	1.35	0.98	0.96
Observations	2762	3918	4403	4403
Adjusted R-squared	0.05	0.04	0.03	0.03
Country F.E.	Yes	Yes	Yes	Yes
Product F.E.	Yes	Yes	Yes	Yes
Month F.E.	Yes	Yes	Yes	Yes
Weighted	Yes	Yes	Yes	Yes

Notes: The table reports country-product level tariff pass-through to import prices (see equation (C1)). Standard errors are clustered by product codes. Each regression is weighted by the total HS-level quantity in the 12-months preceding tariff changes. *Source:* United States International Trade Commission (2010-2019) and authors' calculations.

For another perspective that more closely mirrors our analysis in section E and therefore may better capture the price changes due to indirect effects coming from production relocation, we conduct the regressions at the product-level. To create product-level import prices, we first incorporate tariffs paid at the country-level before aggregating values and quantities; hence, the resulting product-level prices are therefore inclusive of tariffs. Thus

[28] We use the simple average of the firm-level antidumping duty rates outlined in Table B2, resulting in an average tariff rate of 28.3 percent in Korea in 2012, 54.4 percent in Mexico in 2012, and 43.0 percent in China in 2016.

$p_{gt} = \frac{\sum_i p_{igt} q_{igt}(1+\tau_{igt})}{\sum_i q_{igt}}$. For the product-level change average tariff rate we mirror the calculation used in equation (5) by calculating $\Delta\tilde{\tau}_{gt} = \sum_i s_{ig,t-12}\Delta\tau_{igt}$ where $s_{igt-12} = \frac{q_{ig,t-12}}{Q_{g,t-12}}$ are the lagged (12-month) weights. Note that the tariff-inclusive import prices imply that a coefficient of 1 is consistent with complete pass-through. Table C5 summarizes the results. While this product-level specification reduces the pass-through estimates relative to Table C4, the magnitude and variation in the elasticities do not align well with our estimates in section E. While the graphical evidence from Figure 3 might suggest a negative product-level elasticity for the period of Korea/Mexico antidumping duties, the results in column (1) show a positive coefficient. This is due, at least in part, to the high (likely, prohibitive) duties on Mexican imports, as well as the Korean imports of Daewoo; a specification that abstracts from these duties (i.e. sets them to zero) does indeed yield a negative elasticity of -0.51 (not shown in table).

Table C5: Product Level Tariff Pass-Through Regressions on Import Prices (Inclusive of Tariffs)

	Kor/Mex AD	China AD	Sec. 201 Safeguard	
			20% rate	50% rate
	$\Delta \log p_{gt}$	$\Delta \log p_{gt}$	$\Delta \log p_{gt}$	$\Delta \log p_{gt}$
Variables	(1)	(2)	(3)	(4)
$\Delta(1+\tilde{\tau}_{gt})$	0.37	0.24	0.32	0.88
	(0.25)	(0.15)	(0.09)	(0.07)
Constant	0.02	-0.03	-0.04	-0.09
	(0.07)	(0.06)	(0.04)	(0.05)
Implied Elasticity	0.37	0.24	0.32	0.88
Observations	500	713	725	725
Adjusted R-squared	0.22	0.10	0.22	0.42
Product F.E.	Yes	Yes	Yes	Yes
Month F.E.	Yes	Yes	Yes	Yes
Weighted	Yes	Yes	Yes	Yes

Notes: The table reports product-level tariff pass-through to import prices (here, inclusive of tariffs). The $\Delta(1+\tilde{\tau}_{gt})$ is defined mirroring equation (5) in the main text: $\Delta\tilde{\tau}_{gt} = \sum_i s_{ig,t-12}\Delta\tau_{igt}$, where $s_{ig,t-12} = \frac{q_{ig,t-12}}{Q_{g,t-12}}$. The term $\Delta \ln p_{gt}$ is defined as $\Delta \ln p_{gt} = \Delta \ln \frac{\sum_i p_{igt} q_{igt}(1+\tau_{igt})}{\sum_i q_{igt}}$. Each regression is weighted by the total HS-level quantity in the 12-months preceding tariff changes. Robust standard errors are in parentheses.
Source: United States International Trade Commission (2010-2019) and authors' calculations.

C.9 Matched Washers and Dryers

Many washers are produced and sold with matching dryers. In this section, we match the washers with the dryers of the same brand in the Gap Intelligence data with the following procedure

1. For each brand, observe the pattern of model part numbers. In general, the same product family has the same numerical part of the part number.

2. Match washers by the numerical part, debut date, and base color.

3. For the rest unmatched washers, match again by the numerical part and base color. We allow for matched models to have different debut date.

We find that among the washers of the five major brands (LG, Samsung, Whirlpool, Maytag, G.E.), 75.3 percent of the 571 models have matching dryers. In general, within the matched group, one washer can be matched with two dryers: one gas dryer and one electric dryer. Gas dryers are usually priced higher than the electric dryers. After excluding the gas dryers and comparing only the electric washers and electric dryers within the matched group, we find the price correlation between washers and dryers is 0.967. In addition, for 86.3 percent of the matched observations, the washer has exactly the same price as the matching dryer.

C.10 Correlations of Sales Ranks

We scrape three retailer websites for appliances (Home Depot, JC Penny and Best Buy), obtaining a February 2019 snapshot of the sales rank of each model for every product (washers, dryers, dishwashers, refrigerators and ranges) based on the "Best Selling" indicator on the site. We also collect the model number and name. The data is then cleaned to extract the names of our five major brands (Whirlpool, Maytag, LG, Samsung and GE) from the product name. In a next step we create ranks within each brand (brand ranks) to match appliances based on brand name and brand rank.

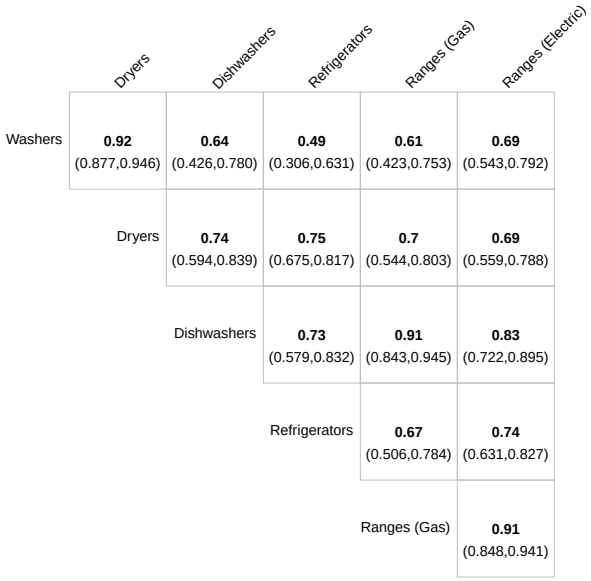
For instance, for a specific retailer the highest ranked Whirlpool washer is given a brand rank of one, the highest ranked LG washer for this retailer is also given a brand rank of one, the second highest ranked Whirlpool washer for this retailer is given a brand rank of two, and so on for each product and each retailer. We pair the highest ranked Whirlpool washer with the highest ranked Whirlpool dryer, refrigerator, dishwasher, and range. The second highest ranked product is matched with other second highest ranked products. If there is no 10th LG dryer to match with the 10th LG washer, we simply assign a missing value to the LG dryer.

