The Differential Effect of Tariffs by Quality

Estimates from Scotch Whisky

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Abstract

I investigate the distributional consequences of tariffs on consumer goods, focusing on how the pass-through and variety-loss effects are heterogeneous by product quality. I use product level data from Pennsylvania during the United States' 25% tariffs on single malt Scotch from 2019 to 2021 to estimate a difference-in-differences model and find that the tariffs caused more pronounced price increases for lower quality products but higher likelihood of product exit for higher-quality products. I then estimate a discrete choice demand model to model the heterogeneous consumer preferences for these products, and find that compared to a baseline scenario of uniform tariff-effects, accounting for the quality differential effect decreases the welfare of low-income consumers even further but increases welfare for high-income consumers, suggesting that tariffs may be more regressive than previously studied. I find that the heterogeneous pass-through rates can be explained by markup adjustments driven by the relationship between price and demand curvatures. This study contributes to understanding the distributional effects of tariffs, emphasizing heterogeneity in both tariff-effects and consumers.

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†Researcher(s)' own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the NielsenIQ data are those of the researcher(s) and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

1 Introduction

Assessing the burden of tariffs on final consumer goods depends on a precise measure of the distributional impact on consumers. Tariffs may impact consumers through several channels, such as a pass-through of the tariff cost to retail prices and a decrease in imported varieties. Individual product quality, however, may substantially affect each product's degree of pass-through or availability. For instance, less vertically differentiated products of "lower quality" tend to have lower markups, which in the face of a tariff may lead to a little room for tariff absorption and so higher pass-through. On the other hand, due to the lower sales volume of high-quality products, the demand may shift inwards to the point that the product becomes unprofitable to export and drops out. These quality differential effects of the tariffs may have significant distributional consequences, as low-income consumers tend to purchase cheaper lower-quality goods which may see higher price increases, while the high-income consumers may have been more likely to purchase the expensive products that drop out. Ex-ante, however, whether individual product quality does significantly alter the pass-through and availability is an open empirical question, with potential distributional implications and relevance for evaluating the costs of tariff policy.

In this paper, I utilize detailed product-level data to answer whether product quality significantly modulates the impacts of tariffs and its implications for consumers of differing incomes. I examine the effect of tariffs in both how prices respond (do lower quality products see a higher passthrough of tariffs?) and the variety of products imported (do higher quality products drop from the market?). I then estimate a consumer demand model with heterogeneous consumers and apply the descriptive findings to quantify the welfare loss by income levels for both the price and variety effect. I find that the degree of passthrough of the tariffs differs with the quality of the product, and disproportionately hurts the welfare of the lower-income consumers. On the other hand, I find that the tariffs led to a disproportionate decrease in imports of higher-quality goods. As higher-income consumers were more likely to purchase these higher-quality goods, this loss of variety led to a disproportionate welfare loss for higher-income consumers. Overall, the tariffs pose a larger loss for low-income consumers, but high-income consumers lose substantially as well due to the tariffs.

I study the 25% ad valorem tariffs, which were in effect from October 2019 to March 2021, on single malt Scotch imposed by the United States on the European Union as part of a package of tariffs approved by the World Trade Organization (WTO) relating to the Boeing-Airbus subsidies dispute. These specific tariffs are an ideal setting to study the quality bias of tariffs for several reasons. First, the tariffs were born out of a dispute on airliner subsidies, unrelated to the Scotch industry. This alleviates concerns over whether single malt Scotches were targeted for reasons related to demand or domestic industry protection. Second, Scotch has several salient features of quality, such as branding and spirit age, that vary widely across products and provide ample variation to study how tariff impact differs by quality. Third, single malt Scotch has an ideal control group of blended Scotch, which shares most production processes with single malt Scotch. The tariffs overlap with several potential confounding factors like COVID-19 and Brexit, which the blended Scotch effectively controls for. A detailed discussion of the tariffs and Scotch industry is provided in Section 2 of this paper.

I study the Scotch whisky market in Pennsylvania, where the Pennsylvania Liquor Control Board (PLCB) maintains a monopoly on the distribution and sales of liquor and wine within the state. With the weekly sales data from January 2019 to August 2021, I can observe how prices and variety changed before, during, and after the tariffs. Furthermore, the PLCB also publishes a quarterly catalog of products along with the retail prices, and a monthly sales list, and maintains constant prices throughout most of the state[1], which all allow me to track the changes in prices and variety throughout the state.

I start with a difference-in-differences design to measure the policy impact of the tariffs on single malt Scotch prices and variety. To account for confounding cost shocks from COVID and Brexit, I use the prices and variety of blended Scotch as a control group for

[1]There is an exception for certain stores at the state border

single malt scotch. I find that relative to blended Scotch, single malt Scotch prices in Pennsylvania increased by 10.4% on average. Broken down by quality, however, there is a wide heterogeneity of the tariff effect: the price increases range from 15.0% for lower quality goods to 6.70% for higher quality goods. For the variety effect, I find that there is a 26% overall decrease in the availability of products, but once again, large heterogeneities by quality from 8% for the lower quality products to 41.2% for the higher quality products.

There are a few potential explanations from theory for why the tariff effect may vary so substantially by product quality. On the pass-through side, since firms create market power via product differentiation, more vertically differentiated ("higher quality") products may face a less elastic demand that corresponds to higher markups via the inverse elasticity pricing rule. Thus when hit with a cost shock such as a tariff, the firms have larger margins to adjust and may absorb more of the tariffs in the form of lower markups, unlike the undifferentiated products that are operating at prices closer to costs and cannot absorb the tariffs. However, whether such markup adjustment actually occurs is dependent on the curvature of the demand - if the residual demand becomes more elastic as prices increase[2], markups will decrease, and vice versa. Thus, concavity in the demand for high-quality goods and convexity for low-quality goods may explain these results; the substitution of less price-sensitive consumers to low-quality goods in the face of increased prices may induce convexity in the demand for low-quality goods and explain the markup adjustments that we observe. The curvature of the residual demand for each product depends on the heterogeneity of consumers demanding the good, and on the substitution of consumers to and away from the products in the market. Using my demand model, I find that there is substantial heterogeneity in the demand curvature across products of different prices, in particular, more concave for high-quality products and convex for low-quality, suggesting that the patterns from the reduced form model may be explained by markup adjustment behavior of the firms. I find that this difference in curvature can be explained by the substitution of high-income

[2]i.e., Marshall's Second Law of Demand, which states that holding all else fixed, a price increase will lead to demand becoming more elastic

consumers to cheaper products, leading to lower average price sensitivity of consumers of cheaper products and thus higher markups charged by the firms.

