Quality and the Unequal Gains from Tariff Liberalization *

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Abstract

We study how product quality shapes the unequal consumer gains from trade liberalization by examining the effect of China's drastic tariff reduction on imported passenger vehicles in 2018. Combining data on prices, sales, and attributes for the universe of new passenger vehicles, we find that lower tariffs lead to larger consumer welfare gains in richer cities. This pro-rich bias of tariff reduction is explained by two mechanisms. First, imported cars are of higher quality than domestic cars, and car consumption in richer cities is more skewed towards imported cars. Second, lower tariffs lead to larger price reductions for higher-quality imported and domestic cars. The larger tariff-passthrough for high-quality cars can be explained by the pattern of quality specialization and firm's strategic price interactions.

Key Words: Quality, tariff pass-through, real income inequality

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1 Introduction

Over the past decades, a vast number of countries, developing ones in particular, have experienced large-scale trade liberalization, lowering their import tariffs substantially. Textbook economics tell us tariff reductions lower prices and benefit consumers. However, are rich and poor consumers benefited identically? Answering this question has direct implications for understanding how trade affects real income inequality. A number of studies approach this question by showing how different income groups differ in their consumption basket across sectors or products. However, specialization across countries today is increasingly taking the form of within-product specialization, with different countries producing the same good but with different quality (Schott, 2004). So, how does product quality affect the distributional effect of trade liberalization?

Theoretically, quality can lead to unequal consumer gains from trade liberalization through two channels. First, high-income (low-income) countries export high (low) quality goods and import low (high) quality goods.[1] Because rich people spend disproportionately more on high-quality goods, this pattern of quality specialization implies a higher share of imported goods in consumption for poor (rich) people in high-income (low-income) countries. Lowering import tariffs therefore disproportionately benefits the poor consumers in the high-income country and the rich consumers in the low-income country (Fajgelbaum et al., 2011). Second, prices of goods with different quality may respond differently to changes in trade costs. For example, liberalizing imports is pro-rich (pro-poor) if prices of high-quality goods are more (less) sensitive to the reduction in trade costs. In turn, how price responses vary with quality depends on market structure and a country's pattern of quality specialization.

In this paper we examine how product quality shapes the unequal consumer gains from trade liberalization through these mechanisms by focusing on an empirical setting – China's drastic tariff reduction on passenger vehicles. On May 23, 2018, China lowered its import tariffs for imported passenger vehicles from 25% to 15%. Combining data on prices, sales, and attributes of the universe of new passenger vehicles in China, we examine the impact of the tariff reduction on consumer welfare across cities with widely varying income levels. We first document stylized facts regarding quality specialization and non-homotheticity in consumption in China's car market. Next, we estimate tariff pass-through into the price of imported and domestic cars, and examine how tariff pass-through varies across quality segments. Finally, we calculate the consumer welfare changes induced by the tariff reduction with first-order approximation techniques.

We restrict our analysis on cars for a number of reasons. First, for this sector we have detailed information for the universe of varieties, both imported and domestic. This allows us to document

[1] Empirical evidence on quality specialization across countries are provided in Hummels and Klenow (2005); Khandelwal (2010); Hallak and Schott (2011); Feenstra and Romalis (2014). Theoretical explanations for such quality specialization include differences in factor abundance (Schott, 2004) and in preference for quality (Fajgelbaum et al., 2011).

quality specialization and estimate pass-through by comparing the quality and prices of imported versus domestic varieties. Information on domestic varieties in China is hardly available for other sectors. Second, detailed data on car attributes allow us to obtain reliable measures of quality, following standard practices in the literature. Lastly, the specific event of China's import tariff reduction in 2018 on cars provides a natural experiment setting to examine the distributional implications of actual trade liberalization policies.

We find lower tariffs lead to a substantial welfare gain of 34.6 billion RMB (or approximately $5.13 billion) for Chinese car consumers. Richer cities benefited relatively more. Measured by equivalent variation relative to initial car expenditure, welfare increased by 0.9% for the richest 10% of cities, but 0.3% for the poorest 10% cities. This pro-rich bias of tariff reduction is driven by two mechanisms. First, imported cars are of higher quality than domestic cars, and car consumption in richer cities is more skewed towards imported cars. Second, lower tariffs lead to larger price reductions for higher-quality imported and domestic cars, which are dis-proportionally consumed more by rich consumers. For example, a 10-percentage point reduction in tariffs reduced the tariff-inclusive price of low-quality, medium-quality, and high-quality imported cars by 1%, 2.7%, and 4.8%, respectively. The tariff reduction also slightly reduced the price of high-quality domestic cars, but had virtually no impact on the prices of low-quality domestic cars.

The higher tariff pass-through for higher quality cars is a surprising result in light of the recent studies on the relationship between quality and exchange rate pass-through(Auer et al., 2018; Chen and Juvenal, 2016; Antoniades and Zaniboni, 2016), since these studies generally document lower exchange rate pass-through rates for higher quality products. We show that our new empirical finding can be rationalized by the quality specialization pattern in our data, as well as firms' strategic pricing interactions. In China's car market, the market share of imported car is strongly increasing in quality. For example, the market share of imported car is only 0.2% in the low-quality segment but 38% in the high-quality segment. This means that a greater proportion of varieties are directly exposed to tariff reductions in the high-quality segment. When there are strategic interactions, the price setting of a variety depends on its price relative to other competing varieties, and therefore on the proportion of varieties that are exposed to the tariff reductions. The relative price of an imported car to its competitors will change less in the high-quality segment, since a greater proportion of their competitors are also imported cars and are exposed to the same tariff reductions. As a result, car producers in the high-quality segment will have less incentive to adjust their markups following the tariff reduction, leading to a higher tariff pass-through. We sketch a simple model a-la Arkolakis and Morlacco (2017) and Amiti et al. (2019) to illustrate this intuition. The model also predicts that lower tariffs will lead to larger price reductions of domestic cars in the higher quality segment. We find strong empirical support for this prediction in the data.

Our paper contributes to the literature regarding the impact of trade on inequality through the expenditure channel. Earlier works of this literature emphasize cross-sector consumption differences in driving the distributional effects of trade (Porto, 2006; Fajgelbaum and Khandelwal, 2016; Han et al., 2016). Unlike these studies, we focus on within-sector consumption differences. The distributional implications of within-sector consumption differences have also been investigated in other recent works (Faber and Fally, 2022; Heins, 2019). A few studies have incorporated both cross-sector and within-sector consumption differences (Borusyak and Jaravel, 2021; Hottman and Monarch, 2020). Our paper contributes to this literature in several aspects. First, we provide new evidence that trade liberalization in a developing country has a pro-rich bias through the quality channel, lending empirical support to the theoretical predictions in Fajgelbaum et al. (2011). Note that this result may be reversed for developed countries where imports are usually of lower quality than domestic goods. Second, we study the distributional effects of an actual instead of counterfactual trade policy shock. An advantage of our data-driven approach is that we can estimate the price response of imported and domestic goods to tariff changes, instead of relying on the conjectured pass-through implied by a specific demand system and market structure. Finally, we propose a new mechanism linking product quality with the distributional effects of trade, that is, the differential pass-through rate across quality segments.

Our paper is also related to the large literature on the response of prices to international shocks such as tariffs or exchange rates.[2] In particular, it is closely related to the recent literature on the relationship between quality and pass-through. A number of studies find lower exchange rate pass-through for goods with higher quality (Auer et al., 2018; Chen and Juvenal, 2016; Antoniades and Zaniboni, 2016). We contribute to this literature in two respects. First, we provide new evidence on how tariff pass-through varies with quality. To the best of knowledge, our paper is the first to find larger tariff pass-through rate for high-quality goods, and we show these new findings can be explained by quality specialization and firms' strategic complementarity in pricing. Second, we show the relationship between quality and pass-through has distributional implications, a point not investigated in previous studies.

The rest of the paper is structured as follows. Section 2 introduces the policy background and data, Section 3 estimates quality and present basic stylized facts on car quality and car consumption. Section 4 estimates tariff pass-through into the prices of imported cars. Section 5 investigates the price responses of domestic cars. Section 5 quantifies the impact of the tariff cut on consumer welfare across cities with different income levels. The last section concludes.

[2]For exchange rate pass-through, see Feenstra et al. (1996); Amiti et al. (2014); Amiti et al. (2019); Auer et al. (2018); Chen and Juvenal (2016); Antoniades and Zaniboni (2016); Berman et al. (2012), and Burstein and Gopinath (2014). For tariff pass-through, see Nicita (2009); Amiti et al. (2019); Amiti et al. (2020); Fajgelbaum et al. (2020); Cavallo et al. (2021); Ludema and Yu (2016).

2 Background and Data

2.1 China's automobile market and automobile tariffs

China has the world's largest car market. In 2017, sales of new passenger vehicles have reached 24.7 million units, accounting for about one third of world total. Imported car account for 4% of China's total car sales in terms of number of units sold. The majority of imported brands are from developed countries, including U.S., Germany, Japan, France, and Korea.

Before joining the WTO, China placed high protection on its automobile sector. The tariffs for passenger vehicles ranged from 80%-100% in 2000. After joining the WTO, China gradually lowered these tariffs over the following years. Tariffs for passenger vehicles were reduced to 25% in 2006, and have stayed at that level since then for 11 years. Starting from 2017, the Chinese authorities started to actively promote China's imports from the rest of the world. As part of this import promotion strategy, the Customs Tariff Commission of the State Council announced The Reduction of Import Tariffs on Automotive Vehicles and Parts on May 23, 2018. The announcement cut China's import tariffs for all imported passenger vehicles from 25% to 15% since July 1, 2018. In addition, tariffs for auto parts were also reduced from 8% -25% to 6% -15%. According to the official announcement, the policy was aimed at "furthering opening-up and reform", "satisfy consumer needs", and "promote restructuring of the automobile industry".

Foreign automobile manufacturers have responded actively to this policy change. For example, one day after the government announcement, BMW announced on its China official website to adjust its manufactured suggested retail price for imported models of BMW cars sold in China.[3] Other manufacturers such as Mercedes Benz, Audi, Chrysler, and Jeep have also announced price adjustment plans in the following weeks.

2.2 Data

We collect data on prices, sales, and attributes for the universe of passenger vehicles in China during 2017-2019 from multiple sources.

Price data. We obtain car price data from *DaaS-Auto*, a Chinese consulting firm specialized in providing data and consulting service related to the automobile industry. The data reports monthly trim-level manufactured suggested retail price (MSRP) of the universe of passenger vehicles sold in China from 2017-2019.[4] The data also reports information such as the manufacturer, brand, series, car type (Sedan, SUV, or MPV), fuel type (petroleum, diesel, electric, mixed), and displacement. Importantly, it also reports if the car is imported, produced locally by a domestic

[3]https://www.bmw.com.cn/zh/campaign/2018/duty-tax-deduction/index.html
[4]Examples of a trim is "BMW X5 xDrive35i".

manufacturer, or produced locally by a Sino-foreign joint venture.[5] We will call the latter two types of cars "domestic" in the subsequent analysis.

Manufactured suggested retail price is set by the manufacturer and is the same nation-wide for each trim-month. Discounts provided by individual dealers may lead transaction prices to deviate from MSRP. However, MSRP is a reasonable approximation for the actual transaction price paid by consumers because heavy discounts for cars in China are uncommon (Barwick et al., 2021). We compare MSRP and the transaction price for a small subset of trims for which we have transaction price data obtained from one car retailer in Beijing. The correlation between the MSRP and the transaction price is 0.99. Also, the deviation of the transaction price from MSRP exhibits no significant differences between imported and domestic varieties, which suggests that using MSRP instead of the real transaction price will not introduce bias to our estimation.

