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The Impact of the 2018 Tariffs on Prices and Welfare

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It is common for US presidents to introduce protectionist measures early in their first terms. In 1971, Richard Nixon imposed a 10 percent tariff ("surcharge") on dutiable imports; in 1977, Jimmy Carter placed a quota on shoe imports; in 1981, Ronald Reagan pressured the Japanese government to implement a "voluntary export restraint" agreement limiting the exports of Japanese automobiles to the United States; in 2002, George W. Bush imposed tariffs on steel; and in 2009, Barack Obama placed 35 percent tariffs on Chinese tires. Only George H. W. Bush and Bill Clinton seem to have resisted the pattern, with Bill Clinton actually *liberalizing* trade in his first year by signing the North American Free Trade Agreement in 1993. These examples of past unilateral US tariffs have frequently been the subject of complaints to the World Trade Organization by US trading partners.

The Trump administration followed this precedent seeking trade protection early in its first term, although it has done so with more breadth and force than episodes like the tire tariffs of 2009 or the steel tariffs of 2002. For example, the Trump administration has sought to renegotiate existing free trade agreements, like the North American Free Trade Agreement with Canada and Mexico and the

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US-Korea Free Trade Agreement. The Trump administration also withdrew from the negotiations for the Trans-Pacific Partnership, which, renamed as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership, has now taken effect for the eleven countries that remained in the negotiations.

Even more notable, the United States imposed tariffs on $283 billion of US imports in 2018, with rates ranging between 10 and 50 percent. As with earlier presidential administrations, the Trump administration did not wait for authorization from the dispute settlement process of the World Trade Organization before imposing these tariffs but instead offered various US-based legal justifications. For example, Section 201 of the Trade Act of 1974, which allows protection if an import surge is a substantial cause of serious injury to an industry, was invoked for tariffs on imported washing machines and solar panels. Section 232 of the Trade Expansion Act of 1962, which allows for protection when imports threaten to impair national security, was invoked for imposing tariffs on imported steel and aluminum. Section 301 of the Trade Act of 1974, which allows the United States to impose tariffs if a trading partner is deemed to have violated a trade agreement or engages in unreasonable practices that burden US commerce, was invoked for tariffs on US imports from China.

In response to these US tariffs, China, the European Union, Russia, Canada, Turkey, Mexico, Switzerland, Norway, India, and Korea have all filed cases against the United States at the World Trade Organization. Additionally, many countries retaliated against the US actions by applying tariffs of their own. In April 2018, China began by levying tariffs on $3.3 billion of US exports of steel, aluminum, food, and agricultural products, followed by tariffs on $50 billion of US exports in July and August, and on another $60 billion of US exports in September. The European Union, Mexico, Russia, and Turkey also began levying retaliatory tariffs on US exports. All told, these retaliatory tariffs averaged 16 percent on approximately $121 billion of US exports. Such tit-for-tat sequences of imposing tariffs are typically characterized as a "trade war," a term that we adopt throughout.

In this article, we show how the economic implications of these changes in policy stance can be evaluated with conventional and straightforward economic models, together with empirically based estimates for key parameters. We begin in the next section by introducing the conventional conceptual framework for assessing the impact of trade policy, with a focus on tariffs because they are by far the most prominent form of import protection. We show that the extent to which the incidence of these tariffs falls on domestic versus foreign agents depends crucially on what happens to the price charged by foreign exporters.

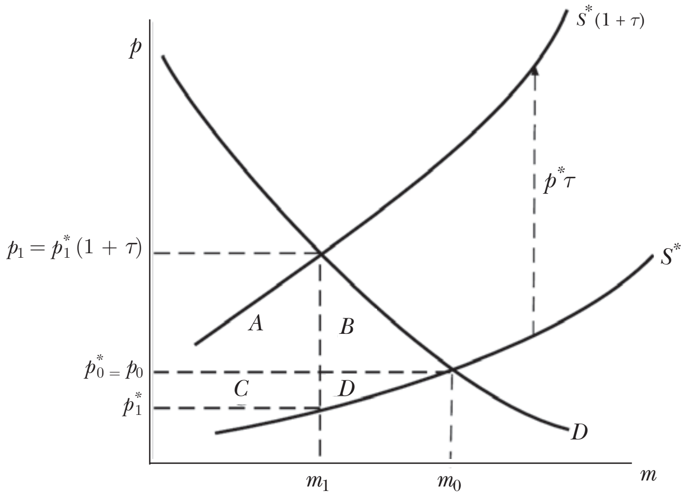
The tariffs introduced by the Trump administration during 2018 have stimulated a burgeoning literature on their economic effects, including Fajgelbaum et al. (2019), Flaaen, Hortaçsu, and Tintelnot (2019), and Cavallo et al. (2019). In this article, we use these 2018 tariffs as a natural experiment to illustrate the conventional conceptual framework. Specifically, we offer some estimates of the effects of tariffs on prices and quantities of imports, and thus of associated deadweight losses. We find that by December 2018, import tariffs were costing US consumers and the firms that import foreign goods an additional $3.2 billion per month in added tax costs and another \$1.4 billion per month in deadweight welfare (efficiency) losses. Tariffs have also changed the pricing behavior of US producers by protecting them from foreign competition and enabling them to raise prices and markups, and we estimate that the combined effects of input and output tariffs have raised the average price of US manufacturing by 1 percentage point, which compares with an annual average rate of producer price inflation from 1990 to 2018 of just over 2 percentage points. US tariffs and the foreign retaliatory tariffs also affect international supply chains, and we estimate that if the tariffs that were in place by the end of 2018 were to continue, approximately \$165 billion of trade per year will continue to be redirected in order to avoid the tariffs. We also show that the rise in tariffs has reduced the variety of products available to consumers. Throughout the discussion, we also offer some comparisons of our quantitative results and methodological approach to other studies of the effects of tariffs.

Conventional Theory of Price Impacts of Tariffs

The conventional framework for evaluating the effects of tariffs on prices and welfare is a partial equilibrium model of import demand and export supply with a perfectly competitive market structure. In Figure 1, the horizontal axis plots the quantity of home imports (m), and the vertical axis corresponds to import prices (p) and foreign exporter prices (p^*). The foreign export supply curve (S^*) rises with prices, which reflects the fact that higher prices induce foreign producers to increase production and foreign consumers to decrease consumption. In contrast, home import demand (D) falls with prices, which captures the fact that higher prices also reduce demand by domestic consumers and increase production by domestic firms. In the absence of tariffs, markets will clear with an equilibrium price ($p_0 = p_0^*$) that equalizes import demand and export supply when imports equal m_0.

Within this framework, an ad valorem tariff on imports of τ raises the cost of the imported good in the domestic market from p^* to $p^*(1 + \tau)$. As a result of this higher price, domestic consumers cut back demand for imports to m_1. At this import level, there is a wedge between the prices charged by foreign producers (p_1^*) and the prices paid by domestic consumers (p_1) that equals the per unit tariff being collected ($p_1^*\tau$). Home consumers lose welfare represented by regions $A + B$, with the rectangular region A reflecting the higher prices paid on the imports purchased and the triangular region B capturing the deadweight welfare loss (reduction in real income) from the distortion of domestic production and consumption decisions. The home government gains the rectangular region $A + C$ in tariff revenue. Because rectangle A represents a transfer from consumers to the government, whether the tariff benefits the country as a whole depends on the sign of $C - B$. This amount can be thought of as the difference between the gain in a country's "terms of trade" (its ability to extract rents from foreign producers by forcing them to drive their prices down in order to continue exporting to the home market) and the deadweight welfare loss given by B. The foreign country clearly loses in this setup, since an amount of their

Figure 1
Impact of a Tariff on Prices



Source: Authors.
Note: Horizontal axis shows the quantity of imports; vertical axis displays the price of the good; *D* corresponds to the import demand curve; S^* represents the export supply curve.

