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# The Production, Relocation, and Price Effects of US Trade Policy: The Case of Washing Machines

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

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**Abstract**

We analyze several rounds of U.S. import restrictions against washing machines. Using retail price data, we estimate the price effect of these import restrictions by comparing the price changes of washers with those of other appliances. We find that in response to the 2018 tariffs on nearly all source countries, the price of washers rose by nearly 12 percent; the price of dryers—a complementary good not subject to tariffs—increased by an equivalent amount. Factoring in the effect of dryers and price increases by domestic brands, our estimates for the 2018 tariffs on washers imply a tariff elasticity of consumer prices of between 110 and 230 percent. The 2016 antidumping duties against China which accounted for the overwhelming majority of U.S. imports – led to minor price movements due to subsequent production relocation to other export platform countries. Perhaps surprisingly, the 2012 antidumping duties against Korea led to relocation of production to China, actually resulting in lower washer prices in the United States. We find that our measure of the tariff elasticity of consumer prices may differ in sign and magnitude from conventional pass-through estimates which are based on a regression of country-specific import price changes on country-specific tariff changes. Production relocation effects, price changes by domestic brands, and price changes of complementary goods all contribute to the differences between these measures.

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# 1 Introduction

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. During the course of the 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 today's particular environment are long-standing questions of international trade theory with little or conflicting empirical evidence. Prominent among these questions is the incidence of tariffs: whether the amount of import taxes is passed through to consumers in the form of higher prices or absorbed by the foreign producer by lowering their export price. As noted by Irwin (2014), direct evidence on this question is scarce, particularly for the case of a large economy like the United States with the potential for monopsony power. Although new tariffs offer many possibilities for study, most of these were placed on intermediate goods where tracking the price effects through the economy is a particular challenge. This paper focuses on a final consumer good, washing machines, and provides evidence on the effects of recent trade policies on trade flows, domestic production, and, most notably, prices.

There are several reasons why the study of washing machines offers useful lessons for how trade policies affect the economy. First, imports of washing machines have been subject to a wide range of different trade policies in recent years. The contrasting effects of these policies offer lessons for how the specific 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 extent of the effects of these tariffs are evident more readily than those imposed more recently on China in the summer and fall of 2018. Finally, features of the product in question—relatively simple means of classification, clear channels for complementarities (washers and dryers), and reasonable concentration of production—make this episode relatively straightforward for detailed study.[1]

The first round of trade policy measures against imported washing machines took the form of country-specific antidumping duties, targeting specific companies producing in particular locations. The result of these antidumping duties, first on Mexican/Korean production in 2012 and later on Chinese production in 2016, was a shift in production to other countries while keeping the overall magnitude of U.S. imports roughly the same. Such "country-

[1]The tariffs on washing machines have received considerable attention from the media. For several examples, see Tangel, Andrew. 2017. "Trades Test Case: Your Washing Machine." *The Wall Street Journal*, October 4., Tangel, Andrew and Josh Zumbrun. 2018. "Whirlpool Wanted Washer Tariffs. It Wasnt Ready for a Trade Showdown." *The Wall Street Journal*, July 16., Tankersley, Jim. 2019. "How Tariffs Stained the Washing Machine Market" *The New York Times*, January 25., and "Will Trump's tariffs help U.S. workers? It could be a wash." *PBS Newshour*, 2018, June 14.

hopping" behavior is intuitive from existing theories of tariff avoidance and models with export platform FDI. The second round of new trade policies utilized a little-used area of U.S. trade law, enacting "safeguard" tariffs on what amounted to 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 frontrunning—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 and continued falling thereafter. The 12 months after the China antidumping duties saw a decline of about the same magnitude – roughly 5 percent. 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 of major appliances. A concern with comparing the prices of washing machines before and after trade policy changes would be 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 mark-ups. 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 applied to Chinese imports were strikingly different from the safeguard tariffs applied to many countries in 2018. Although China accounted for a whopping 80 percent of washing machine imports into the United States prior to the application of tariffs, we find that there was very little effect on retail prices from these 2016 China-specific tariffs. This could be explained by the relative ease by 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, we document a notable spike in washer prices in the months following the new 2018 global safeguard tariffs: about 12 percent more than the corresponding change in our control group. Moreover, we show that prices of a complementary good—clothes dryers—also jumped at the same time by a similar magnitude, despite the fact that these products were not subject to any new tariffs during this period.

We contrast the tariff elasticity of consumer prices—or tariff pass-through—implied by our results with the conventional practice of estimating this elasticity based on a regression of tariff changes on changes in import prices (unit values from trade data). This paper shifts the focus to measure the changes in prices 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 due to import tariffs. Although our sample of micro-level prices does not overlap with the Korea/Mexico antidumping duties, we report evidence – a drop in the unit values 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 tariffs. Our estimates of the tariff elasticity of consumer prices for the country-specific antidumping duties on Chinese production, though positive, are quite small. In contrast, the conventional approach yields elasticities implying complete pass-through of these antidumping duties to import prices from the countries on which the duties were levied. We argue that production relocation plays a prominent role in the differences in these estimates. Indeed, as we show theoretically in section 2, the potential for production relocation leads to a response of prices to tariff changes that is non-monotone.

We find a much higher tariff elasticity of consumer prices for the global 2018 safeguard tariffs; once accounting for the effect on dryers prices, our estimates imply a pass-through to consumer prices of these safeguard tariffs of between 107 and 226 percent. In this case, a comparison of this episode to estimates from the traditional approach reveals the importance of analyzing the price changes by domestic competitors as well as the price effects of complementary goods. 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 costs to consumers of just over 1.5 billion USD on an annual basis. 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 the collected tariff revenues).

Our analysis contributes to the literature on the incidence of tariffs. Irwin (2014) 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. Beginning with Feenstra (1989), several papers have analyzed the response of unit values of trade data to tariff changes from more recent policy changes (e.g., Winkelmann and Winkelmann 1998; Trefler 2004; Broda and Weinstein 2006; Broda, Limao and Weinstein 2008; Spearot 2012; Ludema and Yu 2016). 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.

The results of this paper highlight the advantages of domestic price data over unit values from trade data. The domestic retail prices reflect the impacts of tariffs on domestic competitors, production relocation, and complementary goods, while unit values from trade data would miss these channels.[2] For example, we find either flat or increasing unit values of imported washers from Korea in response to the antidumping duties in 2012, but domestic prices in the United States fell as foreign production relocated to China. In addition,

[2]Using Belgian manufacturing data, Amiti, Itskhoki and Konings (2016) document that large firms respond to competitors cost changes induced by exchange rate changes.

export unit values (measured at the border) may reflect transfer pricing strategies to reduce the costs of tariffs for trade between related parties. They therefore may not accurately characterize the price change faced by consumers.[3]

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.[4]

# 2 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.

We assume that there is a foreign monopolist that supplies washers to the United States. We further assume that consumer preferences for washers lead to a constant elasticity of substitution demand function and that the foreign supplier has constant marginal cost in each of the available production locations. 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. Our assumptions on demand and production cost imply that the monopolist charges a constant mark-up over marginal cost.

Consider first the textbook case without production relocation by the foreign monopolist. This case is depicted in Figure 1a. If the U.S. government charges a tariff on washing machine imports of $\tau$ per unit of washer imported, the U.S. consumers pay the foreign monopolist price plus the tariff.[5] The loss in consumer surplus is $a+b$, the government revenue collected

[3]Recognizing this issue, the firm-level study of Ludema and Yu (2016) drops related-party transactions from their sample. Transactions between related parties account for 85% of washing machine imports (see Appendix B.1). Transfer pricing motives would typically lead to lower pass-through estimates as firms attempt to lower the tariff / antidumping duties costs by lowering import prices.

[4]These findings reflect a third-country effect from trade policy that has been 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 survey of the literature on the effects of trade policy see Goldberg and Pavcnik (2016).

[5]For simplicity we assume the importer is a perfectly competitive intermediary who in turn sells the washers to U.S. consumers, so there is no mark-up added to the tariff. This is not critical for the example and merely simplifies the exposition. Similarly, the analysis can be extended to ad-valorem tariffs.

is equal to region $a$, and the overall welfare loss for the United States is $b$.

Next, let us consider the case of Figure 1b, 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 $p_V - p_C \leq \tau$. 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 effect of the tariff on U.S. consumer prices is less than in the example of Figure 1a. The case presented in Figure 1b is an example of trade diversion due to asymmetric tariffs across countries.[6] 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.

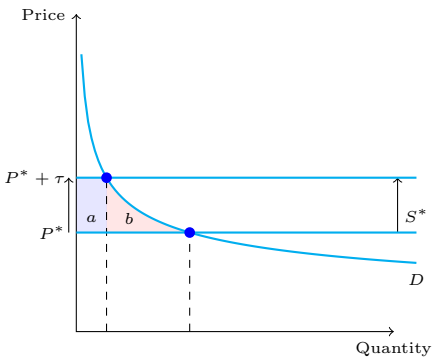
Finally, consider the case depicted in Figure 1c. Here, in addition to producing in country $K$, the foreign monopolist has also the option of producing in country $C$, in which the marginal cost of producing the good is lower than in country $K$. Suppose the monopolist faces additional fixed cost $F$ 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 $\sigma$ 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 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 $a_2 + e_2 + h_2$ 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 $e_2 + d_2 + c_2$.

Hence, as depicted in Figure 1d, 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 1c would not occur in a competitive market where new firms from country $C$ could enter on their own. In that case, in the absence of tariffs, production would never occur in country $K$. 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.

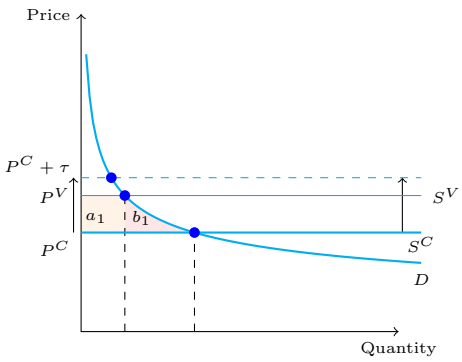
[6] Trade diversion is often discussed in context of regional free trade agreements. The main idea being that in response to a tariff reduction for only selected countries, one may forgo tariff revenue and purchase the good from a producer within the regional free trade area, even though the cheapest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

**Figure 1:** A Simple Model of Production Response to Tariffs

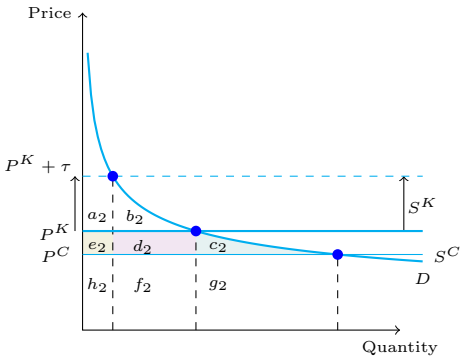
(a) Textbook Example



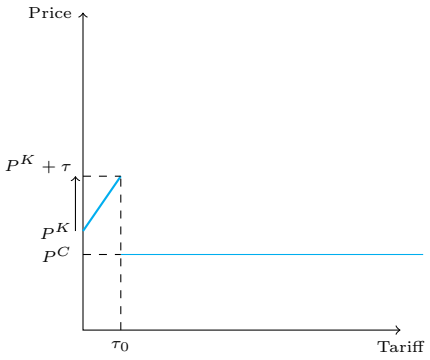

(b) Relocation Dampens the Consumer Price Increase




(c) Relocation Reduces the Consumer Price




(d) Price Change in (c)




These examples illustrate the importance of analyzing jointly the production and price effects from import restrictions. Motivated by these theoretical considerations, we turn to analyzing the changes in trade flows and prices in the data.

# 3 Import Restrictions and Changes in Trade Flows

In this section we provide the institutional background and relevant details for the three sets of trade policy actions affecting washing machines that we evaluate in this paper.

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 it acquired Maytag, its main competitor. This merger substantially increased the concentration of both washing machines and clothes dryers: according 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 ten percent—of U.S. sales during this time. At 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.[7]

specific countries.

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

### 3.1 Antidumping Investigations

Following steady gains in market share by the two Korean companies, in late 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). In this antidumping petition, Whirlpool alleged 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 both a particular type of unfair pricing behavior as well as actual (or threat of) material injury resulting from that behavior. Any remedial measures—which are 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 that recommended antidumping measures; in July of that year, the Commerce Department announced import duties ranging from 9.2 to 82.4 percent on several firms (Department of Commerce (2012)).[8] In the two years following the new antidumping duties, the quantity of imports from Korea fell by roughly 75 percent (the blue line in Figure 2a).[9]

Contemporaneous with the drop in imports from Korea (and to a lesser extent, Mexico) was a substantial increase in imports from China (the red line in Figure 2a). In late 2015, Whirlpool filed another antidumping petition with the USITC, this time against the imports of Samsung and LG washing machines produced in China. In February 2016, the USITC issued another ruling in favor of antidumping measures, and final antidumping duties announced by the Commerce Deparmtent ranged from 38.4 percent (LG) to 57.4 percent (Samsung) (Department of Commerce (2016)).[10] The results of this policy 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 (the purple and yellow lines in Figure 2a) increased sharply, from essentially zero in 2015 to nearly 3.3 million units (combined) in 2017.

Another lens by which to view these changes in sourcing locations is through Korean exports of washing machine parts, given that both Samsung and LG have their global headquarters in Korea. Figure 2b plots the value of Korean exports of washing machine parts

to proceed.

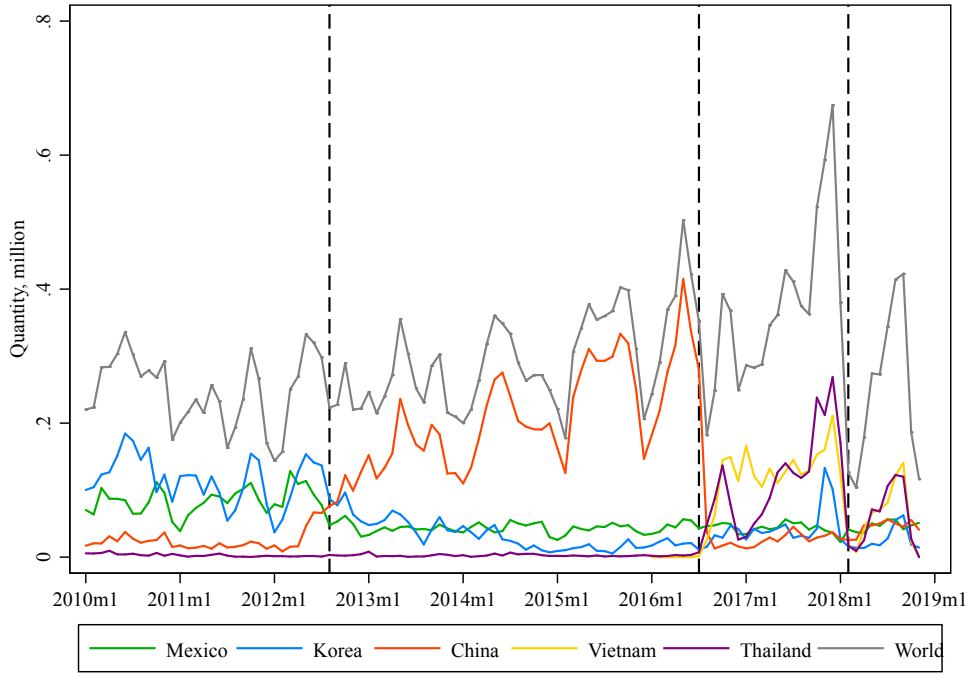
[8]Preliminary antidumping duties were first applied in August of 2012; this date is identified by the first dashed line on the left in Figure 2a and 2b.

[9]Korea subsequently disputed these duties with the WTO. Korea argued that the method used by the United States for the final determination of sales at less than fair value was illegal. The method used by the United States, referred to as "zeroing", zeros out any instances of negative dumping (when an imported product is sold in the United States at prices higher than in the home country) in the calculation of whether dumping has taken place. The WTO ultimately agreed that these antidumping duties were a violation of WTO rules, a decision that was upheld by an appellate body. As of 2018, the case is still in dispute. Korea has issued further complaints to the WTO, indicating that the United States has not taken the necessary steps to bring the antidumping measures into conformity with WTO decisions. In annual reviews of these duties, the U.S. Department of Commerce removed the dumping margins on LG Electronics, but retained and increased the margins on Samsung Electronics, citing that the firm did not cooperate with the USITC investigations. However, according to company reports, Samsung had stopped exporting to the United States from Korea altogether.

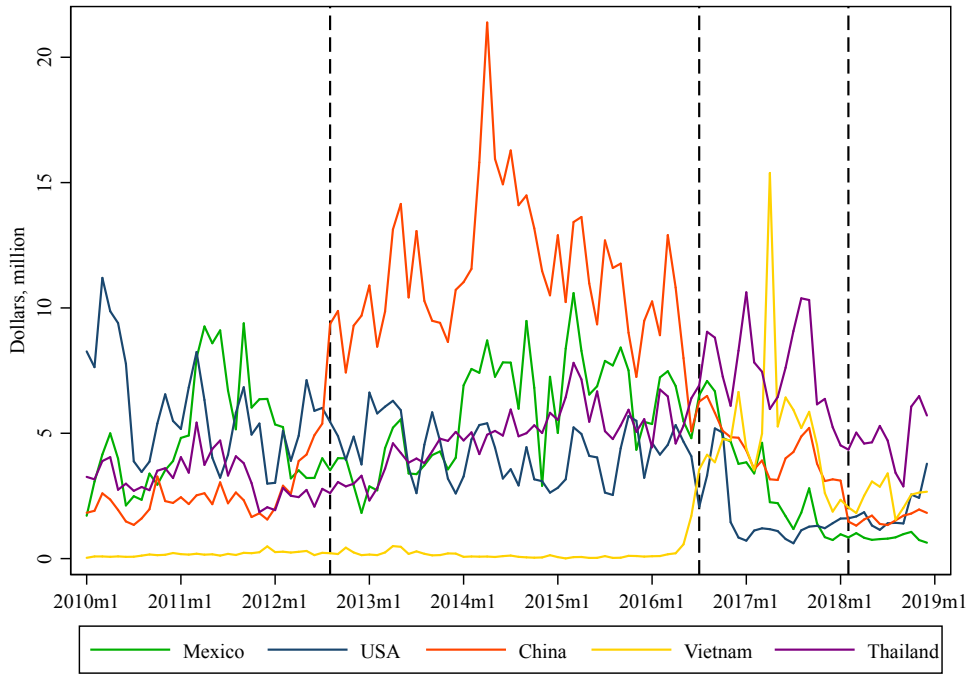
[10]The new antidumping duties on Chinese imports began five months later in July 2016, as identified by the dashed line in the middle in Figure 2a and 2b.

**Figure 2:** U.S. Washing Machine Imports and Korean Washing Machine Part Exports by Country

**(a)** Monthly U.S. Imports of Washing Machines by Country (Quantity)




**(b)** Monthly Korean Exports of Washing Machine Parts (Millions of U.S. Dollars)




*Notes:* Data from USITC and Korea Customs Service. Residential washing machines are classified under HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090. Washing machine parts are classified under HS845090. The seasonality adjusted version of Figure 2a is shown in the Appendix as Figure A10.