Using this data, we compute the Pearson correlation coefficient between the sales ranks of every pair of products based on all pairwise non-missing observations in each retailer.

The results are shown in Figure C10. As is clear in the matrix of correlations, there is an especially tight connection between washers and dryers among the set of appliances for these retailers.

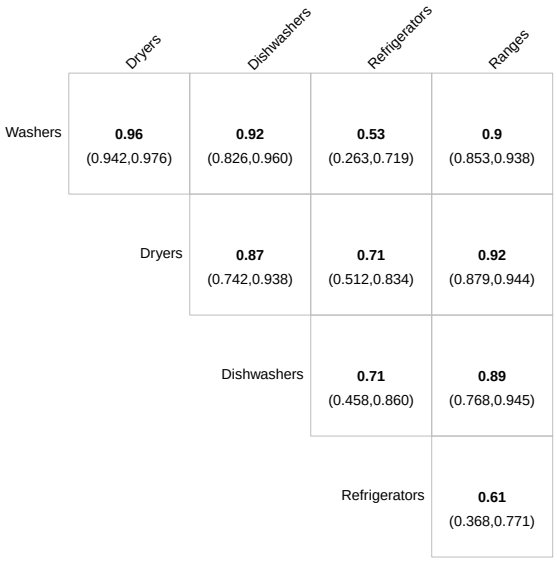
Figure C10: Sales Rank Correlations across Retailers

(a) Home Depot Appliance Sales Rank Correlation



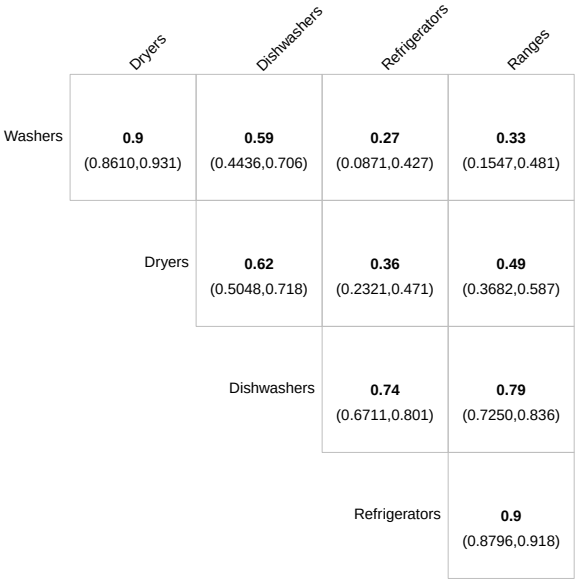
	Dryers	Dishwashers	Refrigerators	Ranges (Gas)	Ranges (Electric)
Washers	**0.92** (0.877,0.946)	**0.64** (0.426,0.780)	**0.49** (0.306,0.631)	**0.61** (0.423,0.753)	**0.69** (0.543,0.792)
Dryers		**0.74** (0.594,0.839)	**0.75** (0.675,0.817)	**0.7** (0.544,0.803)	**0.69** (0.559,0.788)
Dishwashers			**0.73** (0.579,0.832)	**0.91** (0.843,0.945)	**0.83** (0.722,0.895)
Refrigerators				**0.67** (0.506,0.784)	**0.74** (0.631,0.827)
Ranges (Gas)					**0.91** (0.848,0.941)

(b) JC Penny Appliance Sales Rank Correlation



	Dryers	Dishwashers	Refrigerators	Ranges
Washers	**0.96** (0.942,0.976)	**0.92** (0.826,0.960)	**0.53** (0.263,0.719)	**0.9** (0.853,0.938)
Dryers		**0.87** (0.742,0.938)	**0.71** (0.512,0.834)	**0.92** (0.879,0.944)
Dishwashers			**0.71** (0.458,0.860)	**0.89** (0.768,0.945)
Refrigerators				**0.61** (0.368,0.771)

(c) Best Buy Appliance Sales Rank Correlation



	Dryers	Dishwashers	Refrigerators	Ranges
Washers	**0.9** (0.8610,0.931)	**0.59** (0.4436,0.706)	**0.27** (0.0871,0.427)	**0.33** (0.1547,0.481)
Dryers		**0.62** (0.5048,0.718)	**0.36** (0.2321,0.471)	**0.49** (0.3682,0.587)
Dishwashers			**0.74** (0.6711,0.801)	**0.79** (0.7250,0.836)
Refrigerators				**0.9** (0.8796,0.918)

Notes: Correlations are Pearson's R. Confidence intervals in parentheses.
Source: Sales Rank Dataset (2019).

C.11 Foreign Trade Zone Production

One important feature of U.S. imports of washing machines is the use of foreign trade zone (FTZ) production in the United States. Created at the request of a U.S. firm to the U.S. Department of Commerce, a manufacturing facility in an FTZ operates outside of the customs border of the United States.[29] The intent, as the case in many developing countries, is to allow for processing production for re-export without incurring tariffs on the imported components. Hence, for the case of washing machines, an FTZ would allow a U.S. manufacturer to import the components of washing machines with little or no associated tariffs.

Typically, an imported good will be recorded twice: first as a "general import" when it arrives at the border, and then again as an "import for consumption" after it passes through customs. Most of the time differences in the recorded values between these two definitions are small and reflect idiosyncratic timing in customs clearance as well as time spent in temporary storage in bonded warehouses. FTZ production introduces another potential discrepancy between these two definitions, as FTZ production exists outside the customs border of the United States. Specifically, in FTZ production the imported component parts will enter the country recorded as "general imports," but will not be recorded as an "import for consumption" because they are processed inside the FTZ and therefore never cross the U.S. customs border.[30]

Another discrepancy can occur if the final good produced by the FTZ is not re-exported but rather ends up entering the U.S. market. This can be the case due to another motivation for FTZ production apart from removing traiffs on imported components of production for re-export: exploiting differences in the tariff rates between imported components and the final product. If the finished product of an FTZ enters the United States for domestic consumption, then the firm must then pay duties on the value of the imported parts. However, the FTZ firm is allowed to choose whether they pay the tariff rate of the finished product (washing machine) or the imported components (various washing machine parts). As the tariff rate on the finished product is lower, the firm records the import for consumption under the final product code classification (as a washing machine), but only on the foreign value-added component of production.

The increasing importance of FTZs for washing machine production destined for the U.S. market is evident in Figure C11. As shown in Figure C11a, a large gap emerges between imports for consumption and general imports in 2014; Figure C11b demonstrates that roughly all of this discrepancy owes to a jump in the Cleveland Customs District.