MSRP is inclusive of value-added tax (VAT), consumption tax, and tariffs (for imported cars). VAT rate is 17% for all cars. The consumption tax rate ranges from 1%-40% and is higher for cars with larger displacement. The composite tax rate is calculated using a compounding rule.[6] Table A1 in the Appendix reports the composite tax rate for imported and domestic cars with various displacement. The composite rate ranges from 13% to 144%. One thing to note is that because of the compounding rule, the uniform 10 percentage point tariff cut in May 2018 will lead to different *percentage point* change of the composite tax rate for imported cars with different displacement. For example, for imported cars with displacement smaller than 1L, the tariff cut lowered the composite rate from 48% to 36% (a 12 percentage point reduction), but for imported cars with displacement larger than 4L, the reduction is from 144% to 124% (a 20 percentage point reduction). However, the *log change* of the composite rate induced by the tariff change ($\Delta ln(1+T)$, where T is the composite tax rate), is the same across all displacements and is exactly equal to the log change of the tariff (i.e. $\Delta ln(1 + T) = \Delta ln(1 + tariff)$). This suggests that the tariff cut leads to the same log change in tax burdens for all imported cars.

Sales data. Sales data for year 2017-2019 are obtained from the new vehicle registration records from the Ministry of Public Security. The data reports model-level number of new vehicle registration in each prefecture city for each month.[7] We use the number of new registration as a proxy for sales.[8] The data also distinguishes whether the buyer is an individual or an institution. We focus on individual purchases because institutional purchases are often made beyond market

[5]Multinational automakers in China were required to partner with a local company and were not allowed to establish a purely foreign-owned firm. See Bai et al. (2020) and Barwick et al. (2021) for a discussion of the policy.

[6]Denoting the tariff rate, VAT rate, and consumption tax rate as $tariff$, vat, and ct, respectively, the composite tax rate is calculated by "$compositerate = (tariff + vat + ct + tariff \times vat)/(1 - ct)$. The composite rate is higher than the simple add-up of the three component rates because the tax base for consumption tax is inclusive of tariffs, and the tax base for value-added tax is inclusive of both tariffs and consumption tax.

[7]A model in the sales and attribute data is a unique combination of "firm-brand-series-car type-fuel type-transmission type-import status". Trims in the price data are more dis-aggregated than models. i.e. A model may include multiple trims.

[8]It is rare for consumers to purchase the car in one city and register in another city.

considerations.[9]

Attribute data. We manually collect data of car attributes, such as horsepower, displacement, fuel consumption, length, width, height, wheelbase, etc., at the model level from *Auto-Sina*, *Auto-Home*, as well as the official websites of the manufacturer. These attributes are used to infer quality in the subsequent analysis.

We match the models across the price, sales, and attribute data. The matched sample include 1,833 models and account for 86% of aggregate sales of passenger vehicles in China during 2017-2019. Section A2 in the Appendix describes the matching procedures and results in more detail.

Additionally, we collect GDP per capita, population, and the distance to the nearest sea port at prefecture city level for 2017-2019. These variables will be used for examining the relationship between car consumption and income across cities.

3 Quality and Consumption Patterns

3.1 Quality of imported and domestic cars

Following Goldberg and Verboven (2001) and Auer et al. (2018), we construct hedonistic indices of car quality that relate prices to attributes such as horse power, width, and fuel consumption. The idea is that higher quality is reflected as having more desirable attributes - such as higher horsepower or a more spacious cabin - that consumers are more willing to pay. Specifically, we estimate the following equation:

$$log\tilde{p}_i = \beta^{'}\mathbf{X_i} + \varepsilon_i \tag{1}$$

Where $log\tilde{p}_i$ is the time-averaged price of model i, net of taxes (we use a tilde to indicate the price is exclusive of tax).[10] $\mathbf{X_i}$ is a vector of observable car attributes, including maximum horsepower, displacement, fuel consumption, wheelbase, width, and height. We also estimate one specification including brand dummies to capture "soft" quality, such as brand names, reputation, or after-sales services.

One concern is that firms may upgrade quality in response to tariff reductions (Ludema and Yu, 2016). This is not a major issue for our study because our sample period covers only one and half years after the tariff adjustment. It is unlikely for firms to substantially change the quality of a model in such a short period of time. To ensure robustness, we also experimented with estimating quality using the sample for 2017 (i.e. one year before the tariff adjustments) in order to rule out the quality-upgrading effects. All results are similar.

[9] Individual purchase account for 80% of aggregate automobile sales in China in 2017.

[10] Net-of-tax prices are calculated as MSRP divided by the composite tax rate.

We report the estimation results of Equation (1) in Table A3 in the Appendix. The results show that maximum horsepower, displacement, wheelbase, and width are positively correlated with prices, while fuel-consumption is negatively correlated. Height has a negative contribution to prices in Column (1), but the effect becomes muted once brand dummies are controlled for. In general, these results are consistent with those obtained in the existing literature (Auer et al., 2018). The R-squared in all columns are high (0.83 for the specification including only observable characteristics and 0.95 for the specification with brand dummies), suggesting that the attributes included capture the dominant proportion of price variations across models.

We calculate the predicted log prices as our hedonistic quality index and normalize it to facilitate interpretation. The indices with and without incorporating soft quality have a strong correlation of 0.93. In the subsequent analysis we will call the index without incorporating soft quality (i.e. Column 1 of Table A3) "Quality Index 1", and that incorporating soft quality (i.e. Column 2 of Table A3) "Quality Index 2". Both measures also have a strong cross-sectional correlation with car prices, as shown in Table A4 in the Appendix.

Table 1 compares the quality of imported and domestic models. Column (1) and (2) shows that imported models are about 5 times as expensive as domestic ones even when taxes are net out. The next three columns show that imported cars in general have more desirable attributes, such as larger horsepower, larger displacement, and a more spacious cabin. The last two columns show that the hedonic quality indices we construct are also higher for imported cars. Taken together, these evidences suggest that imported models have higher quality than domestic ones.

Another important fact is that imported cars account for a substantial share of the high-quality market but a very small share of the low-quality market. To show this, we split all models into several quality segments and calculate the share of imported cars in terms of sales and number of models in each quality segment. Panel A of Table 2 split all models into high-end (MSRP>¥400,000), medium-end (¥200,000<MSRP<¥400,000), and low-end (MSRP<¥200,000) segments. The share of imported car is negligible in the low-end segment. In contrast, in the high-end segment, imported car accounts for 87% in terms of number of models and 38% in terms of sales. Panel B split all models into high, medium, and low quality segments based on the 50th and 75th percentile of the hedonistic quality index distribution. Similar pattern holds. Imported car accounts for 71% of the high-quality segment in terms of number of models and 22% in terms of sales. Their share in the low-quality segment is ignorable.

3.2 Consumption pattern across income distribution

Next, we show how the choice between imported and domestic cars vary across cities with different income. Income levels vary tremendously across cities in China. GDP per capita of the city at the 90th percentile of the income distribution is 4.2 times that of the city at the 10th percentile. Panel (a) in Figure 1 plots the share of imported models in total car consumption against GDP per-capita for each prefecture city for year 2017. The results show that the consumption share of imported cars increases strongly with GDP per-capita. In Table A5 in the Appendix, we use regression analysis to confirm that this positive relationship is statistically significant, and is robust to controlling for a series of other variables, such as population size, trade costs (proxied by the distance to the nearest ports), and province fixed effects.

Richer cities tend to purchase not only imported cars, but also high-quality domestic cars. Panel (b) in Figure 1 shows the share of high-quality domestic cars in total car consumption rises with income, and Panel (c) shows the share of low-quality domestic cars sharply declines with income. This relationship is also robust to controlling for other city-level characteristics, as shown in Table A5 in the Appendix.

The fact that household in richer cities consume relatively more imported models have important implications for the distributional effects of tariff liberalization. Since the tariff cut directly reduces the costs of imported cars, cities purchasing more imported cars are expected to benefit more from the event. To quantify this effect, we need to estimate the price responses to tariff changes, which we turn to next.

4 Estimating Tariff Pass-through

4.1 Empirical strategy

Baseline specification. To identify the effect of tariffs on the price of imported cars, we estimate the following equation at the trim level:

$$log(price_{it}) = \alpha + \beta Import_i \times Post_t + v_i + \lambda_t + \varepsilon_{it} \tag{2}$$

Where $log(price_{it})$ is the log tariff-inclusive price of trim i in year-month t. $Import_i$ is a dummy variable which equals 1 if the trim is imported. $Post_t$ is a dummy variable which takes values of 1 after May, 2018, the month of the tariff cut announcement.[11] We include trim fixed effects (v_i) to control for the effect of time-invariant car characteristics on prices, and time fixed effects (λ_t) to absorb macro-level economic and policy shocks that affect imported and domestic cars simultaneously.

The coefficient of interest is β, which captures the average price change of imported cars relative to domestic ones after the tariff cut. We expect β<0, as tariff cut reduces the tariff-inclusive price of imported automobiles relative to the domestic ones. Besides this simple difference-in-difference specification that only distinguishes pre and post periods, we also estimate an event-

[11]Following Fajgelbaum et al. (2020), we define the pre and post indicators based on the month of the announcement, instead of the month of implementation. As shown in Figure 2, many car producers lowered their prices immediately following the announcement of the tariff adjustments.

study specification to examine the dynamics of the price response:

$$log(price_{it}) = \alpha + \sum_{k=-6}^{6} \beta_k Import_i \times I_k + v_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Where I_k is the dummy for the kth month after the tariff cut. Since the tariff cut was a one-time event in May, 2018, we set I_1=1 for May, 2018, I_2=1 for June, 2018, etc. We omit I_0, which equals 1 for the month prior to the announcement of the tariff cut. The coefficient β_k captures the price changes of imported cars relative to domestic ones k months after the announcement of the tariff cut. To facilitate demonstration, we group all months later than 6 months after the tariff cut into period 6, and all months before 6 months prior to the tariff cut into period -6.

Quality and tariff pass-through. To examine how tariff pass-through varies with quality, we augment the baseline specification with interactions between quality measures and the treatment variable. Specifically, we split all models into three quality segments (low, medium, high) and set the low-quality segment as the omitted group. Then we estimate the following equation:

$$log(price_{it}) = \alpha_0 + \alpha_1 Import_i \times Post_t + \sum_k \beta_k QS_k \times Post_t + \sum_k \gamma_k QS_k \times Import_i \times Post_t + v_i + \lambda_t + \varepsilon_{it} \quad (4)$$

Where QS_k is an indicator for quality segment k ($k \in \{Medium, High\}$). We will use alternative quality measures to ensure the results are not sensitive to a specific measure. The regression also includes the interaction term between quality indicators and the post variable. The interaction term between quality and importing is absorbed by the trim fixed effects. The coefficients of interest are α_1 and γ_k. α_1 captures the tariff pass-through for cars in the low-quality segment, and γ_k captures how the tariff pass-through for the high and medium quality segment varies relative to the low-quality segment.[12]

Caveats for identification. Before presenting the results, several caveats about identification are in order.

First, the use of domestic cars as the control group rests on the assumption that the prices of domestic cars are not affected by tariffs. From a theoretical point of view, the prices of domestic cars can be indirectly affected by tariffs through strategic price interactions with imported cars in oligopolistic models.[13] However, as we will show shortly, in our data the average price of domestic cars barely changed with tariffs (see Figure 2). The main reason for this muted response is that a dominant share of domestic car is in the low-quality segment, where imported cars are almost non-existent (see Table 2). Intuitively, domestic cars and imported cars are targeting different

[12] An alternative specification is to interact the treatment variable ($Import_i \times Post_t$) with a continuous quality index. We have also implemented this specification and found qualitatively consistent results. We prefer the specification with quality segment dummies because this specification is more consistent with our theoretical model in Section A1, where we allow competition stance to vary across quality segments.

[13] Amiti et al. (2019) studied the strategic price interactions between imported and domestic varieties.

market segments and barely compete directly with each other. As we will show in Section 5, the prices of high-quality domestic cars, which are expected to compete more directly with the imported cars, indeed responded modestly to the tariff cut. Nevertheless, their modest price changes yield ignorable impact on the average price of the domestic cars since high-quality models only account for a very small share of domestic cars. In the robustness check, we use the low-quality domestic cars as an alternative control group, and find no material changes of the results.