(under HS845090) to the various countries highlighted above. Figure 2b demonstrates that

shifts in Korean exports of parts follow the corresponding shifts in washing machine production[11]. Exports of parts to China jump in 2013 and 2014 before falling back in 2016 and 2017 as exports of parts to Thailand and Vietnam rise. In addition, overall Korean washing machine parts exports (not shown) rise nearly 60 percent between 2010 and 2016, a fact consistent with the reduced amount of parts used in Korea for washing machine production for export. Taken together, Figures 2a and 2b are a striking illustration of the changes in supply chains induced by U.S. tariffs.

## 3.2 The Global Safeguards Investigation

Following the "country hopping" response to the localized nature of the antidumping duties, in 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 has no requirement 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.[12] Use of this trade measure has been rare; Section 201 safeguard tariffs were last implemented in 2002 on steel and steel products.

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.[13]

As shown in the far right portion of Figure 2a, imports surged in late 2017 and early 2018 as foreign producers rushed to ship washing machines to the U.S. before the 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.[14] Imports fell sharply again in October

[11] Korea Customs Service (link) contains the monthly import and export data by country and by commodity. Commodities can be queried by their HS codes up to 10 digits.

[12] There were ultimately a few country exclusions to the section 201 safeguard tariffs. Canada was excluded, as the final announcement indicated that Canadian imports do not account for a substantial share of the total and do not contribute to the injury identified by the USITC. 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.

[13] 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). For products subject to antidumping duties, the dutiable value (for Section 201 tariffs) would be the value of the imported product *prior to* any antidumping duties being assessed.

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

and November.[15]

In Table A1 we provide a summary of the key dates associated with the three rounds of import restrictions against washing machine imports.

## 3.3 Onshoring of U.S. Production

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 Electronic factory in Clarksville, Tennessee, is scheduled for a late 2018 or early 2019 opening, 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.

## 3.4 The Relation to Import Prices

Before we turn our attention to the analysis of how retail prices were affected by the tariff changes described above, we first evaluate the evidence on the relationship between production relocations and cost changes highlighted in the theoretical discussion above from section 2.

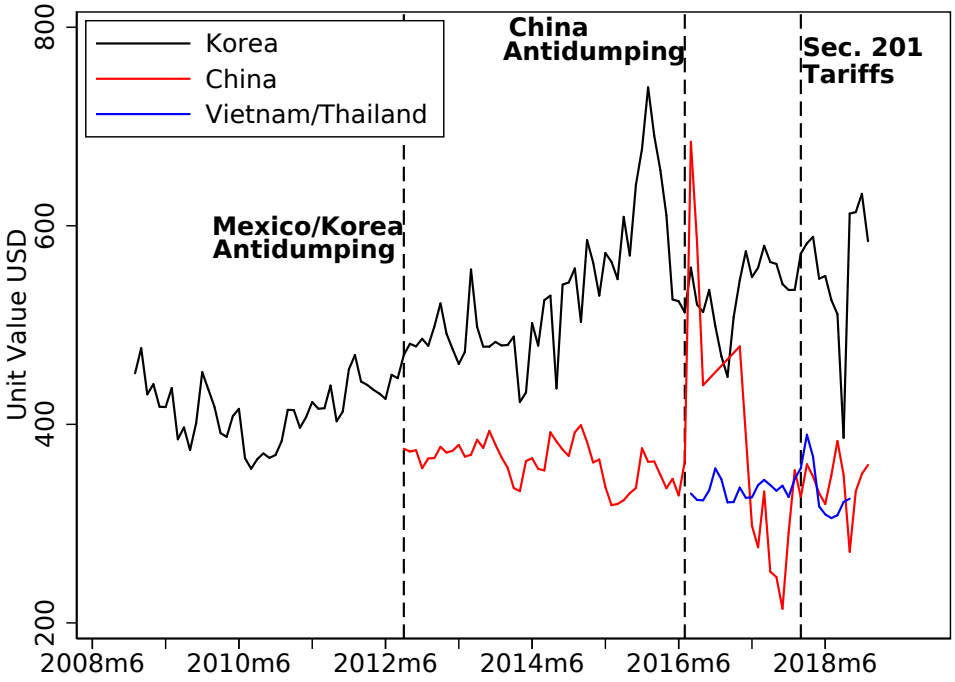
While the retail price data we utilize below are the preferred conceptual benchmark and provide the greatest detail for a general analysis of tariff pass-through to consumer prices, we temporarily turn our attention to the unit values from publicly available trade statistics for several reasons. Unlike the retail price data, these import unit values provide a direct link to the location of production. Second, because they do not include retail markups, they provide a closer proxy for the marginal costs that are the object of interest of the theory described above. Finally, for the case of washing machines, the relative simplicity of the product classification and widely reported quantity information imply that the unit values are reasonably well-behaved.

Figure 3 reports the pattern of import unit values for each major trading partner during and after the period for which these countries were the dominant U.S. source of imports.[16] Because the quantity of imports decreases substantially for those countries subject to new tariff actions, the import unit values tend to behave more erratically in the months following the application of new tariffs. Figure 3 reveals that unit values decreased following the Korea/Mexico antidumping duties as production relocated to China; the unit values from China (the red line) tend to be lower than the unit values from Korea (the black line) prior

[15] Figure 2a actually may understate the responsiveness of import quantities to the Section 201 safeguard tariffs, as not all washers within the selected HS product codes were included as within-scope for the investigation. At the request of Whirlpool, stacked washer/dryers, commercial washers, front-loading washers with a controlled induction motor, top-loading washers with a belt drive train, and extra-wide front-loading washers were excluded from the investigation. Appendix B.2 discusses results that split the quantity of U.S. imports, and corresponding implied tariff rates, for 2018 according to the whether the imports were assessed Section 201 safeguard tariffs.

[16] The value used here for the calculation of unit values is *exclusive* of tariffs and duties.

**Figure 3:** Average Unit Values by Production Location




*Notes:* Data from USITC. Includes residential washing machines classified under HS8450200040, HS8450200080, and HS8450200090. The display of country-level unit values are restricted to the periods of majority production in the data: through July 2012 for Korea, July 2016 for China, and beyond for Thailand/Vietnam.

to the antidumping order. In contrast, the unit values tend to be roughly equivalent during the switch from China to Vietnam/Thailand (the blue line).

While we demonstrate the theoretical underpinnings of a negative price response to tariff changes (or negative rate of tariff pass-through) above, the evidence from unit values 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. On the other hand, as we show below in Figure 4, 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. At a basic level, Figure 3 makes clear that the price effects of tariff changes are not restricted to same-country changes in import prices. The detailed micro-level data we have available from retail stores will prove helpful in the more comprehensive review of price responses of washer tariffs we provide below.

# 4 Effects of Trade Policy Measures on Retail Prices

The overall welfare impact of tariffs depends on the extent to which they are passed on to consumers; yet, the paucity of consumer-facing prices has limited research in this critical area of trade policy. In this section, we exploit detailed, high-frequency microdata from retail stores to offer a novel perspective on the effect of these tariffs on consumers and welfare.

## 4.1 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 is both high frequency and detailed with respect to brand, features, and retailer. We obtain data with these features from Gap Intelligence, 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.[17] 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 those stores with both an online and physical presence); in addition, the data contains the number of each retailers' brick-and-mortar stores in the U.S. in a given quarter. Gap Intelligence pays weekly visits to major retailers in 22 metropolitan areas in the United States 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. While some heterogeneity in prices across retail locations may exist, the provided weekly retailer-product specific price information is what Gap Intelligence considers the nationally representative price.[18]

We apply several sample restrictions. 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. All models present in the first week of March 2013 have their initial debut date in that week. As this introduces large measurement error in products' ages in 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. While some measurement error in age remains at the beginning of the sample, this should not be an issue for the period near the China antidumping event in 2016 or the Safeguard tariffs in 2018. 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

[17] The price data for dishwashers starts in November 2013.

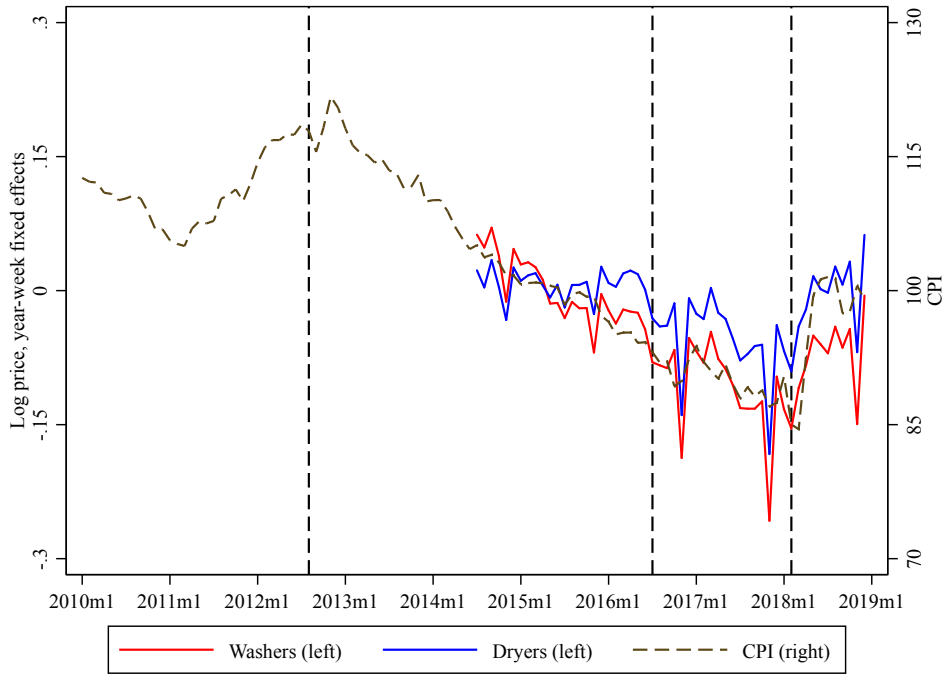
[18] Hitsch, Hortacsu and Lin (2017) and DellaVigna and Gentzkow (2017) report evidence suggesting uniform pricing in U.S. retail chains across locations.

prices of washers and dryers:

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

where subscripts $i$, $r$, $t$ stand for model, retailer, and time (measured by week) respectively. The notation $C(i)$ refers to the product category (washer, dryer,...) whereas $B(i)$ refers to the brand (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 A11 for a full list of characteristics by product category). The $\lambda_{C(i)t}$ term refers to a product category week fixed effect, while the $b_{B(i)C(i)}$ term captures a brand and product category specific fixed effect.[19] The term $\gamma_r$ denotes a retailer fixed effect. We also capture life-cycle effects of product pricing: the $\text{age}_{it}$ 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 data set, and then include dummies for the following 23 months, as well as a dummy whether the product has debuted more than two years ago.

**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 the right axis are simple to compare. The dates of the three vertical lines are August 2012, July 2016, and February 2018, which are discussed in the text.

In Figure 4 we plot the $\lambda_{C(i)t}$ fixed effects, which depict the trends in washer and dryer prices during our sample period. The red line displays the washer-week fixed effect from the log price regression in equation (1) (averaged by month), and the blue line displays the dryer-week fixed effect (again averaged to its monthly level). These fixed effects summarize

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

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 Bureau of Labor Statistics. 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 the price of dryers of about 7 percent. The CPI for laundry equipment (which is 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, while the CPI for laundry equipment is seasonally adjusted. However, we find very similar seasonal patterns for all five household appliances, so seasonality will not drive our estimates of the tariff effects discussed further below. The product-category-time fixed effects for all five appliances are provided in Figure A11 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.

## 4.2 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 China antidumping duties of 2016/2017 and the safeguard tariffs of 2018.

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 subsequent details were complicated, as a number of countries were successful in negotiating exclusions from these tariffs in exchange for strict quota limits on their exports of these metals to the United States. The ultimate 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 the fact that all appliances were similarly affected by these changes in inputs costs (see Appendix B.3 for a discussion of the metals content of appliance production). The product category closest to washers and dryers with respect to steel content is ranges, and we therefore choose it as the control product group.

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 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.

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

Most of the coefficients in (2) are the same as in equation (1), with the difference being that $\lambda^d_{C(i)t}$ measures the product category week fixed effect relative to the week fixed effect from ranges.[20] 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 the safeguard tariffs ($t = -1$ of January 28, 2018) set to zero. The term $\ell_t$ absorbs shocks to prices that commonly affect all household appliances, such as changes in the price of steel.

Figure 5a reports the estimates of $\lambda^d_{C(i)t}$ for the categories of washers, dryers, refrigerators, and dishwashers during the periods before and after the 2016 China antidumping duties. Figure 5b report 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 Figure 5b 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, it appears that refrigerator prices (Figure 5a) were 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 A11 for price changes in all 5 appliances). Hence, though the patterns evident in Figure 5 are informative, we must factor in the different trends (see, for example, 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 /antidumping event as:

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

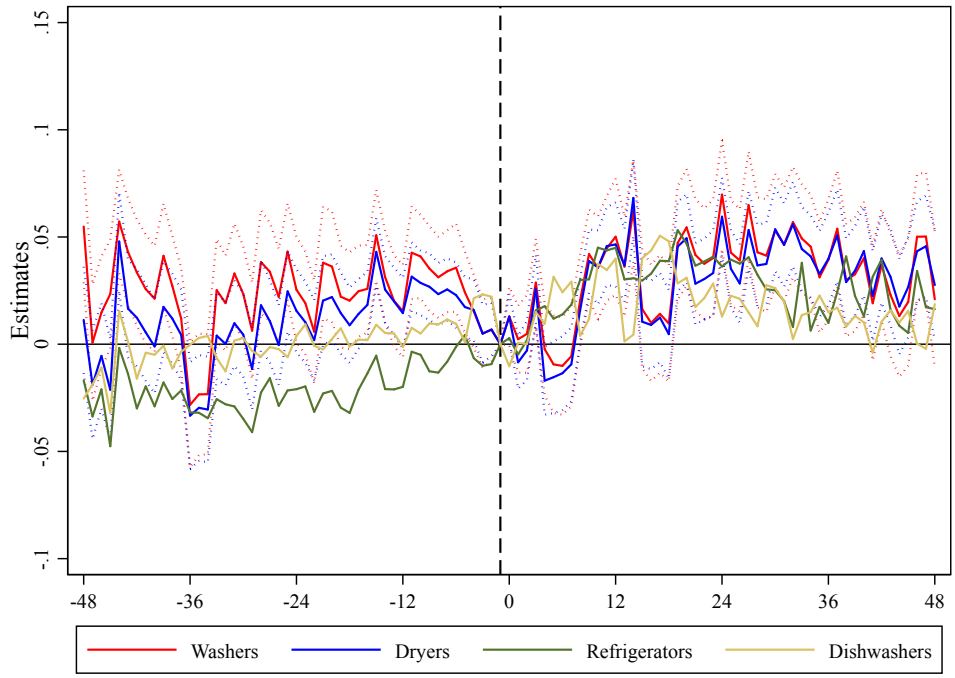
and an eight month effect analogously, where we define the end points using periods -44 to -36 weeks and +28 to +36 weeks relative to the policy date.

As shown in Table 1, after accounting for differential pre-trends, we find only modest price changes caused by the antidumping case against China. The estimates in columns 1 and 2—when controlling for model characteristics—suggest a price increase of only 1.5 to 3.5 percent for washers and dryers in the 4 and 8 months periods. In columns 3 and 4—when utilizing model fixed effects as controls—the estimates for all four appliances increase and become statistically significant relative to the price levels of ranges. Compared to dishwashers and refrigerators the price increase estimates pertaining to washers and dryers are only slightly

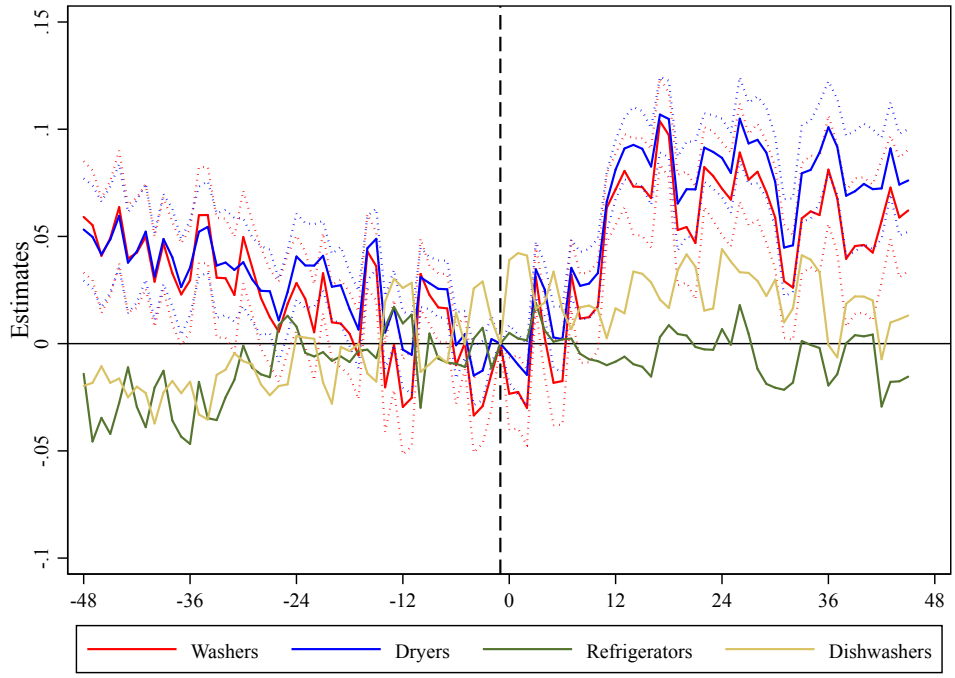
[20] Additional detail on the other covariates in regression 2 are available in Table A11 in the Appendix. Standard errors are clustered by model.