This feature of reporting by FTZ production provides valuable information for the calculation of the foreign import share of domestic value-added. Since the reported import values of washing machines in FTZs actually reflect the foreign value-added component (from parts) on the quantity of finished products, the unit values of the FTZ-based imports capture the per-unit value of foreign components used in production. We take these FTZ unit values and compare them to the average wholesale unit value of these washing machines from AHAM data to arrive at an estimate of the import share in value-added. The result is somewhere in

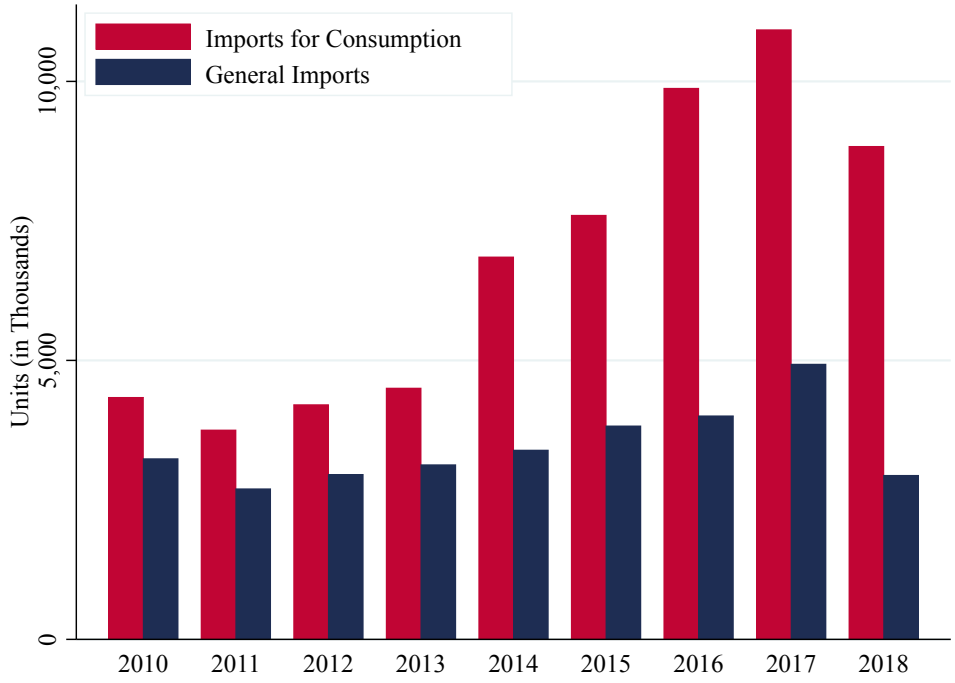
[29] Foreign trade zones exert a large influence on economic activity more generally. According to research by Grant (2017), foreign trade zones account for roughly one-sixth of U.S. manufacturing value-added, and one-eighth of the value of U.S. imports.

[30] Or, in the language of U.S. Customs Bureau, they remain as "Foreign Status" goods.

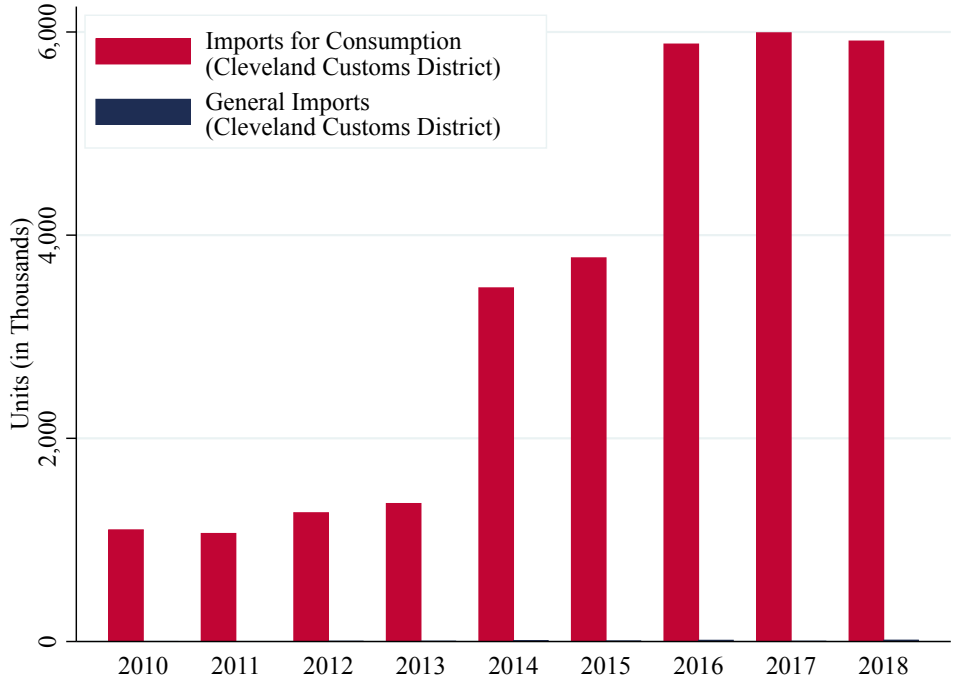
the vicinity of 5 and 11 percent of the average wholesale unit value from the AHAM data.

Figure C11: Annual 2010-2017 Quantity of Washing Machine Imports: Total and Cleveland Customs District

(a) Total



(b) Cleveland Customs District



Notes: Includes HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090.
Source: United States International Trade Commission (2010-2019).

C.12 Further Production Relocation Details

The details regarding how foreign firms relocated production are difficult to ascertain as they involve proprietary knowledge that is often not documented in public sources. Nevertheless, some useful pieces of information can be inferred from news reports and various documents prepared as part of the USITC investigation.[31] In 2017, LG had manufacturing operations for large residential washers in Korea, China, Thailand, and Vietnam, while Samsung had manufacturing operations in Mexico, Korea, China, Vietnam, and Thailand. Both of these firms did not begin producing these large washers in Vietnam until 2016, while production in Thailand increased sharply in 2016. Both expected production to decline from 2017 to 2018.

In both Vietnam and Thailand, these firms reported producing other products on the same equipment and machinery used to produce large residential washers. Thailand was a significant exporter of small residential washing machines (HS 845011) prior to the U.S. antidumping duties on China, and so its possible that some capacity was re-routed from small washers to large washers in Thailand.

These patterns are also confirmed by the firm-level import data described below in Section C.14.

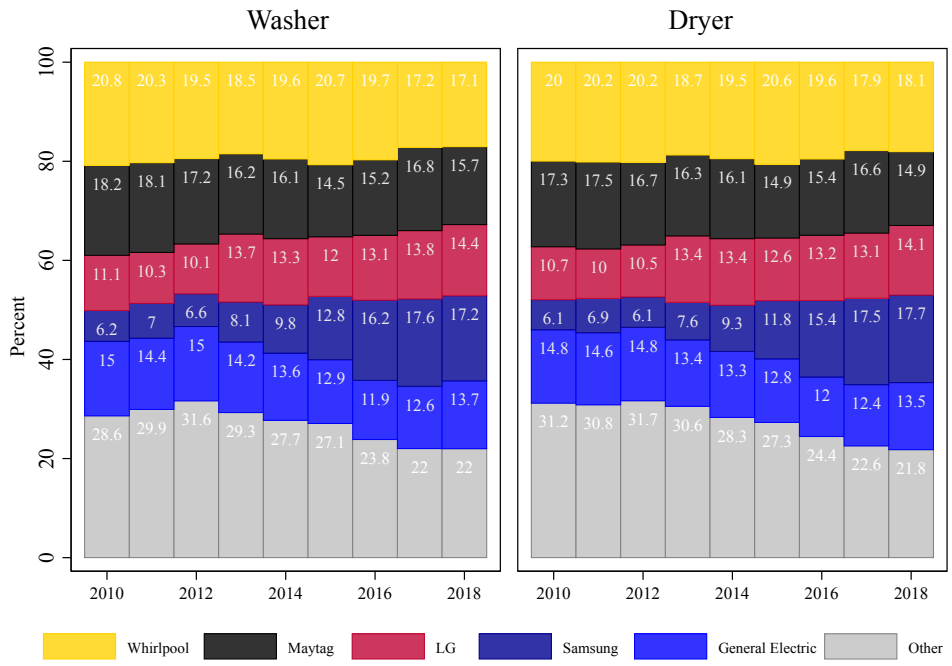
In the United States, both firms engaged in extensive construction of facilities. In early 2017, LG announced plans to build a new facility for washing machine production outside Clarksville, TN, with investments totally 360 million USD. Production did not begin in earnest until May 2019. Samsung also announced in mid-2017 the purchase of the site of a former Caterpillar factory in Newberry, SC, citing investments of 380 million USD. Production of washers began a short time later, in early 2018. [https://news.samsung.com/us/samsung-kicks-off-us-home-appliances-production/] The shorter time required for Samsung could have been due to their strategy to retrofit an existing facility, rather than engage in a greenfield investment.