On the variety side, the fixed cost of exporting may suggest why we observe high-quality products drop out of the market more. Romer (1994) emphasizes the role of fixed cost on the extensive margin of trade (i.e., introduction and exit of products), which Hummels and Klenow (2005) builds on with a quality dimension to argue that only the varieties with sufficiently low marginal cost relative to quality will be profitable to export. Thus, while the higher quality goods can absorb more of the tariffs by downward markup adjustments, the decrease in the demand may make the fixed cost of exporting unrecoverable. Further, as Arkolakis et al. (2008) notes, the first products to exit in the face of higher trade costs are the low-volume varieties, which in this case tend to be the high-quality goods as few people may afford to purchase these products. Lower-quality goods on the other hand, while they pass through more of the tariffs, may be able to cover the fixed costs of exporting with their higher sales volumes. Industry sources also indicate that many high quality varieties were ceased importing after the imposition of the tariffs. These results show that the impact of tariffs is moderated by market shares.

The differential effect of the tariffs on pass-through and variety may have important distributional implications for consumer welfare. While tariffs and other taxes are often understood to be regressive due to the higher income-share of consumption of low-income consumers, the higher pass-through for the lower quality products may exacerbate this regressiveness due to the low-income consumers predominantly purchasing lower quality products. On the other hand, the variety impact will be felt the most by the high-income consumers. While a low-income consumer may not care that a $300 limited-release bottle of Scotch is no longer available to purchase, high-income consumers will be more likely to have been purchasing the high-quality bottles - a progressive effect.

Thus, to quantify the welfare impact of the tariffs, I estimate a random coefficients nested logit (RCNL) model of demand (Berry 1994 and Berry et al. 1995) that flexibly models substitution behavior. Consumers choose each pricing period, which roughly corresponds to a month, to purchase one bottle of Scotch or Irish whisk(e)y[3], with utility determined by the price, alcohol content, bottle size, and brand. Substitution is driven by consumer heterogeneity in prices and proof, and a nesting structure further captures the preference for bottles of the same category (single malt Scotch, blended Scotch, single malt Irish, blended Irish, outside good). To estimate how consumers of different incomes are impacted differently by the tariffs, consumers are modeled to be of four income groups (< \$45K, \$45K - \$70K, \$70K - \$100K, > \$100K) with distinct price sensitivities for each income group. Prices are instrumented using the tariff and wholesale prices in New York state as exogenous cost shifters, as well as an indicator for product sales promotion status, which I argue induces exogenous shifts in demand. The consumer heterogeneity is estimated by matching consumer purchasing patterns with model predictions.

With the demand model, I can calculate the change in welfare from single malt Scotch consumption of the tariffs under different scenarios. First I calculate the welfare loss from increased prices, with and without the quality bias by taking the product choice set in October 2019 (at the beginning of the tariffs) and imposing reduced-form estimated price increases by March 2021 (at the end of the tariffs). I find that under a uniform pass-through assumption, the lowest income consumers (yearly income of less than \$45K) see a 53% decrease in consumer surplus from Scotch consumption, while the highest income consumers (yearly income of more than \$100K) see a 12% decline. However, by incorporating the heterogeneous pass-through rates by quality into the pass-through estimates, I find that the lowest income consumers' surplus decreased by 66%, and 17% for the high-income consumers.

I next calculate the welfare loss due to a decrease in variety, following a similar procedure to the pass-through estimates. I estimate a logit model of the exit probability of each product, with and without allowing for differing effects by quality, between October 2019 to March 2021. I then run Monte Carlo simulations of randomly dropping different products

[3] I introduce Irish whiskey to broaden the definition of the inside good market, as the choice of the outside good is relevant for substitution

according to an estimated probability of being dropped and calculate the loss in consumer surplus in each case. This approach has the caveat of ignoring new product introduction, so the interpretation of the results is limited to "how does the decrease in product choice set correlated with the tariffs decrease consumer surplus?". I find that when simulating the exit of products independent of quality, lowest-income consumers' welfare decreases by 15% and 7% for high-income consumers. Once quality is accounted for, the welfare decrease is lessened, to 0.18% for low-income consumers and 1.25% for high-income consumers. I find that these results are driven by the fact that once accounting for quality, the low-quality goods, which had higher market shares, are less likely to drop out. This result was discussed in Arkolakis et al. (2008), in that the gains (loss) from product introduction (exit) tend to be muted because of the low market shares of the marginal products. The novel result here is that because low market share products tend to be high-quality products, the welfare loss from variety loss is higher for high-income consumers than low-income consumers.

My final welfare calculation involves comparing (1) uniform price increases and uniform product exit and (2) heterogeneous price increases and heterogeneous product exit. That is, I compare the estimated welfare loss with no quality differential effects and with quality differential effects. I find that the lowest income consumers see a decrease in welfare by 60% compared to 18% for the highest income, but once the quality bias (in both prices and variety) is accounted for, the numbers become 66% and 18%, respectively. These findings suggest import distributional implications for evaluating the welfare consequences of tariffs. Assuming a uniform pass-through underestimates the welfare loss and assuming uniform product exit overestimates the welfare loss, as the majority of purchases across all income groups are generally the cheaper products which saw the highest pass-through rates and lower product exit. Combining the two effects, however, low-income consumers lose out the most due to the dominating price effect while high-income consumers actually see a decrease in their welfare loss. Absent complete tariff absorption and no change in product variety by the suppliers, these findings suggest that the tariffs for differentiated consumer products disproportionately hurt low-income consumers, more so than previously estimated with uniform effects.

There are a few potential concerns and qualifications to this study. The first is whether unit price is an appropriate measure of quality. While unit price is often used as a proxy for quality, there may be cases of high-quality goods that are priced lower due to, say, the productivity of the exporting firm. However, as I show later in Section 2, observable quality measures such as branding and age statement are highly correlated with prices and thus suggest that price acts as a good proxy for quality[4]. Second, as a partial equilibrium analysis, my study ignores any strategic responses by domestic firms in response to the tariffs or any income effects due to the tariffs. For example, as in Flaaen et al. (2020), upon observing the price increase of single malt Scotch due to tariffs, domestic Bourbon producers may have raised their prices in response. Whether this effect is relevant depends on how much Scotch consumers perceive Scotch and Bourbon to be substitutes. However, by ignoring such strategic responses outside the Scotch market, my analysis may underestimate the harm of the tariffs on consumers. Finally, there may be concerns that the results are driven entirely by the business decisions of the Pennsylvania Liquor Control Board and not by the suppliers. Thus, I also present an analysis quantifying the impact of the tariffs using wholesale price data from New York, i.e., prices charged by manufacturers to wholesalers, and find that these results hold as well.