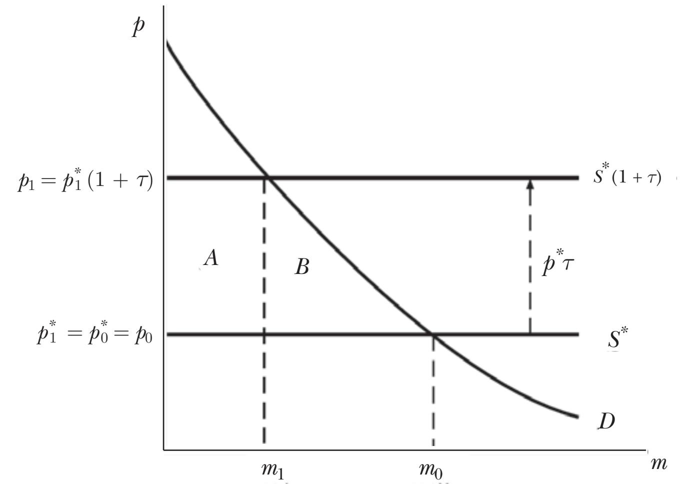
producer surplus, equal to *C*, is transferred in the form of tariff revenue to the home government, and the triangular region *D* constitutes the deadweight welfare loss from the distortion of foreign production and consumption decisions.

A clarifying special case of the impact of tariffs on prices and welfare comes when exports are supplied perfectly elastically and so the export supply curve is horizontal, as shown in Figure 2. In this case, the imposition of a foreign tariff will have no effect on foreign prices. This means that the home country will necessarily lose, because region *C* is zero and hence there is no term of trade gain—leaving the home country with only the welfare loss due to the distortion of domestic production and consumption decisions. Therefore, Figures 1 and 2 illustrate that the welfare effects of a tariff depend crucially on how steep the export supply curve is.

This conventional approach can be used to obtain a quantitative estimate of the effect of the import tariff on welfare. If we assume that the import demand curve has a constant slope and approximate region *B* by a triangle, we can then calculate the deadweight welfare loss if we know the value of imports after the imposition of tariffs, the tariff rate, and the percentage change in the quantity of imports in response to the tariff.[1]

[1] In algebraic terms, the height of this triangle is given by $p_1^* \tau$ and its base is given by $m_0 - m_1$. The deadweight welfare loss is then given by $\frac{1}{2} p_1^* \tau(m_0 - m_1) = \frac{1}{2} (p_1^* m_1)\tau(m_0 - m_1)/m_1$, where $p_1^* m_1$ is the value of imports after the imposition of tariffs, τ is the tariff rate, and $(m_0 - m_1)/m_0$ is the percentage change in the quantity of imports due to the imposition of the tariffs.

Figure 2
Impact of a Tariff on Prices with Perfectly Elastic Export Supply



Source: Authors.
Note: Horizontal axis shows the quantity of imports; vertical axis displays the price of the good; *D* corresponds to the import demand curve; S^* represents the export supply curve.

Although we will focus on tariffs as by far the most important protectionist trade policy, these same techniques can be used to examine the effects of quantitative restrictions on imports, such as quotas and voluntary export restraints.[2] Under perfect competition, a quota that restricts imports to the same amount as under a tariff has exactly the same effects on prices, quantities, government revenue, and welfare as the tariff, as long as the home government auctions the licenses to import under the quota competitively. In Figure 1, home consumers lose region $A + B$, and the home government gains region $A + C$ from sales of the quota licenses, leaving a net effect on home welfare of area $C - B$. Therefore, if quota licenses are auctioned competitively, the net effect of the quota on home welfare (like the net effect of the tariff on home welfare) depends on the extent to which there is an improvement in the terms of trade (area *C*). In contrast, if the home government gives these import licenses to foreign firms for free, or if foreign firms voluntarily restrict their exports under a voluntary export restraint, the home government receives no

[2]Governments influence international trade through eight main policy instruments: import taxes (tariffs), export taxes, export subsidies, import subsidies, antidumping actions, quantitative restrictions (in the form of import quotas or export restraints), and standards protection. Of these instruments, export taxes are explicitly prohibited by the US Constitution and import subsidies are rare; the majority of interventions come in the form of tariffs, quantitative restraints, antidumping actions, and standards protection. Of these, tariffs are by far the most common. As argued in the seminal history of US trade policy in Irwin (2017), governments have traditionally used these tariffs for three main objectives: (1) raising revenue, (2) restricting imports to protect domestic producers from foreign competition, and (3) negotiating reciprocity agreements to reduce trade barriers and expand exports.

revenue. In this case, the quota or voluntary export restraint is necessarily welfare reducing, regardless of what happens to the terms of trade, with the net effect on home welfare equal to the loss of consumers of region $A + B$.

Finally, in order to simplify the exposition, we have undertaken all of this analysis starting from zero import protection (free trade), but a directly analogous analysis can be carried out starting from an initial positive value for import protection.

How Did Tariffs Affect US Prices?

We now use the tariffs introduced by the Trump administration during 2018 to illustrate the predictions of the conventional model for prices and import values. In the next section, we use this conventional approach to estimate the impact of the 2018 tariffs on welfare.

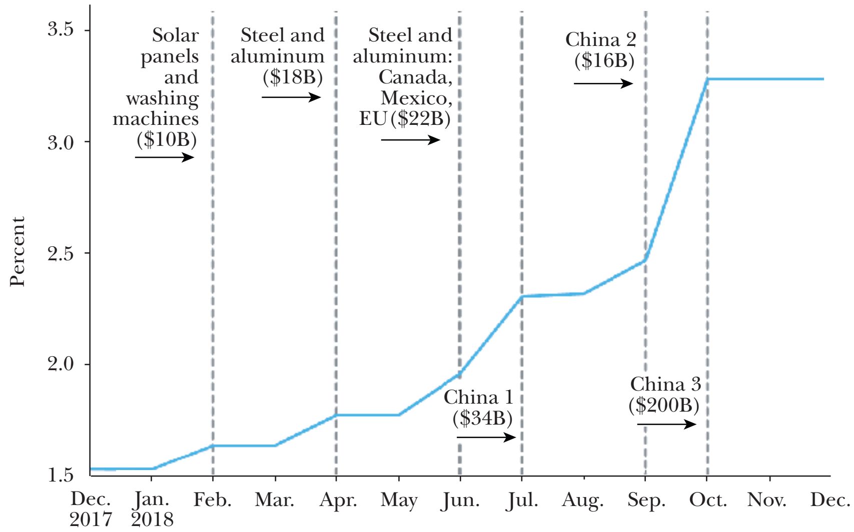
There are several advantages to using the Trump administration's trade war to examine the effects of tariffs on prices and welfare. Because President Trump's election was a surprise to many observers, it is unlikely that the tariffs were anticipated in the affected industries. Although the extent to which the tariff changes were a surprise could have changed over time as the trade war unfolded, Fajgelbaum et al. (2019) find little evidence of pre-trends in the affected industries. In addition, the Trump administration's tariffs are large enough to create meaningful variation across products, time, and countries, which makes it relatively straightforward to discern their effects using conventional datasets.