C.13 Market Shares

To calculate brand-level market shares, we utilize consumer purchase data recorded by a market research firm, Traqline (Stevenson Company). They use internet surveys to track the brand-level information of washer and dryer purchases (and purchases of several other consumer goods). The market shares below are based on 14,500 to 22,500 washer purchases per year (12,500 to 19,000 dryer purchases per year).

[31] A useful news report on production relocations can be found here, with the following relevant section: "In 2012, a previous probe by the U.S. Commerce Department found that Samsung and LG washers made in South Korea and Mexico were sold below production costs in the United States or benefited from unfair subsidies. The South Korean companies subsequently shifted production for the U.S. market to China. In Dec. 7 testimony before the trade commission, lawyers for LG and Samsung said that the companies were now producing washers for the U.S. market in Thailand and Vietnam. In the case of Samsung, that production began in June 2016, about a month before the Commerce Department issued preliminary antidumping duties against Chinese-made LG and Samsung washers." For sources pertaining to the USITC investigations, see United States International Trade Commission 2017*b*.

Figure C12: Market Shares



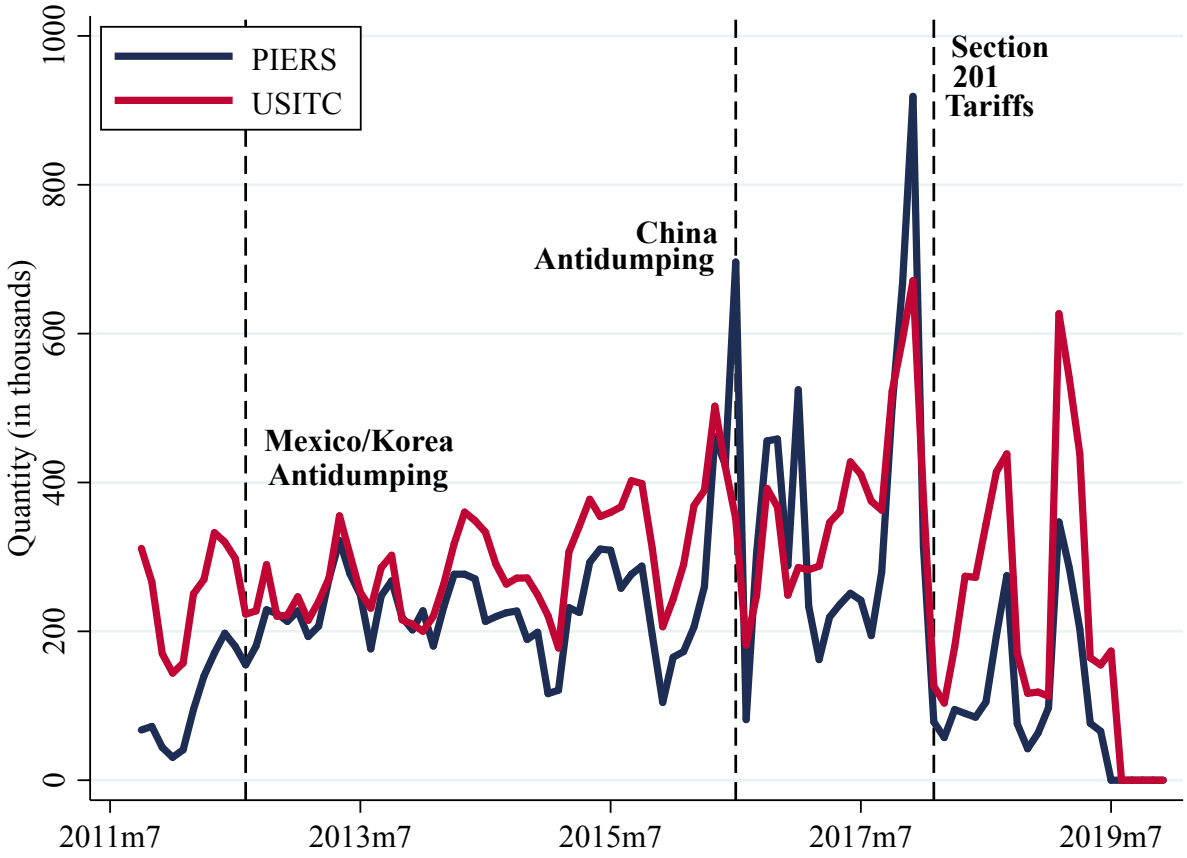
Source: Traqline Market Research (2010-2018).

C.14 Firm-Level Imports

Identifying the firms involved in import transactions is helpful for a variety of purposes, such as the aggregation of the antidumping duties and the further confirmation of production relocation occurring for the firms we study. We utilize the PIERS dataset, which is derived from bill of lading documents pertaining to U.S. ports. This data is shipment level data with variables that align with the relevant producing firm, such as the "shipper", "consignee" and "notify". There are quantities but only a rough estimate of shipment value, and as such we do not attempt to utilize this data for the construction of unit values. An additional concern is the potential for product mis-classification if shippers combine different products in a single shipment. Finally, as this data only captures U.S. imports by sea ports, it will miss imports from Mexico and Canada.

As shown in Figure C13, the alignment between the quantities of imports between PIERS and USITC (suitably adjusted for non-Mexican and non-Canadian source locations) is reasonably good. As can be seen in the figure, the PIERS data looks to exhibit greater lumpiness in monthly quantities, a fact which could be explained by the differences in the timing between when the bill of ladings are submitted and the imports are processed by U.S. Customs. Indeed, this lumpiness (and subsequent degree of mis-alignment) appears to be greatest when an uncharacteristically large mass of U.S. imports occurs directly before the application of the China antidumping and Section 201 tariffs.

Figure C13: U.S. Imports of Washing Machines: PIERS vs USITC



Notes: U.S. imports of washing machines from all source countries excluding Canada and Mexico.
Source: United States International Trade Commission (2010-2019) and PIERS (2012-2019) bill of lading data.