Second, there might be other confounding policies that occur con-temporarily with the tariff cut. One solution to alleviate these confounding factors is to restrict the period of investigation to a shorter period before and after the shock. Following this suggestion, in the robustness check we restrict the sample to include only 4 months before and after the tariff cut. We also consider other concurrent policies such as the US-China trade war. The results barely change.

Third, one may worry there might be anticipations for the policy before it actually occurs. However, we show that before the announcement of the tariff cut, the price evolutions between imported and domestic cars follow very similar trends. This parallel pre-trend also suggests that our results are indeed driven by the tariff changes instead of other factors that may have already existed before the event.

4.2 Baseline Results

We first visualize the impact of the tariff cut on prices. Panel (a) of Figure 2 plots the evolution of log prices of imported and domestic cars before and after the tariff cut.[14] The prices of imported cars fell by about 4 percent immediately following the announcement of the tariff, whereas the prices of the domestic cars barely changed. Also, before the tariff cut, there is no discernible differences between the price evolutions of imported and domestic cars.

Column (1) of Table 3 reports the estimation results of Equation (2). The coefficient of interest is -0.045, which is statistically significant at 1% level. This implies a tariff pass-through of 54%, which is calculated by dividing the coefficient with the proportional change of the tariff ($\frac{\triangle log(\hat{price}_{it})}{\triangle log(1+\tau)} = \frac{-0.045}{-0.083} = 54\%$). In Table A6 in the Appendix, we report the estimation results of the event-study specification in equation (3). The results show that the majority of price reductions occurred within two months after the tariff cut, and kept relatively stable over the following months. In addition, the price evolution of imported and domestic cars are very similar prior to the tariff cut, as reflected by the small and insignificant coefficients for periods before the policy change.

We next examine the relationship between quality and tariff pass-through. In Panel (b) of Fig-

[14]To generate this graph, we regress log prices against two sets of interactions: an imported dummy interacted with the year-month dummies, and a domestic dummy interacted with the year-month dummies, controlling for trim fixed effects. Expressed in equations, we estimate $log(price_{it}) = \alpha + \sum_{k=-6}^{6} \beta_k Import_i \times I_k + \sum_{k=-6}^{6} \beta_k Domestic_i \times I_k + v_i + \lambda_t + \varepsilon_{it}$. The coefficients before the two set of interactions are shown in the plot.

ure 2, we plot the price evolution of the low-quality, medium-quality, and high-quality imported cars. For comparison, we also include the price of domestic cars.[15] The graph shows that imported cars of higher quality reduced their prices more after the tariff cut. High-quality imported cars cut their prices by about 6% while low-quality imported cars by only about 2%. To confirm this relationship, column (2)-(4) of Table 3 reports the estimation results of Equation (4). To ensure the robustness of our results to the measurement of quality, we used three alternative quality measures: quality index based on observable characteristics (Quality Index 1), and quality index based on both observable characteristics and soft quality (Quality Index 2), and time-averaged log(MSRP).[16] Regardless of the quality measure, we find the price reduction is larger for higher-quality cars. This suggests a larger tariff pass-through for higher-quality cars. The estimates based on Quality Index 2, for example, suggests the tariff pass-through for low, medium, and high-quality cars is 12%, 33%, and 58%, respectively.

4.3 Quality and Tariff Pass-through: Discussion

Our finding of a higher pass-through rate for higher quality car is worth some discussions in greater detail. An emerging strand of literature has examined the relationship between product quality and price responses to exchange rate fluctuations. These studies generally find that higher quality goods are associated with lower exchange rate pass-through. Explanations for this empirical relationship includes local distribution costs (Chen and Juvenal, 2016) and market-specific preferences for quality (Auer et al., 2018). Although we are not aware of any previous studies on how tariff pass-through varies with quality, the larger price responses of higher quality cars to tariffs look still surprising in the first place.

We argue that the larger tariff pass-through rate for high-quality cars can be rationalized as a result of firms' strategic complementarity in price setting, combined with the pattern of quality specialization. In our data, imported varieties take up a large market share in the higher-quality segment but a very small market share in the low-quality segment (Table 2). Therefore, for a high-quality imported variety, a large fraction of their close competitors is also imported cars. Since the tariff reduction lowers the costs for all imported cars identically, the price of an imported variety relative to its close competitors will move less with the tariff in higher-quality segments. To fix ideas, consider an extreme case where all varieties in the high-quality segment are imported. For an individual high-quality imported variety (e.g. BMW), the tariff reduction will lower not only its own cost, but also all of its competitors' (Benz, Chrisler) to exactly the same extent. As a result,

[15]We generate this graph by estimating the following equation: $log(price_{it}) = \alpha + \sum_{k=-6}^{6} \sum_{q\in\{H,M,L\}} \beta_{qk} Quality_q \times Import_i \times I_k + \sum_{k=-6}^{6} \gamma_k Domestic_i \times I_k + v_i + \varepsilon_{it}$.

[16]Low, medium, high quality car in Column (2) is defined as cars with time-averaged MSRP below ¥200,000, between ¥200,000 and ¥400,000, and above ¥400,000, respectively. In Column (3)-(4), they are defined according to the 50th and 75th percentile of the distribution of Quality Index 1 and Quality Index 2, respectively.

the tariff reduction will have no effect on the price competitiveness of this individual imported variety relative to its competitors. Since markup is a function of relative prices, this high-quality imported variety will have no incentive to adjust its markups, leading to a complete pass-through rate.

We sketch a simple oligopolistic competition model to illustrate this intuition in the Section A1 in the Appendix. We show that the pass-through rate, which is expressed as the elasticity of tariff-inclusive price with respect to tariffs, can be decomposed into two components: One component reflecting the impact of the tariff on the marginal cost of that variety (cost effect), and the other component reflecting the impact of the tariff on markups, induced by strategic complementarity in pricing in oligopolistic competition (strategic interaction effect). Expressed in equations:

$$\frac{dlogp_q^M}{dlog\tau} = \underbrace{\frac{(1-\omega_\eta)(1+\rho_c)}{1+\Gamma_q}}_{cost\ effect} + \underbrace{\frac{\Gamma_q}{1+\Gamma_q}\frac{dlogP_q}{dlog\tau}}_{strategic\ interactions} \tag{5}$$

Where ρ_c is the elasticity of production cost with respect to tariffs, ω_η is the share of local distribution costs in total costs, Γ_q is the price elasticity of markups in quality segment q, and P_q is the price index in quality segment q.

We prove that strategic interaction effect, which is summarized by the elasticity of the price index in a quality segment with respect to tariff changes ($\frac{dlogP_q}{dlog\tau}$), is an increasing function of the market share of imported cars in that quality segment. Under the assumption that the market share of imported cars is higher in the high-quality segment than the low-quality segment, the model implies that lower tariffs will induce stronger price reductions through the strategic interaction effects in the high-quality segment. This further leads to higher tariff pass-through in the higher quality segment.

As a caveat, we want to emphasize that the result of higher tariff pass-through in the higher quality segment is obtained under certain assumptions. For example, we assume that the share of local distribution costs in total costs are identical across quality segments (i.e. ω_η does not vary with quality). We also assume identical markup elasticity across quality segments (i.e. Γ_q is the same for every quality segments q). Relaxing these assumption may yield ambiguous relationships between quality and tariff pass-through. For example, the literature has pointed out that higher-quality goods usually are more intensive in local distribution (Chen and Juvenal, 2016). As local distribution costs are irresponsive to tariffs, this may lead to lower tariff pass-through for higher-quality goods. Our model can also accommodate these alternative determinants of pass-through rates. In general, the theoretical relationship between quality and tariff pass-through is ambiguous, reflecting several mechanisms whose effects potentially offset each other.

Our model also delivers a second testable hypothesis: lowering tariffs will induce larger price reductions of domestic cars in the higher-quality segments. We find strong empirical support for this prediction in Section 5. The intuition is that tariffs affect the price of domestic car only through strategic interaction effect. The stronger decline in competitor price index induced tariff reduction in the high-quality segment therefore leads to stronger price reductions there.

The difference between our results and those in previous works on quality and exchange rate pass-through could be potentially explained by several reasons. First, the existing studies are focused on the responses to exchange rates, not tariffs. One crucial difference between tariff and exchange rate is that exchange rate only affects imports from a specific country of origin, while the most-favored-nation (MFN) nature of tariffs implies that all imports will be affected, regardless of their country of origin. In this sense, tariff changes are more likely to affect a greater proportion of imports than bilateral exchange rate changes, leading to a stronger strategic complementarity effect. Second, our explanation rests on the specialization pattern that the import share is strongly increasing in quality. This pattern is more likely to hold in a developing country where imports are mostly from the developed countries and have higher quality than domestic varieties. In a developed country, the reverse could be true: imports are of lower quality than domestic ones. If this is the case, lower tariffs will induce a stronger strategic complementarity effect in the low-quality segment and lead to a high pass-through rate there.

4.4 Robustness Checks on Pass-through Estimation

We conduct a series robustness checks for the pass-through estimation.

Alternative Control Group. The baseline specification in section 4 sets the domestic cars as the control group. As we explained in Section 4.1, one concern with this strategy is that the price of domestic models may also be indirectly affected by the tariff cut through strategic interactions. Although Figure 2 shows that tariff cut leads to negligible price changes for all domestic cars as a whole, in principle we still need a "cleaner" control group that is theoretically unaffected by tariffs.

To address this issue, we use the low-quality domestic cars as an alternative control group. The idea is that strategic pricing interactions between imported cars and low-quality domestic cars should be very small because these two types of cars target completely different segments of the market, as shown in Table 2. As such, cost changes of imported cars will lead to little strategic price response of low-quality domestic cars.

To implement this strategy, we redo the regression in equation (2), but dropping medium and high-quality domestic cars from the sample, so the control group only includes the low-quality domestic cars. To examine the relationship between quality and pass-through, we estimate the following equation:

$$log(price_{it}) = \alpha + \sum_{k \in \{L,M,H\}} \beta_k Qimport_{ik} \times Post_t + v_i + \lambda_t + \varepsilon_{it} \qquad (6)$$

where $Qimport_{ik}$ is an indicator for imported cars in quality segment k ($k \in \{Low, Medium, High\}$).

Again, we only keep low-quality domestic cars and drop medium and high-quality domestic cars from the sample. The coefficient captures the price changes of low, medium, and high quality imported cars relative to low-quality domestic cars. Note that in this specification we can no longer include the interactions between quality segment and the post dummy to control for the changes in price trends across quality segments, so we need to assume that price movements are parallel across quality segments in the absence of the tariff. This parallel trend assumption is strongly supported in our data.

The results of estimating equation (6) is reported in column (1) in Table 4. Compared with low-quality domestic cars, the price of imported cars of low, medium, and high quality fell by 1%, 2.6%, and 5.3%, respectively. This confirms our baseline results that high-quality imported cars have a larger tariff pass-through.

Alternative Time Horizons. Our baseline results track the prices changes over the whole period of 2017-2019. This allows us to capture the full dynamics of the tariff pass-through. However, including a long-period after the tariff cut may raise concerns about whether the coefficients are contaminated by confounding policies and economic shocks at occurred at some point after the tariff cut. To address this concern, we re-estimate equation (2) and (4) using data before and after 4 months of the tariff cut.[17] The results in column (2) of Table 4 suggest that our baseline results still hold when we focus on a shorter sample period.