My analysis first contributes to the empirical literature on the passthrough of tariffs. Examples of previous industry-level studies include Feenstra (1989), Irwin (2019), and Flaaen et al. (2020). These papers find a wide range of estimates of pass-through, suggesting that tariffs have idiosyncratic effects by industry and market structure. Fajgelbaum et al. (2019), Amiti et al. (2019b, 2020), and Cavallo et al. (2021) offer more macroeconomic analyses of the recent US trade wars and find complete pass-through in most cases. Nakamura and

[4]There is another often used measure of quality in trade from Khandelwal (2010) that defines quality as shares conditional on prices. Defining quality as shares conditional on prices may lead to an expensive bottle and a cheap bottle, by having similar relative shares conditional on price, to have similar levels of "quality," which is contrary to common notions of Scotch "quality."

Zerom (2010), Ludema and Yu (2016), and Amiti et al. (2019a) study the role of markup adjustments in explaining incomplete pass-through. This paper is the first to study the heterogeneity of pass-through by quality at the individual product level and, using a demand model that accommodates consumers of different incomes and precisely measures consumer purchases, to calculate the distributional effects of tariffs accounting for markups adjustment by quality.

My paper also contributes to the literature on consumer welfare from increased variety via trade. Krugman (1979), Feenstra (1994), and Broda and Weinstein (2006) model the consumer gains from additional variety, while Bernard et al. (2011), Mayer et al. (2014, 2021) approach the relationship between trade costs and variety from the firm side. Hummels and Klenow (2005) in particular studies the quality of exports, while Kehoe and Ruhl (2013) and Arkolakis et al. (2008) study the types of products that are introduced in the extensive margin. On the welfare loss from tariffs, Amiti et al. (2019b) calculates the impact of tariffs on variety and show that tariffs led to a decrease in the variety of imports. In contrast to many of these studies where variety is often defined as a country-product pair, my analysis considers variety within a "product," such as a \$30 vs \$300 bottle of Scotch. I link the changes in the extensive margins of trade to quality, and show that the bias towards high quality goods exiting the market affects high-income consumers.

Finally, estimation of cost pass-through has long been an interest in the industrial organization literature, with a recent resurgence of interest in the role of demand curvature. Weyl and Fabinger (2013) studies the relation between curvature of the log demand and pass-through in the presence of market power, and several recent papers study the role of functional form restrictions on demand curvature, such as Griffith et al. (2018), Birchall et al. (2023), and Miravete et al. (2023a,b). On the empirical side, Kim and Cotterill (2008), Chatterjee et al. (2013), and Allcott et al. (2019) examine pass-through in specific industries, and Miravete et al. (2020) analyze the effects of taxation in a similar setting. I complement the findings in the literature by showing that an industry-wide cost shock can lead to a wide range of pass-through rates for different products, and analyze the role of consumer substitution in determining the demand curvature that drives this heterogeneity.

The rest of this paper is organized as follows: Section 2 presents the institutional context of the Scotch industry and the tariffs, as well as a discussion on the data sources. Section 3 estimates the policy impact of the tariffs on prices and variety. Section 4 discusses the consumer demand model, the estimation strategy, and the results of estimation. Section 5 discusses the mechanisms behind the differential pass-through and analyzes the consumer welfare loss under different scenarios. Section 6 concludes.

2 Institutional Context and Data

Scotch Whisky Industry

Due to the distinctive brand and image associated with Scotch, the Scotch industry is tightly regulated by the government of the United Kingdom. In 2009, the UK Parliament passed a statute (*The Scotch Whisky Regulations 2009*) that lays out nine different conditions for a distilled spirit to be defined as Scotch, from the minimum years of maturation to the capacity of the casks. As a protected brand name under EU law, Scotch must be distilled and aged in Scotland, and single malt Scotch in particular must be bottled before it is exported. These regulations ensure that Scotch is produced in the UK, and thus production relocation of Scotch in response to the tariffs is limited. Single malt Scotch and blended Scotch constitute the majority of the market, accounting for 32% and 60% of Scotch exports by value in 2022, respectively. Single malt Scotch is a scotch whisky produced from only water and malted barley at a single distillery by batch distillation in pot stills, with popular brands such as Glenlivet, Glenfiddich, and Macallan. Blended Scotch is defined as a combination of one or more single malt Scotch whiskies with one or more single grain Scotch whiskies, with popular brands such as Johnnie Walker, Ballantine's, Chivas Regal, and Dewar's. The US is the largest export market for Scotch, at around 1 billion GBP in exports in 2022, constituting around one-sixth of total exports by volume.

The largest players in the industry are Diageo, Pernod Ricard, William Grant & Sons, with around 41%, 22%, and 8% of the Scotch market by sales. These firms often produce both single malt Scotch whiskies and blended Scotch whiskies. Diageo, for example, produces a line of single malt Scotch whiskies from its Talisker Distillery but also uses whisky from Talisker blended with whiskies from its other distilleries to produce the Johnnie Walker Green Label. Distilling, maturing, bottling, storing, and transportation costs are shared between single malt and blended Scotch, which suggests that any potential cost shock to single malt Scotch arising from Brexit or the COVID-19 pandemic that propagates to retail prices would also be shared with blended Scotch as well. Thus, blended Scotch serves as a natural control group for studying the impact of the tariffs on single malt Scotch.

Single malt Scotch whiskies are known for each product's idiosyncratic taste and aroma coming from the particular distillery, aging, cask, and use of peat, amongst many other factors used in production. On the other hand, blended Scotches are made from whiskies from different sources and often "average out" these idiosyncrasies to create a consistent flavor. Scotch, but single malt Scotch, in particular, is differentiated in two main dimensions. The age of a bottle is the main avenue for vertical differentiation. The age of a Scotch is determined by the youngest spirit in the blend[5], and age statements are mostly found on single malt Scotch whiskies. Age is often associated with higher quality due to the complex flavors drawn out of the spirit due to the longer maturation time in the oak casks, although there is a point of decreasing returns at the extremely old ages. Thus, very old whiskies aside, an older age bottle is almost always considered a higher quality bottle, both within a brand and across brands (e.g., a Glenlivet 18 would generally be considered higher quality than a Glenlivet 12 *and* a Macallan 12).