Figure 3 shows that the 2018 US tariffs were introduced in six main waves throughout the year.[3] Starting in January 2018, the first wave of tariffs imposed import duties of 30 percent on solar panels and duties of 20–50 percent on washing machines. These two product categories accounted for approximately $10 billion of imports and created a modest uptick in US average tariff rates, as one can see in the figure. The second wave of tariffs was implemented in March 2018 on $18 billion of steel and aluminum imports. In this wave, aluminum imports were hit with 10 percent tariffs, and a 25 percent tariff was applied to steel imports. The low value of imports covered by the second wave stems from the fact that at least initially, many countries, such as Canada, Mexico, and the countries in the European Union, were exempt. This exemption ended as the third wave of tariffs was imposed on $22 billion of imports from these countries in June 2018.

These early waves of tariffs were dwarfed in size by the China-specific tariffs that began in July and were rolled out in three waves. The first tranche of 25 percent tariffs on $34 billion of imports began in July 2018 (wave 4), followed by a second tranche of 25 percent tariffs on another $16 billion of Chinese imports in August 2018 (wave 5). Finally, another tranche of 10 percent tariffs on an additional $200 billion

[3] We do not count the imposition of aluminum tariffs on $0.1 billion of imports from South Korea on May 1 and $1.2 billion of Turkish imports on August 13, 2018, as separate tariff "waves" given their small magnitudes. However, they are included in the overall analysis.

Figure 3
Average Tariff Rates



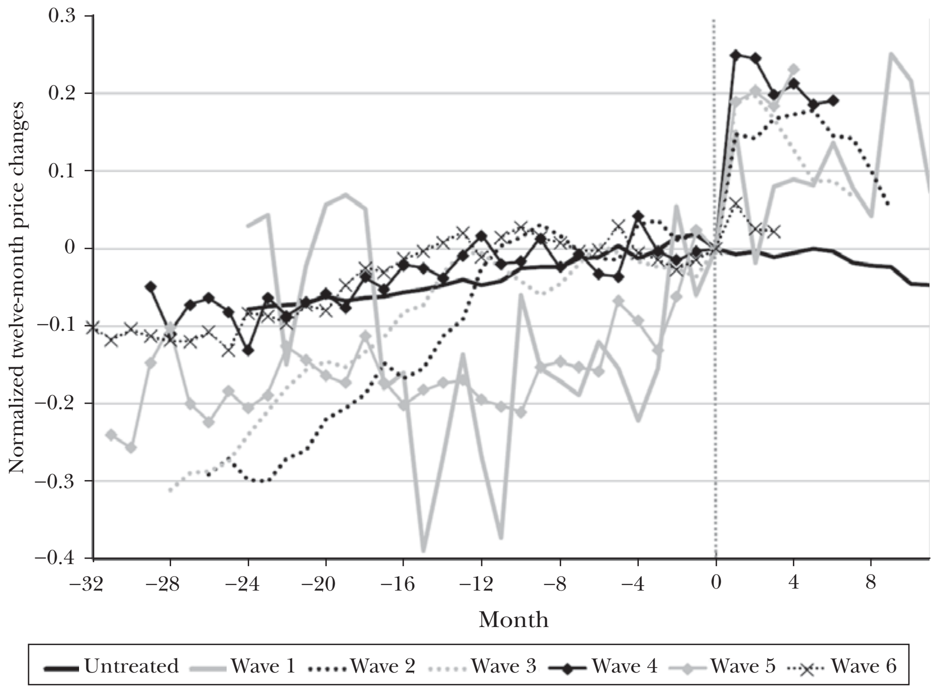
Source: US Census Bureau; US Trade Representative (USTR); US International Trade Commission (USITC); authors' calculations.
Note: Tariffs on the ten-digit Harmonized Tariff Schedule (HTS10) product code by country, weighted by 2017 annual import value. Dashed vertical lines indicate the implementation of each of the six major waves of new tariffs during 2018; tariffs implemented after the fifteenth of the month counted for the subsequent month. Three tranches of tariffs were imposed on China, designated by 1, 2, and 3.

of Chinese imports was imposed at the end of September 2018 (wave 6). Moreover, there was substantial uncertainty about the direction of US trade policy, with the US declaring a postponement on raising the tariffs on wave 6 goods to 25 percent in early December before raising them to this level in May 2019. Figure 3 shows average tariff rates, which include the 62 percent of US imports that continued to enter duty free. However, the fraction of US imports facing duties of over 10 percent rose from 3.5 percent in December 2017 to 10.6 percent by October 2018.

We can obtain a sense of how the tariffs are being passed through into domestic prices by considering what has happened to the prices paid by US importers.[4] US customs data report the foreign export values and quantities of imports by source country at the ten-digit level of Harmonized Tariff Schedule (known as HTS10) data. These data break up monthly US imports from each country into approximately 16,000 narrowly defined categories.

[4]In principle, one could trace the impact of changes in prices paid by US importers through to the Consumer Price Index, but it is difficult to match trade data with Consumer Price Index data in a comprehensive manner.

Figure 4
Twelve-Month Proportional Change in Import Prices by Tariff Wave



Source: US Census Bureau; US Trade Representative (USTR); US International Trade Commission (USITC); authors' calculations.
Note: Proportional change in an import share–weighted average of twelve-month relative changes in US import unit values inclusive of tariffs (import values divided by import quantities) for each tariff wave and for unaffected countries and products. Proportional changes for each wave are normalized to equal zero in the month prior to the introduction of the tariff; for the untreated month, zero is defined as in the first tariff wave. Tariff waves are defined in the section "How Did Tariffs Affect US Prices?"

By dividing the import values by the quantities, one can compute unit values at a very disaggregated level: for example, "baseball and softball gloves and mitts made in China." Importantly, unit values are computed before tariffs are applied, so they correspond to foreign export prices. If we multiply these unit values by the duty rates, available from the US International Trade Commission, we can compute tariff-inclusive import prices. These tariff-inclusive prices provide detailed evidence on what has been happening to US prices as a result of the 2018 tariffs.

Figure 4 illustrates the overall patterns. The zero on the horizontal axis refers to the month before each of the six tariff waves started. We subtract the price change in the month before the tariff was implemented from each price change, so a zero on the vertical axis corresponds to a price change that equals its value before the tariffs were implemented. The price changes shown for each wave refer only to the imports for the specific goods and countries affected by that wave of tariffs and are weighted for each good according to its relative importance in imports. Thus, one can see how prices for the goods involved in all six waves were changing both before and after the tariffs. We also do this for the "untreated" set of goods and countries—that is, those goods and countries that faced no tariff changes in 2018—to have a sense of the baseline movement in prices. For this group, the zero month is the date of the first tariff wave.[5] We drop petroleum imports from all plots and tables because of the volatility of these prices.

Several important patterns emerge from Figure 4. First, the "untreated" prices for sectors not subject to tariffs are fairly flat, which suggests that whatever price movements we observe in protected sectors are likely due to the tariffs. Second, we see large increases in prices of goods that were subject to tariffs, with unit values typically rising from 10 to 30 percent in the wake of the tariffs. These numbers are comparable in magnitude to the tariffs that were applied, which suggests that much of the tariffs were passed on almost immediately to US importers and consumers. Finally, although there seems to be some pre-trend in prices for the specific goods hit in waves 1 and 5, there does not appear to be a pre-trend for the goods in any of the other waves, which is consistent with a belief that the price increases that we observe are likely due to the fact that much of the tariffs have been passed on to importers. The impact of the tariffs on the prices of imports could be larger than suggested by these figures if the tariffs also raised prices for untreated goods in response to the higher tariffs imposed on their competitors.