China-US Trade War. The China-US trade war broke out since 2018 has affected the applied tariff rates for car imports from the U.S.. On June 16, 2018, China announced to impose an additional 25% retaliatory tariff for imported automobiles from the U.S. since July 6, pushing the cumulative tariff rate for imported cars from the U.S. to 40% (15% MFN tariff + 25% retaliatory tariff). This additional tariff was suspended since January 1, 2019. To ensure the results are not driven by the trade-war, we drop cars imported from the U.S. from the sample. The original data includes information of nationality of the manufacturer, but does not report from which country the car is imported. Multinational production may lead the nationality of manufacture to differ from the source country. For example, a Mercedes-Benz car can be produced in the U.S.. To overcome this challenge, we obtain from Daas-Auto a list of mainstream models that are mainly produced in the U.S.. There are 49 models on the list, including models from non-US manufacturers such as Mercedes-Benz GLE, GLS, and BMW X3-X6. Results in Column (3) of Table 4 suggests that excluding these models have little impact on the baseline results, in terms of both signs and magnitude of the tariff effects. In addition, we separately examined how the prices of these US-imported cars responded to the trade war tariffs. We did find that prices responded quickly to the trade-war tariff changes, both for tariff imposition and subsequent tariff suspension.[18]

Distinguishing Domestic and Multinational Brands. Domestic cars in the baseline results include brands produced by Chinese domestic companies and those produced by China-foreign

[17] We also experimented with including 8 months before and after the tariff cut. The results are available upon requests.

[18] These results are available upon requests.

joint ventures. As a robustness check, we distinguish all three types of cars (imported, domestic, joint-venture). We modify Equation (2) and (4) by including interactions of the post dummy with both the imported dummy and the joint venture dummy. So the omitted group includes those cars produced by Chinese domestic manufacturers. The results in column (4) of Table 4 suggest that the baseline results that price of imported cars fell more in the high-quality segment still hold remarkably well. We also find that the price of cars produced by Sino-foreign joint ventures declined slightly compared with purely domestic cars, especially in the high-quality segment. One potential explanation for this difference is that the multinational manufacturers use more imported auto parts and components in their production, especially for higher-quality cars. As a result, the tariff reductions of auto parts and components lowered the costs of these cars relatively more.

Alternative Quality Measure. In the baseline, we measure quality by the hedonic quality index inferred from car attributes. The international trade literature has suggested an alternative way of inferring quality from price and sales data. The basic idea is that controlling for prices, varieties with larger sales are associated with higher quality. We follow Khandelwal et al. (2013) and estimate quality by running the following regression:

$$logq_{ict} + \sigma logp_{it} = \eta_{ct} + \varepsilon_{ict} \tag{7}$$

Where i,c,t refers to model, city, and time, respectively. $logq_{ict}$ and $logp_{it}$ are log quantity and log price. The right-hand side include city-time fixed effects (η_{ct}). We set the CES demand elasticity as 4, a commonly used value in the trade literature (Broda and Weinstein, 2006). We take the residuals and average them over time and across cites to get the quality measure for each model. Table A4 in the Appendix suggests that this measure is highly correlated with the hedonic quality indices we construct in Section 3. The regression results in column (5) of Table 4 suggest that the baseline results are unaffected when we use this alternative quality measure.

Price Response Within Brands. Many multinational auto manufacturers, such as BMW and Mercedes Benz, have established joint ventures in China. These brands may offer both imported and domestic varieties to Chinese consumers. For example, in our data we have both imported BMW cars and domestic BMW cars produced by BMW's China joint venture, BMW Brilliance Automotive Ltd. For such cases, we can identify the effect of tariff reduction by comparing the price response of the imported varieties and domestic varieties for the same brand. We implement this strategy by including brand-time dummies in the regression. This specification is arguably cleaner than our baseline specification because it rules out the effect of any brand-specific price trends. Nevertheless, the results in column (6) of Table 4 shows that our baseline results are still qualitatively unchanged.

Imported Auto Parts. Domestically produced cars may use imported auto parts. The event in May 2018 lowered the import tariffs for auto parts from 8%-20% to 6%-15%. This reduction of input tariffs may reduce the price of domestic cars intensively using imported car parts, inducing upward bias in the previous estimation results. However, we believe this is not likely to have a first-order impact on our previous results. First, the reduction of input tariffs will bias our estimates only by reducing the price of domestically produced cars. However, our previous results find the price of domestically produced cars barely changed after the tariff cut. Second, one may worry that domestic cars of higher quality use imported car parts more intensively, and thus are more strongly affected by the input tariff reduction. If that were the case, the price reductions of the high-quality domestic car would be smaller in the absence of the input tariff cut, and the price reductions of imported cars relative to domestic ones in higher quality segments will be even larger. In other words, if there were no reductions of tariffs for auto parts, we would expect to detect even larger pass-through rates for high-quality cars compared with low-quality ones. Thus, the larger pass-through rates for higher quality cars cannot be driven by tariff reductions of auto parts.

5 Price Responses of Domestic Cars

We now move to estimate the price responses of domestic cars to tariff reduction. Figure 3 shows that the average price of all domestic cars barely changed after the tariff cut. However, the impact of the tariff on the prices of domestic cars may vary across quality segments. Identifying this heterogeneity is challenging because it requires a control group whose prices are unaffected by the tariff cut. Our strategy is to assume that the price of low-quality domestic cars is unaffected by the tariff cut, and interpret the differential price changes of the medium and high-quality domestic cars relative to the low-quality domestic cars after the tariff cut as the pass-through rates. The assumption that low-quality domestic cars are unaffected by the tariff is sensible because imported cars have almost no presence in the low-quality car market in China. This implies that it is unlikely for the cost changes of the imported cars to affect the price of domestic cars through strategic interactions.

Specifically, we run the following regression based on the sample of domestic cars:

$$log(price_{it}) = \alpha + \sum_{k\in\{M,H\}} \beta_k QS_k \times Post_t + v_i + \lambda_t + \varepsilon_{it} \tag{8}$$

Where QS_k is an indicator for domestic car in quality segment k (k includes medium and high quality), and the omitted group is low-quality domestic cars. The coefficient β_k captures the differential price change of medium and high quality domestic cars relative to low-quality domestic cars after the tariff cut. To interpret the coefficients β_k as pass-through rates, we need to assume that the price evolution of high and medium quality cars is identical with that of low quality cars in the absence of the tariff reduction.

Figure 3 plots the price evolution of domestic cars in various quality segments. In periods prior to the tariff cut, price trends for all three quality groups are similar. After the tariff cut, the price of high-quality cars slightly dropped but that of low and medium quality cars barely changed. The regression results in Table 5 confirmed this finding. The price reduction of the high-quality car ranges from 0.2% to 0.9%, depending on the quality measure. This suggests a pass-through rate of 2.4% to 11%. The price change of medium quality car is statistically insignificant.

In Table A7 in the online Appendix, we report the results of an event-study regression where we interact the quality segment dummies with all pre and post time indicators. The results show that the price evolution of cars in the medium and high quality segments are not significantly different from that of low-quality cars in most of the time before the tariff cut. These parallel pre-trends suggest that the price reduction of high-quality domestic car after the tariff cut is indeed driven by the policy change instead of other confounding factors. The price reduction for high-quality cars mainly occurred within two-months after the policy change, which is consistent with the dynamic price response of imported cars as shown in Figure 2 and Table A6. This suggests that the prices of imported and domestic cars move together, and lend further support to the idea that there exists strategic interactions between imported cars and high-quality domestic cars.

6 Distributional Effects of Tariff Reductions

Equipped with the estimates of the price changes of imported and domestic models, we now quantify the impact of the tariff cut on consumer welfare across cities with various levels of income. We take the standard approach and measure welfare changes as the equivalent variation relative to initial expenditure (Deaton, 1989; Fajgelbaum and Khandelwal, 2016; Borusyak and Jaravel, 2021). To a first-order approximation, the equivalent variation induced by automobile price changes for a city (EV_c) can be expressed as follows:[19]

$$EV_c = -V_c \hat{P}_c \tag{9}$$

Where V_c is the total value of car consumption for each city, and $\hat{P}_c$ is each city's proportional change of the automobile price index. Therefore, the changes in consumer welfare relative to the city's initial value of car consumption is exactly equal to the changes in the automobile index.

$$dW_c = EV_c/V_c = -\hat{P}_c \tag{10}$$

We can further write the changes in the automobile price index into a market-share weighted average of the price changes of individual varieties.

[19]Here we only consider the changes in consumer surplus and ignores the potential impact of the tariff cut on producer surplus and tariff revenue.

$$\hat{P}_c = \sum_i s_{ic0} \hat{p}_i \tag{11}$$

Where $\hat{p}_i$ is the proportional change of the price of model i, and s_{ic0} is the share of model i in city c's total car consumption in the initial period (i.e. year 2017). In our implementation, we assume prices changes are identical across models within each "quality-import" group (e.g. high-quality imported cars, low-quality domestic cars), then the price index is reduced to:

$$\hat{P}_c = \sum_{q \in \{L,M,H\}} (s^D_{qc0} \hat{p}^D_q + s^F_{qc0} \hat{p}^F_q) \tag{12}$$

Where $\hat{p}^D_q$ ($\hat{p}^F_q$) is the proportional price changes of domestic (imported) models in quality segment induced by tariff changes, and s^D_{qc0} (s^F_{qc0}) is the initial market share of domestic (imported) cars in quality segment q in the city's total car consumption. We use the estimates in Table 3 and 5 to predict tariff-induced price changes $\hat{p}^F_q$ and $\hat{p}^D_q$, under the assumption that the price of low-quality domestic cars is unaffected by the tariff cut. Market share s^D_{qc0} and s^F_{qc0} are directly obtained from the data.

We can also calculate the changes of consumer welfare for China as a whole (EV) by simply replacing Equation (9) with their national counterpart. In particular, $EV = -V\hat{P}$, where V is China's total value of car consumption, and $\hat{P}$ is the proportional change in China's automobile price index, which can be expressed as the average price changes of individual varieties weighted by the market share of this variety in China's aggregate car consumption.

We find that the 10 percentage point tariff cut enhanced aggregate household welfare in China, as measured by the equivalent variation relative to initial car consumption, by 0.87%. Multiplying this number with the total value of automobile sales in China in 2017 (¥3.98 trillion), the tariff cut leads to a ¥34.6 billion (or approximately $5.13 billion) gains in consumer surplus for car purchasers in China.

This consumer gain is distributed unevenly across cities with different income. Figure 4 plots the welfare changes against the GDP per capita for each city. The strong positive relationship suggests that richer cities experienced larger welfare gains. In Table 6, we split all cities into six income groups, and report the welfare change for each group. The gains from tariff cut is monotonically increasing in income. Welfare increased by 0.9% for the richest 10% of cities, while only by 0.3% for the poorest 10% of cities.

The larger welfare gains in richer cities result from two mechanisms. First, car consumption in richer cities is more skewed towards imported cars, which are of higher quality than domestic cars. Second, due to strategic interaction effect, tariff cuts lead to larger price reductions for both imported and domestic cars in the high-quality segment. Admittedly, quantitatively disentangling these two mechanisms requires a structural model which allows us to conduct counterfactuals. While constructing such a model is beyond the scope of this paper, we conduct some simple exercise to provide suggestive evidence on the relative importance of the two mechanisms. Specifically, we re-calculate the welfare changes for each city, assuming that there is no strategic interaction effects in pricing. In such a case, tariff reduction leads to exactly identical price changes for all imported cars, and zero price changes for all domestic cars. This is implemented by setting the tariff pass-through coefficient to -0.45 (Column 1 of Table 3) for all imported cars, and to 0 for all domestic cars. The hypothetical welfare changes are reported in Column 2 of Table 6. First, welfare gains are smaller than the baseline for all income groups. This is because in the absence of strategic interaction effects, tariff reductions do not reduce the price of domestic cars which accounts for about 96% of China's aggregate car sales. In terms of distributional effects, we find shutting down the price mechanism slightly reduce the differences in welfare gains cross income groups, compared with the baseline. For example, in the baseline, welfare gains for cities at the 75th-90th percentile of the income distribution is 2.23 times that of the cities at the 10th-25th percentile (0.67% versus 0.3%), while in the hypothetical case the number is 2.14 times (0.58% versus 0.27%). We also regress the welfare changes of each city against the city's GDP per capita, and compare the slope coefficients for the baseline and hypothetical case. The slope is 0.33 for the baseline and 0.28 for the hypothetical. These exercise suggest that both the quantity and the price mechanisms lead to unequal gains from tariff reductions, but the majority of unequal gains are due to richer consumers purchase more imported cars.