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

**(a)** Antidumping against China




**(b)** Safeguard Tariffs 2018




*Notes:* These figures report the regression coefficients $\lambda_{C(i)t}$ from equation (2). In 5a the estimates are relative to the week of July 17, 2016 and in Figure 5b 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.

higher. By contrast, and consistent with the preliminary evidence from Figure 5b, the estimated price effects of the Section 201 safeguard tariffs are much more striking. We find

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

| | with model characteristics as controls | | with model fixed effect as controls | |
|---|---|---|---|---|
| | 4 month | 8 month | 4 month | 8 month |
| **Antidumping against China** | | | | |
| Washers | 0.0258 | 0.0342* | 0.0463*** | 0.0583*** |
| | (0.0153) | (0.0169) | (0.0121) | (0.0128) |
| Dryers | 0.0163 | 0.0234 | 0.0333*** | 0.0470*** |
| | (0.0118) | (0.0136) | (0.0090) | (0.0096) |
| Refrigerators | 0.0248* | 0.0083 | 0.0386*** | 0.0276*** |
| | (0.0105) | (0.0128) | (0.0066) | (0.0071) |
| Dishwashers | 0.0121 | -0.0055 | 0.0351*** | 0.0241** |
| | (0.0128) | (0.0139) | (0.0075) | (0.0081) |
| **Safeguard tariffs 2018** | | | | |
| Washers | 0.1092*** | 0.1151*** | 0.1104*** | 0.1185*** |
| | (0.0138) | (0.0181) | (0.0111) | (0.0118) |
| Dryers | 0.1115*** | 0.1141*** | 0.1118*** | 0.1194*** |
| | (0.0126) | (0.0166) | (0.0091) | (0.0095) |
| Refrigerators | 0.0014 | -0.0347* | -0.0022 | -0.0180** |
| | (0.0101) | (0.0150) | (0.0063) | (0.0070) |
| Dishwashers | -0.0099 | -0.0211 | -0.0123 | -0.0170 |
| | (0.0116) | (0.0179) | (0.0075) | (0.0087) |
| N | 1,637,298 | | 1,637,298 | |

*Notes:* The table reports estimates for $\Delta^{4m}_{event}\bar{p}_C$ and $\Delta^{8m}_{event}\bar{p}_C$ 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. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

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 series for dryers which rises simultaneously to washers by an equivalent amount. The price effects on dryers are initially puzzling as these appliances were not subject to any new tariffs during this time; we revisit this feature of our data in greater detail in section 4.4 below. Reassuringly, 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. Included in what was a third round of tariffs imposed on Chinese imports (from the Section 301 provision of U.S. trade law intended to penalize unfair trade practices) were refrigerators and electric/gas ranges; household dishwashers were not subject to new tariffs. These tariffs went into effect in September (roughly $t = 28$ in Figure 5b) at a rate of 10 percent.[21] 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

[21]The tariffs were scheduled to automatically increase to 25 percent on January 1, 2019; however, the Trump administration delayed this increased, first temporarily and then permanently.

Chinese import share for refrigerators was around 17 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 B.4 for more details.

The evidence in Table 1 demonstrate 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 the dollar increase in price attributable to these tariffs on washers and dryers was 86 USD per unit and 92 USD per unit, respectively.

In our baseline specification, we include controls for product characteristics and an interaction of brand and product category fixed effects. In columns 3 and 4 of Table 1, we present results from an alternative specification that includes model fixed effects. When using model fixed effects, the estimated policy effect is identified from the price changes of the products existing before and after the policy change, while the baseline specification estimates price effects that include the price level changes for new products.

Because the tariffs under consideration were not evenly applied across all models in the data, the estimates above 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 re-run specification (2) but allow for separate coefficients for each brand. Specifically, we estimate:

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

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 that is 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 both by appliance and brand. These estimates are shown in Table 2.

The striking feature of Table 2 is 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 to 17 percent, with dryer prices increasing at least as much. Maytag raised washer prices by about 14 percent and dryer prices between 17 to 20 percent. G.E. had lower price increases of around 7 percent for washers and about 10 percent for dryers. LG raised prices over four months by eight percent and over 8 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? There are a number of potential explanations, including increasing marginal costs of domestic production. Indeed, as shown by Pierce (2011) protected domestic plants from antidumping duties tend to exhibit increased prices and markups, with physical productivity actually falling. One potential hypothesis for these results is that the inclusion of new tariffs on washing machines parts (a component of the

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

| | Whirlpool | | Maytag | | LG | | Samsung | | G.E. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4 month | 8 month | 4 month | 8 month | 4 month | 8 month | 4 month | 8 month | 4 month | 8 month |
| **Antidumping against China** | | | | | | | | | | |
| Washers | -0.0306 | -0.0345 | 0.1420** | 0.1897*** | 0.0098 | -0.0110 | 0.0830* | 0.0573 | -0.0020 | 0.0235 |
| | (0.0283) | (0.0360) | (0.0444) | (0.0530) | (0.0387) | (0.0491) | (0.0413) | (0.0498) | (0.0180) | (0.0240) |
| Dryers | -0.0339 | -0.0032 | 0.1140** | 0.1478** | -0.0081 | -0.0361 | 0.0934** | 0.0599 | -0.0165 | -0.0184 |
| | (0.0250) | (0.0336) | (0.0373) | (0.0457) | (0.0289) | (0.0423) | (0.0361) | (0.0408) | (0.0168) | (0.0227) |
| Refrigerators | 0.0075 | -0.0115 | 0.0313 | -0.0142 | 0.0421 | 0.0356 | 0.1155** | 0.0299 | -0.0146 | -0.0076 |
| | (0.0167) | (0.0240) | (0.0494) | (0.0531) | (0.0277) | (0.0417) | (0.0371) | (0.0439) | (0.0159) | (0.0220) |
| Dishwashers | -0.0297 | -0.0456 | 0.0118 | -0.0112 | 0.0116 | -0.0243 | 0.0259 | -0.0537 | 0.0121 | 0.0112 |
| | (0.0213) | (0.0276) | (0.0434) | (0.0477) | (0.0584) | (0.0687) | (0.0614) | (0.0700) | (0.0151) | (0.0179) |
| **Safeguard tariffs 2018** | | | | | | | | | | |
| Washers | 0.1739*** | 0.1292*** | 0.1457*** | 0.1365** | 0.0814*** | 0.1314*** | 0.1528*** | 0.1753*** | 0.0719** | 0.0507 |
| | (0.0328) | (0.0368) | (0.0348) | (0.0500) | (0.0216) | (0.0314) | (0.0314) | (0.0394) | (0.0226) | (0.0312) |
| Dryers | 0.1752*** | 0.1416*** | 0.1685*** | 0.2013*** | 0.0820*** | 0.1250*** | 0.1045*** | 0.0989** | 0.1226*** | 0.1083*** |
| | (0.0282) | (0.0331) | (0.0314) | (0.0469) | (0.0197) | (0.0284) | (0.0281) | (0.0345) | (0.0231) | (0.0298) |
| Refrigerators | 0.0076 | -0.0289 | 0.0302 | 0.1480** | 0.0396 | 0.0216 | 0.0083 | -0.0710* | -0.0353* | -0.0640* |
| | (0.0234) | (0.0287) | (0.0283) | (0.0480) | (0.0215) | (0.0300) | (0.0215) | (0.0285) | (0.0166) | (0.0258) |
| Dishwashers | 0.0409 | -0.0010 | 0.0178 | 0.0094 | 0.1364*** | 0.1577* | -0.0162 | 0.0536 | -0.0519** | -0.0659* |
| | (0.0242) | (0.0321) | (0.0289) | (0.0584) | (0.0360) | (0.0721) | (0.0240) | (0.0501) | (0.0173) | (0.0289) |
| N | 363,800 | | 101,586 | | 313,206 | | 320,698 | | 538,008 | |

*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 A12 in the Appendix displays the corresponding weekly price estimates by brand. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Section 201 safeguard investigation) raised the cost of domestic production, with subsequent pass-through to retail prices of washing machines.[22] On further inspection, it turns out that the effective tariff on parts hardly changed following the Section 201 safeguard tariffs, consistent with this provision being a targeted measure to prevent foreign firms from importing semi-assembled pieces as a way of getting around the tariffs on fully assembled machines. Further details on washing machine parts is available in Appendix B.5. Note also that the effect of the increase in steel prices is differenced-out, as it also applies to ranges (the control group) and the other appliances.

## 4.3 Robustness

We briefly discuss a number of additional results to indicate that our results from section 4.2 are robust to alternative assumptions. In Appendix Table A10 we present results analogous to Table 1, but after including all available stores and brands in our data. Here the price changes from the China antidumping tariff are roughly the same, while the price changes caused by the safeguard tariffs are a touch lower. One might wonder whether any increases of markups would be mitigated in online stores, such that the results when only considering brick-and-mortar stores might be larger. Appendix Table A8 shows results that include all brands but only prices collected from brick-and-mortar stores. The results are essentially the same as before. Finally, Gap Intelligence collects price observations without attempting to utilize sampling weights to construct an estimate of the aggregate price index of the products they research. As such, all observations enter our analysis equally in section 4.2. Although we lack weights on particular brands and models, our data do include the number of brick-and-mortar stores for each retailer in the United States. Appendix Table A9 replicates our

[22] On the other hand, it would be surprising for a petitioning firm to include a parts component to the investigation that would subsequently increase its own costs of production.

baseline results from Table 1 but for all brands, brick-and-mortar retailers, and where each retailer receives a weight corresponding to the number of brick-and-mortar stores in the U.S. The results are robust, with the price effect of both the China antidumping and Safeguard tariffs increasing somewhat (at least, for the eight months estimates) than our baseline.

Finally, Table A6 in Appendix C provides a summary of other robustness results, including those for Figure 4 and Figure 5.

## 4.4 The Response in the Price of Dryers

A surprising feature of the results presented in section 4.2 is that dryers—excluded from any tariffs during this period—experienced price changes that were nearly identical to that of washers. This is true in the aggregate (Figure 1) as well as for each brand separately (Table 2). This section explores the relationship between these two appliances in greater detail.

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; with clothes dryers being substantially less costly to produce, 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).

For additional analysis, we identify the set of matched washer-dryer models within each brand, as discussed in Appendix B.6. 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.[23] 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 this data to calculate the correlations of sales rank for washer and dryers for the major brands we study. As shown in Appendix Figure A7, the Pearson rank correlation of sales for a brand's washer and dryers at a given retailer is quite high, 0.9 to 0.95, depending on the retailer, and typically lower, 0.3 to 0.9, for other appliances pairs. We describe these calculations in greater detail in Appendix B.7.

Taken as a whole, there is clear evidence of complementarities between washers and dryers in our data. As such, it seems plausible that the firms in our sample chose to split the effects of new tariffs on prices between washers and dryers, maintaining the convention of identical prices. Nevertheless, this behavior does raise significant questions. If it is indeed the case that dryers are significantly less costly to produce, why is it that competition (between existing firms, or from a new one specializing in dryers) does not drive down the price? Perhaps the aesthetics of similar design and style features of matched washer-dryer pairs is an important component of consumer behavior in this market.

[23] 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.

## 4.5 Implications for the Tariff Elasticity of Consumer Prices

In this section we use the increases in price identified in sections 4.1 and 4.4 to calculate the tariff elasticity of consumer prices. The conventional approach used in prior papers (dating back to at least Feenstra 1989) is to follow the literature examining the effects of exchange rate changes and estimate the "pass-through" of tariffs to import prices based on a regression of changes in unit values (from trade data) on changes in tariff rates. Specifically, the typical estimated regression is given by:

$$\Delta \ln p_{igt}^{border} = \alpha_0 + \alpha_1 \Delta \ln(1 + \tau_{igt}) + \gamma_{it} + \omega_g + \varepsilon_{igt}, \tag{5}$$

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 $\alpha_1$ 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.

An examination of the evidence we present above would identify a number of shortcomings of this conventional approach. First, the tight country link between tariff changes and trade prices assumes away substitution and in particular the substitution to other countries as firms relocate production. This methodology will then miss or misinterpret the indirect effects of production relocation as they relate to the actual prices faced by consumers. Such effects are particularly problematic for country-specific tariffs such as antidumping and countervailing duties, which have increased in importance in recent decades. A second concern with the conventional method is that it doesn't reflect the full basket of prices available to consumers (both domestically produced and imported products). Even for imported products, the full effect of tariff changes on consumer products will depend on markup adjustments.[24]

A third and more complicated issue arises from identifying the price impacts of complementary goods not subject to tariffs. Even when these products would be included in a pass-through regression, the impacts to import prices would likely not be reflected in the $\alpha_1$ coefficient from equation (5).[25] Finally, measurement from unit values faces the known problem of whether intra-firm transactions reflect prices that are relevant for ultimate consumers.

The richer data on retail prices at our disposal allows us to calculate the tariff elasticity of *consumer* prices that, at least partially, overcomes the shortcomings of the conventional approach. Formally, let $\Delta_t \ln P_C(\Delta\tau)$ denote the log change in the price index of product category $C$ *in response to a tariff change*. Then, we define the tariff elasticity of consumer prices as

$$\text{TECP}_{C,t} = \frac{\Delta_t \ln P_C(\Delta\tau)}{\left[\frac{M_{C,t-1}}{D_{C,t-1}}\right] \sum_K s_{C,t-1}^k \Delta\tau_{C,t}^k}, \tag{6}$$

where $M_{C,t-1}$ and $D_{C,t-1}$ are aggregate imports and consumption of product category $C$, measured in the period $t-1$ before tariffs are applied. The term $s_{C,t-1}^k$ are lagged import

[24] This can be seen easily when writing down the retail price $P_t^R$ as $P_t^R = P_t^I(1+\tau_t)m_t$, where $P_t^I$ is the import unit value, $\tau$ is the tariff, and $m_t$ is the markup. Fully differentiating this expression with respect to the tariff rate yields: $\frac{dP_t^R}{d\tau} = \frac{dP_t^I}{d\tau} + 1 + \frac{dm}{d\tau}$.

[25] Admittedly, our approach above does not reveal any systematic method—apart from the value of a careful review at the micro-level—to identify such complementarities in the data.

shares of country $k$ to apply to the country-specific tariff rate changes ($\Delta_t \tau_C^k$).[26] Equation (6) will more accurately capture 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 prices paid by consumers—made possible by our data—and 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) ensures that the measure reflects an overall elasticity for products consumed. Finally, the measure allows one to identify the product category $C$ to assess whether broader categories of products experience price changes.

To implement equation (6) in our data, we require two adjustments. First, as a measure of the price index, we replace the numerator with the average log change in price we observe in our data. As shown in Figure 4, this estimate actually mirrors the CPI quite well. Second, to capture the causal impact on prices (what is defined as $\Delta_t \ln P_C(\Delta\tau)$ above), we follow our approach from Section 4.2 and utilize our estimates $\widehat{\Delta_t^{8m} \bar{p}_C}$ in equation (3), which uses a set of control group ($J$) products. The control category is meant to subtract out other factors that could be influencing consumer prices for product category $C$ during this time period, apart from tariffs. The modified expression we use is written as:

$$\widehat{\text{TECP}}_{C,t} = \frac{\widehat{\Delta_t^{8m} \bar{p}_C}}{\left[\frac{M_{C,t-1}}{D_{C,t-1}}\right] \sum_{K_C} s_{C,t-1}^k \Delta_t \tau_C^k - \left[\frac{M_{J,t-1}}{D_{J,t-1}}\right] \sum_{K_J} s_{J,t-1}^k \Delta_t \tau_J^k} \tag{7}$$

There are a number of complications with implementing equation (7) on our data. First, calculating the statutory tariff rate change is complicated for both antidumping cases and for the Section 201 safeguard, but for different reasons. For the two antidumping cases where the application of antidumping duties is firm-specific, in aggregate data one is forced to apply some sort of averaging. For the Section 201 safeguard case, there were a number of product-level exclusions (within HS-10 codes), but we are unable to identify these excluded products in the retail price data (see Appendix B.2). To illustrate this latter issue, one can separate out imports of the washing machines by the rate provision code reported by U.S. Customs. Appendix Figure A3 compares the average effective tariff rate for all imports of these products, to the rate implied by only imports subject to Section 201 Safeguard Tariffs. While the imports identified under the Section 201 rate provision code display an applied tariff rate that matches those specified in the statute, the average effective tariff rate across all washer imports is significantly lower. Because it is unclear why these codes were excluded, and to what products they belong, we adopt the conservative convention and simply apply the statutory rate in our calculations in equation (7).

A second complication relates to the fact that the Section 201 safeguard measure was a tariff-rate quota, and therefore exhibits multiple tariff rates during the sample period we study. As mentioned above, the quota of 1.2 million units subject to the lower additional tariff rate was reached in October 2018, and all relevant units thereafter paid a higher rate of 50 percent. These rates reset in February 2019, where the statutory rates decline to 18

[26] These lagged weights are important when evaluating tariffs affecting a small number of country sources. For a global tariff change such as the Section 201 safeguard tariffs, the weights have little effect as the $\Delta_t \tau_C^k$ apply to all source countries.

percent (in quota) and 45 percent (out of quota). Put differently, in addition to accounting for heterogeneity across products, we must also consider how to account for heterogeneity in tariff rates over time. If firms are forward-looking with a rough idea of what fraction of their goods would be subject to the lower (20 percent) and higher (50 percent) rates, then the trade-weighted average of these rates over time would be the relevant object for how these firms would consider the adjustment of prices in response to tariffs. An alternative would be to simply use the maximum applicable rate during the period we study.

Finally, a third issue is how to account for the price changes of dryers, which had no tariff change during this period. Although typically the change in price is only measured for the good subject to the given tariff, we find above that prices of dryers rose in line with washers, consistent with evidence for broader complementarities between these products. It seems likely that firms spread out the increase in prices across both washers and dryers in an effort to keep the retail prices similar between matching models sold as pairs. To add the dryer effect to equation (7), 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 zero tariff rate change for dryers).

Panel C of Table 3 presents the estimates of the price 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.) We use the statutory tariff changes and report estimates separately for 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 other appliances.[27] For the Section 201 safeguard tariffs, we report estimates separately based on whether we use the trade-weighted average or maximum value of the tariff rate applied during the 12-month period following tariffs being implemented.

What is evident in Table 3 is a wide range of this 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, consistent with the theory shown in Figure 1c . On the other hand, the small price increase we estimate for the 2016 antidumping duties against China results in a modest elasticity of 0.23 to 0.35. 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 0.57 to 1.07 if we only use the maximum possible rate.

### 4.5.1 Comparison to Conventional Tariff Pass-Through Calculations

To explore how these estimates compare to those using the conventional method, we estimate tariff pass-through regressions for each of the tariff changes affecting washing machines. We estimate equation (5) and follow Amiti, Redding and Weinstein (2019) in using 12-month log changes, country-by-year fixed effects, and sample periods that include the 12 months before and 12 months after each tariff episode.[28] We use all relevant HS-codes from the appliance

[27] Specifically, we use series CUSR0000SS30021 (laundry equipment) and CUSR0000SEHK02 (other appliances). We utilize the same methodology as equation (3).

[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 3:** Calculation of the Tariff Elasticity of Consumer Prices

| | **Antidumping** | | **Safeguard Tariffs**[1] | |
|---|---|---|---|---|
| | Korea & Mexico | China | Trade-Weighted Average | Maximum |
| | (1) | (2) | (3) | (4) |
| *A: Avg Consumer Price Change*[2] | | | | |
| Washers Only | N/A | 3.4% | 11.5% | 11.5% |
| Washers and Dryers | -7.0% | 2.9% | 11.5% | 11.5% |
| *B: Pre-Period Trade-Weighted Avg. Statutory Tariff Rate Change* | | | | |
| Washers Only | 12.5% | 14.8% | 9.2% | 20.1% |
| Washers and Dryers | 6.9% | 8.3% | 5.1% | 10.7% |
| *C: Tariff Elasticity of Consumer Prices* | | | | |
| Washers Only | N/A | 0.23 | 1.25 | 0.57 |
| Washers and Dryers | -1.02 | 0.35 | 2.26 | 1.07 |

*Notes:* Panels A and B follow the numerator and denominator of equation (7) respectively. The denominator calculates import shares in a pre-period defined as July to December 2011, July to December 2015, and February to August 2017 for the Korea/Mexico antidumping, China antidumping, and safeguard tariffs, respectively. Statutory tariff rate changes for antidumping duties use the preliminary rates (see Appendix Table A2)

[1] 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, whereas the "Maximum" column uses the maximum (50 percent) rate.