Branding is another avenue for product differentiation, as a mix of both horizontal and vertical. For single malt Scotches, the brand is simply the distillery from which the Scotch

[5]Single malt Scotch is technically a blend as well, just that the component spirits are from the same distillery

was produced, e.g., Macallan branded Scotches are distilled at the Macallan distillery in the Speyside region of Scotland. Distilleries are known for their distinctive characteristics; for example, the Laphroaig, Lagavulin, and Ardbeg distilleries are known for their smokey tastes coming from the peat used in the production process. Preference for this smokey taste, also known as "peatiness", is highly idiosyncratic, and thus creates horizontal differentiation. On the other hand, some brands, such as Macallan, are generally considered higher quality than others and act as a form of vertical differentiation. As the Scotch Whisky Association, an industry group notes, "many consumers buy these products because of their provenance and are unlikely to shift to products produced elsewhere," indicating that each brand does create differentiation and a sort of market power.

These two dimensions of differentiation (age and brand) determine the overall (idiosyncratic or common) perceived "quality" of a bottle. A simple hedonic regression of log prices on age and brand of 750 ML bottles with an age statement returns an R-squared of 0.96, or an adjusted R-squared of 0.91, indicating that price is highly correlated with age and brand and strengthening the case for using prices as a proxy for quality. Select output for the hedonic regression is presented in Table 1.

Furthermore, Table 2 shows that the number of products in each age statement is generally decreasing while the median price is increasing, suggesting that more vertically differentiated products do enjoy less immediate competition.

United States Section 301 Tariffs on the European Union

The Section 301 tariffs were imposed by the United States on the European Union (EU) in response to what the U.S. considered illegal subsidies for Airbus. The dispute dates back to 2004 when the U.S. first filed a complaint with the World Trade Organization (WTO) alleging that the EU provided prohibited subsidies to Airbus, negatively impacting Boeing's competitiveness. After years of lawsuits and counterclaims, in April 2019, the U.S. announced a list of products to be tariff-ed pending WTO approval, which was authorized in

	Dependent variable:
	log(prices)
12 YEAR	0.371***
	(0.122)
15 YEAR	0.777***
	(0.130)
25 YEAR	2.235***
	(0.230)
MACALLAN BRAND	0.534***
	(0.188)
TALISKER BRAND	0.648**
	(0.271)
Observations	78
R^2	0.964
Adjusted R^2	0.909
Residual Std. Error	0.171 (df = 31)
F Statistic	17.793*** (df = 46; 31)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 1: Select Output From Hedonic Regression

October 2019. This led to the U.S. imposing a series of tariffs on various European imports.

In March 2021, the U.S. and the E.U. decided to suspend tariffs for four months, and in June 2021, both sides reached an agreement to suspend tariffs for five years, putting an end to this long-standing trade dispute over aircraft subsidies.

The selection of the products to apply the tariff may be relevant for identification of the tariff effect. In particular, there may be concerns about whether the tariffs are not exogenous to demand or cost shocks, or perhaps single malt Scotch was chosen to protect the domestic whiskey industry. While no smoking gun suggests that the US did choose single malt Scotch as-good-as randomly, several pieces of evidence point to that fact. The tariff product list suggests that the products to be targeted were based on choosing "nationally representative" products, rather than in response to demand shocks in particular industries. In addition to single malt Scotch whisky, the tariff list included Irish butter, Irish cream, French and Italian

Age Statement	# Products	Median Price
12	46	$49.99
15	14	$67.49
18	23	$114.99
21	10	$209.99
25	10	$599.99

Table 2: Product Space by Age Statement

cheese, Spanish olive oil, and English wool coats. On the EU side, tariffs were already in place on product categories containing Harley Davidson motorcycles and Bourbon whiskey, also likely not for economic reasons. This tit-for-tat of tariffs between the US and EU appears to be focusing on inflicting political harm rather than economic, thus giving credence to the exogeneity argument. Further, if the US was indeed interested in protecting the domestic whiskey industry from a burgeoning Scotch industry, placing the tariffs on blended Scotch would have been more sensible as they are closer in price and character to domestic whiskies. Thus, I argue that the selection of single malt Scotch for tariffs was unrelated to demand or other economic reasons, and thus the tariff provides a natural experiment for estimating the impact of tariffs.

There is a concern about the potential spillover effect of the tariffs from single malt Scotches to blended Scotches. For instance, blended Scotch producers may increase their prices in response to the tariffs on single malt Scotch due to the strategic complementarity of prices in an oligopoly. Or, as Berry et al. (1999) noted, a multiproduct producer producing both blended and single malt Scotches may lower blended Scotch prices to attract the most price-sensitive consumers who will substitute away from single malt Scotch. To see if blended Scotch prices did respond to the tariffs, in Figure 1 I plot the change in average blended Scotch prices relative to changes in average Irish whiskey prices for each period, with the tariff period shaded in blue. The assumption here is that Irish whiskey prices did not respond to the tariffs, but would capture any other common cost shock affecting both blended Scotch

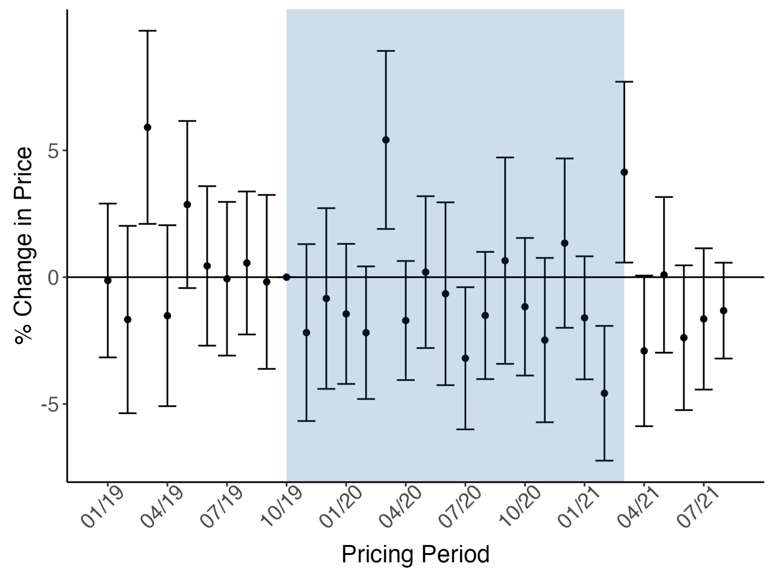


Figure 1: Blended Scotch vs Irish Prices

and Irish. As seen in the figure, there does not appear to be any significant price movements in blended Scotch relative to Irish, suggesting that the tariffs did not have any spillover effects to blended Scotch.