7 Conclusions

By analyzing the event of China's tariff cut on passenger vehicles, this paper examines the role of product quality in driving the unequal consumer gains from trade liberalization. We identify two mechanisms through which quality drives such unequal gain. First, imported cars are of higher quality than domestic cars, and are purchased relative more in richer cities. Second, the price of high-quality imported and domestic cars fell relatively more with the tariff reduction. Combining these mechanisms, automobile tariff reductions lead to a strong pro-rich bias, in the sense that consumers in richer cities experienced larger consumer welfare gains. We argue that the larger tariff pass-through for higher-quality cars can be rationalized as a result of strategic interactions in pricing when markets are segmented by quality.

Although we focus on a specific sector and event, we believe the message that, because of quality differences, tariff liberalization lowers the cost of living more for richer consumers, is quite general for developing countries where imports are of higher quality than domestic goods. Our paper also shows that this pro-rich bias will be stronger if the market is segmented by quality. This has important implications for understanding the widening real income inequality in the episodes of trade liberalization as widely observed in a larger number of developing countries.

References

Amiti, M., O. Itskhoki, and J. Konings (2014). Importers, exporters, and exchange rate disconnect. *American Economic Review 104*(7), 1942–78.

Amiti, M., O. Itskhoki, and J. Konings (2019). International shocks, variable markups, and domestic prices. *The Review of Economic Studies 86*(6), 2356–2402.

Amiti, M., S. J. Redding, and D. E. Weinstein (2019). The impact of the 2018 tariffs on prices and welfare. *Journal of Economic Perspectives 33*(4), 187–210.

Amiti, M., S. J. Redding, and D. E. Weinstein (2020). Who's paying for the us tariffs? a longer-term perspective.

Antoniades, A. and N. Zaniboni (2016). Exchange rate pass-through into retail prices. *International Economic Review 57*(4), 1425–1447.

Arkolakis, C. and M. Morlacco (2017). Variable demand elasticity, markups, and pass-through. *Manuscript, Yale University*.

Auer, R. A., T. Chaney, and P. Saure (2018). Quality pricing-to-market. *Journal of International Economics 110*, 87–102.

Bai, J., P. J. Barwick, S. Cao, and S. Li (2020). Quid pro quo, knowledge spillover, and industrial quality upgrading: Evidence from the chinese auto industry. Report, National Bureau of Economic Research.

Barwick, P. J., S. Cao, and S. Li (2021). Local protectionism, market structure, and social welfare: China's automobile market. *American Economic Journal: Economic Policy 13*(4), 112–51.

Berman, N., P. Martin, and T. Mayer (2012). How do different exporters react to exchange rate changes? *The Quarterly Journal of Economics 127*(1), 437–492.

Borusyak, K. and X. Jaravel (2021). The distributional effects of trade: Theory and evidence from the united states. Report, National Bureau of Economic Research.

Broda, C. and D. E. Weinstein (2006). Globalization and the gains from variety. *The Quarterly journal of economics 121*(2), 541–585.

Burstein, A. and G. Gopinath (2014). *International Prices and Exchange Rates*, Volume 4, pp. 391–451. Elsevier.

Cavallo, A., G. Gopinath, B. Neiman, and J. Tang (2021). Tariff pass-through at the border and at the store: Evidence from us trade policy. *American Economic Review: Insights 3*(1), 19–34.

Chen, N. and L. Juvenal (2016). Quality, trade, and exchange rate pass-through. *Journal of International Economics 100*, 61–80.

Deaton, A. (1989). Rice prices and income distribution in thailand: a non-parametric analysis. *The Economic Journal 99*(395), 1–37.

Faber, B. and T. Fally (2022). Firm heterogeneity in consumption baskets: Evidence from home and store scanner data. *The Review of Economic Studies 89*(3), 1420–1459.

Fajgelbaum, P., G. M. Grossman, and E. Helpman (2011). Income distribution, product quality, and international trade. *Journal of political Economy 119*(4), 721–765.

Fajgelbaum, P. D., P. K. Goldberg, P. J. Kennedy, and A. K. Khandelwal (2020). The return to protectionism. *The Quarterly Journal of Economics 135*(1), 1–55.

Fajgelbaum, P. D. and A. K. Khandelwal (2016). Measuring the unequal gains from trade. *The Quarterly Journal of Economics 131*(3), 1113–1180.

Feenstra, R. C., J. E. Gagnon, and M. M. Knetter (1996). Market share and exchange rate pass-through in world automobile trade. *Journal of International Economics 40*(1-2), 187–207.

Feenstra, R. C. and J. Romalis (2014). International prices and endogenous quality. *The quarterly journal of economics 129*(2), 477–527.

Goldberg, P. K. and F. Verboven (2001). The evolution of price dispersion in the european car market. *The Review of Economic Studies 68*(4), 811–848.

Hallak, J. C. and P. K. Schott (2011). Estimating cross-country differences in product quality. *The Quarterly journal of economics 126*(1), 417–474.

Han, J., R. Liu, B. U. Marchand, and J. Zhang (2016). Market structure, imperfect tariff pass-through, and household welfare in urban china. *Journal of International Economics 100*, 220–232.

Heins, G. (2019). Endogenous vertical differentiation, variety, and the unequal gains from trade. *The Review of Economics and Statistics*, 1–45.

Hottman, C. J. and R. Monarch (2020). A matter of taste: Estimating import price inflation across us income groups. *Journal of International Economics 127*, 103382.

Hummels, D. and P. J. Klenow (2005). The variety and quality of a nation's exports. *American economic review 95*(3), 704–723.

Khandelwal, A. (2010). The long and short (of) quality ladders. *The Review of Economic Studies 77*(4), 1450–1476.

Khandelwal, A. K., P. K. Schott, and S.-J. Wei (2013). Trade liberalization and embedded institutional reform: Evidence from chinese exporters. *American Economic Review 103*(6), 2169–95.

Ludema, R. D. and Z. Yu (2016). Tariff pass-through, firm heterogeneity and product quality. *Journal of International Economics 103*, 234–249.

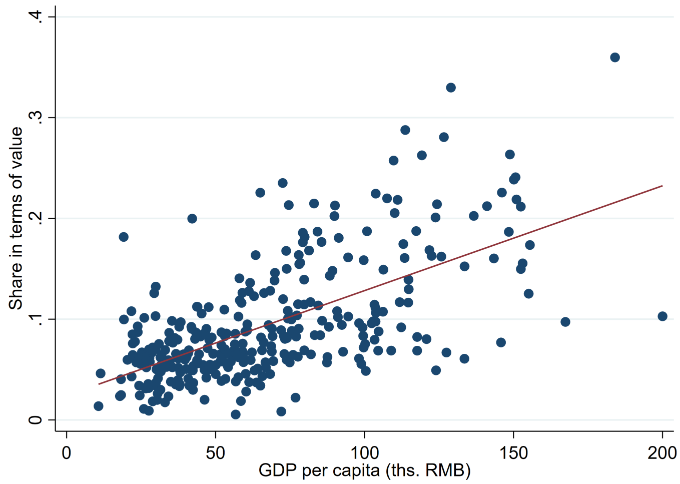
Nicita, A. (2009). The price effect of tariff liberalization: Measuring the impact on household welfare. *Journal of Development Economics 89*(1), 19–27.

Porto, G. G. (2006). Using survey data to assess the distributional effects of trade policy. *Journal of International Economics 70*(1), 140–160.

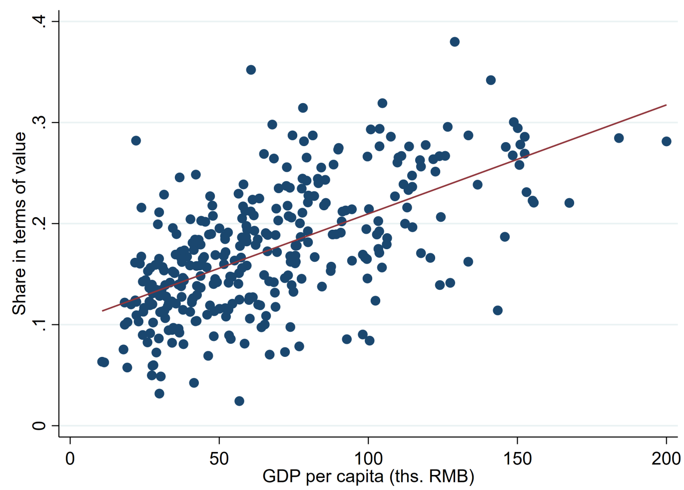
Schott, P. K. (2004). Across-product versus within-product specialization in international trade. *The Quarterly Journal of Economics 119*(2), 647–678.

Figure 1: The Relationship between Car Consumption and Income

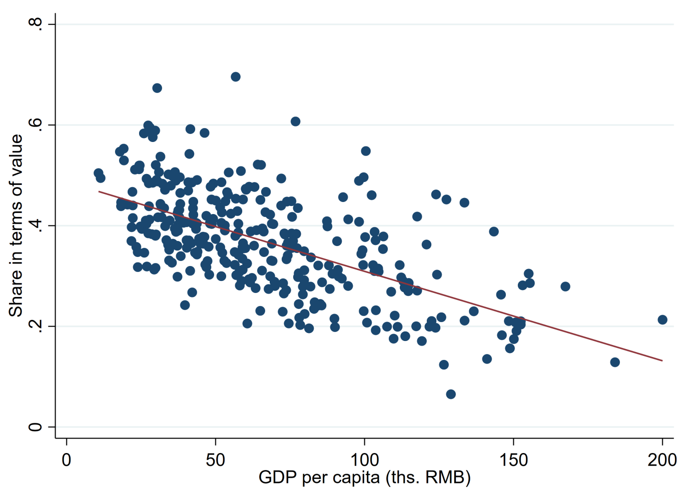
(a) Share of Imported Cars



(b) Share of High-quality Domestic Cars



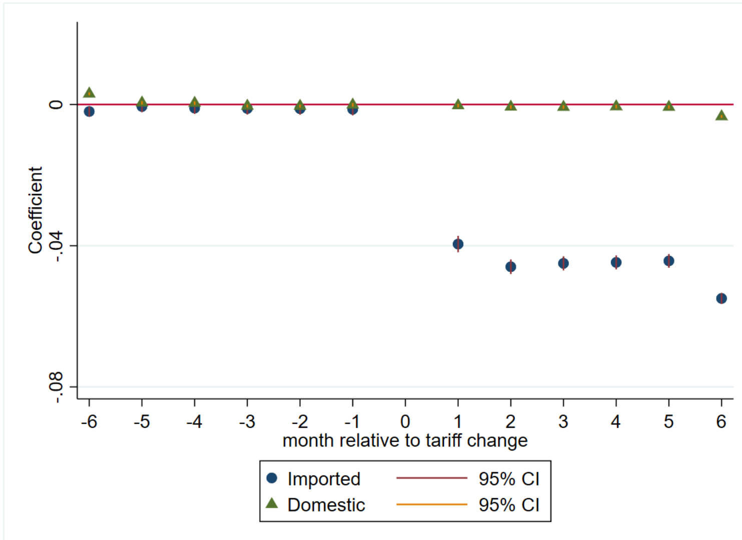
(c) Share of Low-quality Domestic Cars



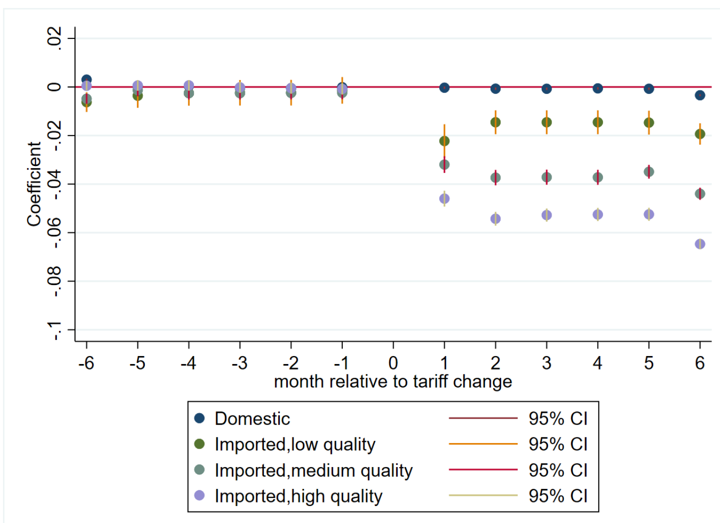
Note: Each dot represents a prefecture city. Horizontal axis is GDP per capita in thousand RMB. Vertical axis: (a) Share of imported car in total car consumption; (b) Share of high-quality domestic car in total car consumption; (c) Share of low-quality car in total car consumption.