[2] 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 is 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)).

categories in section 4.1 (washing machines, dryers, ranges, refrigerators, and dishwashers).

We report the $\alpha_1$ estimates from these regressions, along with the translated pass-through elasticity to import prices, in columns (1) an (2) of Table 4. For comparison to our method, column (3) displays the tariff elasticity of consumer prices estimates from Table 3 above. Table 4 demonstrates that the results from the unit-value based regression often differ markedly from those using the alternative metric. The elasticity based on unit values implies full pass-through (increases) to import prices following the Korea/Mexico antidumping duties, whereas the evidence cited above shows that prices to consumers actually fell during this period. A similar pattern applies to the China antidumping duties: The conventional approach using unit values overstates the increase in prices relative to our estimates based on detailed retail prices. On the other hand, for the Section 201 safeguard tariffs where tariffs affected nearly all imports, the elasticity estimates shown in this paper are actually higher than what would be implied from the method using unit values. This pattern of comparison suggests that the production relocation response to country-specific tariffs may exert an upward bias on the tariff pass-through estimates using the conventional approach; changes in domestic

**Table 4:** Tariff Pass-Through and Tariff Elasticity of Consumer Prices

| | Tariff Pass-Through | | Tariff Elasticity of Consumer Prices (Table 3) |
|---|---|---|---|
| | Coefficient | Implied Elasticity | |
| | (1) | (2) | (3) |
| Korea/Mexico Antidumping | 0.06 | 1.06 | -1.02 |
| | (0.16) | | |
| China Antidumping | 0.32** | 1.32 | 0.35 |
| | (0.15) | | |
| Section 201 Safeguard Tariffs | 0.13 | 1.13 | 1.07 to 2.26 |
| | (0.16) | | |

*Notes:* Column (1) reports the $\alpha_1$ estimates from equation (5), and column (2) converts this to the implied elasticity ($1+\alpha_1$). Column (3) provides, for comparison, the corresponding estimates from Table 3.

prices and to complementary goods could exert a downward bias.

## 4.6 An Estimate of the Consumer Cost Per Domestic Job Created

When evaluating the effects of a policy such as the import safeguards, a common metric combines the effects on consumer prices with the added domestic employment into an estimate of the consumer cost per domestic job created. As indicated above, foreign producers advertised new jobs on the order of 1,600 following new production plans in the United States; Whirlpool, on the other hand, indicated they hired 200 additional workers as a result of the safeguard tariffs.

To translate the price effects we estimated in Section 4.2 into a dollar value, we multiply the overall dollar value increase in washer/dryer prices by the annual level of shipments of both washers and dryers. We use the average level of shipments between 2017 and 2018, recognizing reports based on Association of Home Appliance Manufacturers (AHAM) data that sales of washing machines fell in 2018 (Tankersley (2019)). These numbers are roughly 10 million washing machines and 7.7 million clothes dryers.[29] The result is an increase of 1.542 billion USD in consumer costs per year.[30]

Set against these cost increases is the additional tariff revenue coming from the Section 201 safeguard tariffs. To arrive at an estimate of the tariff revenues generated by these tariffs, we turn to records kept by the USITC. According to data available on their website, 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. Hence, a total annual tariff revenue of 82.2 million USD from these tariffs.

Combining these numbers together reveals a consumer cost per job of roughly 817,000

[29] For the 2017 shipments numbers from the AHAM, see here.

[30] Hence, 86 USD $\times$ 9.7 million $\approx$ 841 million USD plus 92 USD $\times$ 7.7 million $\approx$ 710 million USD. Together, equal to 1.552 billion USD.

USD annually. This number is of the same order of magnitude as other similar exercises. Hufbauer, Lowry et al. (2012) calculate such a metric from the section 421 tariffs on Chinese tire imports, finding a cost of roughly 900,000 USD per job.

All these calculations are made in partial equilibrium. There are a number of other factors that could be added to this analysis; unfortunately, data limitations prevent a full treatment on all of these channels. One might suggest that upstream linkages to domestic suppliers would create a multiplier effect on the number of domestic jobs created from this policy. Although we lack information on such linkages, the main assembly operations of Whirlpool produce in a foreign trade zone (see Appendix B.9), suggesting that imported components are an important piece of their U.S. operations. Downstream linkages could go in either direction. On the one hand, domestic transportation, packaging, and warehousing services could see positive spillovers. However, higher prices of appliances at retail stores may also reduce available income for expenditures on other goods, leading to job losses in other industries.

# 5 Conclusion

Conventional international trade models provide a powerful set of tools for policymakers to understand the effects of tariffs on welfare. A key metric in these calculations is the degree of tariff pass-through to consumer prices. Using a string of U.S. trade policies affecting washing machines from 2012 to 2018, we find a number of complications to the traditional analysis of tariff rate pass-through focused on import prices.

Two sets of antidumping duties against producers in Korea/Mexico and China led to large subsequent shifts in trade and production patterns. Using detailed micro-level data on retail prices, we find that the 2016 antidumping duties on Chinese production had little effect on consumer prices. We sketch out some simple theory whereby the endogenous firm-level response to targeted country-specific tariffs is to relocate production, hence moderating the effects of the trade policy to consumer prices. Indeed, if the tariff induces the firm to shift to a location with overall lower costs of production, consumer prices could actually decrease (amounting to a *negative* tariff rate pass-through). We provide evidence that this was the case following the antidumping duties on Korea and Mexico in 2012.

For the more global-oriented safeguard tariffs applied in 2018, we find large effects on consumer prices. However, the full impact to consumer prices is only realized once we account for the equivalent and simultaneous increase in the price of dryers, a complementary good not subject to tariffs. Taking the effects on both goods together, the overall tariff elasticity of consumer prices is above 100 percent for the 2018 safeguard tariffs. Despite the increase in domestic production and employment, the costs of these 2018 tariffs are substantial: in a partial equilibrium setting, we estimate increased annual consumer costs of around 1.5 billion USD, or roughly 820,000 USD per job created.

With the increased use of trade policies by the United States there is a greater need for further research into the interactions between firm-level decisions and the effects of import restrictions on the domestic economy.

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# Appendix

# A Extended Detail on Timeline

**Table A1:** 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 | Tariffs 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 | HS8450200040, HS8450200080, HS8450200090, HS8450110040, HS8450110080 |
| Washer parts | HS8450902000, HS8450906000 |
| Chapter 99 | HS99034501 (washers within quota), HS99034502 (washers beyond quota) HS99034505 (washer parts within quota) and HS99034506 (washer parts beyond quota) |

**Table A2:** 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 |

Continued on next page

**Table A2:** Continued

| | Rate(%) | Effective date | Period of review | Note |
|---|---|---|---|---|
| | 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 issurance |

**Table A3:** 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 issurance |

# B Additional Results

## B.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 A4, a very large share of U.S. imports of this category occurs between related parties. Figure A1 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 A4:** Related-Party Share of 2016 U.S. Imports by Country, NAICS 335224: Household Laundry Equipment

| Country | Related Party Share | Import Share |
|---|---|---|
| Mexico | .99 | 0.37 |
| China | .76 | 0.36 |
| South Korea | .90 | 0.06 |
| Thailand | .79 | 0.06 |
| Vietnam | .99 | 0.06 |
| **World** | **.85** | **1.00** |

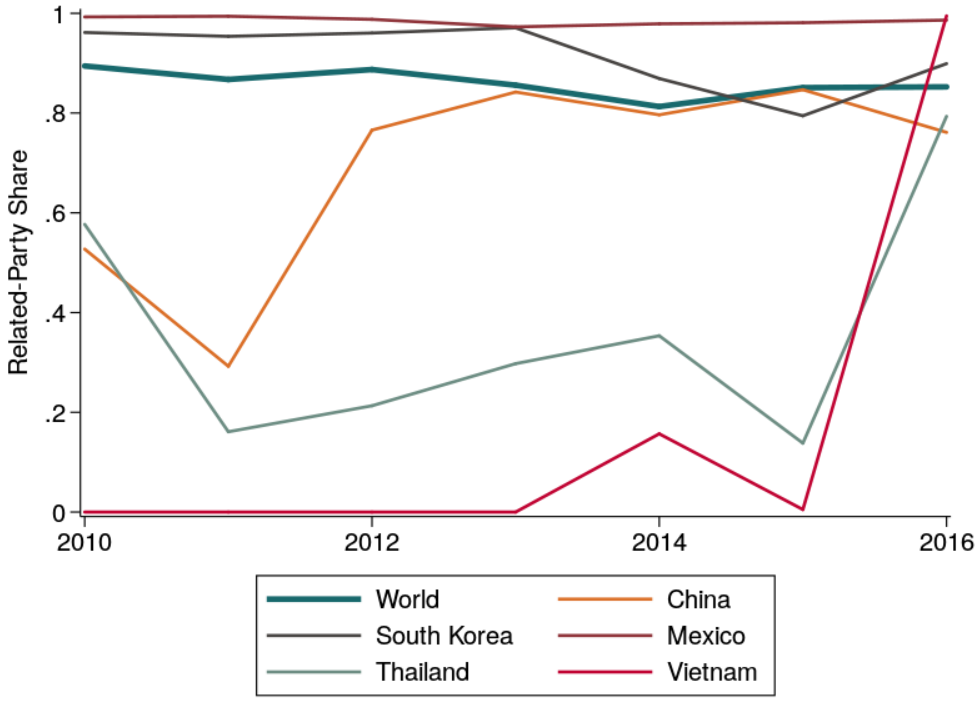
*Source:* U.S. Census Bureau.
*Notes:* Imports are defined as related-party if "any person, directly or indirectly owns, controls, or holds power to vote 5 percent or more of the outstanding voting stock or shares" of the other party. See Section 402(e) of the Tariff Act of 1930. The most disaggregated 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.

## B.2 Application of Section 201 Tariffs

As shown in Figure A2, 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

**Figure A1:** Related Party Share of Household Laundry Equipment Imports to U.S., Selected Countries 2010-2016



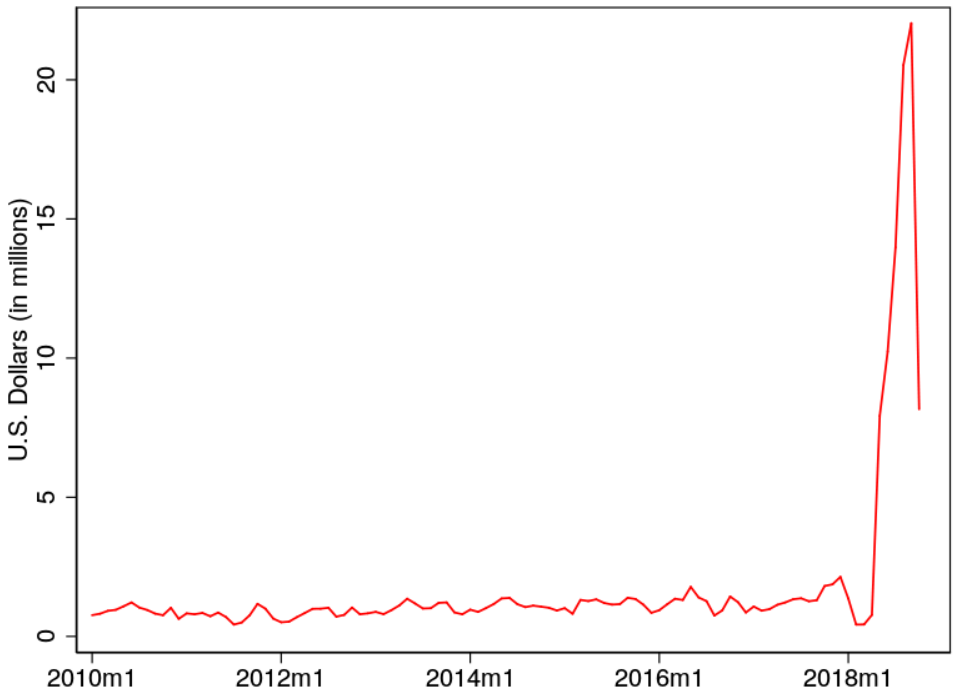

*Source:* U.S. Census Bureau.
*Notes:* Imports are defined as related-party if "any person, directly or indirectly owns, controls, or holds power to vote 5 percent or more of the outstanding voting stock or shares" of the other party. See Section 402(e) of the Tariff Act of 1930. The most disaggregated 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.

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 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.

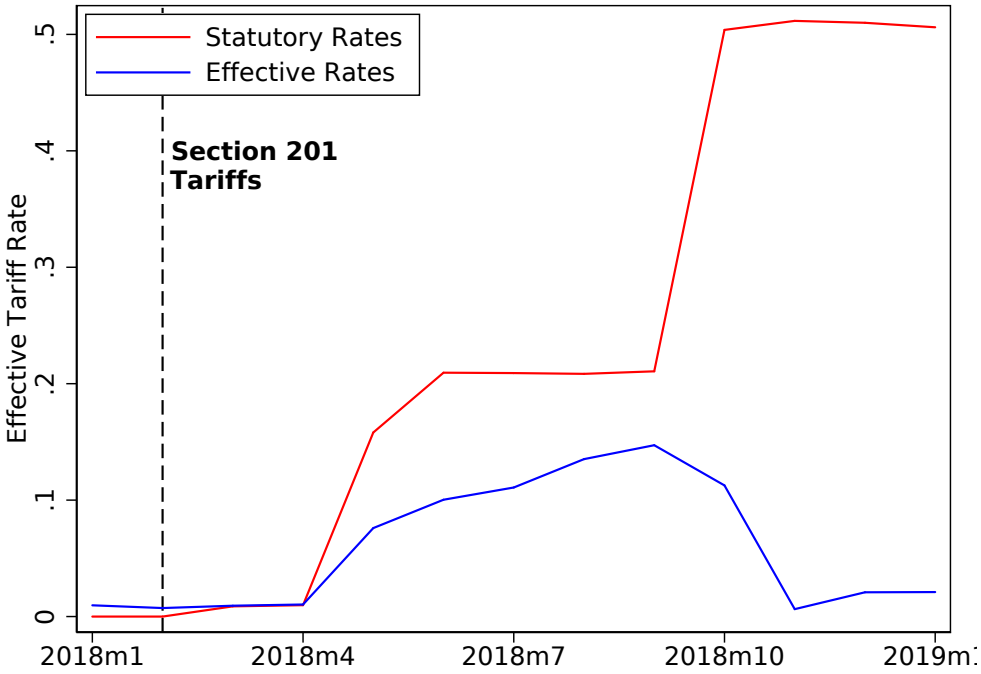
It is unclear why these specialty washers were excluded from the scope. From the investigation documents, we learn that the respondents (LG and Samsung) requested these excluded articles be included within the scope of the investigation, whereas Whirlpool and G.E. urged against amending the scope (see 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 A3 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 A2:** Calculated Duties on U.S. Imports of Washing Machines 2010-2018




*Source:* USITC.
*Notes:* Includes HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090.

**Figure A3:** Effective Tariff Rates of Washing Machines: by Rate Provision Code

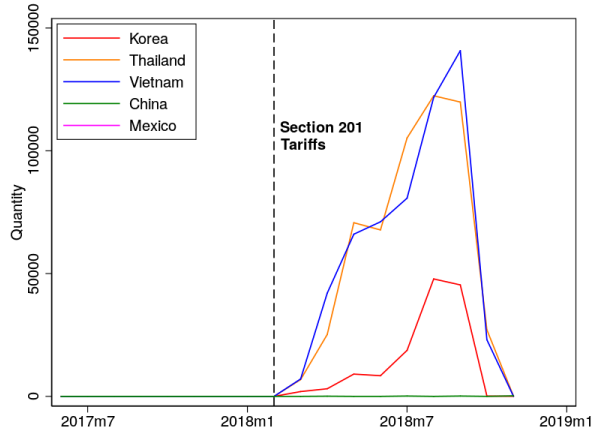



*Notes:* Data from USITC. Includes residential washing machines classified under HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090. Section 201 safeguard tariffs are classified under rate provision code "69 – Dutiable HS chapter 99." The average effective tariff rate is defined as the actual tariffs applied to these imports divided by the tariff-exclusive import value.

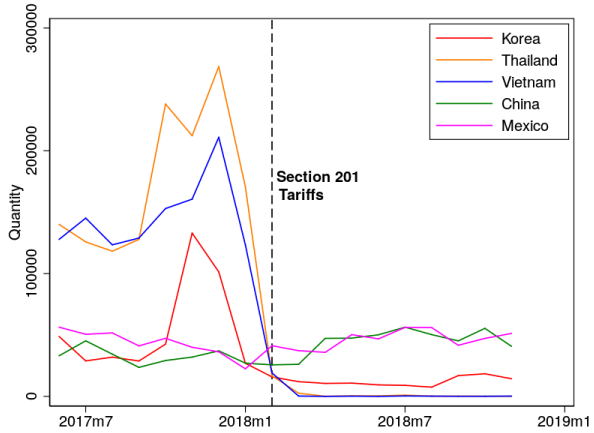
Further detail on the timing and shifts of imports can be seen by also splitting out country-level detail of the rate provision codes. Figure A4 illustrates a number of other patterns in the data.

**Figure A4:** Imports and Responses to Section 201 Tariffs, Washing Machines

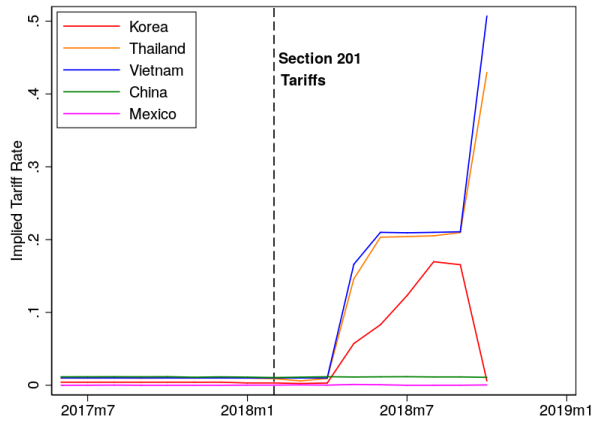
**(a)** Quantity Washer Imports Subject to Section 201



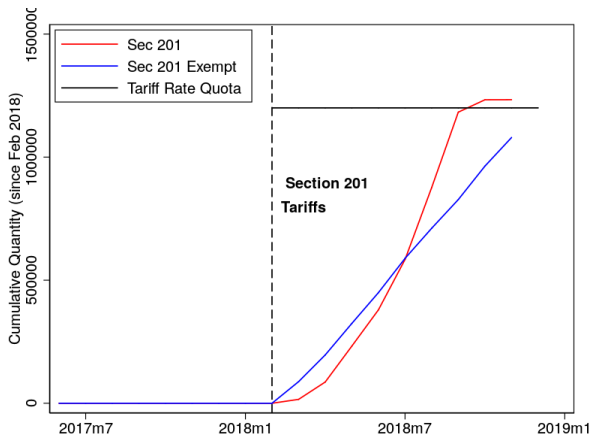

**(b)** Quantity Washer Imports Excluded from Section 201




**(c)** Effective Tariff Rate by Country




**(d)** Cumulative Import Quantities since Feb 2018




*Source:* USITC.
*Notes:* Includes HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090. Section 201 tariffs are classified under rate provision code "69 – Dutiable HS chapter 99."