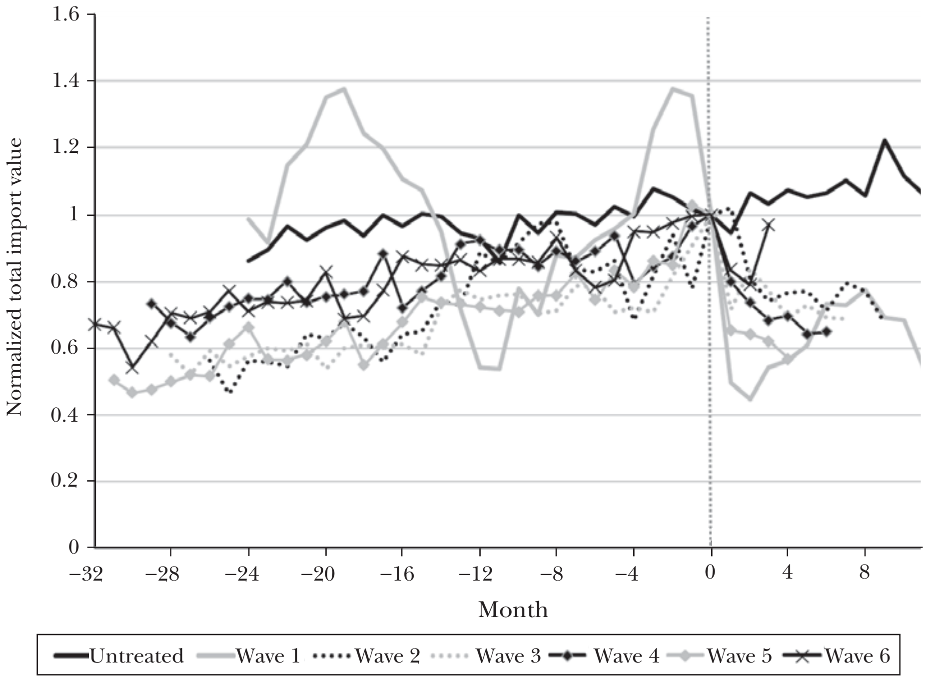
Figure 5 repeats the same plot using the total value of imports instead of unit values, which gives us insight into quantities of imports. In this plot, we normalize the import value in month zero to be one for all goods, so the import values are all relative to imports in the last month before the tariffs were applied. The figure shows a big surge in imports in the wave 1 products, washing machines and solar panels, prior to the imposition of tariffs, which was likely caused by importers moving forward import orders in order to obtain products before the imposition of the tariffs. For the remaining goods, it appears that on average their import levels were rising a little faster than for unaffected goods in the months prior to the imposition of the tariffs. In all cases, import values declined sharply after the imposition of the tariffs, typically falling 25 to 30 percent after the imposition of the tariffs. This

[5] Specifically, if we denote the unit value (price) of an HTS10 good i from country j in month t by p_{ijt}, we can compute the twelve-month relative change in prices for that good and country as $\hat{p}_{ijt} \equiv (p_{ijt}/p_{ij,t-12})$. In working with these price relatives for each good, we difference out any constant choice of units for each good. We work with twelve-month relative changes to avoid seasonality in the unit values. Letting w denote the set of HTS10-country varieties affected by a tariff change, we compute a price index for each wave as the following weighted average of these price relatives:

$$\hat{p}_{wt} \equiv \prod_{i,j \in w} (\hat{p}_{ijt})^{(s_{ij}^{w})},$$

where s_{ij}^{w} is the logarithmic mean of the import shares from country j in sector i in the relevant months from 2017 and 2018 among all HTS10 imports in the categories affected by tariff wave w. Our use of the logarithmic mean import shares as weights ensures that we weight the price change for each good according to its relative importance in imports and that this price index corresponds to a Sato–Vartia price index that is exact for the constant elasticity of substitution demand system. We express these price indexes as proportional changes by subtracting one—that is, $(\hat{p}_{wt} - 1)$.

Figure 5
Total Import Values by Tariff Wave



Source: US Census Bureau; US Trade Representative (USTR); US International Trade Commission (USITC); authors' calculations.
Note: Twelve-month proportional changes in the value of US imports by tariff wave and for unaffected countries and products. Each series is normalized to the value one in the month prior to the introduction of the tariff; for the untreated month, zero is defined as in the first tariff wave. Tariff waves are defined in the section "How Did Tariffs Affect US Prices?"

drop is particularly striking given that imports for unaffected sectors and countries *rose* by about 10 percent over the same period, where this rise could in part reflect some import substitution from affected to unaffected countries and products in response to tariff changes.

Estimating Welfare Losses of Higher Import Tariffs

As we discussed above, a key first step to estimating the welfare effect of tariffs requires an estimate of how the price received by foreign exporters moves in response to a tariff increase. We examine these effects by returning to our data on import quantities and values. Specifically, we use observations at the HTS10-country level for specific products imported during each month, for the period January 2017 to December 2018. All variables refer to the twelve-month change, expressed in logs. The regressions described here include fixed effects at the product level

Table 1
Impact of US Tariffs on Importing

	log change foreign exporter prices (1)	*log change import quantities* (2)	*log change import quantities* (3)	*log change import values* (4)	*log change import values* (5)
	$\Delta\ln(p_{ijt})$	$\Delta\ln(m_{ijt})$	$\Delta\ln(m_{ijt})$	$\Delta\ln(p_{ijt}\times m_{ijt})$	$\Delta\ln(p_{ijt}\times m_{ijt})$
log change tariff	−0.012	−1.310***	−5.890***	−1.424***	−6.364***
$\Delta\ln(1 + Tariff_{ijt})$	(0.023)	(0.090)	(0.590)	(0.086)	(0.773)
N	1,647,617	1,647,617	3,318,912	2,487,370	4,461,376
R^2	0.021	0.024	0.099	0.012	0.102

Source: US Census Bureau; US Trade Representative (USTR); US International Trade Commission (USITC); authors' calculations.
Note: Observations are at the HTS10-country-month level for the period January 2017 to December 2018. Variables are in twelve-month log change. All columns include HTS10 product fixed effects and country × year fixed effects. The dependent variable in column 1 is the log change of prices (before US duties are applied) charged by foreign exporters. The dependent variables in columns 2 and 3 are the log change and the change in the inverse hyperbolic sine of US import quantities, respectively. The dependent variables in column 5 are the log change and the change in the inverse hyperbolic sine of US import values. We use the inverse of the hyperbolic sine transformation, $\log[x + (x^2 + 1)^{0.5}]$, to be able to estimate changes when import quantities or values are zero in t or $t - 12$. Columns 1–3 drop any observations with a ratio of unit values in t relative to $t - 12$ greater than 3 or less than 1/3. Standard errors reported in parentheses are clustered at the HTS eight-digit level, because import tariffs for some goods only vary at the HTS eight-digit level. For additional details of the regression and full results, see the online Appendix available with this article at the *Journal of Economic Perspectives* website.

*, **, and *** indicate significance levels of $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively.

and the country-month level. We treat the Trump administration's tariffs as exogenous and assume that they are uncorrelated with unobserved shocks to unit values. Under this assumption, the estimated coefficient in this regression captures the impact of the tariffs on the prices received by foreign exporters.