Data Sources

The main data source used for both evaluating the impact of the tariffs and for estimating the demand model comes from the Pennsylvania Liquor Control Board (PLCB), acquired via a Freedom of Information Act (FOIA) request. The data covers the sales amount in dollars and sales quantity in units for every product sold at each state-owned liquor store in Pennsylvania, for each week from January 2019 to August 2021. I use a combination of a catalog spreadsheet from the PLCB archives and the quarterly product listing published by the PLCB to identify all the Scotch and Irish products in the sales data, aggregate each product across every store to the state level, and aggregate from the weekly level to the pricing period level (which roughly corresponds to each month).

Up until 2016, the PLCB adhered to a fixed pricing formula that made transparent the product acquisition costs that the PLCB pays to suppliers. Since the period that the data covers is no longer under the formulaic pricing, the PLCB may adjust markups accordingly to the demand for each product. As Cole and Eckel (2018) noted, retail markups may be a relevant factor when considering the incidence of tariffs. However, in response to the COVID-19 pandemic, PLCB elected to not initiate any price increase of their own during 2020 and 2021 and only elected to pass through cost increases from the suppliers. In 2020 for example, PLCB notes that "the PLCB did not pursue any retail price increases in 2020, some suppliers did request retail price increases or raise product acquisition costs ... there were 373 items with supplier-initiated retail price increases ... there were 372 cost increases," indicating that PLCB mostly did not choose to absorb any supplier price increases nor add-on to any price increases initiated by the suppliers besides according to its existing markup strategy. Thus, the evidence suggests that the retail prices observed in Pennsylvania are mostly the results of the decisions of the supplier.

However, to directly look at wholesale prices and supplier markups, I also collect wholesale price data from New York state. While not a state monopoly as in Pennsylvania, New York regulates the liquor and wine market and requires suppliers and wholesalers to publicly post their prices. This feature allows me to directly observe the prices that suppliers are charging to wholesalers, and thus better analyze the tariff effect without the influence of retail markups. Furthermore, the wholesale prices are used in my identification strategy in my demand model as cost proxies.

For data on consumer demographics and purchases, I use the NielsenIQ Consumer Panel, which contains information on household characteristics and their purchases. I identify the households residing in Pennsylvania, categorize them into household income bins, and calculate the average purchase prices of products. By using this data I can correlate the household incomes to their purchases, which will be used in identification of the price sensitivities.

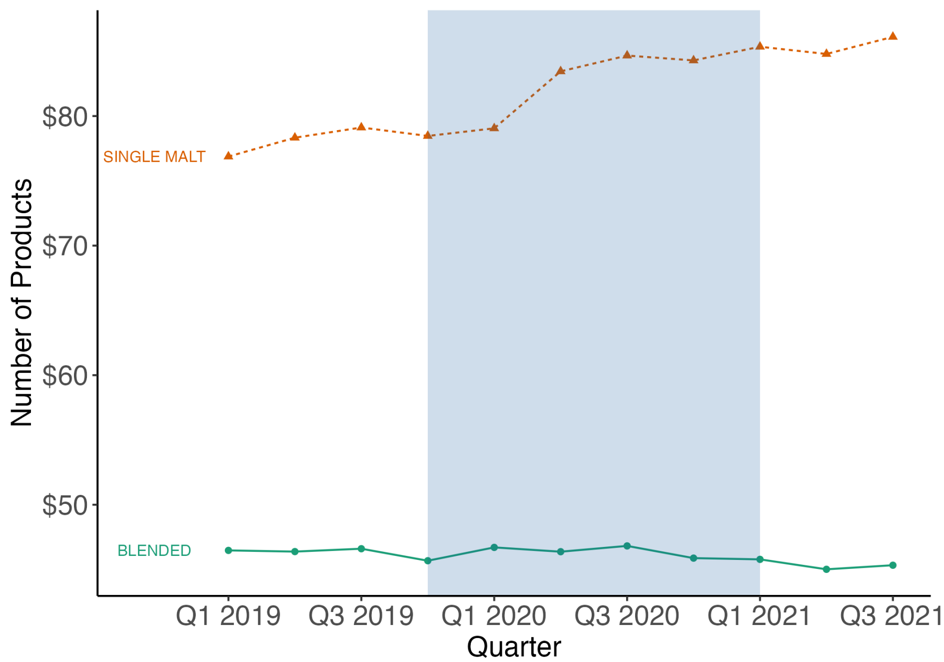


Figure 2: Average Price of 750ML Bottles in Pennsylvania

3 Policy Impact

Tariff Impact on Prices

I start by documenting the change in prices of Scotch and Irish whiskies in Pennsylvania. Figure 2 shows the evolution of the quarterly average prices of single malt Scotch, blended Scotch, and Irish whiskies from January 2019 to August 2021, where the shaded area indicates the periods in which tariffs were in effect. I filter for only 750ML-sized bottles and use a balanced panel to ignore the effect of the introduction or exit of products.

Single malt scotches show a notable increase in prices with a short lag after the imposition of the tariffs. While the tariff period also overlapped with many other cost shocks, such as Brexit and the COVID-19 pandemic, as discussed in the previous section blended Scotches act as a natural control group for assessing the impact of tariffs as both parallel trends and no spill-over seems likely to have occured. As the data shows, blended scotch does not show any noticeable change in prices during the tariff period and beyond, suggesting that the leap in single malt prices seen in April 2020 is the effect of the tariffs, coming at a delay perhaps due to contracts that predetermined the prices up until then or front loading of imports in expectation of the tariffs[6].

To quantify the causal effect of the tariffs on prices, as seen in Figure 2, I estimate the following two-way fixed effects model:

$$ln(p_{it}) = \gamma_i + \lambda_t + \sum_{t=1}^{11\backslash 4} \beta_t D_{it} + \varepsilon_{it} \tag{1}$$

where $p_{i,t}$ is the price of product i in quarter t, γ_i is a product fixed effect, λ_t is a quarter fixed effect, and D_{it} is an interaction of the quarter fixed effect and a dummy variable indicating that product i is single malt. As product characteristics of whisky (proof, age statement, etc.) are invariant, additional product characteristics are not included, and each time period is defined as a quarter. The coefficients of the interaction terms (β_t's) are the main parameters of interest. The fourth quarter of 2019 (the tariff was enacted on October 2019) is excluded for normalization, and the control group is blended scotch. Thus, the coefficients estimate the average price difference between single malt scotch and blended scotch, relative to the average price difference in the fourth quarter of 2019. Since the data runs from January 2019 to August 2021, the coefficients on the first three quarters test for pre-trends, and the coefficients on the last seven quarters estimate the dynamic treatment effect.