Figures A4b and A4a 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 A4b, 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 A4c 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 A4d showing the cumulative amounts of imports for the period subject to Section 201 duties. While Figure A4d 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.

## B.3 Steel Content 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 A5 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 of 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.

**Table A5:** 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.

## B.4 Section 301 Tariffs on Other Household Appliances

A 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 never subject to additional tariffs during the period we study. The additional rates applied to these goods 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 percent, 10 percent, and 30 percent, respectively.

As shown in Figure A5 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.

## B.5 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 A6 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.

## B.6 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.

## B.7 Correlations Using Sales Rank

We scrape retailer websites for washers and dryers, obtaining the sales rank of each model based on the "Best Selling" indicator on the site. We also collect the model number and name. The data is then cleaned to extract brand names from the product name. Because this data yields unequal samples (for instance, some sites may list more LG washers than LG dryers) in order to calculate correlations we pool the data by retailer and create pairs by matching on brand ranking.

Specifically, for each product and for each retailer we calculate a "brand ranking" from the overall sales rank. For instance, for a specific retailer the highest ranked Whirlpool washer is given a brand rank of 1, 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. Then, for each retailer we merge together each product matching on brand and brand rank. For example, this procedure will pair the highest ranked Whirlpool washer with the highest ranked Whirlpool dryer, refrigerator, dishwasher, and range. The second highest ranked product will be matched with other second highest ranked products. We do an "outer join" matching such that if a product has no brand rank match in another product we simply assign null values to the other product. That is, if there is no 10th LG dryer to match with the 10th LG washer, we simply assign a null value to the LG dryer. This way if there is a 10th LG refrigerator it will still be matched with the 10th LG washer such that we maximize the number of observations when calculating each correlation.

Using this data, we compute the Pearson correlation coefficient for every pair of products in each retailer. In all calculations, we compute a 95 percent confidence interval using standard errors obtained from the Fisher Z transformation which is given by $z = \text{arctanh}(r)$, where $r$ is the correlation coefficient.

The results are shown in Figure A7. 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.

## B.8 Changes to Export (to U.S.) Unit Values

We divide values by unit quantities to assess changes in the unit values of of imported products. We first restrict attention to only those imports categorized under the rate provision "69 –Chapter 99" of the Harmonized Tariff Schedule of the United States. As shown in Figure A4a, the imports primarily affected were from Thailand and Vietnam. Figure A8 shows these washing machine unit values for these affected imports, where January 2018 is indexed to be equal to 100. Although prices increase briefly for two of the countries, by the time tariffs are actually assessed (in April/May, see Figure A4c) these prices fall back; averaging between 5 and 10 percent lower than before tariffs were applied.[31]

## B.9 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.[32] 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.

In general, any 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. Typically the differences in the data between these two definitions are small and reflect idiosyncratic timing in customs clearance as well as time spend 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.[33] Another discrepancy can occur if the final good produced by the FTZ ends up entering the U.S. market.

Apart from removing tariffs on imported components of production for re-export, another motivation for FTZ production is to exploit 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).

[31] One likely explanation for the brief increase in average prices is a shift in the composition of imports towards higher-priced models, as firms rushed to move imports into the U.S. before the tariff increase.

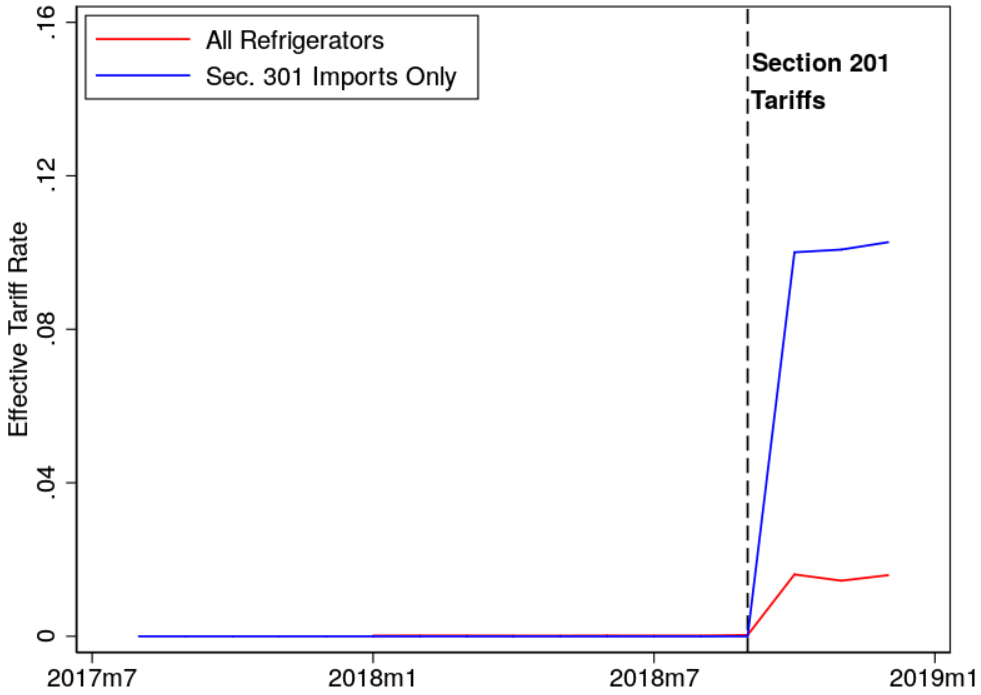
[32] Foreign trade zones exert a large influence on economic activity more generally. According to research by Grant (2017), foreign trade zones account for roughly one-sixth of U.S. manufacturing value-added, and one-eighth of the value of U.S. imports.

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

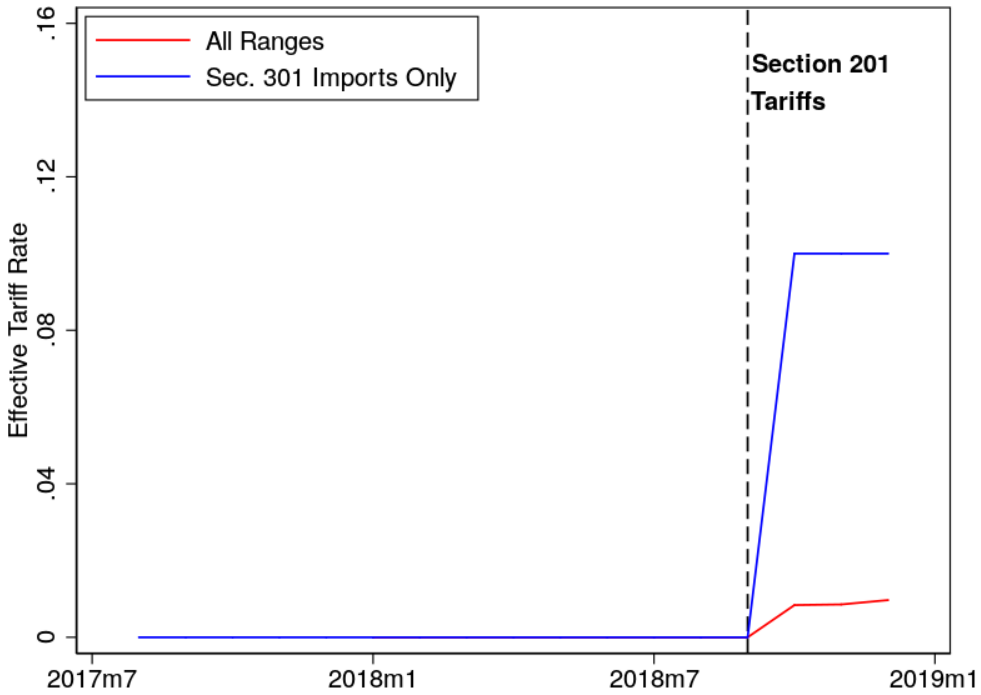
The increasing importance of FTZs for washing machine production destined for the U.S. market is evident in Figure A9. As shown in Figure A9a, a large gap emerges between imports for consumption and general imports in 2014; Figure A9b demonstrates that roughly all of this discrepancy owes to a jump in the Cleveland Customs District.

**Figure A5:** Effective Tariff Rate of Refrigerators and Ranges: All Imports vs Section 301 Imports

**(a)** Refrigerators

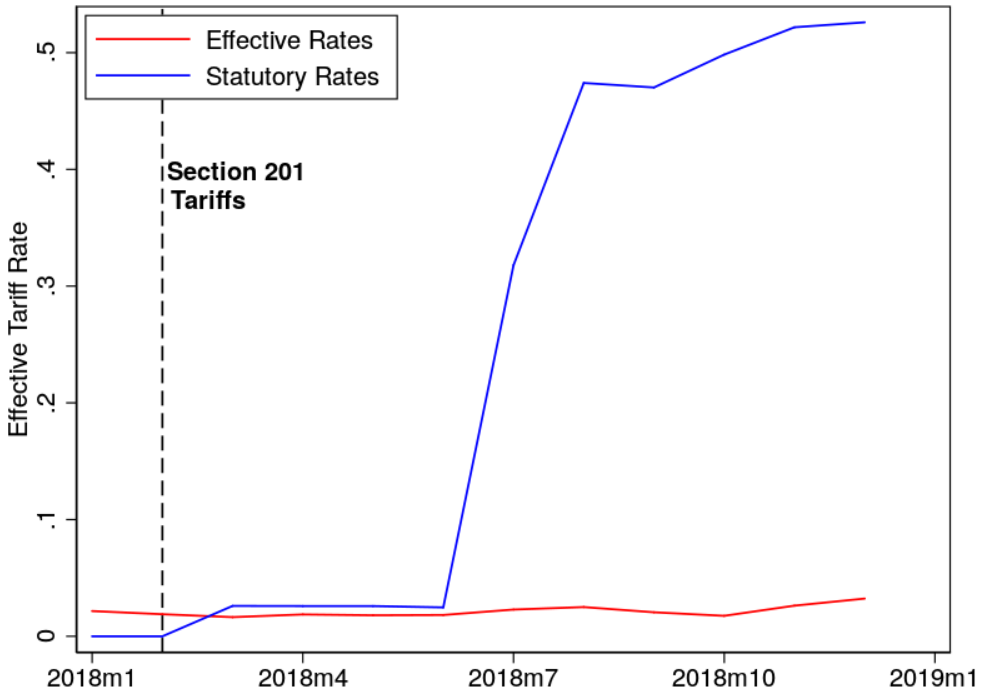



**(b)** Ranges




*Source:* USITC.
*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.

**Figure A6:** Effective Tariff Rate of Washer Parts: Statutory vs Effective Rates




*Source:* USITC.
*Notes:* Includes HS codes listed under HS8450902000 and HS8450906000. Section 201 tariffs are classified under rate provision code "69 – Dutiable HS chapter 99."

**Figure A7:** 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

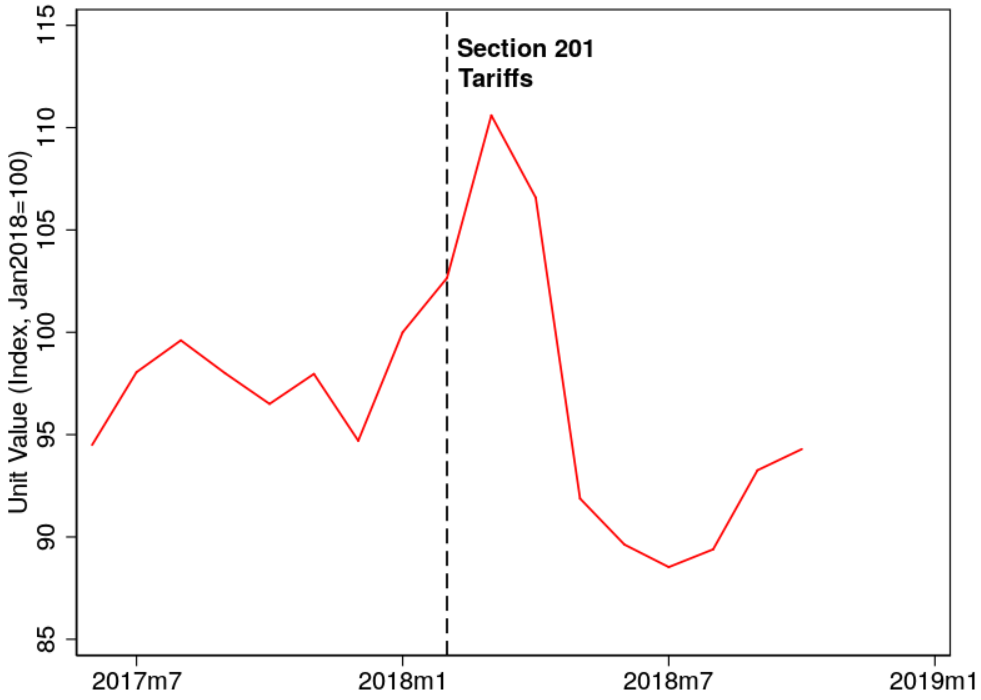
| | Dryers | Dishwashers | Refrigerators | Ranges |
|---|---|---|---|---|
| Washers | **0.96** (0.942,0.976) | **0.92** (0.826,0.960) | **0.53** (0.263,0.719) | **0.9** (0.853,0.938) |
| Dryers | | **0.87** (0.742,0.938) | **0.71** (0.512,0.834) | **0.92** (0.879,0.944) |
| Dishwashers | | | **0.71** (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.

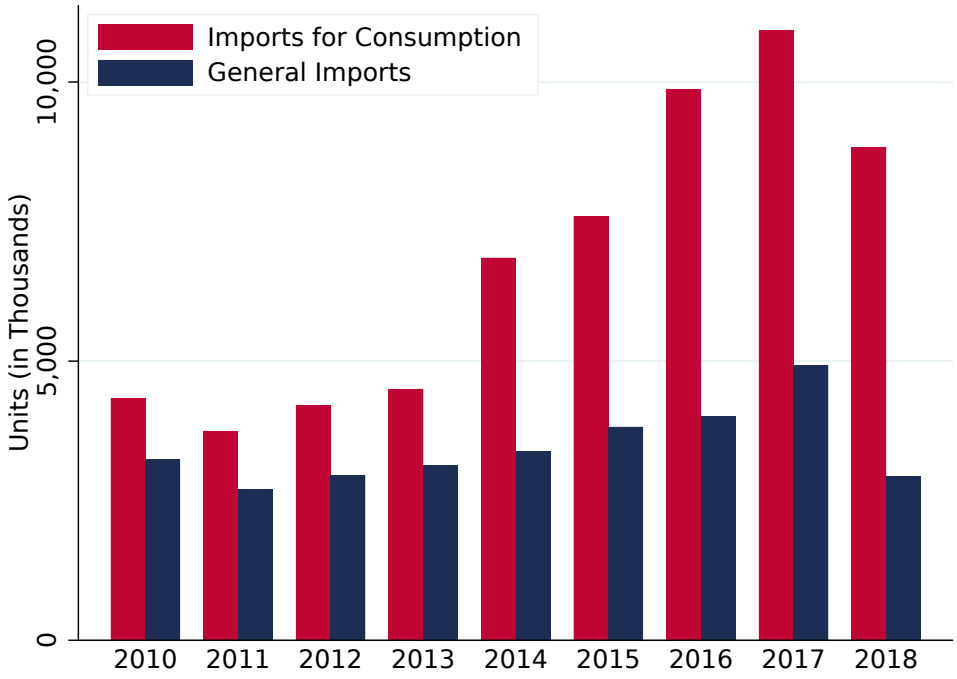
**Figure A8:** Average Import Unit Value for Section 201 Imports



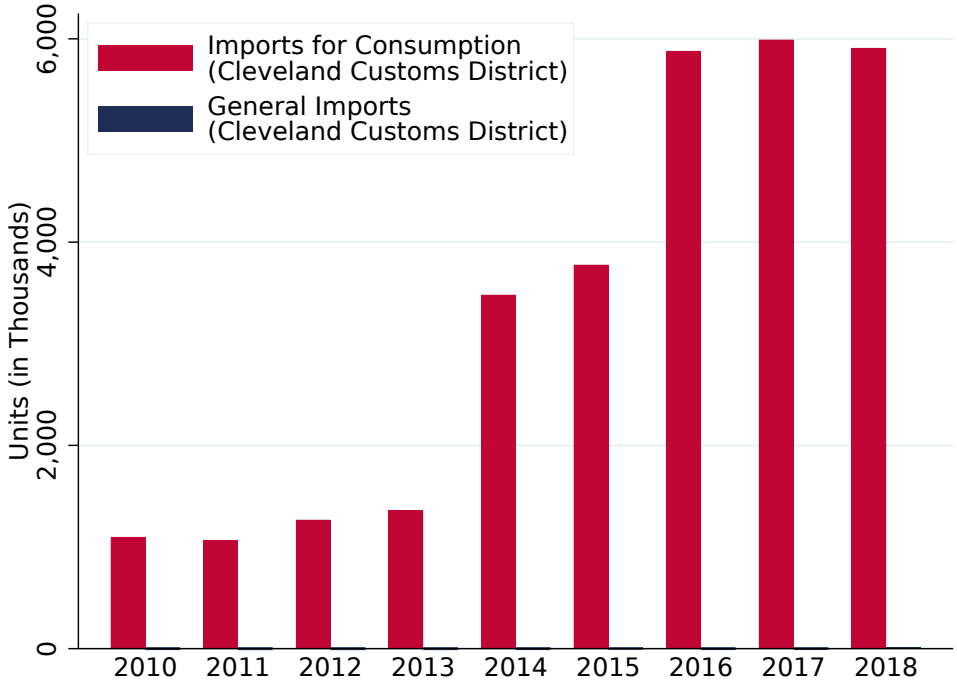

*Source:* USITC.
*Notes:* Includes HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090. For countries Thailand and Vietnam only. See section B.2 for more discussion of the application of tariffs across countries and products.

**Figure A9:** Annual 2010-2017 Quantity of Washing Machine Imports: Total and Cleveland Customs District

**(a)** Total




**(b)** Cleveland Customs District




*Source:* USITC.
*Notes:* Includes HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090.