Table 1 shows some results. In column 1, we regress the change in the log import unit value (measured without including the tariff change) over a twelve-month period on the change in one plus the applied tariff on imports over the same period. We obtain an estimate of tariffs on unit values of −0.012, which suggests that the tariff changes had little to no impact on the prices received by foreign exporters. Moreover, the coefficient is estimated precisely, because the standard error of this estimate is 0.023, so we can reject the hypothesis that there is a substantial impact of tariffs on exporter prices. Thus, it appears that the supply elasticity of exports, at least in the short run, is close to perfectly elastic (as portrayed in Figure 2), which means close to all of the cost of the 2018 US tariffs was borne (so far) by US consumers and importers.

The finding that the Trump administration's tariff changes have been almost entirely passed through into domestic prices, leaving exporter prices unchanged, is consistent with the findings from different estimation methodologies in Fajgelbaum et al. (2019) and Cavallo et al. (2019). However, it is also surprising. The literature on exchange-rate shocks typically finds an elasticity of import prices with respect to exchange-rate shocks of closer to one-half, as surveyed in Goldberg and Knetter (1997). For example, Gopinath, Itskhoki, and Rigobon (2010) estimate an elasticity of about 30 percent for the United States. Furthermore, the estimated export supply elasticities for a number of countries in Broda, Limão, and Weinstein (2008) imply upward-sloping export supply curves. Therefore, a conventional demand and supply framework would predict some adjustment in exporter prices in response to US tariffs.[6]

There are a number of possible reasons for the difference between these two sets of results. First, we are working with monthly data and looking at the impact of tariffs over just a few months, while others such as Broda, Limão, and Weinstein (2008) are often estimating these elasticities at an annual frequency. It is possible that export prices are sticky in the short run, so if we were to look at the impact of these tariffs over longer periods—years rather than months—we would see exporters drop their prices in response to the tariffs. Second, US trade policy in 2018 may have been associated with an especially high degree of uncertainty. Past changes in tariff policy were largely long term in nature, with little uncertainty about what tariffs would be applied a few months in the future. In the face of uncertainty about whether tariffs against China would, say, be lifted, remain at 10 percent, or rise to 25 percent, exporters may have decided not to lower prices because they feared they could not raise them again if the tariffs were lifted. However, this point about uncertainty also applies to exchange rate shocks, and hence the finding of complete pass-through of the 2018 tariffs into US prices remains somewhat of a puzzle.

In column 2 of Table 1, we replace the dependent variable with the twelve-month change in imported quantities. Under the assumption that the Trump administration's tariffs are exogenous, and using our finding that there is no offsetting change in the prices received by foreign exporters, we can interpret the estimated coefficient on the tariff change as the import demand elasticity. Here we see that a 1 percent increase in tariffs is associated with a 1.3 percent decrease in the import quantities. This decline is much smaller than the declines we observed in Figure 5, because prohibitive tariffs result in import quantities of zero that are dropped from the regression. As a fix for this problem, we rerun the regression replacing the log of the quantity change with the inverse hyperbolic sine, which has a defined value for cases in which import quantities are zero.[7] The results from this exercise are reported in column 3. As one can see from this specification, including the trade flows that go to zero results in a substantially higher estimate of the impact of tariffs on trade flows. We estimate that a 1 percent increase in tariffs is associated with a 6 percent

[6] Much of the existing literature on the pass-through of cost shocks into prices focuses on exchange rate shocks (for example, Amiti, Itskhoki, and Konings 2014). However, De Loecker et al. (2016) examine the effect of lower tariffs in India, while Edmond, Midrigan, and Xu (2015) consider the effects using Taiwanese data. Amiti et al. (2017) estimate the effect of China lowering its own tariffs on the US manufacturing price indexes.

[7] The inverse hyperbolic sine of some variable, x, is given by $\ln[x + (x^2 + 1)^{0.5}]$. It equals 0 when $x = 0$, and its slope tracks that of $\ln x$ more closely than $\ln(1 + x)$ when x is small.

fall in import quantities. This estimate is very much in line with standard estimates of trade elasticities, which lie within the range of 4 to 8, as, for example, in Broda and Weinstein (2006), Eaton and Kortum (2002), and Simonovska and Waugh (2014).[8]

In columns 4 and 5 of Table 1, we repeat this exercise using import values as the dependent variable, where these import values are again measured without including the tariff. We now have far more observations, because import values are more frequently reported than import quantities. We find quantitatively similar results for values as for quantities, which is consistent with our earlier finding of no discernible effect on the prices received by foreign exporters. If we multiply the tariff changes by this elasticity estimate, we find that the 2018 US tariffs through wave 6 reduced US imports in the affected HTS10 categories relative to those in the unaffected categories by about 52 percent, which is in line with the steep relative drops in imports that we saw in Figure 5. US total imports probably fell by much less than this, because some of the declines in protected sectors were offset by increases in exports from countries not subject to tariffs. If we multiply the coefficient on the tariff change in column 5 by the tariff change in each sector and then sum across sectors, the *relative* decline in imports from affected sectors amounts to $132 billion in imports on an annual basis.

Importantly, this *relative* decline in imports affected by tariffs is consistent with any aggregate movement in imports as long as the imports of the affected sectors fell by $132 billion more than those of the unaffected sectors. However, the estimate does imply a substantial shock to global supply chains, because it means that at least $132 billion of trade was redirected as a result of the import tariffs. This potentially could imply very large costs for US multinationals (and Chinese exporters) who have made irreversible investments in China. Indeed, given that Lovely and Liang (2018) found that in sectors such as machinery, electrical equipment, appliances, and computer and electronic products the share of exports from China that were made from non-Chinese firms ranged from 59 to 86 percent, it is reasonable to conjecture that US firms may be forced to write off investments in China as their Chinese factories become uncompetitive and new facilities need to be opened elsewhere.

We can use these estimates of the impact of the import tariffs on prices and quantities to obtain an estimate of the deadweight welfare loss from the tariff, using the framework shown in Figures 1 and 2. Under the assumption that the import demand curve has a constant slope, we can compute the deadweight welfare loss in area B using the formula for the area of a 90-degree-angled triangle, which equals one-half times the height times the width of the triangle. The height of the triangle is the size of the tariff (τp_1^*), which is observed in the data. The width of the triangle is the change in imports due to the tariff ($m_0 - m_1$), which we estimate using the coefficient from the quantity regression in column 3 of Table 1.[9] We compute the

[8] We find a similar pattern of results if we augment the specifications in Table 1 with a full set of fixed effects for Harmonized System two-digit (HS2)-sector-year, with marginally smaller coefficients in absolute value.

[9] In particular, the deadweight welfare loss (the area of the right triangle B in Figures 1 and 2) can be rewritten as $\frac{1}{2}$ $(p_1^* \ m_1)\tau(m_0 - m_1)/m_1$. Using the coefficient estimates from the regressions in Table 1, negative one times the coefficient in the quantity regression (β) multiplied by the change in tariff

Table 2
Deadweight Welfare Loss and Tariff Revenue
(current prices in billions of dollars)

Month (2018)	Deadweight loss (1)	Tariff revenue (2)	Total cost to importers (3)
January	0	0	0
February	0.1	0.1	0.2
March	0.1	0.1	0.2
April	0.3	0.4	0.7
May	0.2	0.4	0.6
June	0.4	0.7	1.2
July	0.9	1.4	2.4
August	0.9	1.4	2.3
September	1.0	1.6	2.6
October	1.5	3.2	4.6
November	1.4	3.0	4.4
December	1.4	3.2	4.7
Total	8.2	15.6	23.8

Note: Column 3 is the sum of columns 1 and 2; see the text for the details of these calculations.

value of these deadweight losses for each month in 2018. As shown in Table 2, these losses mounted steadily over the year, as each wave of tariffs affected additional countries and products, and increased substantially after the imposition of the wave 6 tariffs on $200 billion of Chinese exports. By December, these deadweight welfare losses reached $1.4 billion per month. Over the course of 2018, the cumulative deadweight losses amounted to $8.2 billion.