The output of the regression is presented in the first column of Table 3, with the corresponding event study plots in Figure 3. While we cannot reject the null of zero in the three quarters prior to the tariffs, there may be some concerns for pre-trends as there appears to be a slight upward trend in prices pre-tariffs. However, the same event study but estimated at the monthly level (in the appendix) indicates no discernible trends, suggesting that the slight upward trend seen here may be an artifact of the aggregation to the quarterly level. The dynamic nature of the tariffs is clear from the plot, as the prices gradually increase

[6] Front-loading may somewhat be limited with Scotch imports however, as firms cannot simply ramp up production of Scotch. Front-loading would have to come in the form of diverting products from other destinations.

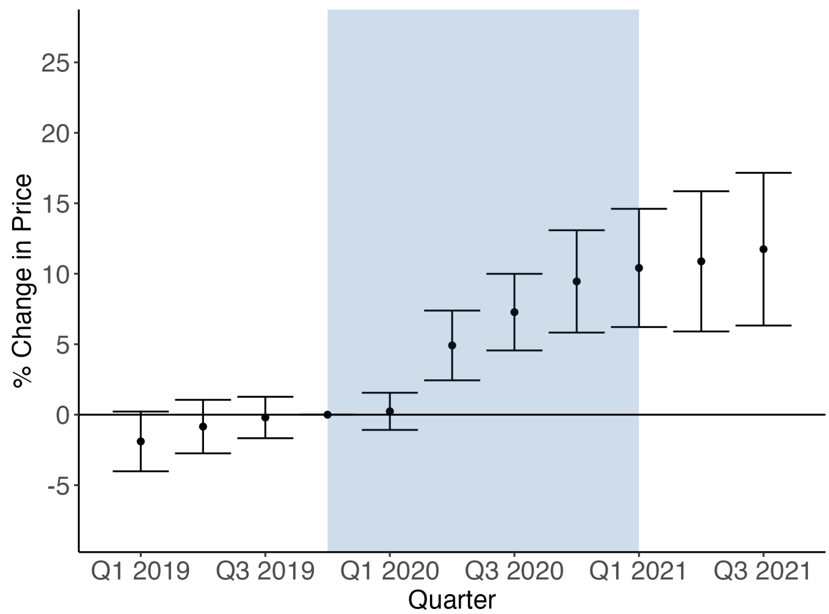


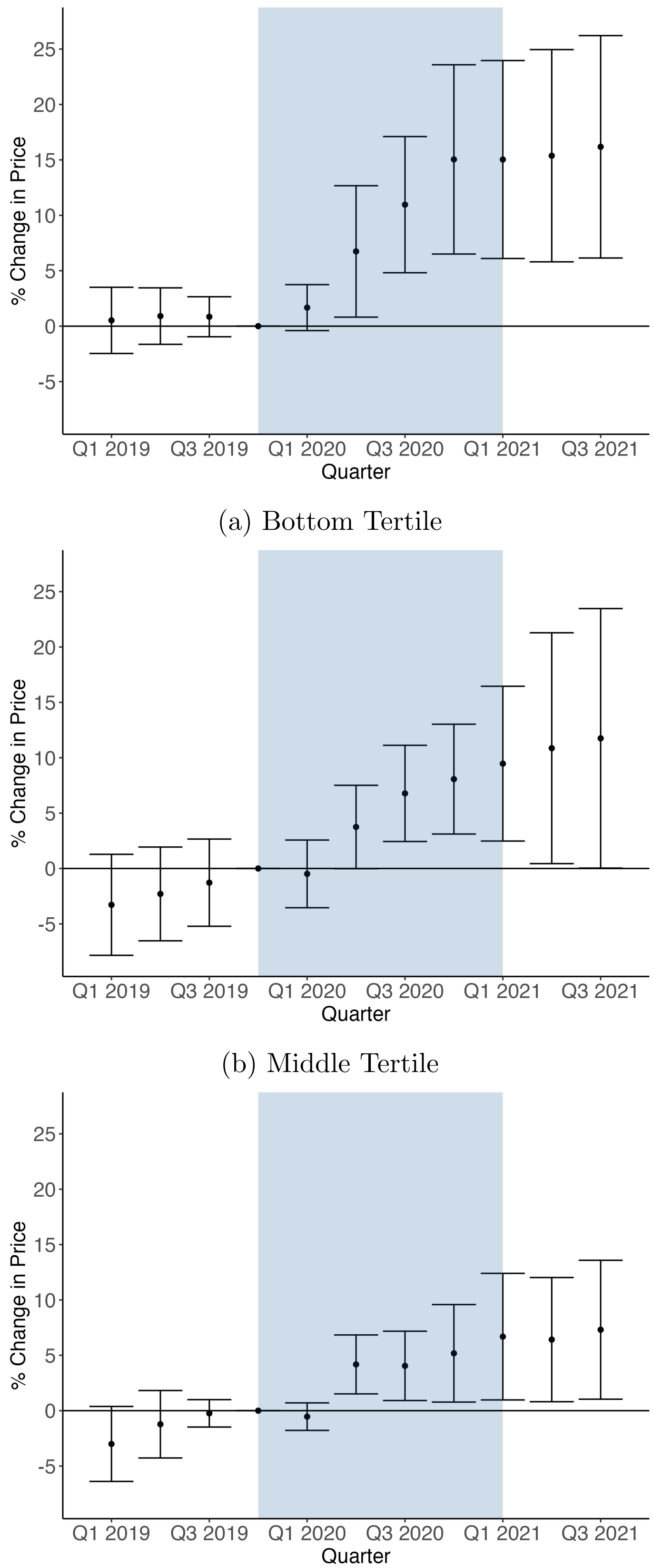
Figure 3: Single Malt vs Blended Price Difference

before tapering off around 11%. The increased prices are sustained even after the tariffs are repealed (March 2021), likely attributable to the uncertainty at the time on whether the tariff repeal would be permanent, or perhaps the "rockets and feathers" phenomenon of prices.

To determine whether the pass-through differs by quality, I split both the single malt and blended Scotch into three groups sorted by pre-tariff price, and estimate Equation 1 for each group. The event-study plots for each tertile (third) are presented in Figure 4 and the results of the regression in the last three columns of Table 3.

At each quarter post-tariff, the pass-through rates are almost uniformly decreasing as the price bins increase. For instance, in the fourth quarter of 2020 (Q8), the pass-through rate from the pooled regression is 0.095. This number masks significant heterogeneity by quality, however, as the pass-through is 0.150 for the cheapest third of products, 0.081 for the middle third, and 0.052 for the most expensive third of products.