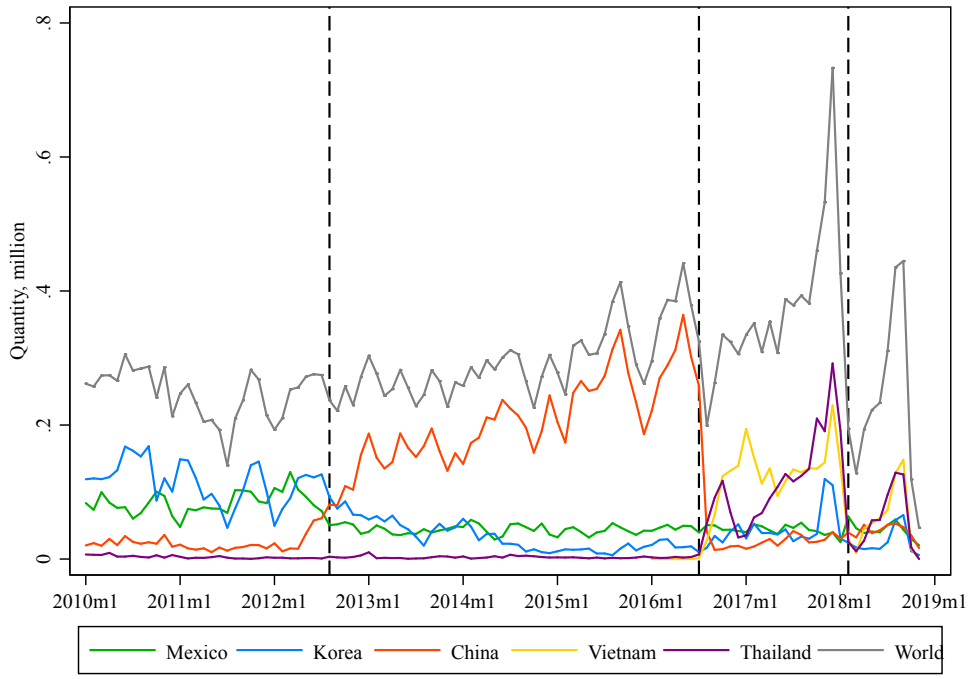
# C Robustness Figures and Tables

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. These robustness checks are summarized in Table A6 below.

**Table A6:** Summary of Robustness Results

| | Robustness for: | | | |
|---|---|---|---|---|
| **Robustness** | **Figure 4** | **Figure 5** | **Table 1** | **Table 2** |
| With model fixed effects | Figure A13 | Figure A14 | - | Table A7 |
| All brands, only offline stores | Figure A15 | Figure A16 | Table A8 | - |
| All brands, offline stores (weighted by number of stores) | Figure A17 | Figure A18 | Table A9 | - |
| All brands, all stores (unweighted) | Figure A19 | Figure A20 | Table A10 | - |

**Figure A10:** Monthly U.S. Imports of Washing Machines by Country (Quantity), Seasonality Adjusted




*Notes:* Data from USITC. Residential washing machines are classified under HS8450110040, HS8450110080, HS8450200040, HS8450200080, and HS8450200090.

**Figure A11:** Time Fixed Effects from Log Price Regression (All 5 Appliances), CPI for Laundry Equipment

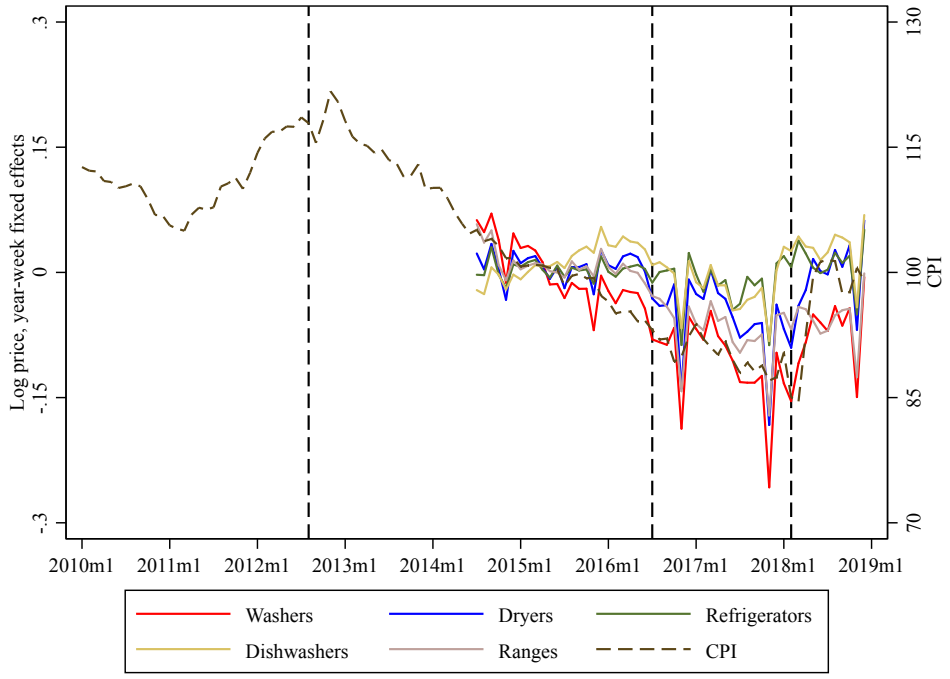



**Table A7:** Difference-in-Difference Estimates: Brand-Specific Price Effects of Washing Machine Tariffs

| | Whirlpool | | Maytag | | LG | | Samsung | | G.E. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4 month | 8 month | 4 month | 8 month | 4 month | 8 month | 4 month | 8 month | 4 month | 8 month |
| **Antidumping against China** | | | | | | | | | | |
| Washers | 0.0375 | 0.0463 | 0.0634* | 0.0859* | 0.0183 | 0.0458 | 0.0669* | 0.0514 | 0.0246 | 0.0228 |
| | (0.0228) | (0.0271) | (0.0314) | (0.0340) | (0.0265) | (0.0259) | (0.0303) | (0.0349) | (0.0146) | (0.0184) |
| Dryers | 0.0353* | 0.0512* | 0.0688** | 0.0805** | -0.0023 | 0.0304 | 0.0599* | 0.0330 | 0.0098 | 0.0113 |
| | (0.0169) | (0.0200) | (0.0250) | (0.0290) | (0.0210) | (0.0217) | (0.0233) | (0.0255) | (0.0109) | (0.0145) |
| Refrigerators | 0.0264* | 0.0220 | 0.0648** | 0.0649* | 0.0187 | 0.0449* | 0.1178*** | 0.0408 | 0.0152* | 0.0146 |
| | (0.0107) | (0.0112) | (0.0232) | (0.0259) | (0.0179) | (0.0197) | (0.0203) | (0.0221) | (0.0075) | (0.0089) |
| Dishwashers | 0.0168 | 0.0113 | -0.0009 | -0.0115 | 0.0397 | 0.0657* | 0.0781** | 0.0269 | 0.0289*** | 0.0216* |
| | (0.0140) | (0.0153) | (0.0281) | (0.0248) | (0.0270) | (0.0284) | (0.0291) | (0.0362) | (0.0081) | (0.0100) |
| **Safeguard tariffs 2018** | | | | | | | | | | |
| Washers | 0.1799*** | 0.1464*** | 0.1427*** | 0.0913* | 0.0537*** | 0.0807*** | 0.1420*** | 0.1544*** | 0.0885*** | 0.0859*** |
| | (0.0244) | (0.0265) | (0.0301) | (0.0397) | (0.0160) | (0.0167) | (0.0265) | (0.0288) | (0.0175) | (0.0176) |
| Dryers | 0.1683*** | 0.1394*** | 0.1632*** | 0.1516*** | 0.0530*** | 0.0672*** | 0.1121*** | 0.1250*** | 0.1156*** | 0.1112*** |
| | (0.0191) | (0.0203) | (0.0271) | (0.0356) | (0.0144) | (0.0133) | (0.0199) | (0.0232) | (0.0136) | (0.0142) |
| Refrigerators | 0.0082 | -0.0104 | 0.0334 | 0.0655* | -0.0010 | -0.0151 | -0.0252 | -0.0767*** | -0.0112 | -0.0082 |
| | (0.0147) | (0.0164) | (0.0217) | (0.0257) | (0.0156) | (0.0116) | (0.0148) | (0.0186) | (0.0086) | (0.0088) |
| Dishwashers | 0.0304 | 0.0250 | 0.0170 | 0.0673* | 0.0461** | -0.0068 | -0.0433** | -0.0272 | -0.0287** | -0.0150 |
| | (0.0167) | (0.0195) | (0.0226) | (0.0330) | (0.0164) | (0.0176) | (0.0161) | (0.0240) | (0.0106) | (0.0114) |
| N | 363,800 | | 101,586 | | 313,206 | | 320,698 | | 538,008 | |

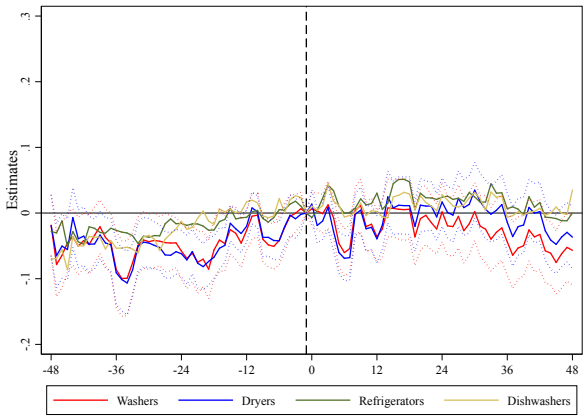
*Notes:* The table reports results analogous to Table 1—based on separate estimates for each brand. Specifically, first equation (4) is estimated (with model fixed effect as controls) and then a linear combination of these estimates is used to compute the left hand side of equation (3)—separately for each brand and product category. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

## C.1 List of Product Characteristics

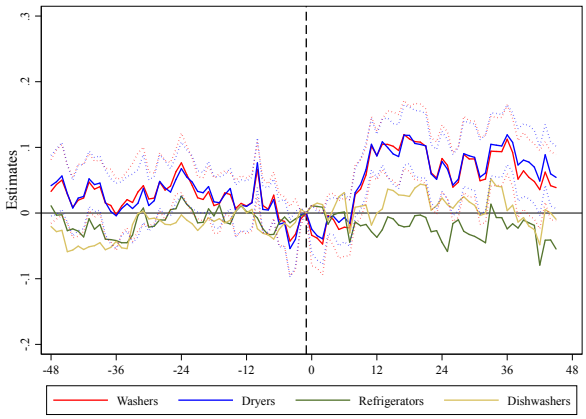
Table A11 describes the additional product characteristic variables included in the Gap Intelligence data.

**Figure A12:** Price Effects of Safeguard Tariffs and Antidumping Duties against China: by Brand, with Model Characteristics as Controls

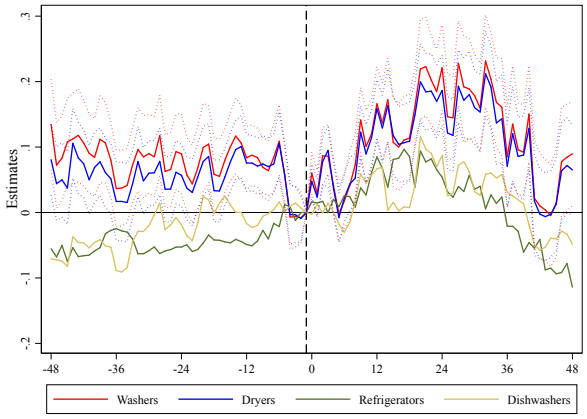
**(a)** Antidumping against China - Whirlpool



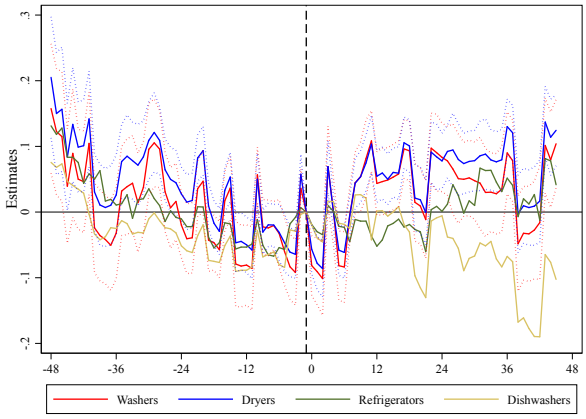

**(b)** Safeguard Tariffs 2018 - Whirlpool



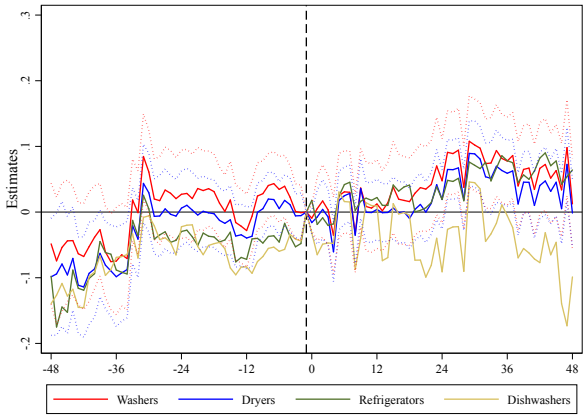

**(c)** Antidumping against China - Maytag




**(d)** Safeguard Tariffs 2018 - Maytag




**(e)** Antidumping against China - LG




**(f)** Safeguard Tariffs 2018 - LG

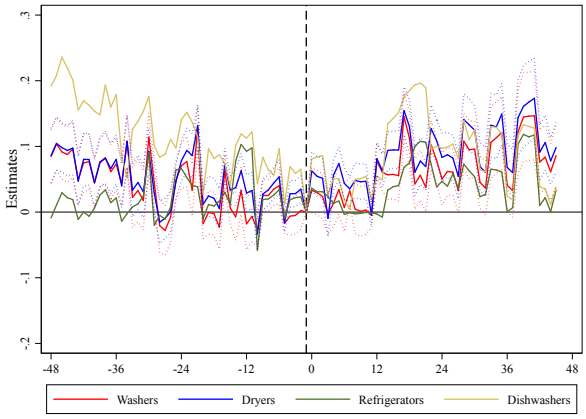
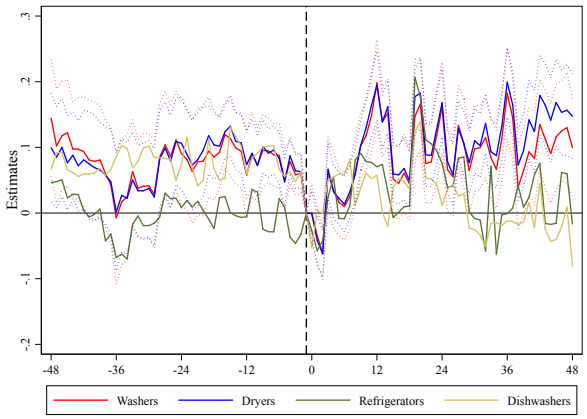
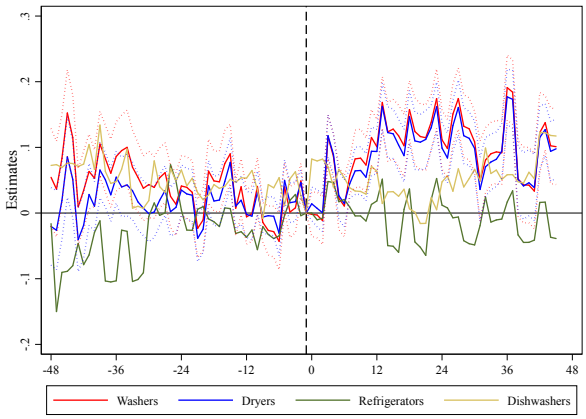


**Figure A12:** Price Effects of Safeguard Tariffs and Antidumping Duties against China: by Brand, with Model Characteristics as Controls (Continued)

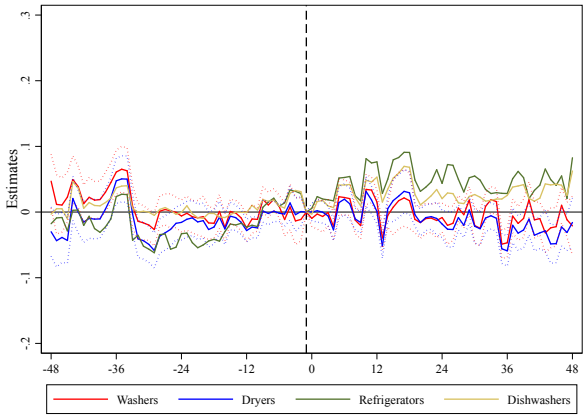
**(g)** Antidumping against China - Samsung



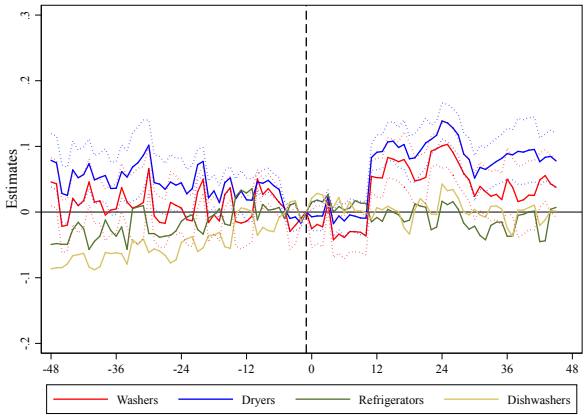

**(h)** Safeguard Tariffs 2018 - Samsung




**(i)** Antidumping against China - G.E.



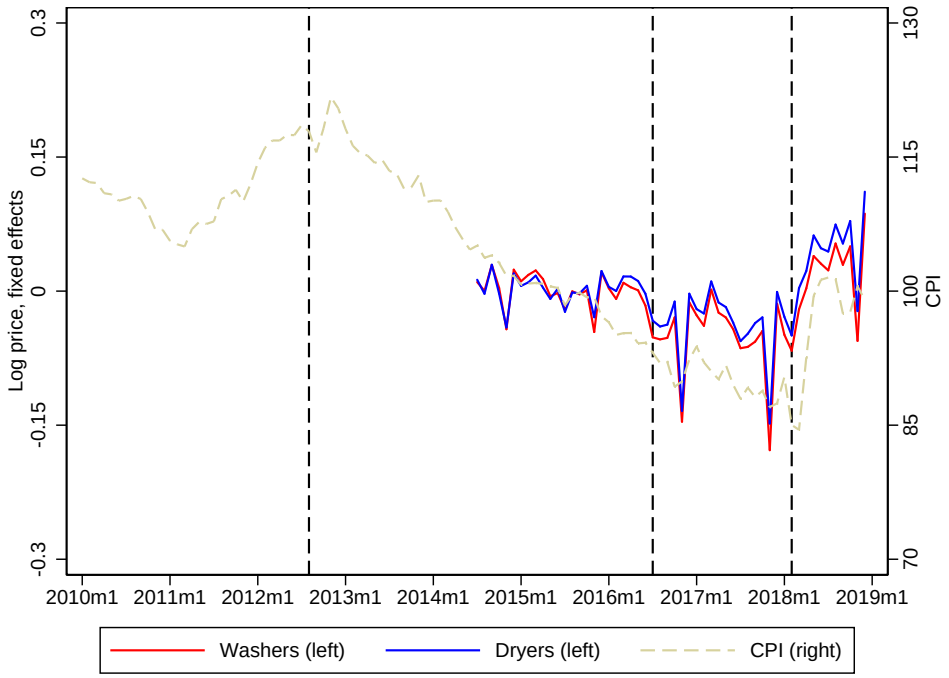

**(j)** Safeguard Tariffs 2018 - G.E.




## C.2 Total Number of Available Models

Figure A21 illustrates the number of available models by brand across the periods we study.