We can also compare these deadweight losses to the value of the tariff revenue raised, which was $15.6 billion for the twelve months of 2018. Given that we find no effect of the tariffs on the prices received by foreign exporters, this tariff revenue is a pure transfer from domestic consumers to the government. If we assume that the US government uses the tariff revenue to generate social welfare benefits equal to the tax burden, the reduction in welfare from the tariff for the economy as a whole is captured by the deadweight loss, while the cost to the consumer and importer equals the sum of the deadweight welfare loss and the tariff revenue transferred to the government. If we were instead to assume that the US government does not generate social welfare benefits equal to the tax payments they receive, the losses to taxpayers could rise by as much as the full value of their tariff payments.

As we mentioned above, this approach to calculating the costs of the tariffs makes a number of simplifying assumptions, including partial equilibrium and perfect competition, and treats the tariffs introduced by the Trump administration as an exogenous shock. Fajgelbaum et al. (2019) offer a more complete treatment

$\ln((1+\tau_t)/(1+\tau_{t-12}))$ tells us the percentage change in imports due to the imposition of the tariff, or $-\beta\ln((1+\tau_t)/(1+\tau_{t-12})) = -\ln(m_1/m_0) \approx (m_0 - m_1)/m_1$. Using this estimate, the deadweight loss can be measured by $-\frac{1}{2}(p_1^* m_1)\tau\beta\ln((1+\tau_t)/(1+\tau_{t-12}))$.

of the welfare effects of these tariffs using a demand system that allows for three tiers of substitution: among varieties of an imported product, among import products, and among imported and domestic aggregates. However, neither our regression specification nor that in Fajgelbaum et al. provides a method to estimate possible effects of tariffs that are common across all foreign trade partners and products (including effects on US wages), which runs the risk that these approaches may miss the way in which tariffs affect the terms of trade.

We can offer several ways to put our estimated welfare losses into perspective. As one comparison, Caliendo and Parro (2015) undertake a general equilibrium analysis of the US welfare gain from tariff reductions under the North American Free Trade Agreement and find that it amounts to 0.08 percent of GDP or about $1.4 billion per month—which is about the same as our estimate of the monthly deadweight loss from the Trump administration tariffs in December 2018.

An alternative benchmark might be obtained by considering what a policy success might look like. In 2017, China paid the United States $8.3 billion in royalties for US intellectual property (Santacreu and Peake 2019). If we assume that a successful trade negotiation would increase the royalties that China pays by 25 percent, it would take four years of these higher royalties to pay off the deadweight welfare loss from the 2018 trade war. Alternatively, if we were to think that a successful outcome from the trade war would be the creation of 35,400 manufacturing jobs—matching the decline in the number of jobs in the steel and aluminum industry in the past ten years—then the deadweight welfare loss per job saved is $232,000, which is almost four times the annual wage of a steel worker of $52,500. These benchmarks suggest that the costs of the trade war are quite large relative to optimistic estimates of any gains that are likely to be achieved.

Effects of Retaliatory Tariffs on US Exporters

Of course, these estimates do not take into account the fact that foreign countries have placed retaliatory tariffs on approximately $121 billion of US exports. These tariffs have hit US agricultural exports as well as exports of steel, automobiles, and consumer goods.

In Table 3, we estimate the same specifications as in Table 1, but using US export data instead of import data. Thus, the unit values we construct are for exports by US firms for each HTS10 product (before applying the foreign tariffs). We are again using monthly data, this time on exports of specific products to each country from January 2017 to December 2018.

Column 1 of Table 3 shows that there also appears to be no decline in US export prices in response to foreign tariffs, which implies that consumers and importers in foreign countries are bearing the full cost of their retaliatory tariffs. However, this does not mean that US exporters are not being affected by the retaliatory tariffs. As we can see in the last column of the table, the elasticity of US export values with respect to foreign tariffs is –3.9, which means that a 1 percent increase in foreign

Table 3
Impact of Foreign Tariffs on US Exporting

	log change US export prices (1)	*log change foreign import quantities* (2)	*log change foreign import quantities* (3)	*log change foreign import values* (4)	*log change foreign import values* (5)
	$\Delta\ln(p_{ijt}^{US})$	$\Delta\ln(x_{ijt}^{US})$	$\Delta\ln(x_{ijt}^{US})$	$\Delta\ln(p_{ijt}^{US} \times x_{ijt}^{US})$	$\Delta\ln(p_{ijt}^{US} \times x_{ijt}^{US})$
log change tariff	0.077**	−1.233***	−3.498***	−1.134***	−3.942***
$\Delta\ln(1 + Tariff_{ijt})$	(0.034)	(0.146)	(0.710)	(0.130)	(0.827)
N	1,320,495	1,320,495	2,784,226	2,191,243	3,930,620
R^2	0.014	0.011	0.076	0.013	0.072

Note: Observations are at the HTS10-country-month level for the period January 2017 to December 2018. Variables are in twelve-month log change. All columns include HTS10 product fixed effects and country-year fixed effects. Columns 1–3 drop any observations with a ratio of unit values in t relative to $t-12$ greater than 3 or less than 1/3. The dependent variable in column 1 is the log change of prices (excluding the tariff) charged by US exporters. The dependent variables in columns 2 and 3 are the log change and the change in the inverse hyperbolic sine of foreign import quantities (US export quantities). The dependent variables in column 4 and 5 are the log change and the change in the inverse hyperbolic sine of foreign import values (US export values). We use the inverse of the hyperbolic sine transformation $\log[x + (x^2 + 1)^{0.5}]$ to be able to estimate changes when import quantities or values are zero in t or $t-12$. Standard errors reported in parentheses are clustered at the Harmonized System six-digit (HS6) level, because foreign export tariffs vary at the HS6 level. For additional details of the regression and full results, see the online Appendix available with this article at the *Journal of Economic Perspectives* website.
*, **, and *** indicate significance levels of $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively.

tariffs is associated with a 3.9 percent decline in the value of US exports. In other words, by the end of 2018, foreign retaliatory tariffs were also costing US exporters approximately $2.4 billion per month in lost exports. Once again, to the extent that US firms have to find new export markets or switch to offshore production to avoid paying the tariffs, it is likely that the retaliatory tariffs are associated with substantial shifts in supply chains and possibly large depreciations in capital equipment based in the United States.

Summing together our estimates for lost exports and imports, we find that by December 2018, approximately $15.3 billion of trade ($4.3 billion of exports and $11 billion of imports) per month was being redirected as a result of the tariffs, which amounts to $183 billion of redirected trade on an annual basis.

The Impact of Tariffs on US Domestic Producer Prices

Tariffs may also affect markups for domestic firms. A large body of empirical work has demonstrated that as foreign firms enter a market, prices and markups of domestic firms fall in response. Amiti, Itskhoki, and Konings (forthcoming) have developed this idea further in a setup that takes into account how trade can affect domestic prices through increased competition in domestic firms' output markets as well as through firms' intermediate input costs. In their framework, a firm's price changes can be written as a log-linear relationship that depends on marginal cost changes and changes in the prices of the firm's competitors.

