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How did China's WTO entry affect U.S. prices?☆

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ABSTRACT

We analyze the effects of China's rapid export expansion following its WTO entry on the U.S. prices of manufacturing goods between 2000 and 2006, exploiting cross-industry variation in trade liberalization. Lower input tariffs in China lowered costs and, in conjunction with reduced U.S. tariff uncertainty, expanded China's export participation. WTO entry therefore led to lower effective prices for Chinese exports, and we find a substantial reduction in the prices of other countries selling to the U.S., too. The largest contribution to the overall price reduction comes from lower inputs tariffs in China, with further price reductions caused by the reduction in tariff uncertainty. Other policy reforms such as the elimination of U.S. quotas under the Multifibre Agreements and of Chinese export controls also reduced prices.

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1. Introduction

China's manufacturing export growth in the last 20 years has produced a dramatic realignment of world trade, with China emerging as the world's largest exporter. China's export growth was especially rapid following its World Trade Organization (WTO) entry in 2001, with the 2001–2006 growth rate of 30% per annum being more than double the growth rate in the previous

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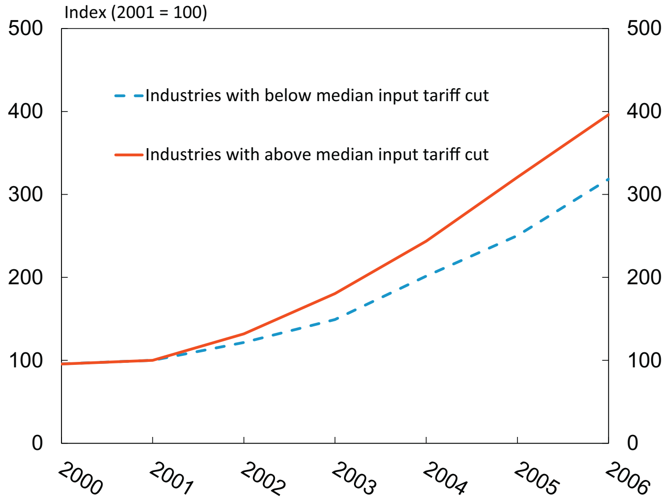

Fig. 1. China's U.S. exports and China's input tariffs.
Notes: The median input tariff cut over the sample period was 4.8 percentage points. The export industries with above-median input tariff cuts (from −4.8 to −12.9 percentage points) increased their export share from 66% of total to 71%.

five years. This growth has been so spectacular that it has attracted increasing attention to the negative effects of the China "trade shock" on other countries, such as employment and wage losses in import-competing U.S. manufacturing industries (Autor et al. (2013), Acemoglu et al. (2016), and Pierce and Schott (2016)). Surprisingly, given the traditional focus of international trade theory, little analysis has been made of the potential gains to consumers of products, whether households or firms, in the rest of the world, who could benefit from access to cheaper Chinese imports and more imported varieties. Our focus is on potential benefits to consumers in the U.S., where China accounts for more than 20% of imports. In principle, gains could be driven by two distinct policy changes that occurred with China's WTO entry. The first, which has received much attention in the literature, is the U.S. granting permanent normal trade relations (PNTR) to China, reducing the threat of China facing very high tariffs on its exports to the U.S. A second channel we identify is China reducing its own input tariffs. In this paper, we quantify how China's WTO entry affected the prices of U.S., Chinese and other countries' firms selling manufactured goods in the U.S. market, and we find that an important cause of these effects was China lowering its own tariffs on intermediate inputs.

To motivate our analysis, in Fig. 1 we plot Chinese exports to the U.S. in industries above and below the median input tariff cut of 4.6 percentage points. With exports of both bins indexed at 100 in 2001, we see substantially faster export growth in industries with larger reductions in their input tariffs. To understand where this faster growth might be coming from, in Table 1 we report a regression of the log-change in HS 6-digit unit values of China's exports to the U.S. between 2000 and 2006 on the corresponding change in Chinese input tariffs for that industry. Column 1 reports a simple OLS regression, and shows that Chinese input tariff reductions are strongly associated with reductions in their export prices. In column 2 we employ a simple IV regression strategy from Goldberg and Pavcnik (2005), exploiting the fact that the size of the tariff reduction is primarily determined by the pre-existing tariff level, so that the pre-existing input tariff is a valid instrument for the change in that tariff. The association between the fall in input tariffs and in export prices is slightly stronger in the IV results, with a coefficient on the change in the input tariff rising from 3.6 to 3.9.

The goal of this paper is to exploit detailed firm-level Chinese data to analyze the results illustrated in Fig. 1 and Table 1. Specifically, we are interested in the impact of China's export growth following its WTO accession on U.S. prices. To measure China's impact, we utilize Chinese firm-product-destination level export data for the years 2000 to 2006, during which China's exports to the U.S. increased nearly four-fold. One striking feature is that the extensive margin of China's U.S. exports accounts for 84% of export growth, mostly due to new firms entering the export market (69% of total growth) rather than incumbents exporting new products (15% of total growth).[1] To ensure we properly incorporate new varieties in measuring price indexes, we construct an exact CES price index, as in Feenstra (1994) which comprises a "price" and a "variety" component.[2] We supplement the Chinese data with U.S. reported trade data for imports from other foreign countries and U.S. domestic sales data to construct overall U.S. price indexes for manufacturing industries. With these data, we explicitly take into account that the China shock affects competitors' prices and net entry into the U.S. market.

We find that China's WTO entry reduced U.S. manufacturing industry price indexes in the median industry by 8.0% between 2000 and 2006, relative to an industry that was not directly exposed to trade reforms. That effect comes from lower effective prices for Chinese exports, and from a substantial reduction in the prices of other countries selling to the U.S., too. The biggest contribution to the overall price reduction comes from lower inputs tariffs in China, while a large contribution also comes from

[1] Though not the focus of our analysis, it is interesting to note that the patterns are similar for Chinese exports to non-U.S. countries: the extensive margin of exporting is 82%, mostly due to the new firm margin; and the corresponding coefficient on the input tariff in the regression in Table 1 is positive and significant, equal to 2.2.
[2] Broda and Weinstein (2006) built on this methodology to estimate the size of the gains from importing new varieties into the U.S. In contrast to that paper, we observe Chinese varieties within detailed trade categories at the firm level.

Table 1
Export prices and input tariffs: 2000–2006.

Dependent variable	$\Delta ln(price_g)$	
	OLS	IV
	(1)	(2)
$\Delta ln(Input\tau_{gt})$	3.606***	3.883***
	(1.061)	(1.231)
# obs.	3167	3167

Notes: The dependent variable is the log-change in the unit value of goods exported from China to the U.S. at the HS 6-digit level, calculated from Chinese reported data for 2000 and 2006. The explanatory variable is the change in Chinese tariffs on intermediate inputs, and the IV used in column (2) is the initial input tariff level. * significant at 10%; ** significant at 5%; *** significant at 1%.

the reduction in tariff uncertainty. Other policy reforms such as the elimination of U.S. quotas under the Multifibre Agreement (MFA) and of Chinese export controls had added impacts on reducing prices. We conclude that the lowering of China's own input tariffs and the granting of PNTR were important sources of price declines in the United States. Other trade policy reforms helped to push down prices further.

Our paper draws on several lines of literature. Pierce and Schott (2016), Handley and Limão (2017) and Feng et al. (2017) study the effect of granting PNTR to China, but they do not study the input tariff reduction channel.[3] A second literature finds that lower input tariffs increase firms' total factor productivity (e.g., Amiti and Konings (2007) for Indonesia; Kasahara and Rodrigue (2008) for Chile; Goldberg et al. (2010) for India; Halpern et al. (2015) for Hungary; Yu (2015) and Brandt et al. (2017) for China) and therefore lower prices. While we are guided by that literature, we do not estimate the impact of lower input tariffs on productivity since our main interest is in the impact on Chinese exporters' prices abroad.[4] Rather, we will examine the impact of China's reduction in its own imported input tariffs and its WTO entry on the prices of Chinese exporters to the U.S. and the effect on other prices in that market.

A limitation of our study is that we consider only the direct benefits to the firms and households purchasing imports, and the competitive effect on U.S. prices, but we do not attempt to trace these price effects through an input-output table and into the labor market, as would be needed to evaluate the overall welfare gains to the U.S. from China's WTO entry. That broader question requires a computable model. For example, Hsieh and Ossa (2016) calibrate a multi-country model with aggregate industry data at the two-digit level, and find that China transmits small gains to the rest of the world.[5] More recently, Caliendo et al. (2019) combine a model of heterogeneous firms with a dynamic labor search model. Calibrating this to the United States, they find that China's export growth created a loss of about 550,000 manufacturing jobs, but still increased aggregate U.S. welfare by 0.2% in the long-run. Both of these papers rely on the assumption of the Arkolakis et al. (2012) (ACR) framework of a Pareto distribution for firm productivities. In contrast, our approach does not rely on a particular distribution of productivities, and also differs from ACR in that we focus on the channels through which trade policy changes in one country (China) lead to consumer gains in another (the United States).

Our paper is organized as follows. Section 2 presents our key assumptions about U.S. consumers and presents a simple model of Chinese exporting firms. Section 3 discusses the data on Chinese exports to the U.S. and the tariffs faced by those firms, as well as data used for other countries selling in the U.S. An obvious problem with the data used in Table 1 is that the prices are in fact *unit values* for China's exports to the United States in each HS6 category. Those unit values could be falling due to the reduction in Chinese tariffs on imported inputs if new exporters are selling lower-priced (and possibly lower-quality) goods, thereby pulling down the unit values. To correct for this limitation, the data that we shall use for Chinese export prices to the United States comes from firm-level prices of those Chinese firms, which allows us to exclude the prices of new firms that begin exporting. We will incorporate those new firms, however, by constructing measures of Chinese import variety into the United States that reflect those new Chinese exporters, as described in section 3.1. We will incorporate that measure of Chinese import variety into the "effective prices" faced by U.S. consumers. For U.S. purchases from countries *other than* China, i.e. purchases from domestic U.S. firms and from other countries' exporters, we will not have the same level of detail as for the Chinese firms, but we will still attempt to construct measures of product variety in addition to the product prices from these countries.

[3] Bai and Stumpner (2019) study total import penetration into the U.S. by industry, and show that increased import shares are associated with lower consumer prices in related AC Nielsen consumer goods categories. Their instrument for import penetration into the U.S. is Chinese product penetration into leading European markets; they are therefore agnostic on the underlying causes of rising import penetration. Jaravel and Sager (2018) match Bureau of Labor Statistics CPI microdata with international trade flows and find that a one percentage point increase in Chinese import penetration leads to a three percentage point fall in the CPI in that industry. They instrument for Chinese import penetration using either the "gap" between US MFN tariffs and "column 2" tariffs or Chinese import penetration in other countries.

[4] In our working paper, Amiti et al. (2018), we show that China's input tariff reductions lower firms' costs both directly (through lower prices of materials) and indirectly (through higher measured TFP), both of which contribute to their lower export prices. We also find evidence consistent with Kee and Tang (2016) that lower input tariffs reduce the price of inputs sold by competing domestic producers and expand the range of domestic input varieties. Lower costs lead to lower export prices and more export participation.

[5] In a multi-country general equilibrium model, di Giovanni et al. (2014) find that the welfare impact of China's integration is larger when its growth is biased towards its comparative disadvantage sectors.

Section 4 constructs overall U.S. manufacturing industry price indexes for China and other countries, and estimates the impact of China's WTO accession and its own lowering of tariffs on imported inputs on U.S. prices. There we find the reduction in U.S. industry price indexes by a median value of 8.0% between 2000 and 2006, with greater reductions for intermediate inputs than for final goods. We check the robustness of our results to other policy reforms and to industry controls. It is not just the average reduction in prices that we are interested in, of course, but also the variation in those price reductions across industries. We show that the cross-industry variation in price reductions has explanatory power for the change in the Chinese import share within U.S. consumption, and for the change in U.S. industry employment. Section 5 concludes.

2. Theoretical framework

2.1. U.S. consumers

By U.S. "consumers" we mean either households or firms that purchase manufactured goods from U.S. or foreign firms, as many traded goods are intermediate inputs rather than final consumption goods. The goal of our paper is to measure the overall price decline in those goods due to China's accession to the WTO, including China's own reduction in Chinese tariffs on imported intermediate inputs. The price declines for U.S. consumers can be either a direct fall in price or an "effective" fall in price that comes from greater *variety* available. We will incorporate both these direct changes in price and the effective changes – through product variety – into an overall U.S. manufacturing price index. In this section we describe the theory underlying the construction of this overall price index.

We shall assume a nested CES utility function for the representative U.S. consumer (i.e. either a household or a firm). At the upper level, the utility from consuming goods $g \in G$ in the U.S. in period t is

$$U_t = \left(\sum_{g \in G} \alpha_g \left(Q_{gt} \right)^{\frac{\kappa - 1}{\kappa}} \right)^{\frac{\kappa}{\kappa - 1}}, \tag{1}$$

where g denotes an Harmonized System (HS) 6-digit industry, G denotes the set of HS 6-digit codes; Q_{gt} is aggregate U.S. consumption of good g in period t; $\alpha_g > 0$ is the taste parameter for the aggregate good g; and κ is the elasticity of substitution across goods. Good g is a CES aggregate of HS6 goods from each country i:

$$Q_{gt} = \left(\sum_{i \in I_{gt}} \alpha_g^i \left(Q_{gt}^i \right)^{\frac{\sigma_g - 1}{\sigma_g}} \right)^{\frac{\sigma_g}{\sigma_g - 1}}, \tag{2}$$

where Q_{gt}^i is aggregate U.S. consumption in industry g of varieties produced by country $i \in I_{gt}$; $\alpha_g^i > 0$ is the taste parameter or quality for the goods in industry g purchased from country i; and $\sigma_g > 1$ is the elasticity of substitution between these aggregate country goods.