C.15 Price Effects Using Alternative Products as Control Group

Table C6: Difference-in-Difference Estimates: Using Refrigerators as Control Group

	Antidumping against China				**Safeguard tariffs 2018**			
	4-month	8-month	4-month	8-month	4-month	8-month	4-month	8-month
Washers	0.001	0.026	0.008	0.031	0.108	0.150	0.113	0.137
	(0.015)	(0.017)	(0.012)	(0.013)	(0.012)	(0.015)	(0.011)	(0.011)
Dryers	-0.008	0.015	-0.005	0.019	0.110	0.149	0.114	0.137
	(0.012)	(0.014)	(0.009)	(0.010)	(0.011)	(0.013)	(0.008)	(0.008)
Dishwashers	-0.013	-0.014	-0.004	-0.003	-0.011	0.014	-0.010	0.001
	(0.013)	(0.014)	(0.007)	(0.008)	(0.010)	(0.015)	(0.007)	(0.007)
Ranges	-0.025	-0.008	-0.039	-0.028	-0.001	0.035	0.002	0.018
	(0.010)	(0.013)	(0.007)	(0.007)	(0.010)	(0.015)	(0.006)	(0.007)
Model characteristics	✓	✓			✓	✓		
Model fixed effects			✓	✓			✓	✓
N	1,637,298		1,637,298		1,637,298		1,637,298	

Table C7: Difference-in-Difference Estimates: Using Dishwashers as Control Group

	Antidumping against China				**Safeguard tariffs 2018**			
	4-month	8-month	4-month	8-month	4-month	8-month	4-month	8-month
Washers	0.014	0.040	0.011	0.034	0.119	0.136	0.123	0.136
	(0.017)	(0.018)	(0.012)	(0.013)	(0.014)	(0.018)	(0.011)	(0.012)
Dryers	0.004	0.029	-0.002	0.023	0.121	0.135	0.124	0.136
	(0.014)	(0.015)	(0.009)	(0.010)	(0.012)	(0.016)	(0.009)	(0.010)
Refrigerators	0.013	0.014	0.004	0.003	0.011	-0.014	0.010	-0.001
	(0.013)	(0.014)	(0.007)	(0.008)	(0.010)	(0.015)	(0.007)	(0.007)
Ranges	-0.012	0.006	-0.035	-0.024	0.010	0.021	0.012	0.017
	(0.013)	(0.014)	(0.008)	(0.008)	(0.012)	(0.018)	(0.007)	(0.009)
Model characteristics	✓	✓			✓	✓		
Model fixed effects			✓	✓			✓	✓
N	1,637,298		1,637,298		1,637,298		1,637,298	

C.16 List of Product Characteristics

Table C8 describes the additional product characteristic variables included in the Gap Intelligence data.

Table C8: List of Product Characteristics

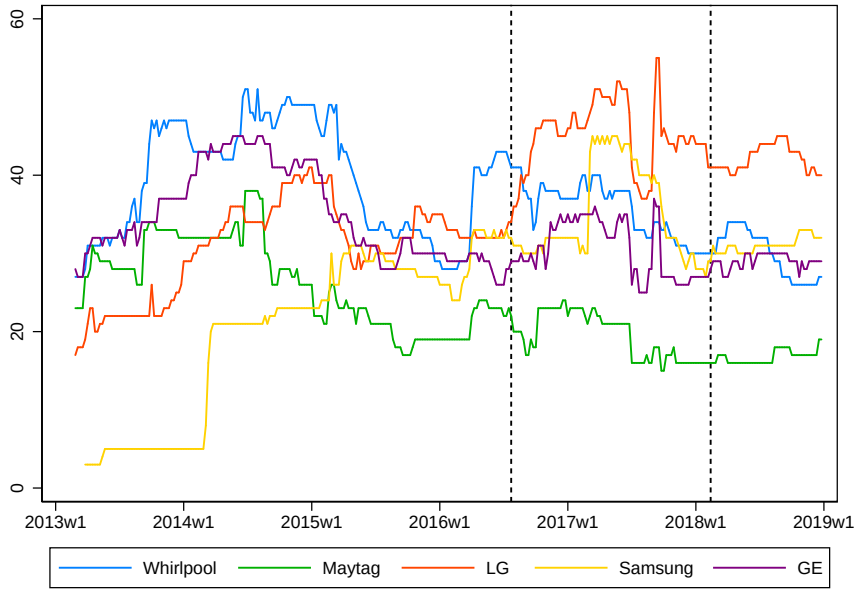
Washers	
Total capacity	Dummies for less than 3.0, 3.0-4.0, 4.0-5.0, more than 5.0 cu. ft.
Steam	Dummy for steam
Energy star	Dummy for energy star
Smart appliance	Dummy for smart appliance
Load type	Dummy for top load
Color	Dummy for white
Digital display	Dummy for digital display
Chrome trim	Dummy for chrome trim
Cycles	Dummies for less than 7 cycles, each of 8-14 cycles, 15 cycles or more
Washing mechanism	Dummy for agitator
Dryers	
Total capacity	Dummies for less than 4.0, 4.0-5.1, 5.9-6.8, 7.0-7.8, no less than 8.0 cu. ft.
Steam	Dummy for steam
Energy star	Dummy for energy star
Smart appliance	Dummy for smart appliance
Electric/gas	Dummy for gas
Color	Dummy for white
Digital display	Dummy for digital display
Chrome trim	Dummy for chrome trim
Cycles	Dummies for less than 7 cycles, each of 8-14 cycles, 15 cycles or more
Dishwashers	
Width	Dummy for 23 inches or more
Place setting capacity	Dummies for less than 10, 12-13, 14, 15, 16 or more, cu. ft.
Energy star	Dummy for energy star
Cycles	Dummies for 1-4 cycles, 5 cycles, 6 cycles, 7 or more cycles
Color	Dummies for black, white, stainless steel
Tub material	Dummy for stainless
Refrigerators	
Width	Dummies for less than 30, 30-35, 35-36, 36 or more inches
Total capacity	Dummies for less than 18, 18-20, 20-23, 23-27, 27 or more cu. ft.
Freezer capacity	Dummies for less than 5, 5-7, 7-9, 9 or more cu. ft.
Exterior dispenser	Dummy for exterior water and ice dispenser
Color	Dummies for white, black, and stainless steel
Product type	Dummies for top freezer, bottom freezer, side by side, and french door
Number of doors	Dummy for 3 or more doors
Ranges	
Cooktop elements	Dummies for 4 or less, 5, 6 or more
Oven capacity	Dummies for no more than 3.4, 3.5-4.45, 4.5-5.5, 5.6-6.5, no less than 6.6 cu. ft.
Cleaning type	Dummy for self-cleaning
Fuel type	Dummies for gas, electric, dual, and induction
Griddle	Dummy for griddle
Double ovens	Dummy for double ovens
Convection	Dummy for convection
Fan	Dummy for fan convection type
Color	Dummies for stainless, white, black
Range type	Dummy for freestanding