Robustness checks in the appendix include estimating Equation 1 using wholesale data from the State of New York. Similar to the pass-through patterns for Pennsylvania, I find



(a) Bottom Tertile

(b) Middle Tertile

(c) Top Tertile

Figure 4: Percentage Change in Prices by Tertile

	Dependent variable:			
	log(price)			
	Pooled	First Tertile	Second Tertile	Third Tertile
Single Malt x Q1	-0.019* (0.011)	0.005 (0.015)	-0.033 (0.023)	-0.030* (0.017)
Single Malt x Q2	-0.008 (0.010)	0.009 (0.013)	-0.023 (0.022)	-0.012 (0.015
Single Malt x Q3	-0.002 (0.007)	0.008 (0.009)	-0.013 (0.020)	-0.002 (0.006)
Single Malt x Q4	-	-	-	-
Single Malt x Q5	0.002 (0.007)	0.017 (0.011)	-0.005 (0.016)	-0.005 (0.006)
Single Malt x Q6	0.049*** (0.013)	0.067** (0.030)	0.037* (0.019)	0.042*** (0.014)
Single Malt x Q7	0.073*** (0.014)	0.110*** (0.031)	0.068*** (0.022)	0.040** (0.016)
Single Malt x Q8	0.095*** (0.019)	0.150*** (0.043)	0.081*** (0.025)	0.052** (0.022)
Single Malt x Q9	0.104*** (0.021)	0.150*** (0.045)	0.095** (0.036)	0.067** (0.029)
Single Malt x Q10	0.109** (0.028)	0.154** (0.049)	0.109** (0.053)	0.064** (0.029)
Single Malt x Q11	0.117*** (0.028)	0.162*** (0.051)	0.118** (0.060)	0.073** (0.032)
Observations	1,364	462	440	462
R^2	0.993	0.982	0.968	0.994
Adjusted R^2	0.992	0.979	0.936	0.993

Table 3: Single Malt Scotch Price Changes Relative to Blended Scotch

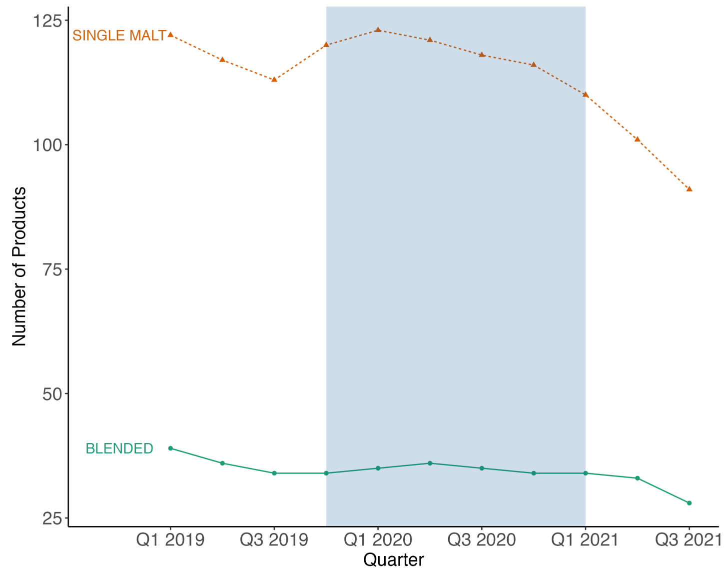


Figure 5: Pennsylvania Product Listings by Category

that the highest price increases are for the cheapest third products, while the middle third and top third expensive products tend to see similar lower price increases. Also, to assess whether the results are robust to the classification by price bins (as the top third of single malt prices are much higher than the top third of blended prices, so they may not be proper comparisons), I reproduce the difference-in-differences model with price ranges instead of price bins and find similar results. This robustness exercise would also address the potential confound from the COVID-19 stimulus checks, which may have encouraged consumers to purchase higher-priced bottles and drive up demand and prices.

Tariff Impact on Variety

Tariffs not only impact prices but also may have an impact on the scope of products that are imported. Figure 5 plots the unique number of products listed in the quarterly price catalogue published by the PLCB from Q1 2019 to Q3 2021.

There is a significant decrease in the number of single malt scotch products listed in the catalog associated with the tariffs, while blended scotch shows a slight decline in variety only near the end of the data period. While the confounding cost shocks (COVID-19, Brexit)

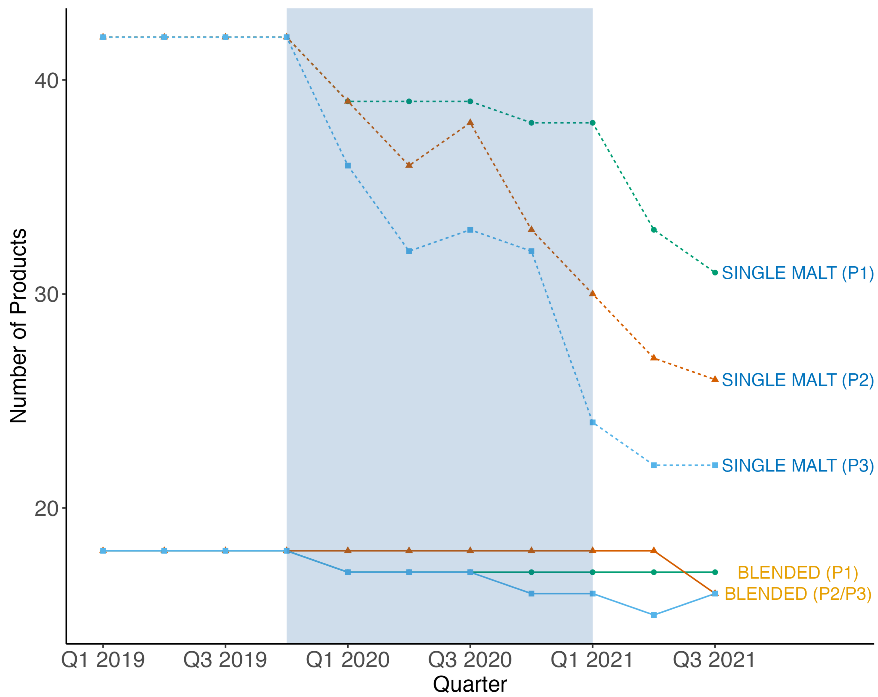


Figure 6: Products with Non-Zero Sales by Price Bins (in Increasing Order)

may have impacted single malt Scotch more than blended, thus threatening identification, if that were the case we would expect to see a decline worldwide in single malt Scotch exports. Detailed export data from the UK does not indicate such a drop in exported however, suggesting that the confounding cost shocks did not contribute to the observed decrease in single malt Scotch variety.