Each country's aggregate good is a CES aggregate of disaggregate varieties. Denoting consumption of the finest-classification of product varieties by $q_{gt}^i(\omega)$, aggregate U.S. consumption of country i output in industry g is:

$$Q_{gt}^i = \left(\sum_{\omega \in \Omega_{gt}^i} q_{gt}^i(\omega)^{\frac{\rho_g - 1}{\rho_g}} \right)^{\frac{\rho_g}{\rho_g - 1}}, \tag{3}$$

where Ω_{gt}^i is the set of varieties; and ρ_g is the elasticity of substitution between varieties in sector g, with $\rho_g > \sigma_g > 1$. In practice, we can think of the finest-classification of product varieties as individual products sold by firms, which in our Chinese data will be 8-digit Harmonized System (HS) products sold by Chinese firms to the United States.[6] The CES price index that is dual to (3) is:

$$P_{gt}^i = \left(\sum_{\omega \in \Omega_{gt}^i} p_{gt}^i(\omega)^{1-\rho_g} \right)^{\frac{1}{1-\rho_g}}. \tag{4}$$

[6] Thus, a variety is defined in the Chinese data as a firm-HS8 product. As noted below, for other countries selling to the United States we do not have the firm-level data, so for these other countries a variety is defined as a 10-digit HS product.

From Eq. (4) it follows that the share of product variety ω within the exports of country i is:

$$s_{gt}^{i}(\omega) \equiv \left(\frac{p_{gt}^{i}(\omega)q_{gt}^{i}(\omega)}{\sum_{\omega\in\Omega_{gt}^{i}} p_{gt}^{i}(\omega)q_{gt}^{i}(\omega)}\right) = \left(\frac{p_{gt}^{i}(\omega)}{P_{gt}^{i}}\right)^{1-\rho_g}. \tag{5}$$

These equations represent the U.S. demand for the products of Chinese firms, as well as exporters from other countries. Notice that as there are more products sold by Chinese firms (country i), then the set of products Ω_{gt}^{i} in (4) expands and with $\rho_g > 1$ the CES price index P_{gt}^{i} falls. So expanding product variety from the entry of Chinese exporters, as well as lower prices from these firms, will lower the price index facing U.S. consumers. In the following section we discuss how we construct the price index for Chinese exporters and following that, in section 2.3, we discuss the price index for other countries selling into the United States and the overall price index.

2.2. Measuring the U.S. CES Price index for Chinese imports

Our goal is to compute a price index that accurately reflects the nested CES structure in section 2.1. We start with Eq. (4) for country $i = China$ and consider two equilibria with CES price indexes P_{gt}^{i} and P_{g0}^{i}, which reflect different prices $p_{gt}^{i}(\omega)$ and $p_{g0}^{i}(\omega)$ and also differing sets of varieties Ω_{gt}^{i} and Ω_{g0}^{i}. We assume that these two sets have a non-empty intersection of varieties, denoted by $\overline{\Omega}_{g}^{i} = \Omega_{gt}^{i} \cap \Omega_{g0}^{i}$. We refer to the set $\overline{\Omega}_{g}^{i}$ as the "common" varieties, available in periods t and 0. Feenstra (1994) shows that the ratio of the price indexes P_{gt}^{i} and P_{g0}^{i} for China can be measured, as:

$$\frac{P_{gt}^{i}}{P_{g0}^{i}} = \left[\prod_{\omega\in\overline{\Omega}_{g}^{i}} \left(\frac{p_{gt}^{i}(\omega)}{p_{g0}^{i}(\omega)}\right)^{w_{gt}^{i}(\omega)}\right] \left(\frac{\lambda_{gt}^{i}}{\lambda_{g0}^{i}}\right)^{\frac{1}{\rho_g - 1}}, \ i = China, \tag{6}$$

where $w_{gt}^{i}(\omega)$ are the Sato-Vartia weights at the variety level, defined using the shares $\overline{s}_{gt}^{i}(\omega)$ within the common set,

$$w_{gt}^{i}(\omega) \equiv \frac{\left(\overline{s}_{gt}^{i}(\omega) - \overline{s}_{g0}^{i}(\omega)\right) / \left(\ln \overline{s}_{gt}^{i}(\omega) - \ln \overline{s}_{g0}^{i}(\omega)\right)}{\sum_{\omega\in\overline{\Omega}_{g}^{i}} \left(\overline{s}_{gt}^{i}(\omega) - \overline{s}_{g0}^{i}(\omega)\right) / \left(\ln \overline{s}_{gt}^{i}(\omega) - \ln \overline{s}_{g0}^{i}(\omega)\right)}, \ \overline{s}_{gt}^{i}(\omega) \equiv \frac{p_{gt}^{i}(\omega)q_{gt}^{i}(\omega)}{\sum_{\omega\in\overline{\Omega}_{g}^{i}} p_{gt}^{i}(\omega)q_{gt}^{i}(\omega)}, \tag{7}$$

and

$$\lambda_{gt}^{i} \equiv \frac{\sum_{\omega\in\overline{\Omega}_{g}^{i}} p_{gt}^{i}(\omega)q_{gt}^{i}(\omega)}{\sum_{\omega\in\Omega_{gt}^{i}} p_{gt}^{i}(\omega)q_{gt}^{i}(\omega)} = 1 - \frac{\sum_{\omega\in\Omega_{gt}^{i}\setminus\overline{\Omega}_{g}^{i}} p_{gt}^{i}(\omega)q_{gt}^{i}(\omega)}{\sum_{\omega\in\Omega_{gt}^{i}} p_{gt}^{i}(\omega)q_{gt}^{i}(\omega)}, \tag{8}$$

and likewise for $\overline{s}_{g0}^{i}(\omega)$ and λ_{g0}^{i}, defined as above for $t = 0$.

The first term in Eq. (6) is constructed in the same way as a conventional Sato-Vartia price index – it is a geometric weighted average of the price changes for the set of varieties $\overline{\Omega}_{g}^{i}$, with log-change weights. The second component comes from Feenstra (1994) and takes into account net variety growth: λ_{gt}^{i} equals one minus the share of expenditure on new products, in the set Ω_{gt}^{i} but not in $\overline{\Omega}_{g}^{i}$, whereas λ_{g0}^{i} equals one minus the share of expenditure on disappearing products, in the set Ω_{g0}^{i} but not in $\overline{\Omega}_{g}^{i}$. A lower λ ratio implies more net variety, and hence a lower price index.[7]

2.3. Measuring the aggregate U.S. CES price index for other countries

While Eq. (6) provides us with an exact price index for varieties sold from country $i = China$ to the U.S., we also want to incorporate all other countries selling good g. This can be done in principle by using the exact price index for every other country, as we have done for China. But we are not able to implement that approach because we do not have the firm-level export data for all other countries. Instead, for countries exporting to the U.S. other than China we will use their unit-values at the HS 10-digit level, and we will measure the product variety of these HS 10-digit products *within* each HS 6-digit industry. That is, for each HS 6-digit industry, we construct the variety terms λ_{gt}^{j} for the HS 10-digit products exported by each country to the U.S. and the change in variety using Eq. (8). We also construct the Sato-Vartia index over the "common" unit-values $uv_{gt}^{j}(\omega)$ for HS10-digit categories $\omega \in \overline{\Omega}_{g}^{j}$ within each HS 6-digit industry, exported by each country other than China in the periods t and 0. For

[7] Note that the quality of products in the "common" set $\overline{\Omega}_{g}^{i}$, as reflected by their taste parameters $\alpha_{g}^{i}(\omega)$, is assumed to be constant over time, but products outside this set and appearing within the λ_{gt}^{i} terms can have changing quality. To achieve this in theory we can choose $\overline{\Omega}_{g}^{i}$ as any non-empty *subset* of $\Omega_{gt}^{i} \cap \Omega_{g0}^{i}$ for which the products have constant quality, and the price index formulas above continue to hold true (see Feenstra (1994)). In practice, however, it is hard to know which products have constant quality, so we shall simply use $\overline{\Omega}_{g}^{i} = \Omega_{gt}^{i} \cap \Omega_{g0}^{i}$.

these other exporters, we therefore measure,

$$\frac{P_{gt}^{j}}{P_{g0}^{j}}=\left[\prod_{\omega\in\overline{\Omega}_g^{j}}\left(\frac{uv_{gt}^{j}(\omega)}{uv_{g0}^{j}(\omega)}\right)^{w_{gt}^{j}(\omega)}\right]\left(\frac{\lambda_{gt}^{j}}{\lambda_{g0}^{j}}\right)^{\frac{1}{\rho_g-1}},\ j\neq i. \tag{9}$$

We will aggregate over these U.S. import price indexes from all source countries j, including the U.S. itself, using Sato-Vartia price weights defined over countries. Denoting the non-empty intersection of countries selling in industry g to the U.S. in period t and period 0 by $\overline{I}_g=I_{gt}\cap I_{g0}$, which we call the "common" countries, the Sato-Vartia weights at the country-industry level are

$$W_{gt}^{j}=\frac{\left(\overline{S}_{gt}^{j}-\overline{S}_{g0}^{j}\right)/\left(\ln\overline{S}_{gt}^{j}-\ln\overline{S}_{g0}^{j}\right)}{\sum_{k\in\overline{I}_{gt}}\left(\overline{S}_{gt}^{k}-\overline{S}_{g0}^{k}\right)/\left(\ln\overline{S}_{gt}^{k}-\ln\overline{S}_{g0}^{k}\right)},\quad \text{with}\quad \overline{S}_{gt}^{j}\equiv\frac{P_{gt}^{j}Q_{gt}^{j}}{\sum_{k\in\overline{I}_g}P_{gt}^{k}Q_{gt}^{k}},\ j\in\overline{I}_g. \tag{10}$$

The share of countries selling to the U.S. in both period t and period 0 is,

$$\Lambda_{gt}\equiv\frac{\sum_{j\in\overline{I}_g}P_{gt}^{j}Q_{gt}^{j}}{\sum_{j\in I_{gt}}P_{gt}^{j}Q_{gt}^{j}}. \tag{11}$$

Then we can write the change in the overall U.S. price index for industry g as,

$$\frac{P_{gt}}{P_{g0}}=\left[\prod_{j\in\overline{I}_g^{j}}\left(\frac{P_{gt}^{j}}{P_{g0}^{j}}\right)^{W_{gt}^{j}}\right]\left(\frac{\Lambda_{gt}}{\Lambda_{g0}}\right)^{\frac{1}{\sigma_g-1}}. \tag{12}$$

The second term on the right of (12) accounts for countries that begin exporting to the U.S. in industry g during the 2000–2006 period, or who drop out due to competition from China, for example if a country j selling to the U.S. in the base period drops out entirely and no longer sells in period t, then that will lower Λ_{g0}^{j} and raise the price index in (12). Provided that the loss in variety from exiting firms and exiting countries is not greater than the gain in variety due to entering Chinese firms, then there will still be consumer variety gains due to the expansion of Chinese trade following its WTO entry. The overall price index (12) accounts for all these offsetting effects, and it will be the basis for our calculations of U.S. prices.

Using all the above equations, we can decompose this industry g price index as,

$$\begin{aligned}\ln\frac{P_{gt}}{P_{g0}}=&\,W_{gt}^{i}\,\ln\left[\underbrace{\prod_{\omega\in\overline{\Omega}_g^{i}}\left(\frac{p_{gt}^{i}(\omega)}{p_{g0}^{i}(\omega)}\right)^{w_{gt}^{j}(\omega)}}_{ChinaP_g}\right]+\left(1-W_{gt}^{i}\right)\ln\prod_{j\in\overline{I}_g\setminus i}\left[\underbrace{\prod_{\omega\in\overline{\Omega}_g^{k}}\left(\frac{uv_{gt}^{j}(\omega)}{uv_{g0}^{j}(\omega)}\right)^{w_{gt}^{j}(\omega)}}_{OtherP_g^{j}}\right]^{\frac{W_{gt}^{j}}{\left(1-W_{gt}^{i}\right)}}\\&+W_{gt}^{i}\,\ln\left[\underbrace{\left(\frac{\lambda_{gt}^{i}}{\lambda_{g0}^{i}}\right)^{\frac{1}{\rho_g-1}}}_{ChinaV_g}\right]+\left(1-W_{gt}^{i}\right)\ln\prod_{j\in\overline{I}_g\setminus i}\left[\underbrace{\left(\frac{\lambda_{gt}^{j}}{\lambda_{g0}^{j}}\right)^{\frac{1}{(\rho_g-1)}}\left(\frac{\Lambda_{gt}}{\Lambda_{g0}}\right)^{\frac{1}{(\sigma_g-1)}}}_{OtherV_g^{j}}\right]^{\frac{W_{gt}^{j}}{\left(1-W_{gt}^{i}\right)}}.\end{aligned} \tag{13}$$

The first term on the right is the Sato-Vartia price index for Chinese exports to the U.S., denoted by $ChinaP_g$ and multiplied by China's relative country weight W_{gt}^{i} from (10). We often refer to this term as the *common-goods price index* for China, because it is constructed over the "common" products in 2000 and 2006. The second term is the common-goods price index constructed over the unit-values $uv_{gt}^{j}(\omega)$ in industry g for *all other* exporting countries, denoted by $OtherP_g^{j}$, and multiplied by the weight $(1-W_{gt}^{i})$ for all those other countries. The third term $ChinaV_g$ is the gain from increased varieties from China, constructed using Chinese firm-level export data. The fourth term $OtherV_g^{j}$ is the combined effective price effect of changing variety at the HS 6-digit level from other countries j, adjusted by the variety term for new countries exporting to the U.S. as discussed just above.