C.17 Total Number of Available Models

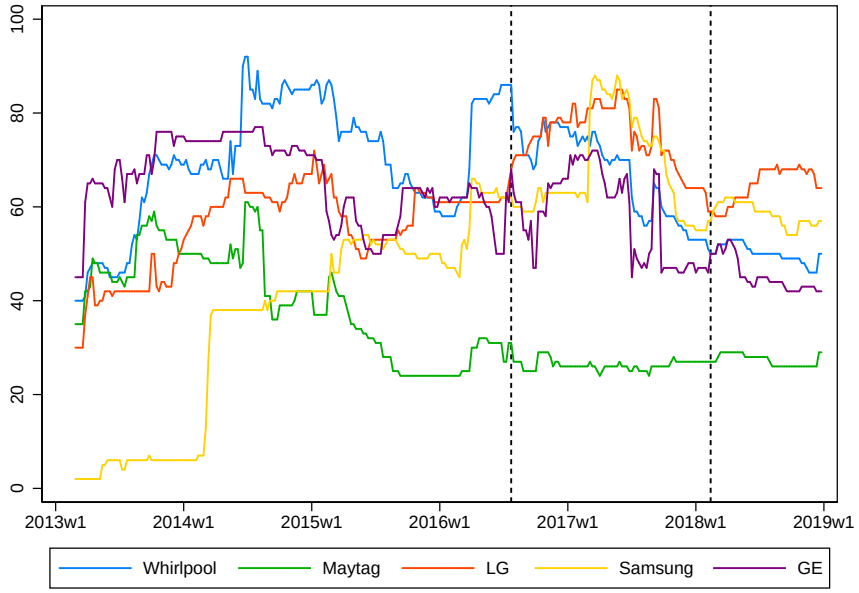
Figure C14 displays the number of available models by brand across the periods we study.

Figure C14: Total Number of Available Models by Brand

(a) Washers



(b) Dryers

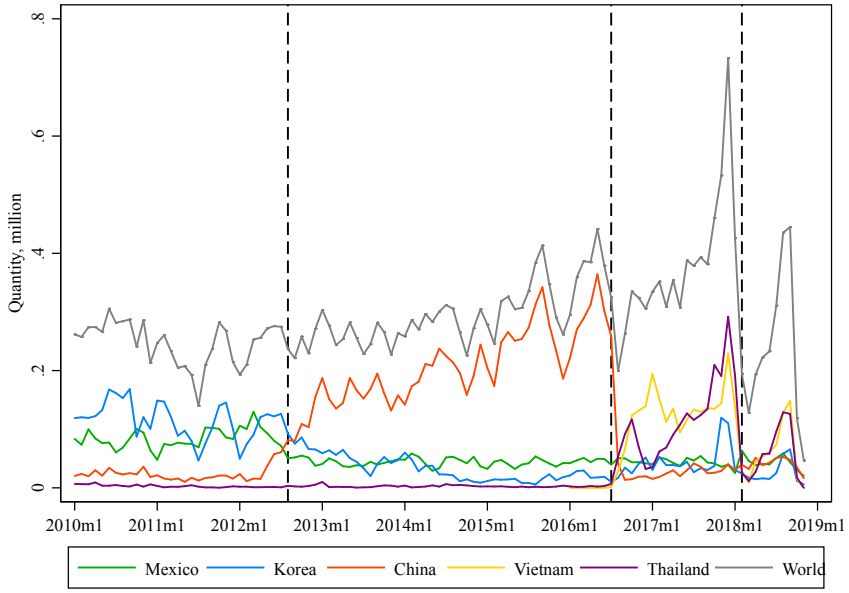


Notes: We count the number of unique models that appeared in a given week. Only 5 major retailers are included in the count. Two vertical date lines are July 26, 2016 and February 6, 2018, which are discussed in the text.

D Robustness Figures and Tables

In this section, we include the results from a variety of robustness checks on our analysis on washing machine price changes following recent trade policy actions.

Figure D1: Monthly U.S. Imports of Washing Machines by Country (Quantity), Seasonally Adjusted



Notes: Residential washing machines are classified under HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090.
Source: United States International Trade Commission (2010-2019).

Figure D2: Time Fixed Effects from Log Price Regression (All 5 Appliances), CPI for Laundry Equipment

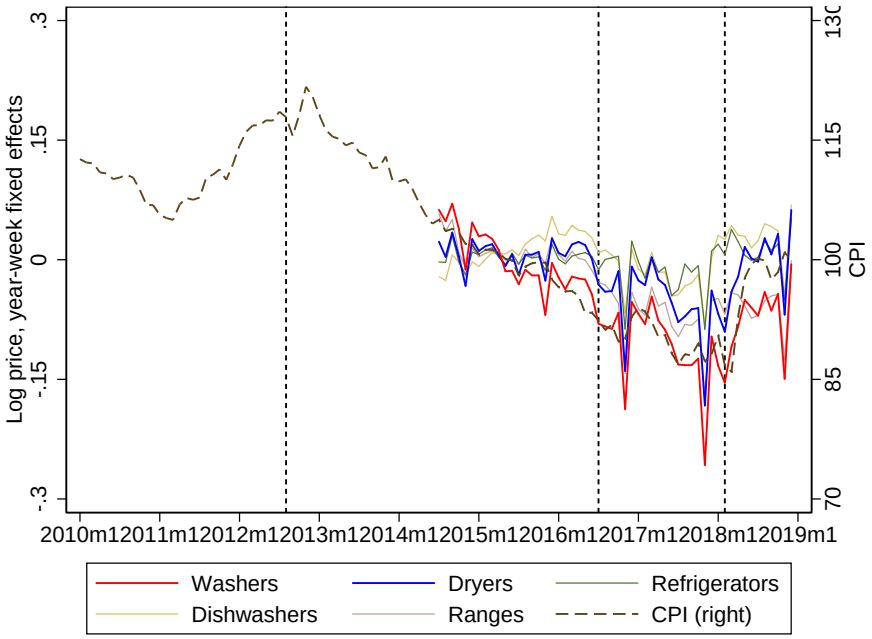
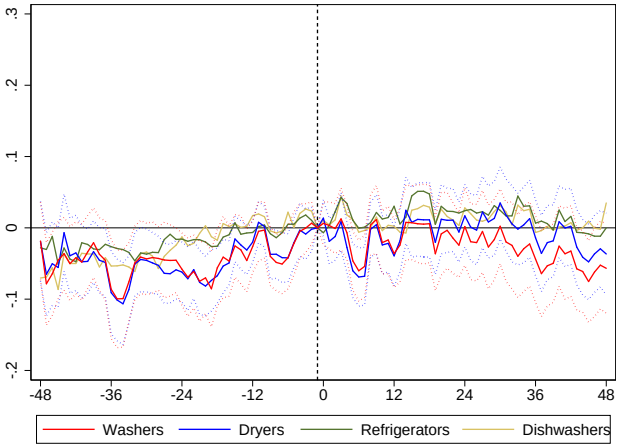
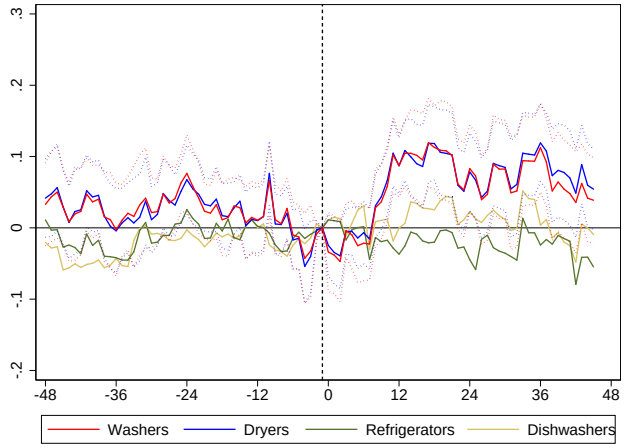