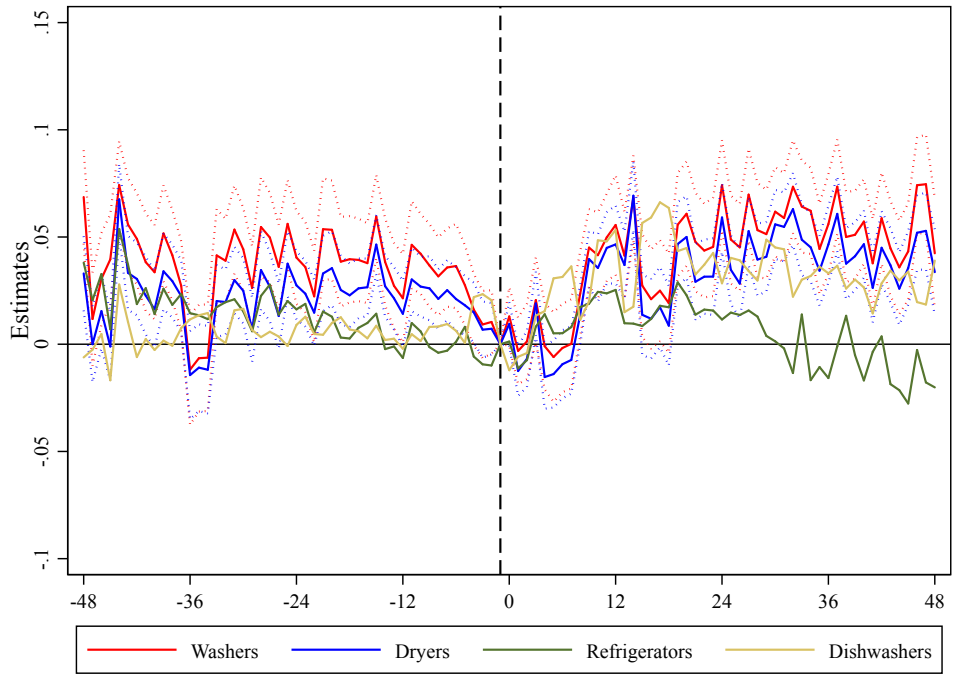
**Figure A13:** Time Fixed Effects from Log Price Regression - with Model Fixed Effect as Controls



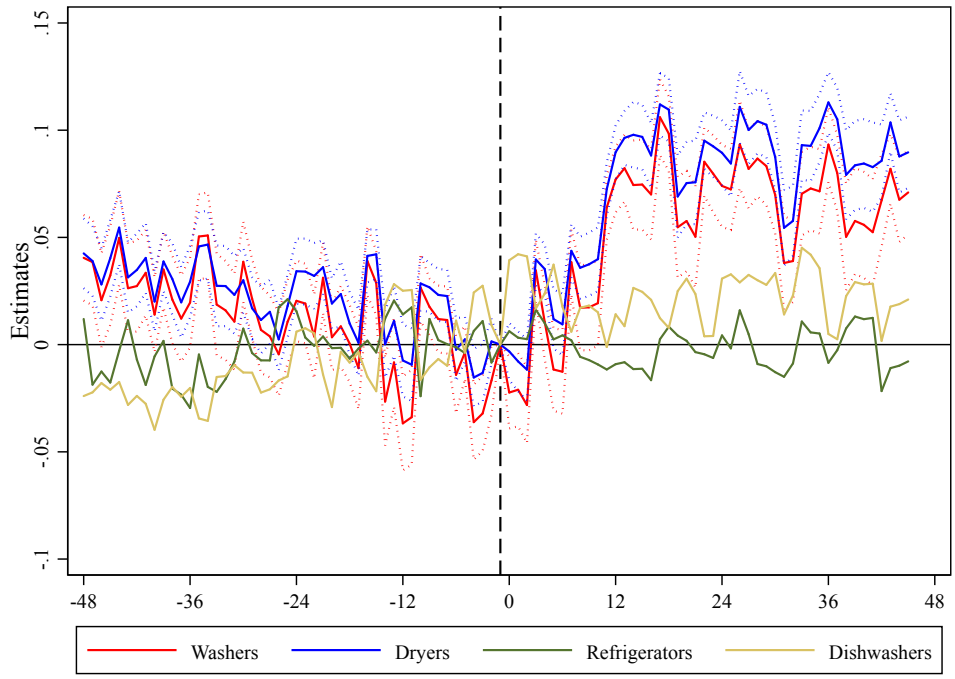

*Notes:* We plot the year-week fixed effects for washers or dryers, averaged over each month, obtained from estimating equation (1). We include model fixed effects instead of model characteristics as controls. We omit the week dummy for the week of April 1, 2015. In that month the CPI for laundry equipment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

**Figure A14:** Price Effects of Safeguard Tariffs and Antidumping Duties against China - with Model Fixed Effect as Controls

**(a)** Antidumping against China

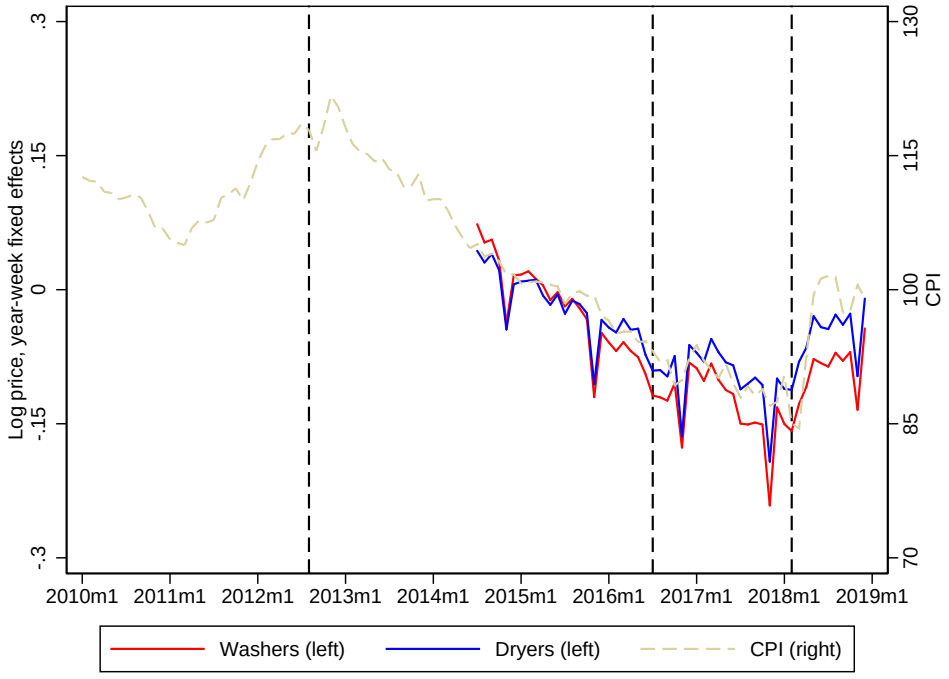



**(b)** Safeguard Tariffs 2018




*Notes:* These figures report the regression coefficients $\lambda_{C(i)t}$ from equation (2). We also use model fixed effects instead of model characteristics as controls. In 5a the estimates are relative to the week of July 17, 2016 and in Figure 5b 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.

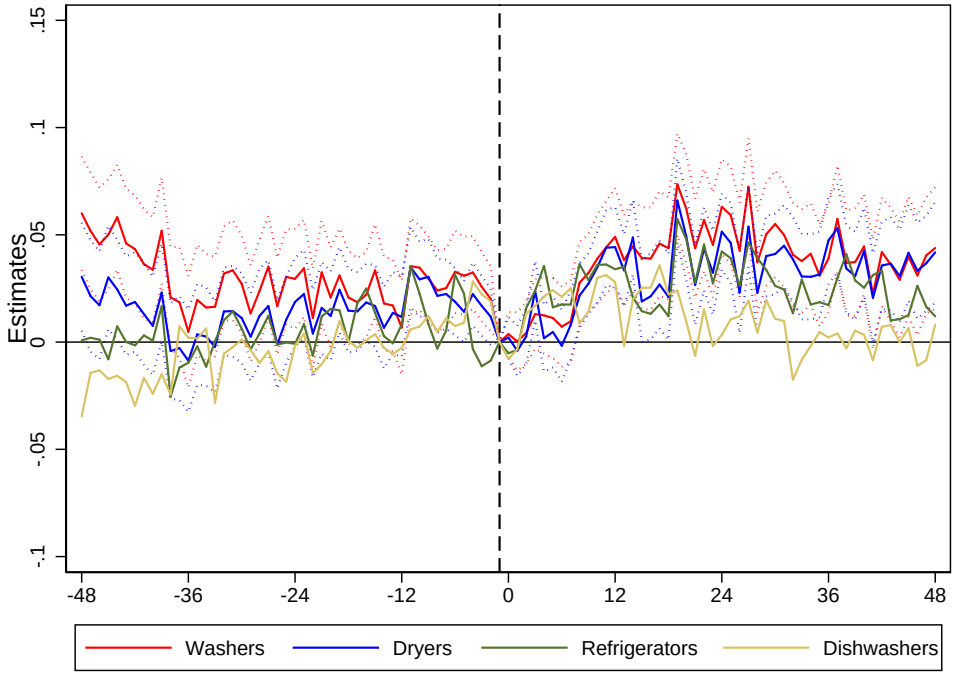
**Figure A15:** Time Fixed Effects from Log Price Regression - All Brands and Only Brick and Mortar Stores



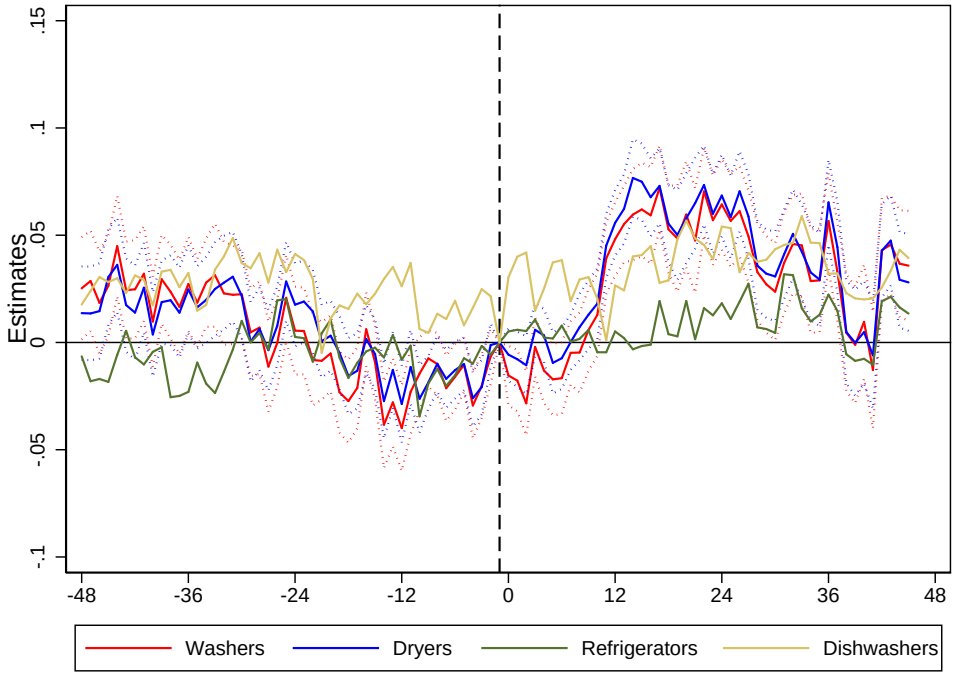

*Notes:* We plot the year-week fixed effects, which are averaged over each month, from the product-by-product regression with life cycle variables, model characteristics controls, brand fixed effects, retailer fixed effects, and year-week fixed effects. We include all brands available in the data but only restrict to the brick and mortar stores of all retailers. Three vertical date lines are August 2012, July 2016, and February 2018, which are discussed in the text.

**Figure A16:** Price Effects of Safeguard Tariffs and Antidumping Duties against China - All Brands and Only Brick and Mortar Stores

**(a)** Antidumping against China




**(b)** Safeguard Tariffs 2018



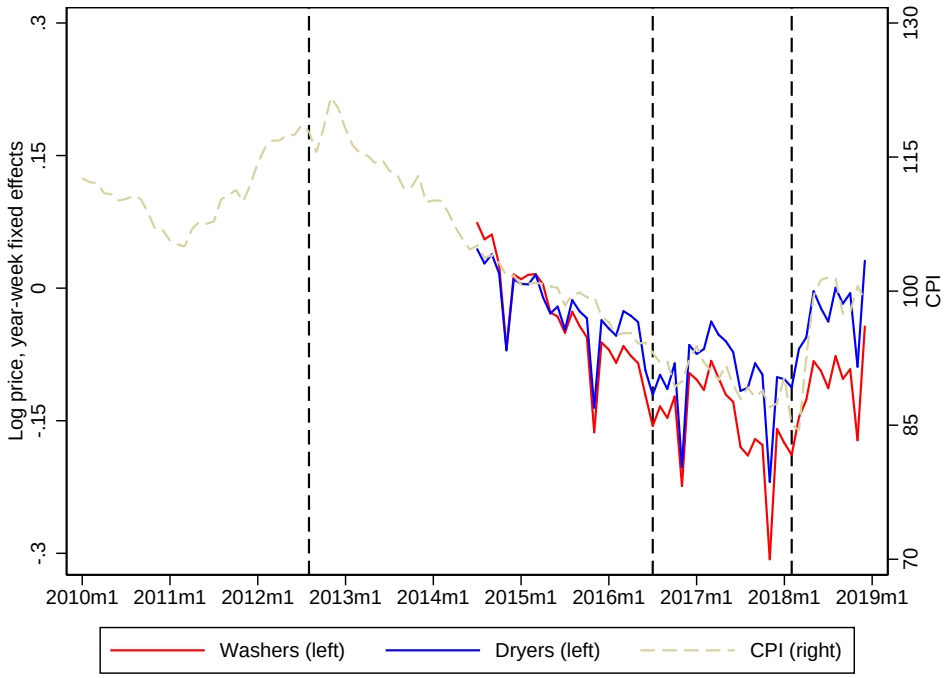

*Notes:* These figures report the regression coefficients $\lambda_{C(i)t}$ from equation (2). We include all brands available in the data but only restrict to the brick and mortar stores of all retailers. In A16a the estimates are relative to the week of July 17, 2016 and in Figure A16b the estimates 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.

**Table A8:** Difference-in-Difference Estimates: Price Effects of Washing Machine Tariffs - All Brands and Only Brick and Mortar Stores

| | with model characteristics as controls | | with model fixed effect as controls | |
|---|---|---|---|---|
| | 4 month | 8 month | 4 month | 8 month |
| **Antidumping against China** | | | | |
| Washers | 0.0311* | 0.0340 | 0.0357** | 0.0446** |
| | (0.0149) | (0.0176) | (0.0129) | (0.0145) |
| Dryers | 0.0201 | 0.0173 | 0.0223* | 0.0290* |
| | (0.0128) | (0.0149) | (0.0105) | (0.0114) |
| Refrigerators | 0.0267* | 0.0159 | 0.0354*** | 0.0289** |
| | (0.0124) | (0.0146) | (0.0084) | (0.0091) |
| Dishwashers | -0.0082 | -0.0332* | 0.0055 | -0.0107 |
| | (0.0144) | (0.0164) | (0.0102) | (0.0107) |
| **Safeguard tariffs 2018** | | | | |
| Washers | 0.0868*** | 0.0908*** | 0.0843*** | 0.1022*** |
| | (0.0141) | (0.0182) | (0.0118) | (0.0128) |
| Dryers | 0.0972*** | 0.0823*** | 0.0976*** | 0.1012*** |
| | (0.0131) | (0.0175) | (0.0103) | (0.0116) |
| Refrigerators | 0.0258* | 0.0198 | -0.0032 | -0.0141 |
| | (0.0116) | (0.0161) | (0.0085) | (0.0094) |
| Dishwashers | 0.0345** | 0.0402* | 0.0270** | 0.0425*** |
| | (0.0122) | (0.0173) | (0.0097) | (0.0124) |
| N | 1,288,914 | | 1,288,914 | |

*Notes:* The table reports estimates for $\Delta^{4m}_{event}\bar{p}_C$ and $\Delta^{8m}_{event}\bar{p}_C$ 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), in which we include all brands available in the data but only restrict to the offline stores of all retailers. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

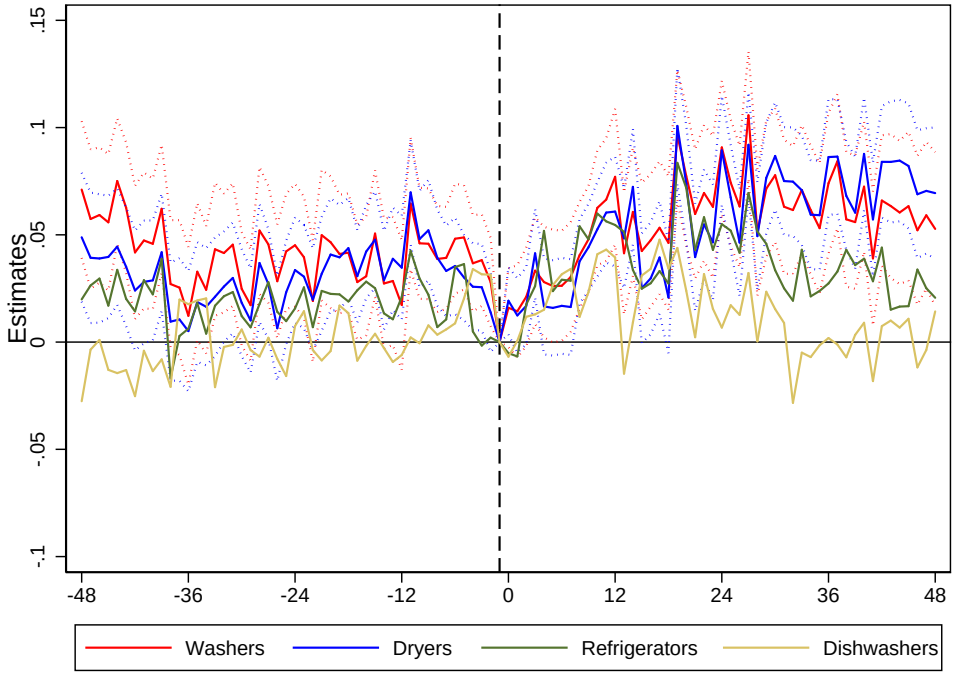
**Figure A17:** Time Fixed Effects from Log Price Regression - All Brands and Brick and Mortar Retailers Weighted by the Number of Stores



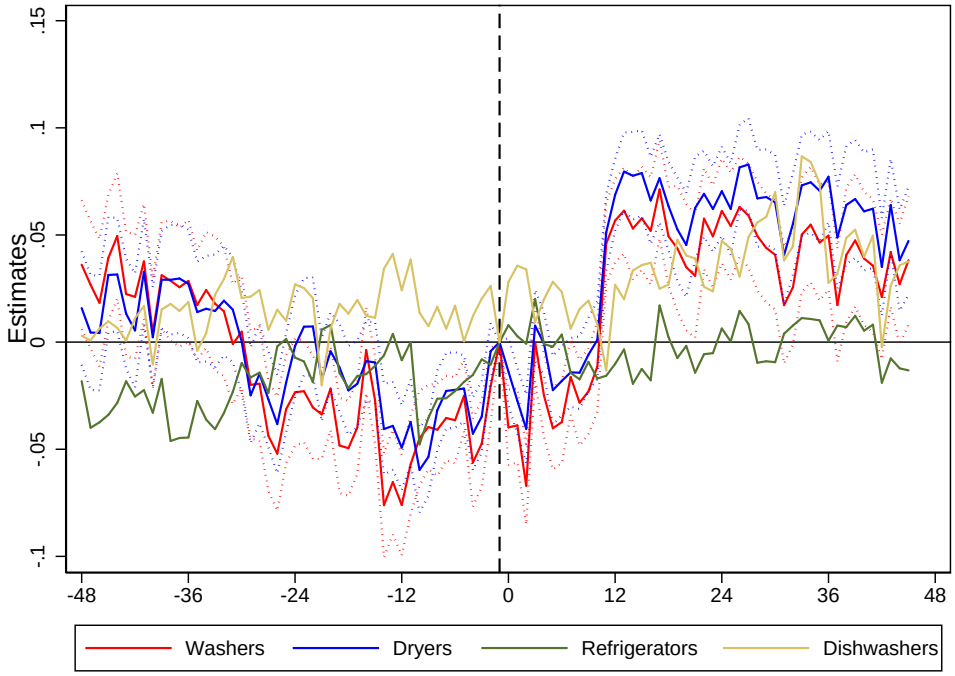

*Notes:* We plot the year-week fixed effects, which are averaged over each month, from the product-by-product regression with life cycle variables, model characteristics controls, brand fixed effects, retailer fixed effects, and year-week fixed effects. We include all brands available in the data but only restrict to the brick and mortar retailers, which are further weighted by the number of stores. Three vertical date lines are August 2012, July 2016, and February 2018, which are discussed in the text.