So far, our discussion in this section has dealt with countries *other than* China exporting to the United States, but we have not discussed U.S. firms themselves selling in their own market, which we also include in the "Other" components. For sales of U.S.

firms our data are more limited than for exporting firms from other countries and especially limited as compared to Chinese exporting firms. We did not have access to any firm-level information for U.S. firms, so for their price indexes denoted by uv_{gt}^{j} in (13) we simply use the Producer Price Indexes (PPI) at a higher level of aggregation than the HS 6-digit industries g. For the U.S. variety term in each industry, we follow Feenstra and Weinstein (2017) and use the share of sales accounted for by the largest four firms, which is a valid measure of λ_{gt}^{j} if these are the same firms over time in each industry.[8]

To aggregate over goods, we follow Broda and Weinstein (2006) and again use the Sato-Vartia weights, now defined at the industry level as:

$$W_{gt} = \frac{\left(S_{gt} - S_{g0}\right)/\left(\ln S_{gt} - \ln S_{g0}\right)}{\sum_{g \in G}\left(S_{gt} - S_{g0}\right)/\left(\ln S_{gt} - \ln S_{g0}\right)}, \text{ with } S_{gt} \equiv \frac{P_g Q_g}{\sum_{g \in G} P_g Q_g}. \tag{14}$$

The U.S. price indexes that we construct in this way reflect the U.S. prices of manufactured goods in each industry g, which as we have noted, is defined by an HS6 category. Further discussion on how we will construct the price and variety indexes is in section 3.1, and details on the data sources are provided in Appendix A.

2.4. Model of Chinese exporting firms

The goal of our empirical work will be to see how the four components of the U.S. industry price index in (13) are related to two policy changes that impacted Chinese firms exporting to the US: (i) the reduction in Chinese tariffs on intermediate inputs used by Chinese exporters (and by all other Chinese firms); and (ii) the granting of PNTR to China, which eliminated the risk that Chinese exports would face high, "column 2" tariffs. Let us assume in this section that firms sell a single variety, so we change the notation from ω (denoting varieties) to φ_t (denoting the productivity of a firm in year t). Thus, $p_t(\varphi_t)$ is the price of a product exported to the United States measured inclusive of U.S. tariffs, where one plus the *ad valorem* tariff is denoted by τ_{gt}. We drop the country superscript i used earlier, since we are focusing on Chinese exporting firms, and for brevity we will also drop the industry subscript g except when dealing with industry-level variables such as the tariff. In this notation, the firm share $s_{gt}^{i}(\omega)$ appearing in Eq. (5) is re-written more compactly as $s_t(\varphi_t)$. Write the marginal costs for this firm as:

$$c\left(P_t^D, P_t^M, \varphi_t\right), \tag{15}$$

where P_t^D is the price index of domestic intermediate inputs (including labor) and P_t^M is the price index of imported intermediate inputs.

We suppose that Chinese firms act as Bertrand or Cournot oligopolists in the U.S. market and we recognize that a change in their prices can have an impact on the country price index in (4). In that case, the perceived elasticity of demand for a firm under Bertrand competition is $\eta_t(\varphi_t) = \sigma_g s_t(\varphi_t) + \rho_g(1 - s_t(\varphi_t))$, and under Cournot competition is $\eta_t(\varphi_t) = [\sigma_g^{-1} s_t(\varphi_t) + \rho_g^{-1}(1 - s_t(\varphi_t))]^{-1}$. The firm's price is obtained as a markup over marginal costs:

$$p_t(\varphi_t) = \frac{\eta_t(\varphi_t)}{(\eta_t(\varphi_t) - 1)} c\left(P_t^D, P_t^M, \varphi_t\right)\tau_{gt}, \tag{16}$$

where τ_{gt} is one plus the *ad valorem* U.S. tariff, as noted above. If more Chinese firms enter the U.S. market and the share of each firm falls, then the elasticity will rise (since $\rho_g > \sigma_g$), so that the markup over marginal costs also falls. This leads to a pro-competitive reduction in prices. Tariffs on Chinese inputs influence marginal costs through the price of these inputs P_t^M, with a reduction in the input tariff lowering marginal costs and therefore lowering producer prices $p_t(\varphi_t)$.

In principle, it is possible that a reduction in imported input tariffs has a *magnified* effect on lowering producer prices, for two reasons. The first is the pro-competitive effect just mentioned: it is possible in theory that a reduction in marginal costs leads to a more-than-proportional reduction in the price of the firm because competition increases and markups fall. That is what we observe in Table 1, for example, where Chinese input tariffs have a pass-through greater than unity on Chinese export prices to the U.S. That is not what Goldberg et al. (2010) find for India, however, where firms absorbed much of the reduction in input tariffs rather than passing it through to lower prices. But Goldberg et al. (2010) find a second reason for the prices of firms to fall due to the reduction in input tariffs in India, and that is because of the *greater variety of imported inputs,* which has a further impact on reducing the imported input price index P_t^M and therefore the producer prices p_t. Extending this evidence, Kee and Tang (2016) find that lower input tariffs in China reduced the price of inputs sold by *domestic* producers, and expanded the range of domestic input varieties. So the reduction in input tariffs not only lowers the imported input price index P_t^M, it can also lower the domestic input price index P_t^D, and in both cases an expanded variety of inputs adds to the effective reduction in input prices and therefore lowers producer prices p_t. So even without a pro-competitive effect, these explanations can account for the *magnified*

[8] This is a valid measure of λ_{gt}^{j} if these are the same firms over time in each industry because, as discussed in note 6, we can choose a subset of firms to form the "common" set over time. If the largest four firms in the industry are chosen, then it is their sales share that is used to construct λ_{gt}^{j}.

pass-through of imported input tariffs to the prices of Chinese exports to the U.S. as found in Table 1, as we discuss further in section 4.[9]

So far in this section we have focused on the prices charged by Chinese exporters when they face changing tariffs on intermediate inputs and a known U.S. tariff of τ_{gt}. We now extend that discussion to allow for uncertainty in the U.S. tariff, which we can incorporate using a simplified version of Handley and Limão (2017).[10] We suppose that the prices of Chinese exporters are chosen *after* uncertainty about the tariff is resolved. Then the quantity sold in the U.S. can be obtained from the CES demand function:

$$q_t(\varphi_t) = \left(\frac{p_t(\varphi_t)}{P_{gt}}\right)^{-\rho_g}\frac{X_{gt}}{P_{gt}}, \tag{17}$$

where X_{gt} is the expenditure on all varieties that the U.S. imports from China in HS 6-digit industry g, and P_{gt} is the price index for these imports (corresponding to P^i_{gt} in (4) but without the superscript $i = China$). Multiplying this equation by $p_t(\varphi_t)$ and using (16), we solve for firm exports:

$$p_t(\varphi_t)q_t(\varphi_t) = X_{gt}\left(\frac{\eta_t(\varphi_t)c_t(\varphi_t)\tau_{gt}}{(\eta_t(\varphi_t)-1)P_{gt}}\right)^{1-\rho_g}, \tag{18}$$

where $c_t(\varphi_t) \equiv c(P^D_t, P^M_t, \varphi_t)$ is the marginal cost given in (15).

The export revenue of the firm must be divided by τ_{gt} to reflect tariff payments, and then further divided by the elasticity $\eta_t(\varphi_t)$ to obtain firm variable profits. After deducting the per-period fixed costs of exporting denoted by F_g, the one-period profits of the firm is then:

$$v\left(\varphi_t, \tau_{gt}\right) = max\left\{\frac{X_{gt}}{\tau_{gt}\eta_t(\varphi_t)}\left(\frac{\eta_t(\varphi_t)C_t(\varphi_t)\tau_{gt}}{(\eta_t(\varphi_t)-1)P_{gt}}\right)^{1-\rho_g} - F_g, 0\right\}.$$

This expression is bounded below by zero because a firm with very low productivity will exit and not pay the fixed costs of F_g, therefore earning zero profits. If there were no uncertainty about tariffs and all other variables including productivity are treated as fixed, then we can use the per-period profits to solve for the free entry condition of an exporter as:

$$\int_\varphi v\left(\varphi, \tau_g\right)dG \geq F^E_g, \tag{19}$$

where $G(\varphi)$ is the distribution function of firm productivities, and paying the sunk cost of F^E_g allows the firm to draw its productivity φ.

The free entry condition (19) is very similar to Melitz (2003) except that we have allowed for sunk costs of *exporting*, so this is a forward-looking *export participation* decision that must be made by a firm. The form of the export participation condition changes, however, when there is uncertainty about tariffs. Suppose that the Chinese firm faces two possible values of the U.S. tariff $\tau_{gt} \in \{\tau^{MFN}_g, \overline{\tau}_g\}$, which are at either the MFN level or the alternative column 2 level $\overline{\tau}_g > \tau^{MFN}_g$. The firm's decision about its price is made after the tariff is known, as noted above, while the decision about whether to participate in the export market is made before the tariff is known, so the tariff is the key variable that changes over time.

We suppose for simplicity that if the tariff starts at its MFN level then it remains there in the next period with probability π, and with probability $(1 - \pi)$ the tariff moves to its column 2 level; whereas if the tariff starts at its column 2 level then it stays there forever. With a discount rate $\delta < 1$, and assuming for simplicity that the productivity of a firm does not change over time, the present discounted value of a Chinese firm facing MFN tariffs is,

$$V\left(\varphi, \tau^{MFN}_g\right) = v\left(\varphi, \tau^{MFN}_g\right) + \delta\left[\pi V\left(\varphi, \tau^{MFN}_g\right) + (1-\pi)V(\varphi, \overline{\tau}_g)\right].$$

Since $V(\varphi, \overline{\tau}_h) = v(\varphi, \overline{\tau}_h)/(1-\delta)$ by our assumption that the column 2 tariff is an absorbing state, we obtain the *export participation condition* for a Chinese firm facing MFN tariffs,

$$\int_\varphi V\left(\varphi, \tau^{MFN}_g\right)dG = \int_\varphi \left\{\frac{v\left(\varphi, \tau^{MFN}_g\right)}{(1-\delta\pi)} + \frac{\delta(1-\pi)v\left(\varphi, \overline{\tau}_g\right)}{(1-\delta)(1-\delta\pi)}\right\}dG \geq F^E_g. \tag{20}$$

[9] In our working paper, Amiti et al. (2018), we attempt to measure the variety of imported intermediate inputs available to Chinese exports. We find the expected positive relationship between this variety and the total factor productivity of exporters, but even controlling for this effect in Chinese firm-level data, still, the pass-through of input tariffs to producer prices is very similar to that found in Table 1.

[10] Our simplified treatment does not allow firms to upgrade their technology, as in Handley and Limão (2017), and draws on Feng et al. (2017).

This form of the free entry condition for Chinese exporters is quite different from that in (19), because the column 2 tariff $\overline{\tau}_g$ enters on the right. In Appendix C, we solve condition (20) and show that entry into exporting depends on the "gap" between the MFN and column 2 tariffs, defined by $Gap_g \equiv (\ \ln \overline{\tau}_g - \ \ln \tau_g^{MFN})$. To match U.S. and Chinese data we construct this gap at the HS 6-digit rather than 8-digit level, which we refer to as Gap_g. Provided that Chinese exporters make their pricing decisions *after* the U.S. MFN tariff is known, then the gap should not affect their pricing decisions, but it will have an impact on the entry of exporters.

So the conclusion from this section is that the first term on the right of (13), which we have denoted by $ChinaP_g$, should be related to the imported input tariffs as we have discussed above but not to the gap. The third term on the right of (13), which we have denoted by $ChinaV_g$ and reflects Chinese variety, should be related to *both* the input tariffs and the gap because the reduction in either of these will encourage entry of Chinese exporters. The second and fourth terms on the right of (13) reflect the price and variety terms for all other countries selling into the United States (including domestic firms), and can be indirectly influenced by the same variables that determine $ChinaP_g$ and $ChinaV_g$ due to competitive pressure across firms selling in the U.S. market. These hypotheses will be tested after we first review the data used to construct all these four terms, as well as the data used to construct the Chinese imported input tariffs and the gap variable.

3. Data preview

To calculate the U.S. manufacturing price index in Eq. (13), we need measures of China's export prices, other foreign export prices, U.S. domestic prices, measures of variety, and estimates of elasticities of substitution. For these, we utilize a number of different data sources. The first is from China Customs, providing annual trade data on values and quantities at the HS 8-digit level by firm-destination for the period 2000 to 2006. This covers the universe of Chinese exporters, and we restrict the sample to manufacturing products which we identify using a mapping to NAICS 2-digit codes in the range 31 to 33. We use these data to construct the China components of the overall U.S. price index as described in section 2.2. In the notation of that section, industries g are defined by HS6 categories, while the underlying products ω are at the Chinese firm-HS8 level. We aggregate over the common (firm-HS8) products from 2000 to 2006 to obtain the common-goods price index $ChinaP_g$, with the variety index $ChinaV_g$, as described in section 2.2 and in the next section.