Figure D3: Price Effects of Safeguard Tariffs and Antidumping Duties against China: by Brand, with Model Characteristics as Controls

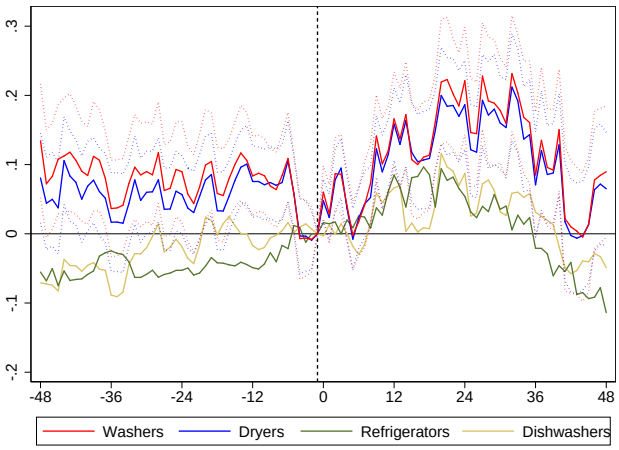
(a) Antidumping against China - Whirlpool



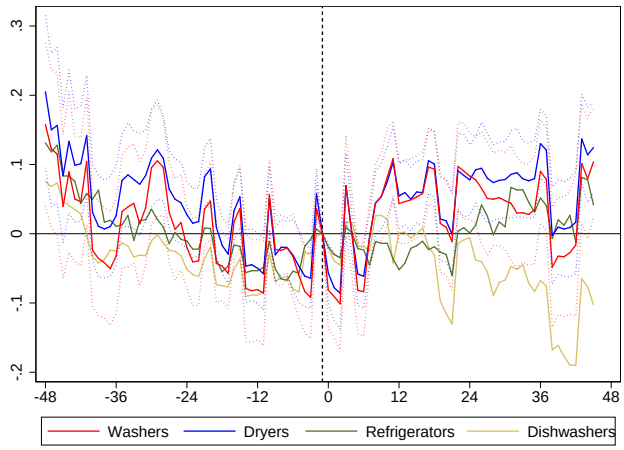
(b) Safeguard Tariffs 2018 - Whirlpool



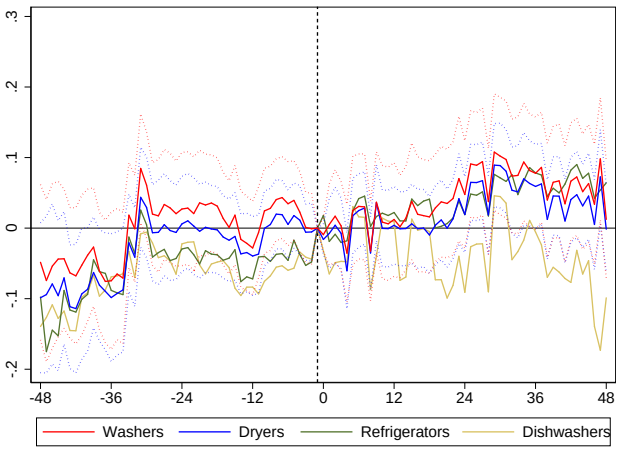
(c) Antidumping against China - Maytag



(d) Safeguard Tariffs 2018 - Maytag



(e) Antidumping against China - LG



(f) Safeguard Tariffs 2018 - LG

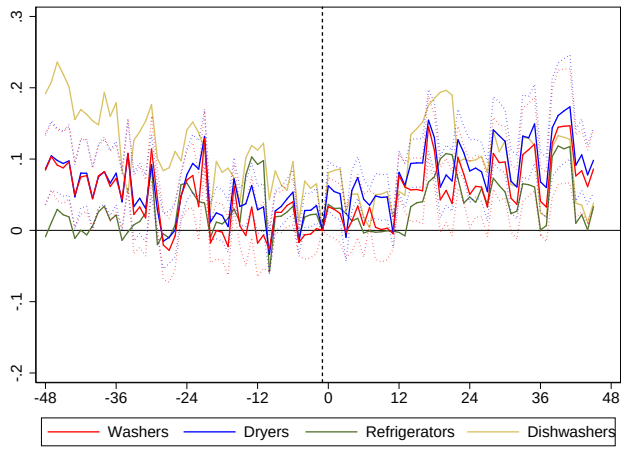
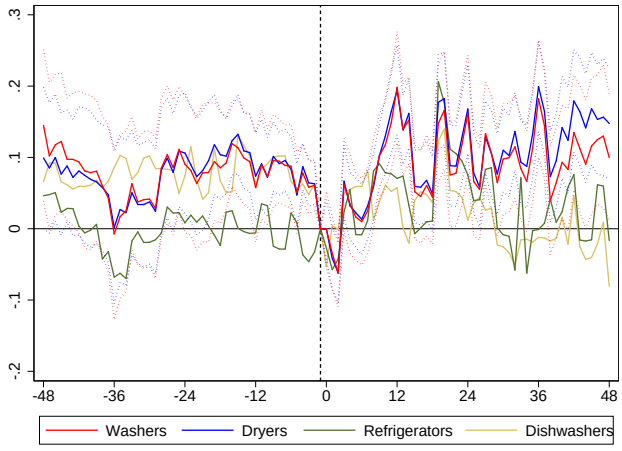
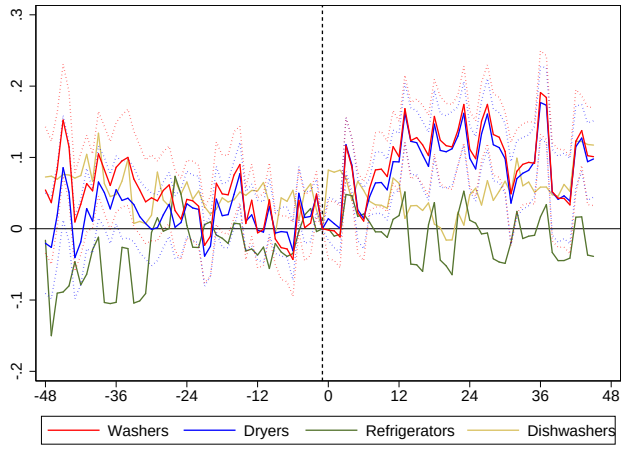


Figure D3: Price Effects of Safeguard Tariffs and Antidumping Duties against China: by Brand, with Model Characteristics as Controls (Continued)

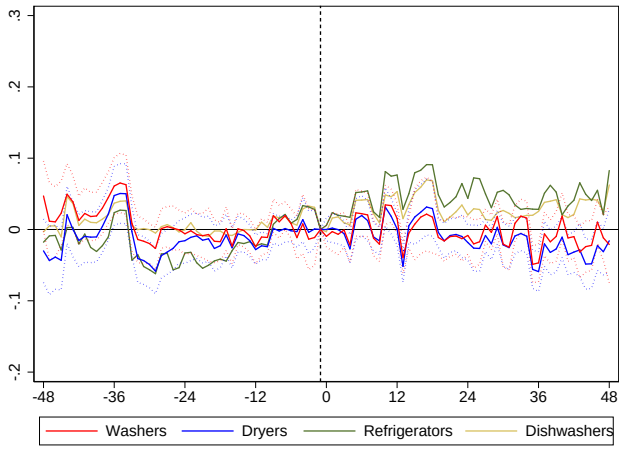
(g) Antidumping against China - Samsung



(h) Safeguard Tariffs 2018 - Samsung



(i) Antidumping against China - G.E.