Figure 2: Price Response of Imported and Domestic Cars

(a) Imported versus Domestic

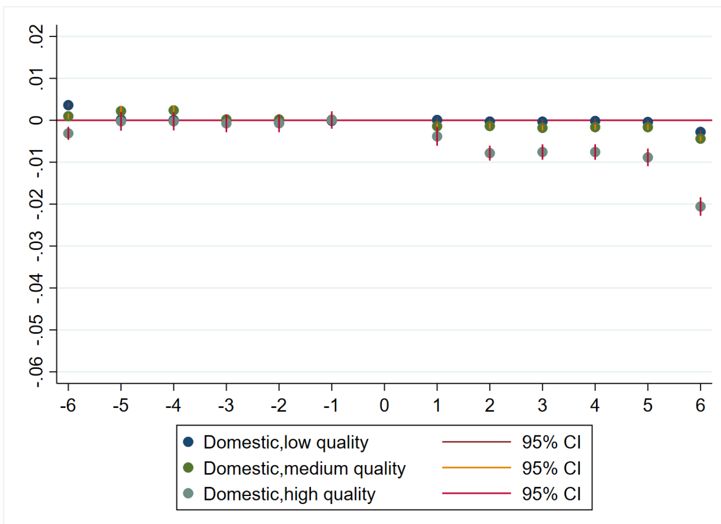


(b) Imported (various Quality) versus Domestic



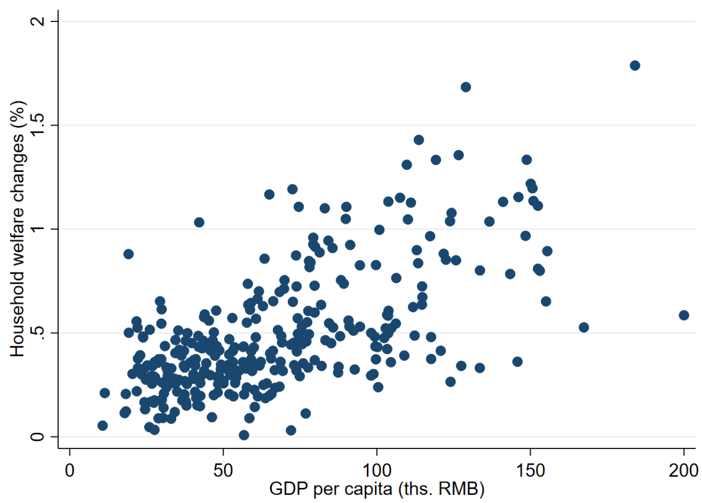
Note: Figure 2a plots the coefficients of $log(price_{it}) = \alpha + \sum_{k=-6}^{6} \beta_k Import_i \times I_k + \sum_{k=-6}^{6} \gamma_k Domestic_i \times I_k + v_i + \varepsilon_{it}$. *Figure 2b plots the coefficients of* $log(price_{it}) = \alpha + \sum_{k=-6}^{6} \sum_{q \in \{H,M,L\}} \beta_{qk} Quality_q \times Import_i \times I_k + \sum_{k=-6}^{6} \gamma_k Domestic_i \times I_k + v_i + \varepsilon_{it}$. *See section 4 for details. Months before (after) 6 months of the tariff cut are grouped into the 6th month before (after) the tariff cut.*

Figure 3: Price Response of Domestic Cars by Quality Segment



Note: This graph plots the coefficients of $log(price_{it}) = \alpha + \sum_{k=-6}^{6} \sum_{q \in \{H,M,L\}} \beta_{qk} Qdomestic_{ik} + v_i + \varepsilon_{it}$. *See section 5 for details. Months before (after) 6 months of the tariff cut are grouped into the 6th month before (after) the tariff cut.*

Figure 4: Relationship between Welfare Effects of Tariff Cut and Income



Note: Each dot represents a prefecture city. Horizontal axis is GDP per capita in thousand RMB. Vertical axis is the welfare change induced by the tariff cut, as calculated in Equation (12).

Table 1: Quality Comparison between Imported and Domestic Car

Type	MSRP (before tax)	MSRP (net of tax)	Max horsepower (kW)	Fuel consumption (L/100km)	displacement (L or T)
Domestic	146,988	116,721	110	7	17
Imported	1,003,146	514,164	219	9	29

Type	Length (mm)	Width (mm)	Height (mm)	Wheelbase (mm)	Quality index1	Quality index2
Domestic	4,566	1,810	1,609	2,694	-0.34	-0.38
Imported	4,735	1,880	1,560	2,824	1.18	1.32

Note: Manufactured Suggested Retail Price (MSRP) is in RMB yuan. The last two columns report the hedonistic quality index calculated in Section 3. Quality index 1 only include observable attributes, Quality index 2 include soft quality captured by brand dummies.

Table 2: Sales of Cars by Quality Group

	(1)	(2)	(3)	(4)	(5)	(6)
Type	Imported + Domestic		Imported		Share of imported	
	# models	sales (mill. unit)	# models	sales (mill. unit)	# models	sales
Panel A: MSRP						
Below ¥200,000	1,181	39.74	23	0.07	0.019	0.002
¥200,000-¥400,000	320	12.26	108	0.80	0.338	0.065
Above ¥400,000	312	5.06	273	1.94	0.875	0.383
Panel B: Quality Index						
Low	907	26.29	15	0.05	0.017	0.002
Medium	453	19.81	67	0.30	0.148	0.015
High	454	10.95	323	2.46	0.711	0.224

Note: Panel A split all models into low-end (MSRP<¥200,000), medium-end (¥200,000<MSRP<¥400,000), and high-end (MSRP>¥400,000). Panel B split all models into low, medium, high quality according to 50th and 75th percentile of the distribution of quality index 2. Column (1)-(2) reports the number of models and sales of domestic+imported cars for each quality group, Column (3)-(4) reports those for imported cars. Column (5)-(6) reports the share of imported cars in terms of number of models and sales. i.e. (5)=(3)/(1); (6)=(4)/(2).

Table 3: Price Response of Imported Cars

	(1)	(2)	(3)	(4)
Dep. Var. : log(Price)				
Quality measure		Quality index 1	Quality index 2	MSRP
$Import \times Post$	-0.045***	-0.027***	-0.010***	-0.011***
	(0.000)	(0.001)	(0.001)	(0.001)
$QS_M \times Import \times Post$		-0.005***	-0.017***	-0.021***
		(0.001)	(0.001)	(0.001)
$QS_H \times Import \times Post$		-0.022***	-0.038***	-0.036***
		(0.001)	(0.001)	(0.001)
$QS_M \times Post$		0.002***	0.001***	-0.002***
		(0.000)	(0.000)	(0.000)
$QS_H \times Post$		-0.002***	-0.005***	-0.009***
		(0.000)	(0.000)	(0.001)
Trim FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	141,226	141,226	141,226	141,226
R-squared	0.99	0.99	0.99	0.99

*Note: Column 1 reports regression results of Equation (2). Column (2)-(4) reports results of Equation (4). Dependent variable in all columns is log price at trim level. Quality measures in column (2)-(4): Quality index 1, Quality index 2, MSRP(time-averaged). QS_M and QS_H indicate medium quality and high quality segment, respectively. Low, medium, and high quality segment in column (2) and (3) are defined according to the 50th and 75th percentile of the quality index distribution. Low, medium, and high quality group in column (4) are defined as cars with time-averaged MSRP below ¥200,000, between ¥200,000 and ¥400,000, and above ¥400,000. All regressions include trim fixed effects and year-month fixed effects. Standard errors in parenthesis. *** p < 0.01, ** p < 0.05, * p < 0.1*

Table 4: Robustness Checks of Tariff Pass-through Estimation

Dep. Var.: log(Price)	(1) Alternative control group	(2) Pre and Post 4 months	(3) Exclude US imports	(4) Joint venture	(5) Alternative quality measure	(6) within-brand estimation
$Import \times Post$		-0.018***	-0.010***	-0.009***	-0.001	-0.017***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$QS_M \times Import \times Post$		-0.007***	-0.014***	-0.020***	-0.018***	-0.016***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$QS_H \times Import \times Post$		-0.028***	-0.038***	-0.047***	-0.049***	-0.028***
		(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
$QS_M \times Post$		0.000	0.001***	0.003***	0.000	0.002***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$QS_H \times Post$		-0.004***	-0.004***	0.004**	-0.005***	0.008***
		(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
$JV \times Post$				0.003***		
				(0.000)		
$QS_M \times JV \times Post$				-0.007***		
				(0.000)		
$QS_H \times JV \times Post$				-0.012***		
				(0.002)		
$Qimport_L \times Post$	-0.010***					
	(0.001)					
$Qimport_M \times Post$	-0.026***					
	(0.001)					
$Qimport_H \times Post$	-0.053***					
	(0.000)					
Trim FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
N	97,427	30,963	138,259	141,226	140,878	141,166

Note: Sample in Column (1) includes all imported cars plus low-quality domestic cars. See Equation (6) for the specification. Column (2) only includes observations within 4 months before or after the tariff cut. Column (3) excludes models imported from the US. Column (4) split all cars into three types: imported, produced by a Chinese domestic manufacturer, and produced by a sino-foreign joint venture (JV). The specification augment equation (4) by also including the triple interaction between JV dummy, quality segment dummies, and post-tariff-cut dummy. The omitted group is domestic cars made by Chinese manufactuers. In Column (5) quality measure is constructed following Khandelwal et al. (2013). See text for details. Column (6) further includes brand-time fixed effects. All regressions include Trim fixed effects and year-month fixed effects. The specification for column (2),(3),(5),(6) is equation (4). Quality measure in all columns except column (6) is Quality Index 2. Standard errors in parenthesis. $^{***} p < 0.01$, $^{**} p < 0.05$, $^{*} p < 0.1$

Table 5: Price Responses of Domestic Cars

	(1)	(2)	(3)
Dep. Var.: log(price)			
Quality measure	Quality index 1	Quality index 2	MSRP
$QS_M \times Post$	0.002***	0.001***	-0.001***
	(0.000)	(0.000)	(0.000)
$QS_H \times Post$	-0.002***	-0.005***	-0.009***
	(0.000)	(0.000)	(0.001)
Trim FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
N	112,845	112,845	112,845
R-squared	0.99	0.99	0.99

Note: This table reports the regression result of equation (8). Dependent variable in all columns is log price at trim level. Sample includes all domestic cars. The omitted group is low-quality domestic car. QS_M *and* QS_H *indicate medium quality and high quality domestic cars. Quality measures in column (1)-(3): Quality index 1, Quality index 2, and MSRP(time-averaged). Low, medium, and high quality group in column (1) and (2) are defined according to the 50th and 75th percentile of the quality index distribution. Low, medium, and high quality group in column (3) are defined as cars with time-averaged MSRP below ¥200,000, between ¥200,000 and ¥400,000, and above ¥400,000. Standard errors in parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$*

Table 6: Welfare Change Induced by Tariff Cuts across The Income Distribution

	(1)	(2)
Income Percentile	dW(%)	dW (counterfactual,%)
0-10th	0.30	0.26
10th-25th	0.30	0.27
25th-50th	0.36	0.31
50th-75th	0.52	0.45
75th-90th	0.67	0.58
90th-100th	0.90	0.78

Note: This table reports the welfare changes induced by tariff cuts for cities at various percentiles of the income distribution. dW_c is calculated according to Equation (10)-(12) and represents equivalent variation relative to initial car consumption. Column (1) reports the baseline results. Column (2) reports the counterfactual welfare changes assuming no strategic interaction effects. See main text for details.