Second, we supplement the China-reported trade data with U.S.-reported data in order to incorporate all other foreign countries and domestic U.S. firms. For U.S. imports from countries other than China we use customs data at the HS 10-digit-country level from the U.S. Census, and we construct the common-goods price index $OtherP_g$, with the variety index $OtherV_g$, using these HS10 observations within each HS6 industry as discussed in section 2.3. In the notation of that section, the underlying products ω for nonChina foreign countries are at the country-HS10 level. The use of the unit-values to construct the common-goods price index for these foreign countries is subject to the error normally associated with unit values, while the variety indexes for these foreign countries (constructed from HS10 but not firm-level data) have considerably less information than our Chinese variety indexes. Finally, for domestic sales by U.S. producers we use the U.S. producer price indexes (PPI) for the common-goods component of the price index, and domestic sales shares of the top 4 U.S. firms, also available from U.S. Census, for the variety component of the price index.[11] Both of these are at the NAICS 6-digit level, which we map to HS10 and then aggregate to our HS6 industries.

3.1. China's export variety

We now construct the variety component of the U.S. price index for Chinese imports. As shown in Table 2, China's manufacturing exports to the U.S. grew a spectacular 290% over the sample period, with growth rates of around 30% every year except in 2001. Determining how much of this growth comes from new varieties is very important for our study. We measure Chinese products at the HS 8-digit level for Chinese exporting firms, so that the index ω denotes an HS8-firm variety. The value of Chinese exports to the U.S. for this firm is $X_{gt}^i(\omega) \equiv p_{gt}^i(\omega) q_{gt}^i(\omega)$ in year t, and we decompose China's aggregate export growth to the U.S. as follows:

$$\frac{\sum_{\omega}\left[X_{gt}^i(\omega)-X_{g0}^i(\omega)\right]}{\sum_{\omega}X_{g0}^i(\omega)} = \frac{\sum_{\omega\in\overline{\Omega}}\left[X_{gt}^i(\omega)-X_{g0}^i(\omega)\right]}{\sum_{\omega}X_{g0}^i(\omega)} + \frac{\sum_{\omega\in\Omega_t\setminus\overline{\Omega}}X_{gt}^i(\omega)-\sum_{\omega\in\Omega_0\setminus\overline{\Omega}}X_{g0}^i(\omega)}{\sum_{\omega}X_{g0}^i(\omega)}, \tag{21}$$

where $\overline{\Omega} = \Omega_t \cap \Omega_0$ is the set of varieties (at the firm-product level) that were exported in t and $t = 0$, $\Omega_t \setminus \overline{\Omega}$ is the set of varieties exported in t but not in 0, and $\Omega_0 \setminus \overline{\Omega}$ is the set of varieties exported in t_0 but not in t. For convenience, we are summing over *all* HS8-firm varieties in these sets, without distinguishing the HS6-digit industries g. Eq. (21) is an identity that decomposes the total export growth into the intensive margin (the first term on the right) and the extensive margin (the last term), which we report in Table 2.

Surprisingly, most of the growth in Chinese exports for the U.S. arises from net variety growth. From the bottom of column 3, we see that the extensive margin accounts for 84% of export growth to the U.S. over the whole sample period (columns 2 and 3 sum to 100% of the total growth). We can further break down the extensive margin to see if it is driven by incumbent exporters

[11] See note 7.

Table 2
Decomposition of China's export growth to the U.S.

Year	Total export growth %	Intensive margin	Extensive margin	Extensive margin new firms	Extensive margin incumbents	Equivalent price change due to Chinese variety
	(1)	(2)	(3)	(4)	(5)	(6)
2001	4.8%	0.16	0.84	0.69	0.14	−0.025
2002	28.9%	0.57	0.43	0.21	0.21	−0.045
2003	32.4%	0.61	0.39	0.23	0.16	−0.069
2004	35.3%	0.66	0.34	0.23	0.12	−0.027
2005	29.2%	0.58	0.42	0.22	0.20	−0.070
2006	24.7%	0.66	0.34	0.20	0.14	−0.018
2000−2006	289.7%	0.16	0.84	0.69	0.15	−0.490

Notes: All these margins are calculated using manufacturing data concorded to HS 8-digit codes at the beginning of the sample. The sum of the intensive margin (column 2) and the extensive margin (column 3) equal 100%. The sum of the extensive margin of new firms (column 4) and the extensive margin of incumbent firms (column 5) equals the total extensive margin (column 3). Column 6 converts the variety gain in column 3 to the equivalent change in the price index i.e. the second term on the right of Eq. (6).

shipping new products or new firms exporting to the U.S. We see from columns 4 and 5 that the extensive margin is almost entirely driven by new exporters — 69% of the total export growth over the sample period comes from new firms while 15% is by incumbent firms exporting new products (columns 4 and 5 sum to the total extensive margin in column 3).[12]

Table 2 clearly shows that most of the growth in China's exports was due to new entrants into the U.S. export market, and this result is robust.[13] Rapid export variety growth leads to a large reduction in Chinese export prices due to the extensive margin, as reported in column 6, where we compute the year-to-year variety adjustment in the China price index and the variety gain over the whole sample period, 2000–2006, i.e. the second term in Eq. (6). The lambda ratios are raised to a power that includes the elasticity of substitution ρ_g, and then weighted across industries using appropriate weights.[14] So column 6 reports the effective drop in the U.S. import price index from China due to the new varieties, which amounts to −49 percent over 2000–2006. Notice that this total change at the bottom of column 6 is not the same as summing the year-to-year changes in the earlier rows, because the calculation for 2000–2006 is performed using the exports that are "common" to those two years. If there is a new variety exported from China in 2001, for example, then its growth in exports up to 2006 is attributed to variety growth; whereas in the earlier rows, only its initial growth of exports from 2001 to 2002 is attributed to variety growth.[15]

3.2. Trade liberalization

We focus on two major policy reforms upon China's WTO entry. First, when China joined the WTO in December 2001 it committed to bind all import tariffs at an average of 9%.[16] Although China had previously reduced tariffs, average tariffs in 2000 were still high at 15%, with a large standard deviation of 9%. Our objective is to determine the impact of China's lower imported intermediate input tariffs on Chinese firms' export prices. We follow the approach of Amiti and Konings (2007) by constructing tariffs on intermediate inputs, $Input\tau_{gt}$, using China's 2002 input-output (IO) tables. The most disaggregated IO table available is for 122 sectors, with 72 of these in manufacturing.[17] We take the HS 8-digit Chinese import tariff data, which are MFN ad valorem rates, and calculate the simple average of these at the IO industry level. The input tariff for each industry g is the weighted average of these IO industry tariffs, using the cost shares in China's IO table as weights.[18] Average tariffs for each year are reported in Table 3. Input tariff levels fell on average by 40% (5 percentage points) over this period and their dispersion also declined. In general, the largest declines in tariffs were in products with the highest initial tariffs. The correlation between the 2000–2006 change in input tariffs and the 2000 level is −0.7.

Input tariffs in the fifth percentile of the industry distribution fell by more than 9 percentage points. Lower input tariffs can benefit Chinese firms by reducing their marginal costs and increasing total factor productivity as they access more imported

[12] Nearly all of these new exporters were already operating in China.

[13] Given that some firms change their identifier over time due to changes of firm type or legal person representatives, we tracked firms over time (using information on the firm name, zip code and telephone number) to ensure that the firm maintains the same identifier. This affects 5% of firms and hardly changes the size of the extensive margin. Even if our algorithm for tracking reclassifications has missed some identifier changes for incumbent firms due to, for example, mergers and acquisitions, our approach to measuring the gains from Chinese firm entry into the U.S. market is driven by *net* entry, which is largely unaffected by reclassifications of product codes or firm codes, as the new entry due to reclassifications would be offset by the exit. See Table AppendixA1 for the number of Chinese exporters by year.

[14] We use the industry-level Sato-Vartia weights, defined in equation (14). The estimation of the elasticities of substitution ρ_g is described in AppendixB, and these elasticities are reported in Appendix Table B3.

[15] This method of using a "long difference" to measure variety growth is consistent with the theory outlined in section 2.1, as it allows for increases in the U.S. taste parameter for that Chinese export variety in the intervening years as it penetrates the U.S. market; see note 7.

[16] See wto.org for more details.

[17] This is preferable to constructing firm-level tariffs, which can only be constructed using import shares rather than overall cost shares of each input and would induce an endogeneity bias.

[18] We thank Rudai Yang from Peking university for the mapping from IO to HS codes, which he constructed manually based on industry descriptions. We include both manufacturing and nonmanufacturing inputs and drop "waste and scrapping".

Table 3
Average tariffs.

Year	Output tariff		Input tariff		Gap	
	Average	Std Dev	Average	Std Dev	Average	Std Dev
	(1)	(2)	(3)	(4)	(5)	(6)
2000	0.15	0.09	0.13	0.04	0.26	0.14
2001	0.14	0.09	0.13	0.05	0.26	0.14
2002	0.11	0.07	0.10	0.04	0	0
2003	0.11	0.07	0.09	0.04	0	0
2004	0.10	0.06	0.09	0.03	0	0
2005	0.09	0.06	0.08	0.03	0	0
2006	0.09	0.06	0.08	0.03	0	0
2006–2000	−0.06	0.07	−0.05	0.03		

Notes: All tariffs are defined as the log of 1 plus the ad valorem tariff so a 5% tariff is $ln(1.05)$. The first column presents the simple mean of China's tariffs on HS6 imports (a simple average of the HS8 tariff lines); and column 3 is a cost-weighted average of China's input tariffs within an IO industry code, using weights from China's 2002 input-output table, and mapped to HS6 industries. The correlation between the change in the output tariff and the input tariff is 0.37. Column 5 presents the simple average of the "gap" defined as the difference between the U.S. column 2 tariff and the U.S. MFN tariff in 2000 at the HS6 level.

Table 4
Distribution of import intensity among Chinese exporters.

Import intensity	# firms	Fraction of firms	Fraction of export value
$\theta = 0$	9,464	0.34	0.06
$0 < \theta \leq 0.1$	9,605	0.34	0.21
$0.1 < \theta \leq 0.4$	4,927	0.18	0.28
$0.4 < \theta \leq 1$	3,922	0.14	0.45

Notes: An exporter's import intensity, θ, is the share of imported inputs in the firm's total variable cost (i.e. material costs plus wagebill) in 2006. This is calculated for the sample of exporters that can be matched in the industrial data.

varieties. The largest Chinese exporters are heavily dependent on imported inputs, as shown in Table 4.[19] Fourteen percent of firms, accounting for 45% of China's exports to the U.S., import more than 40% of their total variable costs. So the benefits are potentially quite large.[20]

Second, upon China's WTO entry, China benefited from trade liberalization by other countries. One benefit was the U.S. Congress granting Permanent Normal Trade Relations (PNTR). It is important to realize that PNTR did not actually change the tariffs that China faced on its exports to the U.S. The U.S. had applied MFN tariffs on its Chinese imports since 1980, but they were subject to annual renewal, with the risk of tariffs reverting to the much higher non-NTR tariff rates assigned to some non-market economies. These non-NTR tariffs are set at the 1930 Smoot-Hawley Tariff Act levels and can be found in "column 2" of the U.S. tariff schedule. Studies by Pierce and Schott (2016) and Handley and Limão (2017) find that the removal of the uncertainty surrounding these tariff rates helped boost China's exports to the U.S. economy. Following this literature, we refer to this measure as the "gap" and define it as the difference between the column 2 tariff and the U.S. MFN tariff rate in 2000. We see from the last two columns in Table 3 that the average gap was very high at 26%, with a large standard deviation. We will exploit this cross-industry variation to analyze its effect on China's U.S. exports.

3.3. Additional reforms

In addition to lowering its own import tariffs, China implemented reforms to export barriers, import barriers, and foreign direct investment (FDI) restrictions during the period encompassing China's WTO entry, and these reforms may also have affected exports and therefore need to be included in our empirical analysis. Chinese firms faced restrictions on exporting and importing based on capital requirements, which were progressively removed during the sample period and were completely removed by 2004. Bai et al. (2017) studied the effect of relaxing export restrictions on Chinese firms' export activity and productivity, and generously provided us with export-restriction data indicating the share of firms allowed to export within a Chinese Industrial Classification 4-digit industry, which we mapped to HS6 industries for our analysis. From this, we constructed an "export restriction" variable equal to one minus the share of firms allowed to export within an HS6 industry.

[19] We calculate import intensity as a share of imported inputs in the firm's total variable cost (i.e. material costs plus wage bill). We combine data on firm-level imports with data on total variable costs from the Annual Survey of Industrial firms. We merge these two datasets using firm names, telephone numbers, and zip codes following Yu (2015).

[20] A high share of imported inputs are processing trade, which allows Chinese firms to import duty free if the goods are for exporting. Nevertheless, these firms still benefit from lower input tariffs, possibly due to spillover benefits i.e. lower imported input prices also lower domestic input prices, as well as encourage entry of more domestic varieties. Also, the lower input tariffs may offer direct benefit for processing firms as low tariffs are less burdensome than complying with processing requirements.

Turning to import barriers, China Customs announced a list of products requiring an import license. Because the total number of licenses is subject to government control, the license essentially serves as a quota. Drawing on annual circulars of the Ministry of Foreign Trade and Economic Cooperation and the Ministry of Commerce, we collect the list of HS 8-digit products to create a measure of the share of a firm's imports that were subject to import license controls. Around 5% of products were subject to license controls in 2000, and this number dropped to 1% in 2006.