(j) Safeguard Tariffs 2018 - G.E.

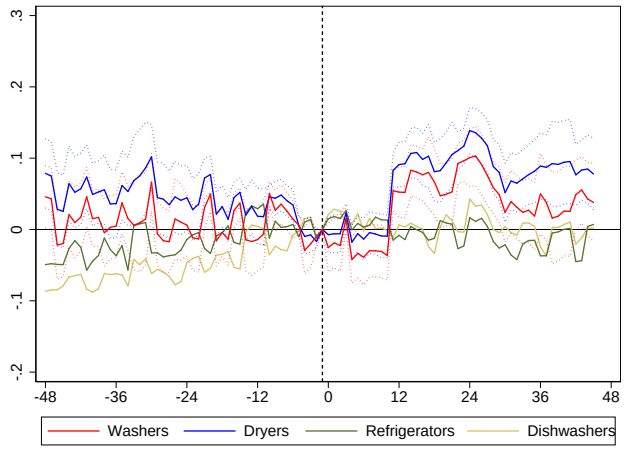


Table D1: Difference-in-Difference Estimates: Brand-Specific Price Effects of Washing Machine Tariffs, Alternative Specification with Model Fixed Effects as Controls

	Washers		Dryers		Refrigerators		Dishwashers	
	4-month	8-month	4-month	8-month	4-month	8-month	4-month	8-month
Antidumping against China								
Whirlpool	0.038	0.046	0.035	0.051	0.026	0.022	0.017	0.011
	(0.023)	(0.027)	(0.017)	(0.020)	(0.011)	(0.011)	(0.014)	(0.015)
Maytag	0.063	0.086	0.069	0.081	0.065	0.065	-0.001	-0.012
	(0.031)	(0.034)	(0.025)	(0.029)	(0.023)	(0.026)	(0.028)	(0.025)
LG	0.018	0.046	-0.002	0.030	0.019	0.045	0.040	0.066
	(0.027)	(0.026)	(0.021)	(0.022)	(0.018)	(0.020)	(0.027)	(0.028)
Samsung	0.067	0.051	0.060	0.033	0.118	0.041	0.078	0.027
	(0.030)	(0.035)	(0.023)	(0.026)	(0.020)	(0.022)	(0.029)	(0.036)
G.E.	0.025	0.023	0.010	0.011	0.015	0.015	0.029	0.022
	(0.015)	(0.018)	(0.011)	(0.014)	(0.007)	(0.009)	(0.008)	(0.010)
Safeguard tariffs 2018								
Whirlpool	0.180	0.146	0.168	0.139	0.008	-0.010	0.030	0.025
	(0.024)	(0.027)	(0.019)	(0.020)	(0.015)	(0.016)	(0.017)	(0.019)
Maytag	0.143	0.091	0.163	0.152	0.033	0.065	0.017	0.067
	(0.030)	(0.040)	(0.027)	(0.036)	(0.022)	(0.026)	(0.023)	(0.033)
LG	0.054	0.081	0.053	0.067	-0.001	-0.015	0.046	-0.007
	(0.016)	(0.017)	(0.014)	(0.013)	(0.016)	(0.012)	(0.016)	(0.018)
Samsung	0.142	0.154	0.112	0.125	-0.025	-0.077	-0.043	-0.027
	(0.026)	(0.029)	(0.020)	(0.023)	(0.015)	(0.019)	(0.016)	(0.024)
G.E.	0.089	0.086	0.116	0.111	-0.011	-0.008	-0.029	-0.015
	(0.018)	(0.018)	(0.014)	(0.014)	(0.009)	(0.009)	(0.011)	(0.011)

Notes: The table reports results analogous to Table 1—based on separate estimates for each brand. Specifically, first equation (4) is estimated (with model fixed effect as controls) and then a linear combination of these estimates is used to compute the left hand side of equation (3)—separately for each brand and product category. Standard errors in parentheses.

Table D2 displays the difference-in-difference estimates for washers and dryers under various robustness specifications.

Table D2: Summary of Robustness Results for Difference-in-Difference Estimates

		(1) Main	(2) All brands, offline stores	(3) All brands, offline stores (weighted)	(4) All brands, all stores (unweighted)	(5) Without age controls	(6) Long sample with alternative age controls
Antidumping against China							
Washers	4-month	0.026	0.031	0.036	0.023	0.021	0.025
		(0.015)	(0.015)	(0.018)	(0.013)	(0.016)	(0.015)
	8-month	0.034	0.034	0.044	0.041	0.027	0.033
		(0.017)	(0.018)	(0.020)	(0.015)	(0.017)	(0.017)
Dryers	4-month	0.016	0.020	0.031	0.014	0.015	0.017
		(0.012)	(0.013)	(0.015)	(0.010)	(0.011)	(0.012)
	8-month	0.023	0.017	0.047	0.023	0.022	0.021
		(0.014)	(0.015)	(0.017)	(0.011)	(0.013)	(0.014)
Safeguard tariffs 2018							
Washers	4-month	0.109	0.087	0.089	0.069	0.112	0.109
		(0.014)	(0.014)	(0.016)	(0.011)	(0.014)	(0.014)
	8-month	0.115	0.091	0.137	0.081	0.126	0.120
		(0.018)	(0.018)	(0.022)	(0.014)	(0.018)	(0.018)
Dryers	4-month	0.111	0.097	0.099	0.074	0.114	0.109
		(0.013)	(0.013)	(0.015)	(0.010)	(0.013)	(0.013)
	8-month	0.114	0.082	0.131	0.077	0.122	0.116
		(0.017)	(0.018)	(0.019)	(0.013)	(0.016)	(0.017)
N		1,637,298	1,288,919	1,193,439	3,955,956	1,637,298	1,950,470

Notes: Column 1 represents the baseline estimates with model characteristics as controls. Column 2 keeps a sample of only offline stores for all retailers and includes all brands. Column 3 weights observations by the number of brick-and-mortar stores for each retailer (i.e., giving more weights to observations at retailers with more stores). The estimates in column 4 are based on a regression that includes all brands and all retailers (both online and offline stores, unweighted). The estimates in column 5 are based on a regression that uses the baseline sample of brands and retailers and excludes product age dummies. The estimates in column 6 are based on the baseline sample of brands and retailers, utilizing all observations starting from March 3, 2013. In addition, all age dummies for initial models are assigned zeros, and one separate dummy for initial models is added.