Online Appendix

A1 Theory Appendix

This theory appendix sketches a model to rationalize our empirical finding that tariff pass-through is increasing in quality. There are two quality segments: high-quality (H) and low-quality (L). In each segment there are a finite number of varieties, which are either imported (M) or domestically produced (D). For simplicity, we assume that all varieties within an "quality-import type" cell (e.g. high-quality imported car, high-quality domestic car) are symmetric. Market structure is oligopoly, firms set their prices in response to the conjectured behavior of their competitors. Our pricing formula follows Arkolakis and Morlacco (2017) and Amiti et al. (2019). For an imported car in quality segment q, write its tariff-inclusive log price as:

$$log p_q^M = log \mu(p_q^M / P_q) + log(\tau c + \eta) \tag{13}$$

Where c represents marginal production costs exclusive of tariffs. $\tau > 1$ is the tariff rate. In addition to production costs, there is additive local distribution costs η, which are incurred after the tariff is paid. We assume these distribution costs are insensitive to tariff changes. Markup μ is assumed to be a function of the price of a variety relative to all competing varieties in the same quality segment. [20] Assuming a CES demand structure, the price index for quality segment q, P_q, can be written as

$$P_q = [n_q^M (p_q^M)^{1-\sigma} + n_q^D (p_q^D)^{1-\sigma}]^{\frac{1}{1-\sigma}} \tag{14}$$

Where n_q^M and n_q^D denotes the set of imported and domestic models.

Totally differentiate equation (1) we obtain

$$dlog p_q^M = -\mathit{\Gamma}_q (dlog p_q^M - dlog P_q) + (1 - \omega_\eta)(1 + \rho_c) dlog \tau \tag{15}$$

where $\mathit{\Gamma}_q = -^{dlog\mu}/_{dlog(p_q^M/P_q)}$ is the markup elasticity with respect to relative price. ρ_c is the elasticity of the production cost with respect to tariff rate, and $\omega_\eta = \frac{\eta}{\tau c + \eta}$ is the share of local distribution costs in total costs. Collect terms and divide the equation by $dlog\tau$, we obtain the following equation for tariff pass-through.

$$\frac{dlog p_q^M}{dlog \tau} = \frac{(1-\omega_\eta)(1+\rho_c)}{1+\mathit{\Gamma}_q} + \frac{\mathit{\Gamma}_q}{1+\mathit{\Gamma}_q} \frac{dlog P_q}{dlog \tau} \tag{16}$$

[20] This formulation assumes that strategic pricing interactions exist among varieties within the same quality segment. This assumption greatly simplifies the analysis. Our result will still hold if we allow strategic pricing interactions between quality segments, provided that the elasticity of substitution among varieties within a quality segment is larger than that between quality segments.

The first term on the right-hand side of equation (4), $\frac{(1-\omega_\eta)(1+\rho_c)}{1+\Gamma_q}$, captures the effect of tariffs on prices by directly affecting firms' marginal cost. The second term, $\frac{dlogP_q}{dlog\tau}$, captures the effect of the tariffs on the price of a variety through strategic pricing interactions among varieties. The changes in competitor prices are reflected in the changes in the price index of quality segment q. Intuitively, in oligopolistic models, when competitors lower their prices, as reflected in a reduction of P_q, the best response of a variety is also to lower its price. Inspecting equation (4) also shows that the strategic interaction effect is larger if lower tariffs induce a larger reduction in the competitor price index P_q.

Likewise, write the log price of a domestic car as

$$logp_q^D = log\mu(p_q^D/P_q) + log(c+\eta) \tag{17}$$

And totally differentiate to obtain the expression for tariff pass-through for domestic cars:

$$\frac{dlogp_q^D}{dlog\tau} = \frac{(1-\omega_\eta)\rho_c}{1+\Gamma_q} + \frac{\Gamma_q}{1+\Gamma_q}\frac{dlogP_q}{dlog\tau} \tag{18}$$

Tariffs do not have direct impacts on the importing costs of domestic cars, but can nevertheless affect the pricing of those cars through affecting production costs and the competition stance in the market.

Now let's focus on the strategic interaction term, $\frac{dlogP_q}{dlog\tau}$. Although strategic pricing interactions are well understood in the theory of oligopolistic competition, they were not given sufficient attention to explain the relationship between quality and pass-through. As we will show, how the strategic interaction effects affect pass-through across quality segments hinges critically on the pattern of quality specialization. To fix ideas, now let's assume there is no local distribution costs ($\omega_\eta = 1$), and that marginal costs do not respond to tariff changes ($\rho_c = 0$). The next lemma relates the magnitude of the strategic interaction effect with observables in the data.

Lemma 1. *The strategic interaction effect, measured by* $\frac{dlogP_q}{dlog\tau}$ *, is increasing in the cumulative market share of imported cars in a quality segment (*S_q^M *).*

$$\frac{dlogP_q}{dlog\tau} = S_q^M \tag{19}$$

Proof. Applying Shepard's lemma to Equation (2) we obtain

$$\frac{dlogP_q}{dlog\tau} = S_q^M\frac{dlogp_q^M}{dlog\tau} + (1-S_q^M)\frac{dlogp_q^D}{dlog\tau} \tag{20}$$

Substituting the expression for $\frac{dlogp_q^M}{dlog\tau}$ and $\frac{dlogp_q^D}{dlog\tau}$ in equation (4) and (6), setting $\rho_c = 0$ and $\omega_\eta = 1$ yields equation (8). □

Lemma 1 states that the magnitude of the strategic interaction effect can be summarized by the cumulative market share of imported car in that quality segment. Now we make the critical assumption that import cars constitute a larger share of the market in higher-quality segments, as we observe in the data:

Assumption 1. *The cumulative market share of imported (domestic) varieties is larger in the high-quality segment:*$S_H^M > S_L^M$.

This assumption naturally leads to our main proposition:

Proposition 1. *Lower tariffs lead to larger price reductions through strategic pricing interactions in the high quality segment. i.e.*

$$\frac{dlogP_H}{dlog\tau} > \frac{dlogP_L}{dlog\tau} \tag{21}$$

Assuming no distributional costs and identical markup elasticity across quality segments, the larger strategic interaction effect also implies higher tariff pass-through in the high quality segment, $\frac{dlogp_H^M}{dlog\tau} > \frac{dlogp_L^M}{dlog\tau}$.

Proof. Combining Assumption 1 and Lemma 1 directly yields $\frac{dlogP_H}{dlog\tau} > \frac{dlogP_L}{dlog\tau}$. Higher tariff pass-through in the high quality segment can be obtained by substituting $\frac{dlogP_H}{dlog\tau} > \frac{dlogP_L}{dlog\tau}$ into Equation (4), and set $\omega_\eta = 1$ and $\Gamma_H = \Gamma_L$. □

The intuition of Proposition 1 is straightforward. In higher quality segment, imported varieties account for a larger share of the market. Since their prices are more affected by tariff changes, it implies larger changes of aggregate prices in higher quality segments.

Discussion. Proposition 1 provides a rationale for the larger tariff pass-through in the higher-quality segment as observed in our data. We discuss the issues related to this proposition as below.

First, the critical assumption leading to larger strategic interaction effect in the higher quality segment is that imported goods account for a larger share of the market in the high-quality segment (Assumption 1). This suggests that the pattern of quality specialization is critical in understanding the relationship between quality and pass-through. In particular, Assumption 1 is more likely to hold for a developing country where imported goods are of higher quality than domestic goods. For a developed country where imported goods are of lower quality than domestic goods, the reverse is true. In this case, tariff reduction will lead to smaller strategic interaction effect and lower tariff pass-through in higher quality segments.

Second, we want to emphasize that the higher tariff pass-through in the higher quality segment can only be obtained under certain assumptions, such as no distributional costs, and identical markup elasticity across quality segments. Relaxing these assumption may yield ambiguous relationships between quality and tariff pass-through. For example, the literature has pointed out that higher-quality goods usually are more intensive in local distribution (Chen and Juvenal, 2016). As local distribution costs are irresponsive to tariffs, this may lead to lower tariff pass-through for higher-quality goods. This is reflected in a smaller ω_η for higher-quality goods in our equation (4). In addition, lower tariff pass-through in the higher quality segment can be obtained if we assume larger markup elasticity in the higher quality segments, i.e. $\Gamma_H > \Gamma_L$. In general, the theoretical relationship between quality and tariff pass-through is ambiguous, depending the relative magnitudes of these offsetting forces.

The strategic interaction effect can also shed light on how price responses of domestic cars vary across quality segments. We summarize the findings in the following proposition:

Proposition 2. Under Assumption 1, lower tariffs lead to larger price reductions of the domestic cars in higher quality segments.

$$\frac{dlogp_H^D}{dlog\tau} > \frac{dlogp_L^D}{dlog\tau} \tag{22}$$

The intuition for proposition 2 is as follows. For domestic cars, tariffs have no direct impacts on their costs, but can nevertheless affect their prices through strategic interactions. When imported cars lower their prices due to tariff reductions, the best response of domestic cars is also to reduce their prices. As shown in Proposition 1, such strategic interaction effect is stronger in the high-quality segment, because a larger share of cars there are imported. More intuitively, low-quality domestic cars and imported cars are in very different quality segments and barely compete with each other. As a result, tariff reductions that lower the costs of imported cars have little impact on the markups of the low-quality domestic cars.

A2 Matching Data Sets

We match the price, sales, and attribute data based on the basic car information provided in all three data sets. These information include: the name of manufacture, brand, series, car type (sedan, SUV, MPV), fuel type (petroleum, diesel, electric, mixed), transmission type (AT, MT), and import status (imported, domestic, produced by joint venture). We drop the observations if either of these variables missing, this drops around 1% of observations. Sometimes the names of the manufacture are slightly different across data sets. We manually adjust these differences. We define a model as a "firm+brand+series+car type+fuel type+transmission type + import status" combination. Table A1-1 reports the number of models in the raw data and in the matched data. Table A1-2 reports the total sales (units) in the raw sales data and the matched data. We also report the sales in the matched data as a share of total sales in the raw sales data.

Table A1-1: Number of Models in The Raw Data and Matched Data

	(1) Sales data	(2) Price data	(3) Attribute data	(4) Matched Data
2017	2,597	1,991	1,923	1,404
2018	2,573	2,053	1,945	1,417
2019	2,490	2,046	1,866	1,398
all years	3,483	2,646	2,420	1,833

Table A1-2: Sales (million unit) in The Raw and Matched Data

	(1) Sales data	(2) Matched Data	(3) Share
2017	19.40	16.47	0.85
2018	18.25	15.61	0.86
2019	16.77	14.65	0.87
all years	54.42	46.72	0.86

Note: Column (1)-(4) of Table A1-1 reports the number of models in the sales, price, and attribute, and matched data. Column (1)-(2) of Table A1-2 reports aggregate sales (in million units) in the sales data and matched data. Column (3) reports the share of sales accounted for by the matched data. i.e. (3)=(2)/(1).