Also potentially affecting Chinese exporters were China's restrictions on inward FDI, which it maintained on some industries when it joined the WTO, including complete prohibitions in certain industries. These restrictions took various forms, such as: higher initial capital requirements; less favorable tax treatment; more complicated business registry and approval procedures; and in the case of joint ventures, requirements of majority shareholding by a Chinese party. China removed many restrictions following WTO accession. The Catalog for the Guidance of Industries for Foreign Investment issued by the Ministry of Commerce of China lists the industries where FDI to China is “restricted” or “prohibited”. This list is amended every 3 to 5 years, and we use the lists issued in 1997, 2002 and 2004, mapping the Catalog's industry descriptions to HS8 digit codes. We categorize an industry as subject to an FDI restriction if it is either “restricted” or “prohibited”.

Another important trade reform for China was the elimination of quotas for textile exports. Before WTO accession, China's textile exports were subject to quota restrictions governed by the MFA, and its successor, the Agreement on Textiles and Clothing (ATC). These restrictions were phased out in 2002 and 2005, leading to a surge in textile exports to the United States and Europe (Khandelwal et al. (2013)). Our data for MFA quotas are drawn from Brambilla et al. (2010), which provides the list of HS10 products under quota restrictions, and the period the quota was removed for each product. We use these data to construct a dummy variable MFA which equals 1 if the quota was removed in 2002 or 2005.

4. Estimating the impact of China's WTO entry on U.S. prices

4.1. Benchmark specification

To analyze how the U.S. manufacturing price index moved due to China's WTO entry, we investigate the four components on the right side of (13), including both the common goods price index and variety components for China and for all other countries. We estimate how these four components are related to two policy changes that impacted Chinese firms exporting to the U.S.: (i) the reduction in Chinese tariffs on intermediate inputs used by those exporters (and by all other Chinese firms); and (ii) the granting of PNTR to China, which removed the risk that Chinese exports would face high “column 2” tariffs.

We regress each of the four components of the price index separately on China's input tariffs and the gap variable. Each reduced-form regression reveals how China's WTO entry has affected the particular price index component by industry, up to a constant term. From (13) we know that the overall price index is simply the weighted sum of the four components, so the overall predicted WTO entry effect by industry is the weighted sum of the predictions for *each* of the price index components. Our reduced-form regression simply takes the form of regressing the four components on the right of (13), denoted generically by Y^i_{gt}, on the two WTO entry variables and a set of industry controls X:

$$\ln\left(\frac{Y^i_{gt}}{Y^i_{g0}}\right) = \beta_0 + \beta_1 \Delta \ \ln Input\tau_{gt} + \boldsymbol{\beta}_2 \ \ln Gap_{g0} + X_{g0}\gamma' + \varepsilon_g, \tag{22}$$

We estimate (22) separately for China and for all other countries selling to the U.S. Our industry controls are driven by a concern that the industries which have experienced the largest falls in input tariffs may be the same industries that experienced faster productivity growth in the U.S. for reasons unrelated to China's WTO entry; or they may be correlated with other industry characteristics such as skill intensity, capital intensity, or the share of intermediate inputs in the value of production. To address these concerns we include the following variables from the NBER-CES Manufacturing Industry Database: 5-factor TFP growth from 1994 to 2000; the ratio of production employees to total employment in 2000; the value of materials purchases divided by the value of shipments in 2000; and the value of the capital stock divided by employment in 2000. To control for any prior trends in prices we also add the change in the unit value of US imports by HS6 industry between 1996 and 2000.[21]

The results of these regressions are shown in Table 5. Columns 1 through 4, respectively, use as the dependent variable Y^i_{gt} in (22): $ChinaP_g$, $OtherP^j_g$, $ChinaV_g$, and $OtherV^j_g$, as defined in (13). We display the estimated coefficients on $\Delta Input\tau_{gt}$, Gap_{g0}, and their standard errors. In column 1, the change in the input tariff has a magnified impact on Chinese prices, with a coefficient of 3.61. The gap variable has an insignificant impact in column 1, as predicted from the theory in section 2.4 if Chinese firms set their prices after that tariff is known. Turning to column 2, the input tariff that applies to Chinese firms *also* impacts the prices of other countries, with a coefficient of 1.27. We now find that the gap has a significantly negative impact on the prices of other countries, which could be due to Chinese entry (discussed in column 3) leading to reduced U.S. shares for other firms and therefore lower markups and prices. Alternatively, the effects of both the input tariff and the gap in column 2 could arise from firms in nonChina countries experiencing lower marginal costs from importing more intermediate inputs from China, and lowering their U.S. prices for that reason. We have split the other country regression in column 2 between the U.S. and nonChina foreign

[21] The choice of 1996 to 2000 for this variable was due to the tariff schedule for these years being based on the same HS6 codes.

Table 5
Decomposition of WTO effect on U.S. manufacturing price index.

Dependent variable	$\ln ChinaP_g$	$\ln OtherP_g^i$	$\ln ChinaV_g$	$\ln OtherV_g^i$	Implied $\ln(P_{gt}/P_{g0})$
	(1)	(2)	(3)	(4)	(5)
$\Delta \ln Input\tau_{gt}$	3.609***	1.270***	1.941**	−0.077	
	(0.796)	(0.470)	(0.958)	(0.186)	
$\ln Gap_{g0}$	0.083	−0.090**	−0.623***	0.044*	
	(0.081)	(0.040)	(0.230)	(0.022)	
US Industry Controls	Yes	Yes	Yes	Yes	
Impact of WTO on Median industry:	−0.144	−0.083	−0.260	0.016	−0.080
Input Tariff:	−0.167	−0.059	−0.090	0.004	−0.063
Gap:	0.023	−0.024	−0.170	0.012	−0.017
N	1,910	65,155	1,910	65,155	
R^2	0.03	0.02	0.01	0.01	

Notes: The dependent variables in columns 1 to 4 are listed at the top of those columns, and correspond to the four components making up the overall U.S. price index in (13), at the HS6-country level. In column 1, the dependent variable is the Chinese price index; in column 2 it is the price index for other countries, with the observations for each nonChina country pooled. Analogously, column 3 refers to the variety component for China and column 4 is the variety component for all non-China observations. Each component is regressed on the change in the log of (1 + input tariff) between 2000 and 2006, the log of the gap in 2000, industry controls from the NBER-CES Manufacturing Industry Database (5-factor TFP growth from 1994 to 2000; the ratio of production employees to total employment in 2000; the value of materials purchases divided by the value of shipments in 2000; and the value of the capital stock divided by employment in 2000), the change in the unit value of US imports by HS6 industry between 1996 and 2000, and country fixed effects (in columns 3 and 4), using OLS. Standard errors are clustered at the IO level, corresponding to the input tariff level of aggregation. The median impact in the lower panel is calculated for a hypothetical industry with $\Delta \ln Input\tau_g = -0.046$ and $\ln Gap_g = 0.273$, with the WTO effect summing over both the tariff and gap effect. Column 5 aggregates each component's impact as in Eq. (13) equal to $W_g^i \ \ln\hat{China}P_g + (1-W_g^i) \ \ln\hat{O}therP_g + W_g^i \ \ln\hat{China}V_g + (1-W_g^i) \ \ln\hat{O}therV_g$, with China's average weight in manufacturing $W_{gt}^i = 0.036$, and the non-China weight $(1 - W_{gt}^i) = 0.964$. * significant at 10%; ** significant at 5%; *** significant at 1%.

countries (see Appendix Table D4). We find that both policy variables have a significant impact on U.S. prices and foreign countries, with the coefficients for the U.S. about one-third larger than for third countries.

Turning to the variety of Chinese exports to the U.S. in column 3, we see a positive significant coefficient on $Input\tau_{gt}$ equal to 1.94, indicating that industries with a greater reduction in input tariffs will also have a larger drop in effective prices due to expansion of export variety. Chinese exporters that import more intermediate inputs because of lower tariffs experience a boost in their total factor productivity, lowering their marginal costs, which results in more entry into the U.S. export market as shown in Amiti et al. (2018). Further, as suggested by the theory, we see that Gap_{g0} has a significant, negative coefficient on the variety of Chinese exports to the U.S. This variable is measured as the difference between the column 2 and the MFN tariff in 2000, so an industry with a higher column 2 tariff will have a larger *drop* in effective prices due to expansion of export variety after China joins the WTO and the uncertainty of the higher column 2 tariffs is removed. For the export variety from other countries, in column 4, however, the coefficients on input tariffs applied to Chinese firms is insignificant, but the coefficient on the gap is marginally significant and positive, consistent with our expectations of seeing some exit of varieties from other exporters to the U.S. or from domestic firms as more Chinese exporters enter, given the findings in Feenstra and Weinstein (2017).

To get a sense of the economic magnitudes, we report the predicted impact of the input tariffs and the gap on each of the four components of the U.S. manufacturing price index at the bottom of Table 5. These present the WTO effect for the median industry relative to an industry with zero change in tariffs and zero gap. In column 1, the predicted WTO effect on $ChinaP_g$ is 14.4%, entirely due to lower input tariffs in China. The predicted effect on $OtherP_g$ is smaller than this direct effect at 8.3%, mostly due to the input tariffs. Turning to the Chinese variety effects in column 3, there is an even larger drop of 26.0% in effective prices due to the expansion of export variety from China that is due to both the decline in input tariffs and the elimination of uncertainty of reverting to column 2 tariffs, with two-thirds (i.e. 17.0/26.0) of this coming from the gap variable. This predicted decline in $ChinaV_g$ can be compared to the *total measured* expansion of Chinese export variety, which leads to a fall in effective prices of 49% in Table 2, column 6. So we are explaining over half of the actual expansion in Chinese export variety using the regression (22). In contrast to these large effects, the predicted changes in $OtherV_g^i$ in column 4 are close to zero.

The predicted WTO effect for the median U.S. manufacturing price index can be calculated by summing across each of these predicted effects using the weights in (13). For example, although the predicted $ChinaP_g$ is large, China's average share in manufacturing, W_g^i, is only 3.6 percent so it needs to be adjusted accordingly. Column 5 aggregates each component's impact as in Eq. (13) to obtain $W_g^i \ \ln\hat{China}P_g + (1-W_g^i) \ \ln\hat{O}therP_g + W_g^i \ \ln\hat{China}V_g + (1-W_g^i) \ \ln\hat{O}therV_g$, with China's weight equal to $W_g^i = 0.036$, and the nonChina weight equal to $(1 - W_g^i) = 0.964$. The total predicted WTO effect for the median industry is then 8.0%, with three-quarters of this effect (i.e. 6.3/8.0) due to the lowering in Chinese input tariffs and about one-quarter due to the elimination of tariff uncertainty in the U.S. The reduction in input tariffs appear to be the main cause of lower prices for continuing exporters (columns 1 and 2) while reductions in tariff uncertainty appear to be the biggest factor explaining the net change in variety (columns 3 and 4). Interestingly, most of the WTO effect on the price index manifests itself through the common goods prices rather than the variety effects. Although the variety effect is large for the China component, it's overall effect is relatively low because of China's small share combined with some variety loss from other countries.

Table 6
Adding output tariffs.

Dependent variable	$lnChinaP_g$	$lnOtherP^j_g$	$lnChinaV_g$	$lnOtherV^j_g$	Implied $ln(P_{gt}/P_{g0})$
	(1)	(2)	(3)	(4)	(5)
$\Delta ln\text{Input}\tau_{gt}$	3.555***	1.189**	1.051	−0.109	
	(0.863)	(0.468)	(1.075)	(0.193)	
$ln\text{Gap}_{g0}$	0.086	−0.084**	−0.574**	0.046*	
	(0.080)	(0.040)	(0.223)	(0.024)	
$\Delta ln\text{Output}\tau_{gt}$	0.058	0.109	0.952*	0.042	
	(0.324)	(0.091)	(0.534)	(0.049)	
US Industry Controls	Yes	Yes	Yes	Yes	
Impact of WTO on Median industry:	−0.143	−0.083	−0.246	0.016	−0.078
Input Tariff:	−0.165	−0.055	−0.049	0.005	−0.056
Gap:	0.024	−0.023	−0.157	0.013	−0.015
Output Tariff:	−0.002	−0.005	−0.040	−0.002	−0.008
N	1,910	65,155	1,910	65,155	
R^2	0.03	0.02	0.01	0.01	

Notes: All regressions are counterparts to Table 5, and each column includes the change in the log of (1 + output tariff) between 2000 and 2006 as an additional policy variable. The median WTO impact in the lower panel is calculated as in Table 5. * significant at 10%; ** significant at 5%; *** significant at 1%.

We have investigated whether our results depend on whether goods are used as intermediate inputs or as final goods, and include tables of these results in Appendix D. By separating these groups of goods, we obtain what is closer to a U.S. CPI sample of final goods and a PPI sample of intermediate inputs, respectively. We find that the coefficient on the input tariff for $ChinaP_g$ is higher for intermediates (4.52) as compared to final goods (1.52). The difference between these two categories is more pronounced for the prices of nonChina countries, where the input tariff has an impact on $OtherP_g$ that is four times higher for intermediates (1.80) than for final goods (0.39). The gap variable has larger coefficients for intermediate goods than for final goods. As a result of the larger coefficients for input tariffs on intermediates, the median predicted impact of WTO entry on U.S. prices (due to the lowering of Chinese inputs tariffs and the elimination of U.S. tariff uncertainty) is −4.6% for final goods and −13.2% for intermediate inputs, as compared to −8.0% in the pooled sample reported in Table 5.