While we do not have access to firm-level price data, we do have access to detailed industry-level data for the Producer Price Index—specifically, North American Industry Classification System data disaggregated at the six-digit level (NAICS6)—so we can run analogous regressions at the industry level. These data contain information on the prices being charged by domestic producers. We merge these data with input-output tables to identify which products are used in each industry. We refer to the weighted-average tariffs protecting the output in any industry as "output tariffs," and the weighted-average tariffs applied to an industry's inputs as the "input tariffs" because they reflect the additional costs that producers in a given sector face when tariffs raise their input price.[10] We thus obtain a measure for each NAICS6 category of the output tariff on final goods and the import tariff on intermediate inputs. We expect that output tariffs have a bigger effect on producer prices in sectors in which imports account for a larger share of domestic sales. Therefore, we adjust our output tariff measure by the share of imports in domestic consumption. Similarly, we expect that input tariffs have a larger impact on producer prices in sectors in which imported intermediate inputs account for a larger share of total variable costs. Therefore, we adjust our input tariff measure by the share of imported intermediate inputs in total variable costs.[11]

In Table 4, we present regressions of the twelve-month change in the Producer Price Index in each of the NAICS6 industries on these adjusted output and input tariffs (a calculation that builds on Amiti, Heise, and Kwicklis 2019). We find that the 2018 US tariffs increased the prices charged by US producers through both of these channels. First, we obtain a coefficient of 1.9 on the weighted input tariff. This coefficient implies that for the average firm that imports 15 percent of its variable costs, a 10 percent higher input tariff causes it to raise its own prices by 2.9 percent (that is, 1.9 × 0.15 × 0.10 × 100). This tariff pass-through into domestic producer prices is incomplete, because higher input costs often cause firms to reduce markups and absorb some of the higher costs in lower profits. Despite this adjustment in markups,

[10] To link these data to the trade data, we matched the Producer Price Index for every NAICS6 sector to the HTS10 codes associated with that NAICS6 sector using the concordance in Pierce and Schott (2012). For any output sector i, we then took an import weighted average of the tariff changes in that sector, using 2017 annual import shares by country-HTS10. Mathematically, the output tariff for NAICS6 sector k in month t is given by $\textit{Output Tariff}_{kt} = \sum_{i \in k} \sum_j s_{ijk} \, \tau_{ijt}$, where i denotes an HTS10 category; j indexes exporters; s_{ijk} is the 2017 value of any HTS10 export value from country j divided by the total imports in the HTS10 sectors within k; and τ_{ijt} is the ad valorem tariff rate on goods in category i from country j in month t. We also have $\textit{Input Tariff}_{kt} = \sum_{\ell \in k} w_{\ell k} \, (\textit{Output Tariff}_{kt})$, where $w_{\ell k}$ is the value of inputs from sector ℓ used by firms in NAICS6 sector k based on the US 2007 input-output table divided by the sum of total intermediate input and labor costs in sector k.

[11] Formally, we weight the output tariffs by $\textit{Import Share}_k \equiv m_k/(d_k + m_k - x_k)$, where m_k, d_k, and x_k are imports, domestic shipments, and exports in sector k. We weight the import tariffs by $\textit{Import Intensity}_k \equiv M_k/(N_k + W_k)$, where M_k, N_k, and W_k are imports of intermediates, total material costs, and labor costs in sector k.

Table 4

Impact of Import Tariffs on Non-Oil Merchandise Producer Price Index (PPI)

Dependent variable: $\Delta log(PPI_{it})$	*Twelve-month change*
A: Regression coefficients	
Input Import Intensity$_i \times \Delta\ln(1 +$ *Input Tariff*$_{it})$	1.867***
	(0.697)
Import Share$_i \times \Delta\ln(1 +$ *Output Tariff*$_{it})$	0.402**
	(0.198)
Fixed effects: industry and time	Yes
B: Implied aggregate effects	
Input tariff effect	0.856
Output tariff effect	0.174
Total effect	1.030
N	8,088
Number of industries	337
R^2	0.521

Note: The dependent variable is the twelve-month change in log(*PPI*), while the tariffs are entered as the twelve-month changes in $\log(1 + Tariff_{it})$. The sample period is monthly data from January 2017 to December 2018. The denominator in the input import intensity is the sum of material inputs and the wage bill. Standard errors, clustered at the Bureau of Economic Analysis input-output level, are reported in parentheses.

*, **, and *** indicate significance levels of $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively.

there is a clear cost-push channel of the tariffs that causes domestic producer prices to rise because their input costs have risen.

We also see a clear markup or competition effect of tariffs in the coefficient on output tariffs. The coefficient of 0.4 on the adjusted output tariff change implies that in a typical sector in which 25 percent of all domestic sales are by foreign firms, a 10 percent tariff is associated with a 1 percent increase in domestic producer prices over twelve months. In other words, domestic producers raise their prices when their foreign competitors are forced to raise prices due to higher tariffs.

In panel B of Table 4, we provide some sense of the economic magnitude of these effects. In particular, we multiply the actual tariff increases by the coefficients from panel A to obtain a back-of-the-envelope estimate of the impact of the tariffs on domestic producer prices in manufacturing. This calculation is clearly a partial equilibrium exercise, because we implicitly assume that the changes in tariffs have no impact on sectors that do not use imports directly affected by the tariffs. This assumption could be violated for a number of reasons, including, for example, any effect of the changes in tariffs on aggregate wages. With these caveats in mind, we estimate that US domestic prices were 1 percent higher in manufacturing industries in 2018 as a result of the new tariffs. These findings are in line with the evidence of the procompetitive effects of international trade in reducing domestic prices in Feenstra and Weinstein (2017).

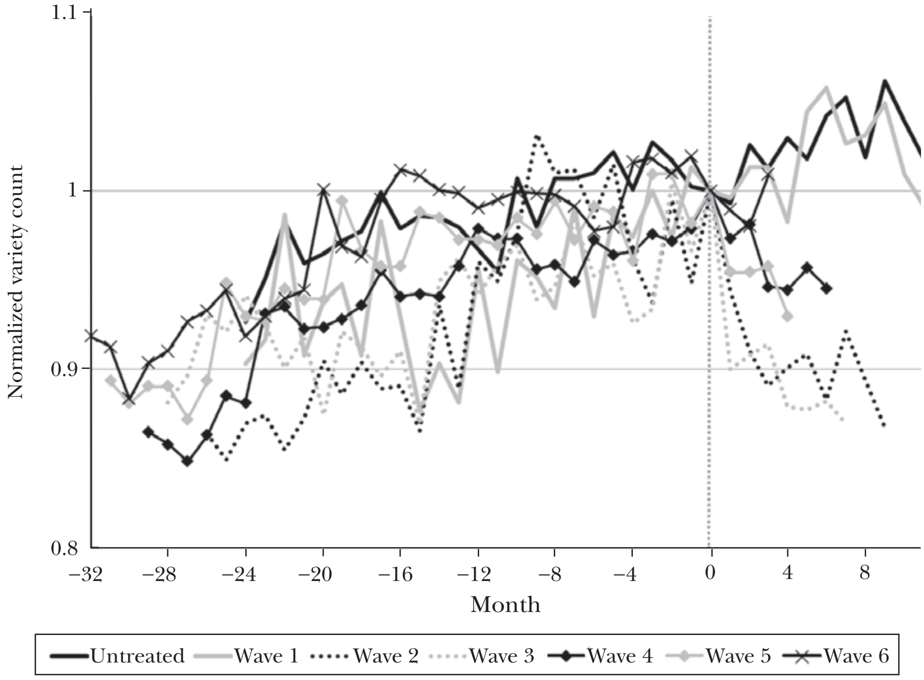
Assessing the Impact of Tariffs on Imported Varieties

The standard textbook model of losses from tariffs is based on the assumption that imported and domestic varieties of goods are perfect substitutes. But realistically, the products produced in one country may be imperfect substitutes for those produced in other countries. Indeed, one distinguishing feature of "new trade theory" is its emphasis on how increases in trade barriers can reduce welfare by restricting the range of varieties that consumers are able to purchase. In these models, consumers benefit from trade liberalization because it gives them access to varieties of products—French wine, Colombian coffee, and Hungarian paprika—that might not be purchased if trade barriers were higher. If trade liberalization is associated with increases in varieties, one might well wonder whether the 2018 tariffs have resulted in a reduction in imported varieties, and if so, what the welfare costs of these variety losses have been.