Table A2: Tariff, Value-added Tax, and Consumption Tax Rates for Cars in China

Displacement (L)	(1) Tariff (before)	(2) Tariff (after)	(3) Value-added tax	(4) Consumption tax	(5) Composite (before)	(6) Composite (after)
Imported						
<1.0	25%	15%	17%	1%	48%	36%
1.0-1.5	25%	15%	17%	3%	51%	39%
1.5-2.0	25%	15%	17%	5%	54%	42%
2.0-2.5	25%	15%	17%	9%	61%	48%
2.5-3.0	25%	15%	17%	12%	66%	53%
3.0-4.0	25%	15%	17%	25%	95%	79%
>4.0	25%	15%	17%	40%	144%	124%
Domestic						
<1.0	0%	0%	17%	1%	18%	18%
1.0-1.5	0%	0%	17%	3%	21%	21%
1.5-2.0	0%	0%	17%	5%	23%	23%
2.0-2.5	0%	0%	17%	9%	29%	29%
2.5-3.0	0%	0%	17%	12%	33%	33%
3.0-4.0	0%	0%	17%	25%	56%	56%
>4.0	0%	0%	17%	40%	95%	95%

*Note: This table reports the tax rate for domestic and imported cars with various displacement levels. Column (1)-(6): tariff rate before May 2018, tariff rate after May 2018, value-added tax rate, consumption tax rate, composite tax rate before May 2018, composite tax rate after May 2018. The composite tax rate is calculated as (tariff+vat+ct+tariff*vat)/(1-ct).*

Table A3: Quality Estimation

	(1)	(2)	(3)	(4)
Dep. Var.: $log(\widetilde{MSRP})_i$				
log(horsepower)	1.124***	0.575***	1.223***	0.662***
	(0.048)	(0.032)	(0.048)	(0.032)
log(displacement)	0.427***	0.269***	0.589***	0.339***
	(0.047)	(0.031)	(0.050)	(0.032)
log(wheelbase)	1.359***	1.141***	1.197***	0.993***
	(0.207)	(0.141)	(0.203)	(0.135)
log(width)	2.010***	3.440***	1.657***	3.347***
	(0.369)	(0.249)	(0.364)	(0.244)
log(height)	-1.520***	-0.161*	-1.136***	0.002
	(0.099)	(0.073)	(0.103)	(0.072)
log(fuel consumption)			-0.466***	-0.257***
			(0.035)	(0.021)
Brand dummies	No	Yes	No	Yes
N	1814	1814	1716	1716
R-squared	0.813	0.943	0.828	0.949

Note: Dependent variable is time-average of log manufacture suggested retail price, net of taxes, for each model. Car attributes include maximum horsepower, displacement, wheelbase, width, height, and fuel consumption, all in logs. Column (2) and (4) include brand dummies to capture soft quality. Sample size in column (3)-(4) are slightly smaller because fuel consumption is not applicable to electric vehicles.

Table A4: Correlation Matrix of Various Quality Measures

Measure	Quality Index 1	Quality Index 2	Quality KSW	Log(MSRP)
Quality Index 1	1			
Quality Index 2	0.9286	1		
Quality KSW	0.9031	0.9707	1	
Log MSRP	0.9017	0.9731	0.9889	1

Note: Quality index 1 and 2 are inferred from car attributes, see Section 3 for details. Quality index 1 only include observable attributes. Quality index 2 also include soft quality captured by brand dummies. Quality KSW is inferred using price and sales data, following Khandelwal et al. (2013).See section 4.4 for details. Log(MSRP) is the log of the time-averaged manufactured suggested retail price.

Table A5: Relationship between Car Consumption and Income

	(1)	(2)	(3)
Panel A: Dep. Var.: import share (quantity)			
log(GDP per capita)	0.024***	0.018***	0.015***
	(0.002)	(0.002)	(0.001)
log(population)		0.010***	0.012***
		(0.001)	(0.001)
log(distance to port)		-0.002**	-0.004***
		(0.001)	(0.001)
N	322	322	322
R2	0.349	0.561	0.756
Province FE	No	No	Yes
Panel B: Dep. Var.: import share (value)			
log(GDP per capita)	0.061***	0.044***	0.040***
	(0.005)	(0.005)	(0.004)
log(population)		0.025***	0.033***
		(0.003)	(0.003)
log(distance to port)		-0.004*	-0.011***
		(0.002)	(0.003)
N	322	322	322
R2	0.302	0.479	0.656
Province FE	No	No	Yes
Panel C: Dep. Var.: High-quality domestic share (value)			
log(GDP per capita)	0.068***	0.060***	0.050***
	(0.005)	(0.006)	(0.004)
log(population)		0.015***	0.028***
		(0.003)	(0.003)
log(distance to port)		-0.002	-0.003
		(0.002)	(0.003)
N	322	322	322
R2	0.318	0.365	0.745
Province FE	No	No	Yes
Panel D: Dep. Var.: Low-quality domestic share (value)			
log(GDP per capita)	-0.113***	-0.098***	-0.083***
	(0.008)	(0.009)	(0.007)
log(population)		-0.032***	-0.041***
		(0.005)	(0.004)
log(distance to port)		0.001	0.014**
		(0.003)	(0.005)
N	322	322	322
R2	0.354	0.442	0.716
Province FE	No	No	Yes

*Note: All variables are at prefecture city level. Dependent variable in each panel: A. share of imported car in total car consumption (in terms of quantity); B. share of imported car in total car consumption (in terms of value); C. share of high-quality domestic car in total car consumption; D. share of low-quality domestic car in total car consumption. Column (2) includes log population and log distance to the nearest sea port. Column (3) further includes province fixed effects. Robust standard error in parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$*

Table A6: Price Response of Imported Car: Event-study Specification

Dep. Var.: log(price)	(1)	(2)	(3)	(4)
Quality measure		Quality Index 1	Quality Index 2	MSRP
$Import \times pre6$	-0.005***	-0.009***	-0.013***	-0.010***
$Import \times pre5$	-0.001*	-0.002	-0.006**	-0.004*
$Import \times pre4$	-0.001**	-0.001	-0.004*	-0.003
$Import \times pre3$	-0.001	-0.001	-0.004	-0.002
$Import \times pre2$	-0.001	-0.000	-0.003	-0.002
$Import \times pre1$	-0.001*	-0.001	-0.003	-0.001
$Import \times post1$	-0.039***	-0.030***	-0.022***	-0.022***
$Import \times post2$	-0.045***	-0.030***	-0.015***	-0.014***
$Import \times post3$	-0.044***	-0.030***	-0.015***	-0.014***
$Import \times post4$	-0.044***	-0.030***	-0.015***	-0.014***
$Import \times post5$	-0.044***	-0.027***	-0.015***	-0.014***
$Import \times post6$	-0.052***	-0.033***	-0.017***	-0.017***
$QS_M \times Import \times pre6$		0.010***	0.011***	0.004**
$QS_M \times Import \times pre5$		0.003	0.005*	0.000
$QS_M \times Import \times pre4$		-0.001	0.002	-0.002
$QS_M \times Import \times pre3$		-0.001	0.003	-0.001
$QS_M \times Import \times pre2$		-0.001	0.003	-0.001
$QS_M \times Import \times pre1$		-0.001	0.002	-0.001
$QS_M \times Import \times post1$		0.002	0.001	-0.008***
$QS_M \times Import \times post2$		-0.002	-0.011***	-0.022***
$QS_M \times Import \times post3$		-0.003	-0.012***	-0.021***
$QS_M \times Import \times post4$		-0.002	-0.012***	-0.021***
$QS_M \times Import \times post5$		-0.003	-0.014***	-0.019***
$QS_M \times Import \times post6$		-0.000	-0.014***	-0.023***
$QS_H \times Import \times pre6$		0.006***	0.011***	0.014***
$QS_H \times Import \times pre5$		-0.000	0.003	0.005*
$QS_H \times Import \times pre4$		-0.000	0.001	0.003
$QS_H \times Import \times pre3$		0.001	0.002	0.002
$QS_H \times Import \times pre2$		0.000	0.002	0.002
$QS_H \times Import \times pre1$		0.001	0.001	0.000
$QS_H \times Import \times post1$		-0.012***	-0.021***	-0.020***
$QS_H \times Import \times post2$		-0.019***	-0.034***	-0.032***
$QS_H \times Import \times post3$		-0.018***	-0.032***	-0.031***
$QS_H \times Import \times post4$		-0.017***	-0.032***	-0.030***
$QS_H \times Import \times post5$		-0.022***	-0.032***	-0.029***
$QS_H \times Import \times post6$		-0.021***	-0.035***	-0.026***
N	141,209	141,226	141,226	141,209
$QS_M \times$Time indicators	No	Yes	Yes	Yes
$QS_H \times$Time indicators	No	Yes	Yes	Yes
Trim FE	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes

Note: Dependent variables in all columns are log price at trim level. Column (1) reports estimation results of equation (3). Column (2)-(4) augment equation (3) by including the interactions between quality segment dummies with all pre and post indicators. Quality measures in column (2)-(4): Quality index 1, Quality index 2, log MSRP(time-averaged). QS_M and QS_H indicate medium quality and high quality segment, respectively. Low, medium, and high quality segment in column (2) and (3) are defined according to the 50th and 75th percentile of the quality index distribution. Low, medium, and high quality group in column (4) are defined as cars with time-averaged MSRP below 200,000, between 200,000 and 400,000, and above 400,000. All regressions include trim fixed effects and year-month fixed effects. Column (2)-(4) include quality segment dummies interacted with all pre and post indicators. Standard errors are not reported due to space constraints. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table A7: Price Response of Domestic Cars: Event-study Specification

Dep. Var.: Log(Price)	(1)	(2)	(3)
Quality measure	Quality index 1	Quality index 2	log(MSRP)
$QS_M \times pre6$	-0.003***	-0.002***	-0.002***
$QS_M \times pre5$	-0.000	0.001*	0.002***
$QS_M \times pre4$	0.000	0.001	0.002***
$QS_M \times pre3$	0.000	0.000	0.001*
$QS_M \times pre2$	0.000	0.000	0.001*
$QS_M \times pre1$	-0.000	-0.000	0.000
$QS_M \times post1$	-0.000	0.000	-0.001***
$QS_M \times post2$	0.000	0.001	-0.001**
$QS_M \times post3$	0.000	0.001	-0.002***
$QS_M \times post4$	0.000	0.001	-0.002***
$QS_M \times post5$	0.001	0.002***	-0.001***
$QS_M \times post6$	0.001***	-0.001	-0.002***
$QS_H \times pre6$	-0.002***	-0.004***	-0.005***
$QS_H \times pre5$	0.001	0.002**	-0.000
$QS_H \times pre4$	0.001	0.002***	-0.000
$QS_H \times pre3$	-0.001	0.001	-0.000
$QS_H \times pre2$	-0.001	0.001	-0.000
$QS_H \times pre1$	-0.001	0.000	0.000
$QS_H \times post1$	-0.001	-0.003***	-0.004***
$QS_H \times post2$	-0.001*	-0.003***	-0.008***
$QS_H \times post3$	-0.001**	-0.004***	-0.007***
$QS_H \times post4$	-0.002**	-0.004***	-0.007***
$QS_H \times post5$	-0.001	-0.003***	-0.008***
$QS_H \times post6$	-0.005***	-0.008***	-0.018***
N	112,845	112,845	112,845
Trim FE	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes

*Note: Dependent variables in all columns are log price at trim level. Sample include only domestic cars. Quality measures in column (2)-(4): Quality index 1, Quality index 2, log MSRP(time-averaged). $Qdomestic_M$ and $Qdomestic_H$ indicate medium quality and high quality domestic cars, respectively. Low, medium, and high quality segment in column (2) and (3) are defined according to the 50th and 75th percentile of the quality index distribution. Low, medium, and high quality group in column (4) are defined as cars with time-averaged MSRP below 200,000, between 200,000 and 400,000, and above 400,000. All regressions include trim fixed effects and year-month fixed effects. Column (2)-(4) include quality segment dummies interacted with all pre and post indicators. Standard errors are not reported due to space constraints. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$*