It is important to note that these various median estimates cannot be interpreted as absolute price declines brought about by WTO entry, however, since the regressions do not identify an average effect. Rather, these estimates are the *relative* price decline for the median industry as compared to a hypothetical industry that had *zero* change in input tariffs and zero gap. Even for an industry that has zero imports from China, we could still expect a counteracting general equilibrium response to the median relative fall in prices we have found, and that would likely be to *raise* the price of all traded goods and services in the U.S. to limit the exit of resources from that sector; or in other words, a real exchange rate depreciation. That real exchange rate depreciation would in practice limit the fall in prices that we have measured, but our approach is unable to identify those general equilibrium effects.

With this limitation of our analysis recognized, we are still interested in the robustness of our estimated price reductions, as we discuss in the next section, and in whether the variation of these price changes across industries can explain industry outcomes in the United States, as we discuss in the section after that.

4.2. Robustness

The large price effects from input tariffs is puzzling. In this section we explore factors that may be contributing to this result. In particular, we consider potentially confounding factors such as other policy reforms that were implemented at the same time, and the potential endogeneity of the change in China's input tariffs. In Table 6, we re-estimate our baseline specification in Table 5 augmented with the reduction in output tariffs. There is only one notable effect of this addition, and that is in column 3 for the Chinese variety term regression. The coefficient on the gap is unaffected, and the estimated combined effect of Chinese tariff reductions (input and output) is unaffected, but the regression appears to be having some difficulty disentangling the different effects of the two tariff terms. The Chinese input and output tariffs are jointly significant at the 5% level, but the individual input tariff coefficient is insignificant while the output tariff coefficient is significant at the 10% level. We see no obvious reason why a reduction in Chinese output tariffs in an industry should lead to an expansion in Chinese export variety for the same industry. The results might be in part due to how the two tariffs are constructed. The output tariff is simply aggregated from the Chinese HS8-digit tariff codes to the HS6-digit level. The input tariff on the other hand has to be aggregated up to the level of detail of Chinese input-output tables using the input weights in the Chinese input-output tables. To put it simply, the output tariff data is measured with less error, and as a result may be picking up some of the effect of the positively correlated input tariff. However, this does not appear to be causing problems for the three other regressions reported in Table 6.

Table 7
Other policy reforms.

Dependent variable	$lnChinaP_g$	$lnOtherP_g^j$	$lnChinaV_g$	$lnOtherV_g^j$	Implied $ln(P_{gt}/P_{g0})$
	(1)	(2)	(3)	(4)	(5)
$\Delta ln\text{Input}\tau_{gt}$	2.028**	1.288**	1.279	0.056	
	(0.790)	(0.505)	(1.567)	(0.159)	
$ln\text{Gap}_{g0}$	0.182**	−0.116**	−0.656***	0.021	
	(0.083)	(0.050)	(0.233)	(0.024)	
MFA_{g0}	−0.164***	0.008	0.008	0.024	
	(0.041)	(0.020)	(0.110)	(0.014)	
$\text{ExportControls}_{g0}$	0.046	−0.135*	−0.751***	−0.050**	
	(0.167)	(0.075)	(0.246)	(0.025)	
ΔFDI_{gt}	−0.009	−0.028	0.041	0.010	
	(0.050)	(0.028)	(0.074)	(0.012)	
$\Delta\text{ImportLicense}_{gt}$	0.061	0.046	0.033	0.014	
	(0.078)	(0.042)	(0.160)	(0.024)	
$\Delta ln\text{Output}\tau_{gt}$	0.096	0.083	0.867	0.017	
	(0.305)	(0.103)	(0.521)	(0.049)	
US Industry Controls	Yes	Yes	Yes	Yes	
Impact of WTO on Median industry:	−0.039	−0.123	−0.432	−0.008	−0.143
Input tariff:	−0.094	−0.060	−0.059	−0.003	−0.066
Gap:	0.050	−0.032	−0.179	0.006	−0.030
Output tariff:	−0.004	−0.004	−0.037	−0.001	−0.006
Export controls:	0.010	−0.028	−0.157	−0.011	−0.043
N	1,910	64,399	1,910	64,399	
R^2	0.027	0.017	0.016	0.008	

Notes: All regressions are counterparts to Table 5, and each column includes the following additional reform variables: MFA_{g0} is a dummy variable equal to 1 if the a quota was lifted during our sample period; $ExportControls_{g0}$ is the share of Chinese firms measured by revenue within g not allowed to export in the year 2000; ΔFDI_{gt} is the change in the proportion of HS8 codes within g with an FDI restriction; $\Delta ImportLicence_{gt}$ is the change in the proportion of HS8 codes within g where an import license is required.; $\Delta ln\text{Output}\tau_{gt}$ is the log change in China's output tariff in industry g. The median WTO impact in the lower panel is calculated as in Table 5. * significant at 10%; ** significant at 5%; *** significant at 1%.

In Table 7, we re-estimate our baseline specification in Table 5 augmented with the following additional policy reforms, described in section 3.2: (i) the elimination of restrictions on exports from China under the MFA; (ii) the elimination of export controls in China; (iii) the lifting of FDI restrictions in some industries; (iv) the removal of some import licenses; and (v) the reduction in output tariffs.

Interestingly, the inclusion of these additional reforms nearly halves the input tariff coefficient for $ChinaP_g$ to 2.03. The size of the input tariff coefficient in the $ChinaV_g$ regression is again smaller with bigger standard errors, as in Table 6, and almost no change in coefficients for $OtherV_g$. There are two notable coefficients when we include the additional policy controls. Firstly, the MFA variable is highly significant in the $ChinaP_g$ regression, which we would expect because the MFA would disproportionately affect lower-priced items.[22] Secondly, relaxation of Chinese export controls had a very large effect on Chinese variety, comparable to the effect of reduced US tariff uncertainty. Despite the smaller coefficients in the China specifications, the overall median impact of the input tariff and the gap is now slightly higher at 9.6%, relative to an industry with zero change in any included trade policy and zero gap. This is because of the larger gap coefficient in $OtherP_g$ and a change in the (still insignificant) input tariff coefficient in $OtherV_g$, and the large average weight of “Other” countries in manufacturing industries. Overall, the input tariff has a larger effect than the gap due to its large effect on the price of continuing exports; and the other reforms push down further the prices in the affected industries relative to the less affected ones. This suggests that the significant WTO impact in Table 5 is not due to omitting other trade reforms.

Next, we consider whether the potential endogeneity of input tariffs and other confounding factors could be driving the large coefficients on the common goods component of the price indexes even though Chinese tariffs followed their agreed WTO liberalization schedule extremely closely over our sample period. We address potential concerns over the endogeneity of such tariff reductions by employing the simple IV regression strategy from Goldberg and Pavcnik (2005), exploiting the fact that tariff reductions were heavily influenced by the pre-existing tariff level. In Table 8, we instrument for the change in the input and output tariffs with their initial levels. The instruments comfortably pass weak instrument tests. In the first two columns of Table 8, we reestimate our specification in Table 6 with the only difference being the instrumental variables estimation. The IV estimates reported in columns 1 and 2 of Table 8 are similar to the corresponding OLS estimates in columns 1 and 2 in Table 5, with the most

[22] We do not report a median effect of the MFA variable, as the great majority of industries were not affected by the MFA.

Table 8
Endogeneity.

Dependent variable	$ChinaP_g$	$OtherP_g^j$	$ChinaP_g$	$OtherP_g^j$
	(1)	(2)	(3)	(4)
$\Delta ln\text{Input}\tau_{gt}$	4.178***	1.723***	2.934**	1.875***
	(1.182)	(0.565)	(1.346)	(0.629)
$ln\text{Gap}_{g0}$	0.122	−0.052	0.194**	−0.111**
	(0.080)	(0.042)	(0.085)	(0.049)
$\Delta ln\text{Output}\tau_{gt}$	0.221	0.181	0.269	0.136
	(0.731)	(0.135)	(0.765)	(0.136)
Other reforms	no	no	yes	yes
US Industry Controls	yes	yes	yes	yes
N	1,910	65,155	1,910	64,367

Notes: All regressions are estimated with instrumental variables, where $\Delta ln\text{Input}\tau_{gt}$ and $\Delta ln\text{Output}\tau_{gt}$ are instrumented with $ln\text{Input}\tau_{g0}$ and $ln\text{Output}\tau_{g0}$. The instruments comfortably pass weak instrument tests. Column 3 and 4 include the additional reforms in Table 7. All regressions include the percentage change in the unit value of U.S. imports by HS6 industry between 1996 and 2000, and controls for U.S. industry characteristics for the year 2000 from the NBER-CES Manufacturing Industry Database: 5-factor TFP growth from 1994 to 2000; production employees divided by total employment; material costs divided by the value of shipments; and the value of the capital stock to employment. Additional controls are suppressed to save space. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 9
Corroborative evidence.

	$\Delta ChinaShare_g$	$\Delta ChinaShare_g$	$\Delta lnEmp_g$	$\Delta lnEmp_g$	$\Delta USshipmentsP_g$	$\Delta USshipmentsP_g$
	(1)	(2)	(3)	(4)	(5)	(6)
$ln\text{ChinaP}_g$	−0.376*		1.891**		0.635***	
	(0.194)		(0.894)		(0.164)	
$ln\text{ChinaEPI}_g$		−0.209**		1.203**		0.360***
		(0.089)		(0.492)		(0.094)
N	1910	1910	2340	2340	2310	2310

Notes: The dependent variable in columns 1 and 2 is defined as the change in China's share of U.S. demand, defined as China's exports to the U.S. as a share of U.S. shipments + imports - exports, all at the HS6 level. In columns 3 and 4, the dependent variable is the log change in employment at the NAICS level. In columns 5 and 6, the dependent variable is the log change in US shipment deflators at the NAICS level. $ChinaP_g$ is the conventional Chinese export price index, while $ChinaEPI_g$ also includes the variety adjustment. All regressions are estimated by two-stage least squares, with the instruments being $\Delta lnInput\tau_{gt}$ and $lnGap_{g0}$. The instruments comfortably pass weak instrument tests in all columns. The Hansen J statistics of the overidentifying restrictions have *p*-values well above the 5% threshold in columns 2, 4 and 6, but not in columns 1, 3 and 5. Standard errors in columns 1 and 2 are clustered on Chinese IO codes, while standard errors in columns 3 and 4 are also clustered on both IO codes and 6-digit NAICS codes. Since some HS6 codes map to multiple NAICS codes, the number of observations grows slightly in columns 3 and 4. * significant at 10%; ** significant at 5%; *** significant at 1%.

notable difference being a greater sensitivity of the price index components to Chinese input tariff changes and a lesser sensitivity to the gap. In the next two columns, we add in the additional trade reforms from Table 7, and again we see that instrumenting for input tariffs acts to push up the input tariff coefficients (compare columns 3 and 4 in Table 8 with columns 1 and 2 of Table 7), while the sensitivity to the gap is maintained.

4.3. Corroborative evidence and discussion

Our analysis suggests that China's WTO accession has produced some very substantial effects on relative prices. If such effects did in fact occur then we should see evidence of those effects in data that we have not directly exploited. One expected effect is that a decline in Chinese prices due to WTO accession should cause an increase in China's share of U.S. demand. We test this by running IV regressions of the change in China's share of U.S. demand between 2000 and 2006 by HS6 industry[23] on changes in Chinese manufacturing prices, using $\Delta\ ln\ \text{Input}\tau_{gt}$ and $ln\text{Gap}_{g0}$ as instruments:

$$\Delta ChinaShare_g = \beta_0 + \beta_1 lnChinaP_g + \varepsilon_g. \tag{23}$$

The results are reported in column 1 of Table 9. There is a *negative* association between the change in China's share of US demand and Chinese price changes, as theory predicts. Column 2 of Table 9 presents results from a similar regression, replacing

[23] U.S. demand is defined as domestic shipments + imports - exports. The U.S. share of demand is calculated at the 6-digit NAICS level, which is matched to HS6 codes. The share of other countries is computed at the HS6-digit level.

$lnChinaP_g$ with the change in variety-corrected price indexes for China. Again, the change in China's share in U.S. demand negatively responds to Chinese price changes, as theory predicts.

We would also expect that substantial changes in relative prices would affect U.S. employment in manufacturing industries. We merge NAICS-based employment data from the NBER-CES manufacturing industry database and replace the dependent variable in (23) with the log-change in U.S. employment. We report the results for regressions of employment on conventional Chinese price indexes in column 3 of Table 9, while regressions on variety adjusted Chinese price indexes are reported in column 4. In both cases, declining Chinese prices are associated with declining U.S. employment, which is consistent with U.S. industries shrinking where WTO accession has made Chinese industries more competitive, a result consistent with Autor et al. (2013) and Pierce and Schott (2016). The magnitude is also quite substantial. Taking estimates from column 3, a 1% decline in Chinese export prices to the U.S. causes a 2% decline in U.S. employment in that industry.

We also estimate the relationship between the deflators for US shipments reported in the NBER-CES manufacturing database and Chinese price changes and report the results in columns 5 and 6 of Table 9. We find positive relationships, so that Chinese price reductions caused by WTO entry appear to cause reductions in the US shipment price deflators.