**Figure A18:** Price Effects of Safeguard Tariffs and Antidumping Duties against China - All Brands and Brick and Mortar Retailers Weighted by the Number of Stores

**(a)** Antidumping against China




**(b)** Safeguard Tariffs 2018



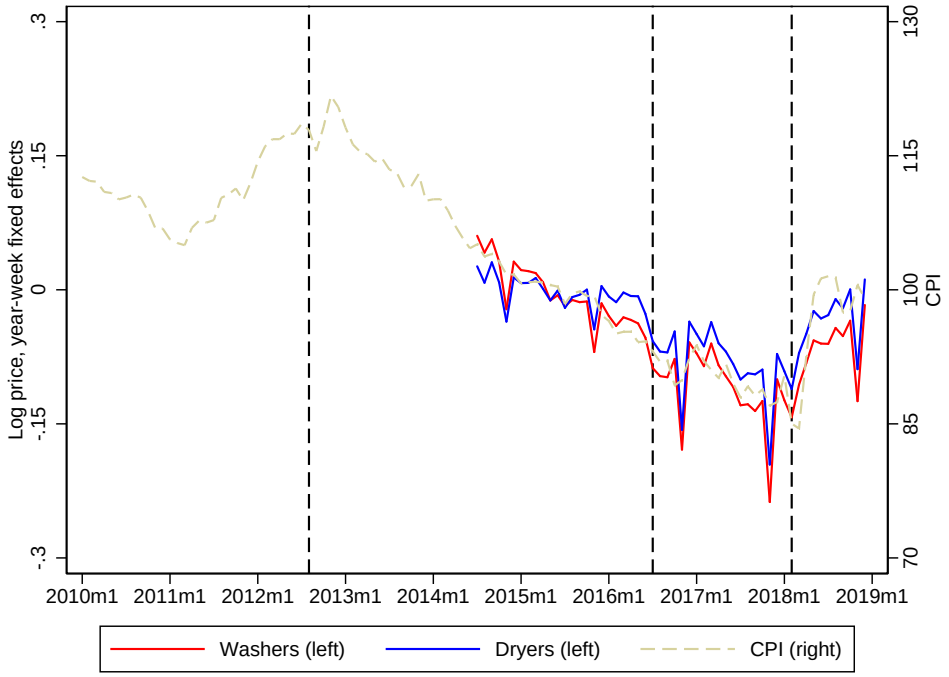

*Notes:* These figures report the regression coefficients $\lambda_{C(i)t}$ from equation (2). We include all brands available in the data but only restrict to the brick and mortar retailers, which are further weighted by the number of stores. In A16a the estimates are relative to the week of July 17, 2016 and in Figure A18b 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.

**Table A9:** Difference-in-Difference Estimates: Price Effects of Washing Machine Tariffs - All Brands and Brick and Mortar Retailers Weighted by the Number of Stores

| | with model characteristics as controls | | with model fixed effect as controls | |
|---|---|---|---|---|
| | 4 month | 8 month | 4 month | 8 month |
| **Antidumping against China** | | | | |
| Washers | 0.0359* | 0.0441* | 0.0520** | 0.0585*** |
| | (0.0181) | (0.0200) | (0.0159) | (0.0157) |
| Dryers | 0.0307* | 0.0467** | 0.0352** | 0.0550*** |
| | (0.0152) | (0.0172) | (0.0130) | (0.0133) |
| Refrigerators | 0.0437*** | 0.0292 | 0.0577*** | 0.0413*** |
| | (0.0132) | (0.0154) | (0.0099) | (0.0102) |
| Dishwashers | -0.0035 | -0.0345* | 0.0115 | -0.0087 |
| | (0.0150) | (0.0165) | (0.0107) | (0.0111) |
| **Safeguard tariffs 2018** | | | | |
| Washers | 0.0894*** | 0.1367*** | 0.0909*** | 0.1310*** |
| | (0.0164) | (0.0217) | (0.0138) | (0.0155) |
| Dryers | 0.0988*** | 0.1311*** | 0.1004*** | 0.1285*** |
| | (0.0151) | (0.0188) | (0.0121) | (0.0133) |
| Refrigerators | 0.0141 | -0.0026 | -0.0122 | -0.0169 |
| | (0.0131) | (0.0160) | (0.0103) | (0.0108) |
| Dishwashers | 0.0171 | 0.0420* | 0.0003 | 0.0267* |
| | (0.0149) | (0.0182) | (0.0119) | (0.0127) |
| N | 1,288,914 | | 1,288,914 | |

*Notes:* The table reports estimates for $\Delta^{4m}_{event}\bar{p}_C$ and $\Delta^{8m}_{event}\bar{p}_C$ 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), in which we include all brands available in the data but only restrict to the brick and mortar retailers that are further weighted by the number of stores. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

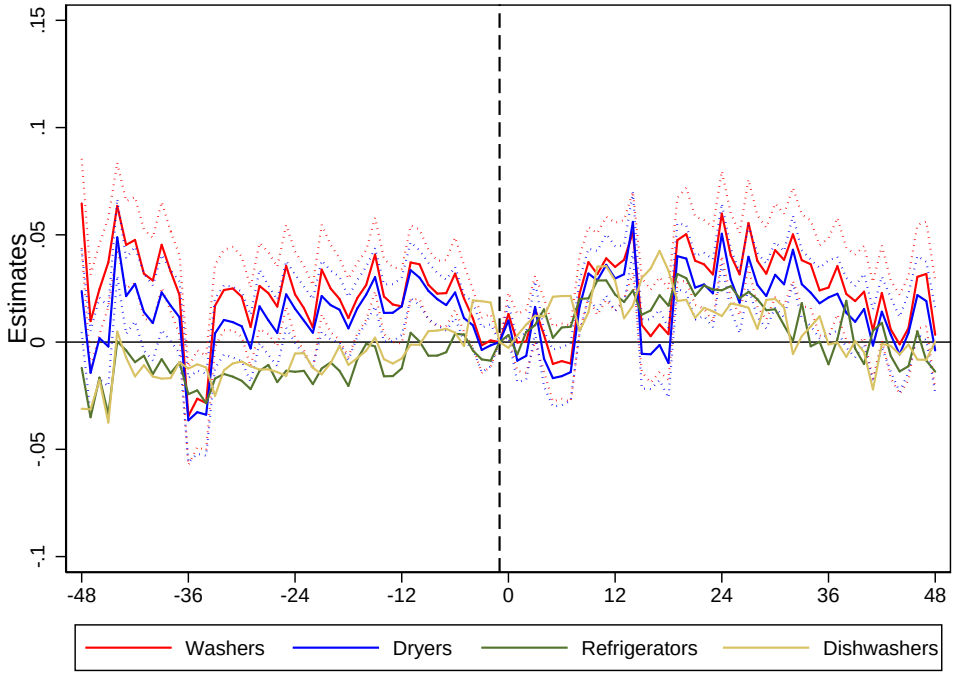
**Figure A19:** Time Fixed Effects from Log Price Regression - All Brands and All Retailers



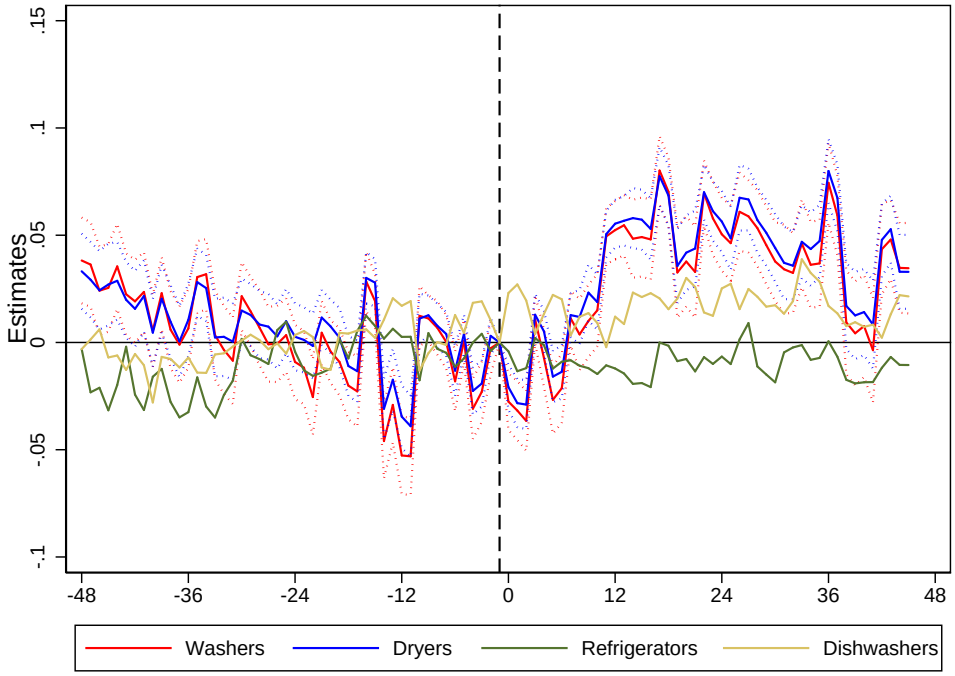

*Notes:* We plot the year-week fixed effects, which are averaged over each month, from the product-by-product regression with life cycle variables, model characteristics controls, brand fixed effects, retailer fixed effects, and year-week fixed effects. We include all available brands and retailers in the data. Three vertical date lines are August 2012, July 2016, and February 2018, which are discussed in the text.

**Figure A20:** Price Effects of Safeguard Tariffs and Antidumping Duties against China - All Brands and All Retailers

**(a)** Antidumping against China




**(b)** Safeguard Tariffs 2018




*Notes:* These figures report the regression coefficients $\lambda_{C(i)t}$ from equation (2). We include all available brands and retailers in the data. In A20a the estimates are relative to the week of July 17, 2016 and in Figure A20b 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.

**Table A10:** Difference-in-Difference Estimates: Price Effects of Washing Machine Tariffs - All Brands and All Retailers

| | with model characteristics as controls | | with model fixed effect as controls | |
|---|---|---|---|---|
| | 4 month | 8 month | 4 month | 8 month |
| **Antidumping against China** | | | | |
| Washers | 0.0231 | 0.0406** | 0.0285** | 0.0486*** |
| | (0.0126) | (0.0145) | (0.0102) | (0.0116) |
| Dryers | 0.0141 | 0.0228* | 0.0203** | 0.0375*** |
| | (0.0095) | (0.0111) | (0.0076) | (0.0084) |
| Refrigerators | 0.0122 | 0.0018 | 0.0159*** | 0.0113* |
| | (0.0077) | (0.0095) | (0.0048) | (0.0055) |
| Dishwashers | -0.0004 | -0.0178 | 0.0025 | -0.0068 |
| | (0.0090) | (0.0107) | (0.0056) | (0.0065) |
| **Safeguard tariffs 2018** | | | | |
| Washers | 0.0695*** | 0.0807*** | 0.0760*** | 0.0949*** |
| | (0.0114) | (0.0137) | (0.0096) | (0.0095) |
| Dryers | 0.0741*** | 0.0765*** | 0.0825*** | 0.0929*** |
| | (0.0103) | (0.0126) | (0.0078) | (0.0078) |
| Refrigerators | -0.0115 | -0.0230* | -0.0148** | -0.0254*** |
| | (0.0079) | (0.0108) | (0.0049) | (0.0053) |
| Dishwashers | -0.0023 | -0.0073 | 0.0019 | 0.0087 |
| | (0.0088) | (0.0123) | (0.0060) | (0.0074) |
| N | 3,955,951 | | 3,955,951 | |

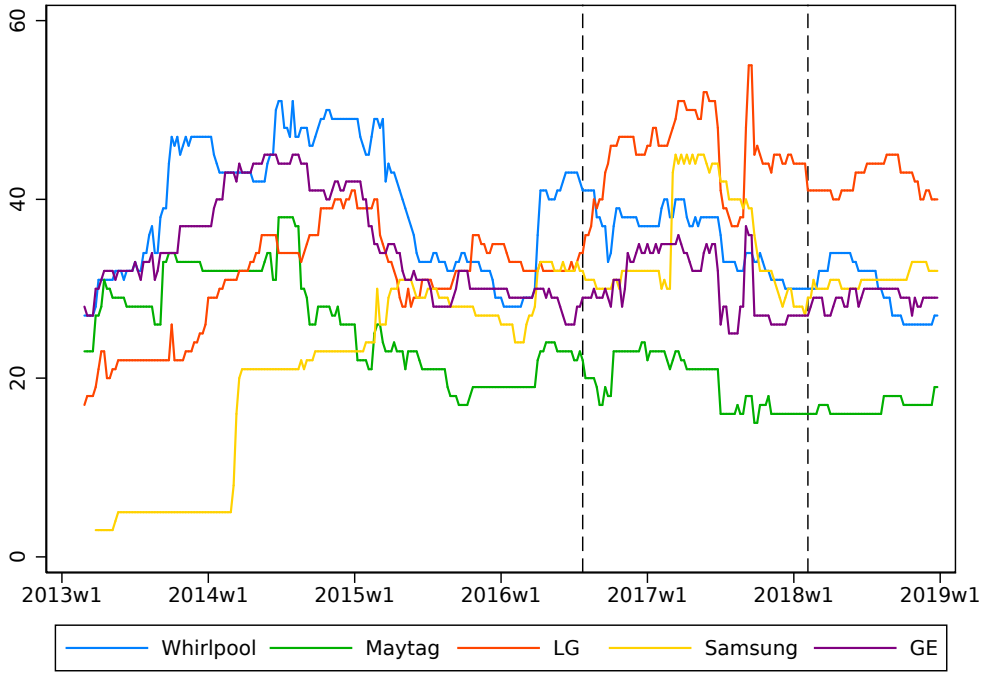
*Notes:* The table reports estimates for $\Delta^{4m}_{event}\bar{p}_C$ and $\Delta^{8m}_{event}\bar{p}_C$ defined in equation (3) and the text below it. The right hand side of equation (3) is a linear combination of the estimates from equation (2), in which we include all available brands and retailers in the data. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

**Table A11:** List of Product Characteristics

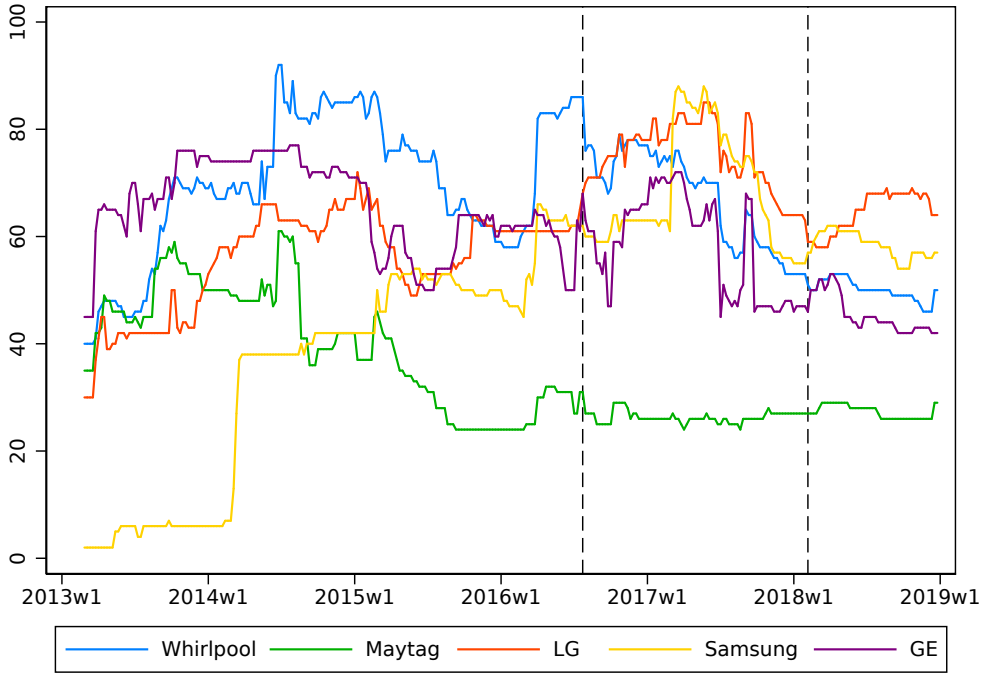
| | |
|---|---|
| **Washers** | |
| Total capacity | Dummies for less than 3.0, 3.0-4.0, 4.0-5.0, more than 5.0 cu. ft. |
| Steam | Dummy for steam |
| Energy star | Dummy for energy star |
| Smart appliance | Dummy for smart appliance |
| Load type | Dummy for top load |
| Color | Dummy for white |
| 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 |

**Figure A21:** Total Number of Available Models by Brand

**(a)** Washers




**(b)** Dryers




*Notes:* We count the number of models that appeared in a given week. 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.