Figure 6 presents some evidence on how the trade war has influenced imported varieties, where we define a variety as an HTS10-country code (for example, French red wine). For each set of HTS10-country codes that were affected by a particular wave of tariffs, we compute a count of the number of varieties imported. We use the same normalization as before, so month zero corresponds to the last month before the new tariffs were implemented, and we normalize the number of varieties within the set of HTS10 codes in each tariff wave to be one in month zero. We see that for the three years prior to the imposition of these tariffs, all the categories of goods typically experienced increases in the number of varieties. However, the imposition of the tariffs is associated with sharp drops in the number of imported varieties entering the United States in all sectors, except in wave 1, which affected only a small number of product codes (washing machines and solar panels). These results suggest that some of the tariffs were prohibitive, reducing imports of certain goods from certain countries to zero.

Starting with Feenstra (1994), economists have developed tools to measure how costly it is to reduce access to some varieties even when the prices of remaining varieties are unchanged. The key insight is that for some widely used classes of preferences we can divide the cost of consumption into two components. The first is a "common-goods" component, which captures price changes for the set of goods that exist in both time periods, and the second is a "variety adjustment," which captures the fact that whenever a good exits a sample, we can think of it as if its price rose so much that it became prohibitively expensive. Similarly, the variety adjustment accounts for the fact that whenever a good enters the sample, it is as if its price fell from some prohibitively high level to a level at which consumers are willing to purchase the product (for discussion, see also Broda and Weinstein 2006, 2010; Redding and Weinstein 2016, 2017).

Figure 6
Number of Varieties by Tariff Wave



Source: US Census Bureau; US Trade Representative (USTR); US International Trade Commission (USITC); authors' calculations.
Note: Twelve-month proportional changes in the number of import varieties, defined as an HTS10-country code, by tariff wave and for unaffected products. Each series is normalized to the value one in the month prior to the introduction of the tariff; for the untreated month, zero is defined as in the first tariff wave. Tariff waves are defined in the section "How Did Tariffs Affect US Prices?"

While the algebra for deriving these expressions can be somewhat involved, the intuition is straightforward. For many demand systems, the value of any variety of a good comes down to two terms. First, we need to know how substitutable a good is with other goods. The elasticity of substitution matters because consumers are more likely to appreciate being able to purchase new differentiated goods (like French red wine) than highly substitutable ones (French wheat). Thus, all things equal, tariffs that cause varieties of differentiated products to disappear are likely to be more costly than tariffs that cause varieties of homogeneous products to disappear. We define varieties as HTS10-country codes (like French red wine) and assume an elasticity of substitution between these varieties of 6, which, as discussed above, is a standard value in the international trade literature and is in line with our estimates from Table 1.

Second, the quality of a product relative to its cost also matters. In many common demand systems, the market share of a product is a sufficient statistic for a product's quality relative to its price because any increase in quality or reduction in price will increase a product's market share by an amount determined by the demand system. In other words, products with low quality relative to their price will have low market shares, and products with high quality relative to their cost will have high market shares. For example, the market success of German beer relative to Chinese beer in the US market tells us that US consumers as a group think that spending a given amount of money on a bottle of German beer yields more utility than spending the same amount on a Chinese beer. Operationally, this means that the entry or exit of a variety with a large market share is going to have a much bigger impact on consumer welfare than the entry or exit of a product with a small market share. Therefore, we combine the market share of entering and exiting varieties with our assumed elasticity of substitution of 6 to compute the contribution of the entry and exit of varieties to changes in welfare over time.

Existing studies have found these effects of entry and exit on welfare to be substantial. Using a demand system with a constant elasticity of substitution between varieties and data on US imports from 1972 to 2001, Broda and Weinstein (2006) estimate the value to US consumers of the observed expansion in import variety to be 2.6 percent of GDP. Using a more flexible demand system that allows for procompetitive effects of international trade on domestic prices, Feenstra and Weinstein (2017) estimate that international trade raised US welfare by 0.9 percent between 1992 and 2005, with product variety contributing one-half of that total. In the case of the tariffs introduced by the Trump administration, the decline in variety, while clearly visible in Figure 6, is much more modest than the secular growth in US import variety over time.[12] When variety is taken into account, the effect of tariffs on prices is larger than the simple pass-through regressions suggest, but the effect of less variety in terms of higher prices is probably less than one-tenth of the overall rise in prices caused by the higher tariffs.

Conclusion

Conventional trade models provide a powerful framework for understanding how tariffs affect prices, quantities, and welfare. We find that the US import tariffs were almost completely passed through into US domestic prices in 2018, so that the entire incidence of the tariffs fell on domestic consumers and importers up to now, with no impact so far on the prices received by foreign exporters.

The deleterious impacts of the tariffs imposed by the Trump administration in 2018 have been largely in line with what one might have predicted on the basis of a simple supply and demand framework. During 2018, prices of US-made intermediate and final goods rose significantly in sectors affected by the tariffs relative to unaffected sectors, and the US economy experienced large changes to its supply-chain

[12] In the online Appendix available with this article at the *Journal of Economic Perspectives* website, we derive the key expression for the common variety price index and the variety adjustment for entry and exit and provide an illustrative regression showing the magnitude of the decrease in variety.

network, reductions in the availability of imported varieties, and complete pass-through of the tariffs into domestic prices of imported goods. We estimate the cumulative deadweight welfare cost (reduction in real income) from the US tariffs to be around $8.2 billion during 2018, with an additional cost of $14 billion to domestic consumers and importers in the form of tariff revenues transferred to the government. The deadweight welfare costs alone reached $1.4 billion per month by December 2018. These estimates are in line with the findings of a growing number of studies of the 2018 tariffs, including Fajgelbaum et al. (2019), Flaaen, Hortaçsu and Tintelnot (2019), and Cavallo et al. (2019).

Our estimates are likely to be a conservative measure of the losses from the tariff increases of 2018 for several reasons. Reductions in the range of varieties available for consumption should also be taken into account. The redirection or loss of trade may require firms to incur fixed costs in reorganizing their global supply chains (such as the creation of new production facilities). We have also omitted the potentially considerable costs of policy uncertainty, as emphasized by Handley and Limão (2017) and Pierce and Schott (2016). These costs of higher uncertainty may be reflected in the substantial falls in US and Chinese equity markets around the time of some of the most important trade policy announcements.

On the other hand, the absence of terms of trade effects in the 2018 data remains a puzzle, especially in light of prior work on exchange rate pass-through and export supply curves. If we start to see foreign firms absorbing more of the tariff duties, we may see the costs of these tariffs fall in future years. Understanding why the United States bore virtually all of the cost of its 2018 import tariffs is therefore likely to be a topic for much future research.

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