The association between the predicted price effects from WTO accession with (i) China's share of U.S. demand; and (ii) U.S. employment provides supporting evidence that we are picking up a real phenomenon and not some spurious correlation in cross-industry prices. Evidence found by other authors using different methodologies and different data further support the conclusion that China's trade growth following WTO accession has led to substantial manufacturing price effects in the U.S. Bai and Stumpner (2019) use U.S. scanner data from 2004 to 2015 to find that increased Chinese import penetration led to a 0.2% annual reduction in the price index of consumer tradables. Jaravel and Sager (2018) match BLS CPI microdata with international trade flows and find that a one percentage point increase in Chinese import penetration leads to a three percentage point fall in the CPI in that industry. Hottman and Monarch (2019) analyze detailed U.S. import data from 1998 to 2014 and show that China has had a notable direct deflationary effect for U.S. consumers. While overall import inflation was 0.47% annually, nonChina import inflation was 0.73%.

Our rather large predicted impact of China's WTO entry, particularly the impact of the lowering of input tariffs, is due to the large pass-through coefficients of Chinese input-tariff reductions on the price of Chinese exports to the U.S., and on the price of firms from nonChina countries selling in the U.S. How do we explain this puzzling feature of our results? In competitive markets one might think that the effect of an input tariff reduction would be well-approximated by the cost-share of imported inputs; which is obviously a number considerably less than 1 in most cases, while our baseline specification has a coefficient of 3.6. But this first-order approximation misses important features that play a critical role. There are likely two broad effects amplifying the impact of input-tariff reductions: productivity changes and other production changes linked to those tariff reductions; and markup changes linked to those tariff reductions. This is somewhat comparable to how Baqaee and Farhi (2019) demonstrate how first-order approximations can underestimate the macroeconomic effects of microeconomic shocks.[24]

There have been numerous investigations of how trade exposure can lead to productivity gains. Any true TFP gain caused by input tariff reductions should produce price reductions. Since our reduced-form regressions do not control for TFP, those TFP gains will magnify the coefficient on input tariffs. Many studies have now linked input tariff reductions to substantial productivity improvements. A recent study by Grieco et al. (2019) estimating a dynamic structural model to analyze the impact of Chinese input tariff liberalization on Chinese paint manufacturers from 2000 to 2006 is very much on point. Not only do they find that the input tariff reduction directly lowers costs for importers, but that there are also indirect benefits. Firstly, the import tariff reductions lead to greater trade participation through importing more inputs, leading to potential productivity improvements and to greater exploitation of the lower quality-adjusted prices of imported inputs. Further, the complementarity between importing and exporting leads to further productivity gains through greater contact with export markets. Finally, they find that WTO accession led to an improvement in the allocation of output to more efficient firms. Input tariffs for paint manufacturers fell from 15% in 2000 to 7% in 2006. After 5 years, aggregate productivity gains grow to 3.1%, and are estimated to grow to 8.6% over 15 years, which would provide a substantial amplification of the first-order price impact of input tariff reductions. Amiti and Konings (2007) analyzed plant-level data on Indonesian firms between 1991 and 2001 and found that a 10 percentage point fall in input tariffs caused a productivity gain of 12% for firms that import their inputs, with some gains also accruing to nonimporters, while Topalova and Khandelwal (2011) find similar results for India.[25] Brandt et al. (2017) find large productivity gains for Chinese firms following their trade liberalization.

The paint industry described above would appear to provide a fairly mundane example of how better access to basic inputs for a traditional industry can meaningfully boost productivity. But we believe that something more transformational could be at work. Better access to inputs may not only be directly reducing costs, but may be critical for inducing domestic and foreign firms to invest in China, upgrading both technology and scale and driving its firms down their long-run average cost curves. China' s WTO entry and associated trade reforms appear to be an important contributor to China' s continued evolution from having a primitive manufacturing sector to having an increasingly large and sophisticated manufacturing sector, as evidenced by rapid Chinese manufacturing TFP growth linked to trade policy reforms in Amiti et al. (2018). It is reminiscent of the description by Verhoogen (2008) of the production lines in a Mexican plant of the Volkswagen Original Beetle compared with the New

[24] Carvalho et al. (2016) empirically analyzed a manifestation of this when they studied the propagation of a Japanese earthquake shock over input-output linkages. They found that the aggregate decline in Japan's gross output in the following year was an order of magnitude higher than the direct effects.

[25] See also Khandelwal et al. (2013) that show greater-than-expected gains from trade liberalization in the Chinese textile and clothing industry due the the reduction in misallocation of resources.

Beetle, Jetta and Golf. The former used essentially the same technology that was adopted when the plant opened in 1964, technology in use in Germany from the 1950′s. The production lines for the newer models used state of the art technology. Substantial exports from the plant commenced in 1989, just four years after liberalizing policies commenced. Better access to import and export markets surely facilitates this type of technological transformation in developing countries. Perhaps a more salient modern example is iPhone manufacturing (Duhigg and Bradsher (2012)), with the very first model manufactured in China in 2007, which given the very large role of imported inputs, surely would not have happened without low-cost access to imported inputs.

Due to the effect on productivity and costs, input tariff reductions would appear to cause greater availability of, and competition from, Chinese products in other markets. Greater competition from Chinese products may help drive technical change in the U.S. and other countries. Bloom et al. (2016) found that innovation increased in European firms most affected by imports from China, and that Chinese import competition caused European output to be reallocated towards more productive firms. They found that these two effects accounted for 14% of European technology upgrading over 2000–2007, essentially the period we study. Greater ability to source intermediate inputs from China would also lower costs and therefore prices of firms in other countries, as found for U.S. firms in Antràs et al. (2017).

Finally, increased competition from Chinese firms may lead to competitor firms reducing their markups, which would also contribute towards an amplified coefficient on input tariffs in our reduced form regressions. Amiti et al. (2019) investigated the strength of strategic complementarities in price setting across firms and found that a typical firm adjusts its price with an elasticity of 0.4 in response to competitor's price changes and 0.6 in response to its own cost shocks. This mechanism may partly explain the large coefficient we find on Chinese input tariffs. For firms that also source inputs domestically, input tariff reductions will lead to lower prices of competing domestically produced inputs. Further, strategic complementarity in price-setting may partly explain the significant positive coefficient for non-Chinese prices on the input tariff reductions. Chinese firms will at least pass on part of their cost reductions that are directly or indirectly attributable to input tariff cuts, and foreign competitors will respond by lowering their prices.[26]

5. Conclusion

The value of China's exports to the U.S. grew by 290% within six years of joining the WTO, with the bulk of this growth coming from new exporters. This extraordinary growth suggests the strong likelihood of a substantial impact on U.S. prices, which we quantify. Analysis of the channels through which China's WTO entry can affect U.S. prices shows that China's substantial input tariff cuts led to lower prices from existing exporters and more firms exporting to the U.S. This firm-entry effect is enhanced by the reduction in tariff uncertainty following the U.S. granting China PNTR status.

Our analysis uses highly disaggregated Chinese firm-product data for the period 2000 to 2006 to build exact CES price indexes for all U.S. manufacturing, which we correlate with WTO policy variables. Intuitively, the largest impact is on China's export prices. In addition to this direct effect, our analysis explicitly takes account of China's trade shock on competitor prices and entry. The reduction in China's tariffs on intermediate inputs also led *other* countries selling to the U.S. to lower their prices. This may be due to the lower cost of intermediate inputs, lower markups, or exit of inefficient firms. Our results suggest that China's WTO entry reduced the U.S. price index for the median U.S. manufacturing industry by 8.0% relative to a hypothetical industry with zero tariff change and no PNTR benefit over this period. We find that the largest contribution to the reduction in the effective price comes from the lowering of the Chinese tariffs on inputs, while a substantial contribution also comes from the elimination of tariff uncertainty in the U.S. Our paper is the first to show that a key mechanism underlying the China WTO effect on U.S. prices is China lowering its own import tariffs on intermediate inputs.

Appendix A. Data construction

To estimate the effect of trade liberalization on Chinese firms, we need detailed information on the trade and production activity of those firms. China Customs provides annual trade data on values and quantities at the HS 8-digit level by firm-destination for the period 2000 to 2006. This covers the universe of Chinese exporters. We restrict the sample to manufacturing products, which we identify using a mapping to NAICS 2-digit codes in the range 31 to 33.

The total number of exporters is reported in Table A1. The striking pattern to emerge from Table A1 is the massive net entry into exporting. In the customs data, we see that the number of U.S. exporters more than tripled over the sample period. This represents actual net entry into the market since the customs data represents the universe of exporters. This pattern is also mirrored for exporting to the world.

[26] Our earlier working paper Amiti et al. (2018) found that firms substantially expanded their import sourcing activity following input tariff liberalization. Kikkawa et al. (2019) investigate supplier-buyer specific markups that depend on bilateral input shares and find large distortions due to double-marginalization. They find that a 20% reduction in firm-to-firm markups would lead to a 10% increase in household consumption, which must be due to a considerable reduction of prices in relation to household incomes. An input tariff reduction could easily be a force that leads to a reduction in such markups by reducing firm reliance on individual suppliers.

Table A1
Number of Chinese exporting firms.

Year	# exporters in customs	# US exporters in customs
2000	62,746	23,437
2001	68,487	26,172
2002	78,613	31,835
2003	95,690	39,556
2004	120,590	49,878
2005	144,031	63,193
2006	171,205	76,081

Product concordances: We make the China HS 8-digit codes consistent over time, by mapping all HS8 codes to back to 2000, using a concordance over time from the General Administration of Customs of China.

The mapping between HS8 and IO codes uses the HS2002 version so we converted that to HS 2000 codes. We built on a concordance from HS6 2002 to IO from one constructed manually by Rudai Yang, Peking University, using a mapping from HS to SITC to IO.

We made the U.S. reported HTS 10 codes time consistent using the concordance from Pierce and Schott (2012). Once we had both the China reported HS codes and the U.S. reported codes mapped back to 2000, we could match them to a consistent 1996 HS 6-digit revision.

U.S. domestic sales: We employ a concordance from HS 10-digit to NAICS 6-digit to convert U.S. production data from NAICS 6-digit to HS 6-digit. We follow Feenstra and Weinstein (2017) (p45 of their Appendix) and assume that the domestic share ($share_k$) in total consumption is the same in each HS 10-digit category as it is in the corresponding NAICS 6-digit category. Denoting a NAICS industry by k, and U.S. domestic sales as $domestic_k \equiv production_k - exports_k$, then domestic sales at the HS 10-digit level is obtained as,

$$domestic_h = \left(\frac{share_k}{1-share_k}\right) * Imports_h.$$

Once we have U.S. domestic sales at HS10, we can easily aggregate to HS 6-digit and combine with the import data to get total sales in the U.S. market.

Price Indexes: To calculate the U.S. price index of manufactured goods in Eq. (13), we need measures of China's export prices, other foreign export prices, U.S. domestic prices, measures of variety, and estimates of elasticities of substitution. For these, we utilize several data sources. The first is from China Customs. We use these data to construct the China components of the overall U.S. price index. We supplement the China-reported trade data with U.S.-reported data to incorporate all other foreign countries and domestic U.S. firms in the construction of the U.S. price index for manufacturing industries. For U.S. imported goods from countries other than China, we use customs data at the HS 10-digit-country level from the U.S. Census; for domestic sales by U.S. producers we use the U.S. producer price indexes (PPI) for the common goods component of the price index, and domestic sales shares of the top 4 U.S. firms, also available from U.S. Census, for the variety component of the price index. Both of these are at the NAICS 6-digit level, which we map to HS10.

Table A2
Correlation table for trade policy variables (standard deviations on leading diagonal).

	$\Delta ln\text{Input}\tau_{gt}$	$\Delta ln\text{Output}\tau_{gt}$	$ln\text{Gap}_{g0}$	MFA_{g0}	$\text{ExportControls}_{g0}$	ΔFDI_{gt}	$\Delta\text{ImportLicense}_{gt}$
$\Delta ln\text{Input}\tau_{gt}$	0.03						
$\Delta ln\text{Output}\tau_{gt}$	0.37	0.07					
$ln\text{Gap}_{g0}$	−0.23	−0.19	0.14				
MFA_{g0}	−0.52	−0.27	0.32	0.39			
$\text{ExportControls}_{g0}$	−0.03	−0.08	−0.13	0.07	0.11		
ΔFDI_{gt}	0.05	0.07	0.04	0.13	−0.02	0.29	
$\Delta\text{ImportLicense}_{gt}$	0.12	0.18	0.08	0.00	0.04	0.13	0.20

Appendix B. Estimating elasticities of substitution

We estimate the elasticity of substitution between varieties following Feenstra (1994), Broda and Weinstein (2006), and Soderbery (2015).[27] We follow the methodology described and coded in Appendix 2.1 of Feenstra (2010) to estimate three sets of elasticities of substitution, all at the HS6 industry level: (i) Elasticities of substitution between firm-HS8 Chinese varieties exported to the U.S. (China ρ_g); (ii) Elasticities of substitution between varieties sold in the U.S. by all non-Chinese exporters (Other ρ_g); and (iii) Elasticities of substitution across HS 6-digit varieties (σ_g). For each set of elasticities, we filled in any missing HS 6-digit elasticity with the median estimate within the same HS 4-digit code. All data is cleaned by dropping price ratios (the unit value in t relative to $t-1$) less than 1/10 or greater than 10.

For China's exports to the U.S., we estimate the elasticities of substitution across varieties, defined at the firm-HS 8-digit level and within an HS 6-digit industry, ρ_g.[28] This parameter enters in the variety adjustment for Chinese goods in the price index — the second term in Eq. (6). The median ρ_g, reported in Table B3, is 5.67. We estimate a wide range in the elasticities. Variety growth in industries with low elasticities will generate the largest gains whereas variety growth in industries with high elasticities will have a smaller effect on the U.S. price index.

We do not have access to firm-level data for non-Chinese exporters, so we use the most disaggregated data available to us, which is U.S. reported import data at the country-HS 10-digit level. We estimate "Other ρ_g" as the elasticity of substitution across HS10 varieties produced by the same country. We do this by pooling the top 40 exporting countries to the U.S. (which account for 95% of total U.S. manufacturing imports) and constrain Otherρ_g to be the same for all exporting countries other than China. There were too few observations for some countries to estimate country-specific elasticities. We assume that Other ρ_g also applies to U.S. produced varieties. We see that the median elasticity for "other countries" is lower at 3.15. This was expected because a variety is defined at a more aggregate level.

Finally, we estimate σ_g, the elasticity of substitution between varieties in industry g produced in different countries that appears in the last term of Eq. (13). We estimate σ_g in two steps. First, we calculate an exact price index for each country-HS6 pair using Eq. (9) and the within-country elasticity of substitution ρ_g, and then we estimate the between-country elasticity, σ_g, using the same procedure as with the ρ_g's. The median estimate of σ_g is 3.55.[29] We ensure there are a minimum of 3 country varieties within each HS 6-digit estimation, and drop the top and bottom 1 percentiles of the λ ratios and exact price indexes.

Table B3
Distribution of elasticities of substitution.

	Chinaρ_g	Other countries ρ_g	σ_g
Percentile 5	1.87	1.59	1.72
Percentile 25	3.36	2.39	2.72
Percentile 50	5.67	3.15	3.55
Percentile 75	10.89	5.03	5.54
Percentile 95	34.59	16.72	16.24

Notes: The China ρ_g are estimated using Chinese firm-HS8 level US export data for each HS 6-digit industry g. The "Other countries" ρ_g are estimated using U.S. import data at the HS 10-digit country level. And the σ_g are elasticities of substitution across different countries' HS6 digit goods exported to the U.S.

Appendix C. Uncertainty in tariffs and export participation

For simplicity, consider the case where the shares sold by individual Chinese firms are small enough that they treat their elasticity of demand as constant. The pricing decision, revenue and variable profits for the firm are still governed by Eqs. (16), (18), but with $\eta_t(\varphi)$ replaced by ρ_g. After deducting the per-period fixed costs of exporting, the one-period value of the firm is

$$v\left(\varphi,\tau_{gt}\right) = max\left\{\frac{X_{gt}}{\tau_{gt}\rho_g}\left(\frac{\rho_g c_t(\varphi)\tau_{gt}}{\left(\rho_g-1\right)P_{gt}}\right)^{1-\rho_g}-F_g, 0\right\},$$

where we have substituted for export revenue from (18) and the marginal costs are $c_t(\varphi) = c(P_t^D, P_t^M, \varphi)$. P_{gt} is the CES index as in (4) taken over the Chinese firms' prices in (16), from which it follows that $P_{gt} = \rho_g C_{gt}\tau_{gt}/(\rho_g - 1)$, where C_{gt} denotes the CES

[27] This methodology is also used in Ossa (2015).

[28] We trim outliers by dropping any price ratios greater than 10 or less than 1/10. If there were insufficient observations to estimate an elasticity for an HS 6-digit industry, we used the median in the next level of aggregation.

[29] It is not a surprise that the median σ_g is slightly higher than the "other-countries" ρ_g. While we estimate ρ_g across *different* HS 10-digit varieties, we estimate σ_g using price indexes that incorporate the same HS 10-digit categories.

index as in (4) but now taken over the Chinese firms' marginal costs $c_t(\varphi)$. Substituting above, we obtain a slightly simpler equation for the one-period profits,

$$v\left(\varphi,\tau_{gt}\right) = \max\left\{\frac{X_{gt}}{\tau_{gt}\rho_g}\left(\frac{c_t(\varphi)}{C_{gt}}\right)^{1-\rho_g} - F_g, 0\right\}. \tag{C.1}$$

As explained in the main text, we suppose that if the tariff starts at its MFN level then it remains there in the next period with probability π, and with probability $(1-\pi)$ the tariff moves to its column 2 level; whereas if the tariff starts at its column 2 level then it stays there forever. This Markov process applies to all industries simultaneously. We need to keep track of what happens to overall Chinese exports under the differing tariffs, so let $\overline{X}_g$ (X_g^{MFN}) denote the value of Chinese exports X_{gt} when all tariffs are at their column 2 (MFN) level. It might be that firms anticipate that the Chinese tariffs on imported inputs are reduced so that $c_t(\varphi)$ falls for each firm and C_{gt} falls for the industry. Assuming for convenience that all Chinese firms use the same bundle of domestic inputs and the same bundle of imported inputs with quantities in proportion to their productivity, then $c_t(\varphi)/C_{gt}$ remains constant in the above expression and we can ignore it.

With a discount rate $\delta < 1$, the present discounted value of a Chinese firm facing MFN tariffs is

$$V\left(\varphi,\tau_g^{MFN}\right) = v\left(\varphi,\tau_g^{MFN}\right) + \delta\left[\pi V\left(\varphi,\tau_g^{MFN}\right) + (1-\pi)V(\varphi,\overline{\tau}_g)\right].$$

Since $V(\varphi,\overline{\tau}_g) = v(\varphi,\overline{\tau}_g)/(1-\delta)$ by our assumption that the column 2 tariff is an absorbing state, we obtain the *export participation condition* for a Chinese firm facing MFN tariffs,

$$\int_\varphi V\left(\varphi,\tau_g^{MFN}\right)dG = \int_\varphi\left\{\frac{v\left(\varphi,\tau_g^{MFN}\right)}{(1-\delta\pi)} + \frac{\delta(1-\pi)v\left(\varphi,\overline{\tau}_g\right)}{(1-\delta)(1-\delta\pi)}\right\}dG \geq F_g^E, \tag{C.2}$$

where $G(\varphi)$ is the distribution function of firm productivities and F_g^E is a sunk cost of exporting. We can simplify this condition by first using (C.1) to evaluate the one-period profits with the column 2 and MFN tariffs as:

$$v\left(\varphi,\overline{\tau}_g\right) + F_g = \left[v\left(\varphi,\tau_g^{MFN}\right) + F_g\right]\left(\frac{\overline{X}_g/\overline{\tau}_h}{X_g^{MFN}/\tau_g^{MFN}}\right).$$

Substituting this term into (C.2), we obtain the export participation condition written in terms of one-period profits:

$$\int_\varphi v\left(\varphi,\tau_g^{MFN}\right)dG \geq \left(T_g-1\right)F_g + T_g(1-\delta)F_g^E, \tag{C.3}$$

where,

$$T_g \equiv \left\{\frac{(1-\delta)}{(1-\delta\pi)} + \frac{\delta(1-\pi)}{(1-\delta\pi)}\left(\frac{\overline{X}_g/\overline{\tau}_g}{X_g^{MFN}/\tau_g^{MFN}}\right)\right\}^{-1}. \tag{C.4}$$

These conditions hold in the presence of tariff uncertainty. After China's entry to the WTO, U.S. tariffs are permanently at their MFN level, and the export participation condition for Chinese firms becomes

$$\int_\varphi v\left(\varphi,\tau_g^{MFN}\right)dG \geq (1-\delta)F_g^E. \tag{C.5}$$

The right-hand side of (C.5) differs from (C.3) by the term $(T_g-1)[F_g + (1-\delta)F_g^E]$, which we interpret as the "effective" tariff term (T_g-1) multiplied by fixed costs and amortized sunk costs. The effective tariff we have obtained is similar to the results in Handley and Limão (2017) and Feng et al. (2017), except that in (C.4) we also keep track of what happens to overall Chinese exports to the U.S. Measuring the effective tariff (T_h-1) by the first-order approximation $(T_g-1) \approx \ln T_g$, if discounting is small so that $\delta \to 1$, we have that

$$\ln T_g \to \left(\ln\overline{\tau}_g - \ln\tau_h^{MFN}\right) - \left(\ln\overline{X}_g - \ln X_g^{MFN}\right). \tag{C.6}$$

The first term on the right of (C.6) is the "gap" between the column 2 and MFN *ad valorem* tariffs, as first used by Pierce and Schott (2016). That variable acts as an effective drop in the fixed costs of entry facing Chinese exporters following WTO accession, which will lead to greater entry of those firms. We will therefore incorporate the "gap" into the specification of our export participation equation. The second term on the right of (C.6) keeps track of what happens to the value of Chinese exports to the U.S. market. We will not attempt to measure this additional term.

Appendix D. Additional tables

Table D4
Decomposition of other component: U.S. and third countries.

	$lnOtherP_g^j$		$lnOtherV_g^j$	
	US	NonUS	US	NonUS
	(1)	(2)	(3)	(4)
$\Delta ln\text{Input}\tau_{gt}$	1.628*	1.249***	0.286	−0.115
	(0.826)	(0.453)	(0.215)	(0.196)
$ln\text{Gap}_{g0}$	−0.123**	−0.090**	0.092	0.040*
	(0.050)	(0.041)	(0.056)	(0.023)
US Industry Controls	Yes	Yes	Yes	Yes
N	4,069	61,086	4,069	61,086
R^2	0.33	0.02	0.05	0.01

Notes: Columns 1 and 2 are in parallel to column 2 of Table 5, splitting the $OtherP_g^j$ observations into U.S. in column 1 and other nonChina countries in column 2. Columns 3 and 4 are in parallel with column 4 of Table 5, splitting $OtherV_{gj}$ in U.S. in column 3 and other nonChina countries in column 4. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table D5
Final goods.

Dependent variable	$lnChinaP_g$	$lnOtherP_g^j$	$lnChinaV_g$	$lnOtherV_g^j$	Implied lnP_{gt}/P_{g0}
	(1)	(2)	(3)	(4)	(5)
$\Delta ln\text{Input}\tau_{gt}$	1.516	0.388*	2.923	0.083	
	(1.056)	(0.206)	(1.744)	(0.112)	
$ln\text{Gap}_{g0}$	−0.011	−0.005	−0.602***	0.051**	
	(0.148)	(0.048)	(0.201)	(0.022)	
US Industry Controls	Yes	Yes	Yes	Yes	
Impact of WTO on Median industry:	−0.116	−0.030	−0.397	0.009	−0.046
Input tariff:	−0.113	−0.029	−0.218	−0.006	−0.050
Gap:	−0.003	−0.001	−0.179	0.015	0.004
N	577	22,225	577	22,225	
R^2	0.034	0.038	0.024	0.020	

Notes: This table is in parallel to Table 5, but limits the sample only to those HS6 industries that are classified as final goods according to the Broad Economic Categories (BEC categories 112, 122, 522, 51, 6). The median impact in the lower panel is calculated for a hypothetical industry with $\Delta ln\text{Input}\tau_{gt}$=-0.07 and $ln\text{Gap}_{g0} = 0.298$. Column 5 aggregates each component's impact as in Eq. (13) equal to $W_g^i \ \ln\hat{C}hinaP_g + (1-W_g^i) \ \ln\hat{O}therP_g + W_g^i \ \ln\hat{C}hinaV_g + (1-W_g^i) \ \ln\hat{O}therV_g$, with China's average weight in final goods W_{gt}^i=0.051, and the non-China weight $(1 - W_{gt}^i) = 0.949$. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table D6
Intermediate goods.

Dependent variable	$lnChinaP_g$	$lnOtherP_g^i$	$lnChinaV_g$	$lnOtherV_g^i$	Implied lnP_{gt}/P_{g0}
	(1)	(2)	(3)	(4)	(5)
$\Delta ln\text{Input}\tau_{gt}$	4.517***	1.796***	2.173	0.003	
	(1.126)	(0.584)	(2.059)	(0.246)	
$ln\text{Gap}_{g0}$	0.128	−0.162***	−0.736**	0.008	
	(0.102)	(0.059)	(0.357)	(0.027)	
US Industry Controls	Yes	Yes	Yes	Yes	
Impact of WTO on Median industry:	−0.171	−0.124	−0.294	0.002	−0.132
Input tariff:	−0.205	−0.082	−0.099	0.000	−0.088
Gap:	0.034	−0.043	−0.195	0.002	−0.044
N	1,330	42,715	1,330	42,715	
R^2	0.030	0.018	0.016	0.008	

Notes: This table is in parallel to Table 5, but limits the sample only to those HS6 industries that are not classified as final goods according to the Broad Economic Categories (BEC categories 112, 122, 522, 51, 6), which we refer to as intermediate goods. The median impact in the lower panel is calculated for a hypothetical industry with $\Delta ln\text{Input}\tau_{gt}$=-0.045 and $ln\text{Gap}_{g0} = 0.265$. Column 5 aggregates each component's impact as in Eq. (13) equal to $W_g^i\ \ln\hat{C}hinaP_g + (1-W_g^i)\ \ln\hat{O}therP_g + W_g^i\ \ln\hat{C}hinaV_g + (1-W_g^i)\ \ln\hat{O}therV_g$, with China's average weight in intermediate goods W_{gt}^i=0.029, and the non-China weight $(1 - W_{gt}^i) = 0.971$. * significant at 10%; ** significant at 5%; *** significant at 1%.

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