The main question is whether the products that were discontinued were of higher quality than the products that continued to be sold. To study this with the sales data, I take the products that were sold in all four quarters of 2019, and once again I divide each group into thirds by pre-tariff price (P1 to P3 in increasing order of prices). I track the changes over time of whether the products register a sales, and plot the results in Figure 6.

Here, we can see that for single malt scotch, the top third of products by price exhibit the steepest decline in variety, although the remaining two-thirds also exhibit a significant decline in variety. Blended scotch, on the other hand, shows very few products dropping out of sales. This plot suggests that the tariffs impacted the variety of single malt scotch, but particularly the most expensive products. While this analysis ignores any potential introduction of new products, it provides evidence that the overall decrease in products seen in the catalogue (which does account for new products) may be more biased towards high quality goods.

Because I use the sales data, there may be concerns that I am misconstruing zero sales for product unavailability. However since the data is aggregated to the quarter level, zero sales would mean that not a single bottle of the product was sold across three months across the entire state of Pennsylvania, while it was sold in all of 2019. Thus, this observed decline in the variety of products sold would be more attributable to the discontinuation of products than zero sales.

To quantify the average drop-out rate by price bins, I estimate a similar model to Equation 1, with product availability as the dependent variable,

$$I_{it} = \gamma_{(i)} + \lambda_t + \sum_{t=1}^{11\backslash 4} \beta_t D_{it} + \varepsilon_{it} \tag{2}$$

where $I_{i,t}$ is whether product i was available in quarter t, $\gamma_{(i)}$ is a fixed effect for the category of product i, λ_t is a quarter fixed effect, and D_{it} is an interaction of the quarter fixed effect and a dummy variable indicating that product i is single malt. As before, the fourth quarter of 2019 is excluded for normalization, and the control group is blended scotch. The coefficients of the interaction terms (β_t's) are the main parameters of interest. Here, these coefficients estimate the differences in mean availability of single malt scotch and blended scotch, relative to the difference in the fourth quarter of 2019 (which is zero, by the way the products were chosen); in that sense, this model resembles less of a linear probability model and more of two-sample t-test for difference in means across time. Similar to the price effect, I estimate the model with the products pooled together, and also by splitting the products into thirds by prices, with the output presented in Figure 4.

Sources from industry insiders also indicate that the tariffs had a significant impact on

	Dependent variable:			
	Availability			
	Pooled	First Tertile	Second Tertile	Third Tertile
Single Malt x Q1	0.000 (0.066)	0.000 (0.096)	0.000 (0.110)	0.000 (0.131)
Single Malt x Q2	0.000 (0.066)	0.000 (0.096)	0.000 (0.110)	0.000 (0.131)
Single Malt x Q3	0.000 (0.066)	0.000 (0.096)	0.000 (0.110)	0.000 (0.131)
Single Malt x Q4	-	-	-	-
Single Malt x Q5	-0.058 (0.066)	-0.016 (0.096)	-0.071 (0.110)	-0.087 (0.131)
Single Malt x Q6	-0.114* (0.066)	-0.016 (0.096)	-0.143 (0.110)	-0.183 (0.131)
Single Malt x Q7	-0.090 (0.066)	-0.016 (0.096)	-0.095 (0.110)	-0.159 (0.131)
Single Malt x Q8	-0.127* (0.066)	-0.040 (0.096)	-0.214* (0.110)	-0.127 (0.131)
Single Malt x Q9	-0.214*** (0.066)	-0.040 (0.096)	-0.286*** (0.110)	-0.317** (0.131)
Single Malt x Q10	-0.275*** (0.066)	-0.159 (0.096)	-0.357*** (0.110)	-0.310** (0.131)
Single Malt x Q11	-0.280*** (0.066)	-0.206** (0.096)	-0.270** (0.110)	-0.365*** (0.131)
Observations	1980	660	660	660
R^2	0.156	0.089	0.194	0.214
Adjusted R^2	0.147	0.059	0.168	0.189

Table 4: Availability Relative to 2019

variety, and particularly in the higher-end products. In response to an inquiry on the impact of tariffs, the Scotch Whisky Association, an industry trade group, stated that "for some companies, the tariff meant they had to cease exporting to the US for the time the tariffs were in place – to focus on other markets." Further, *Whisky Advocate*, a trade magazine, interviewed importers who explicitly stated that the tariffs led to a decrease in product variety of higher-end single malt. For example, one importer stated when the tariffs were lifted they were "once more gearing up to bring older, more exclusive single malts stateside, after sidelining them in the face of dramatic price surges." Another importer states: "Last year we deferred [importing] some of our portfolio because of the impact the tariff would have on them, so we can certainly bring those whiskies over now."

4 Model of Differentiated Products Market

Quantifying the welfare effects of the tariff impact requires an model of consumer substitution patterns and purchasing behavior. For example, if a high quality product drops out but consumers consider it to be highly substitutable, then the welfare losses will be muted. I thus estimate a random coefficients nested logit demand model[7] which can accommodate flexible substitution patterns and consumer heterogeneity in incomes.

Model of Demand

Each pricing period, a Pennsylvanian consumer decides to purchase a bottle of Scotch/Irish whiskey (inside good), or some other whiskey (outside good), of sizes 375ml, 750ml, 1000ml, or 1750ml. Consumer i's indirect utility of purchasing product j in pricing period (market) t is given as:

$$U_{ijt} = x_j\beta_i - \alpha_i p_{jt} + \xi_{jt} + \tilde{\varepsilon}_{ijt} \tag{3}$$

[7] Previous studies have used the random coefficients nested logit (RCNL) model in estimating demand for alcohol, such as Miller and Weinberg (2017), Miravete et al. (2018), and Conlon and Rao (2023).

x_j is a vector of product characteristics, which includes bottle size and proof, and p_{jt} is the price of product j. The unobserved mean valuation for product j in time t is defined as

$$\xi_{jt} = \xi_{\tilde{j}} + \xi_t + \Delta\xi_{jt}, \tag{4}$$

where $\xi_{\tilde{j}}$ is a fixed effect for the brand of a bottle (e.g., Johnnie Walker) and ξ_t is a fixed effect for the pricing period. Including the pricing period fixed effects will account for market-wide trends; for example, the online alcohol retailer Drizly has reported that Scotch market shares increase in the holiday season as consumers look to buy more expensive bottles. Finally, $\Delta\xi_{jt}$ represents product-specific unobserved mean valuation that is not explained by brand and pricing period effects and will be the structural error that will form the moment conditions for estimation.

The $\tilde{\varepsilon}_{ijt}$ forms the stochastic term, and can be further decomposed into

$$\tilde{\varepsilon}_{ijt} = \zeta_{ijt} + (1-\rho)\varepsilon_{ijt} \tag{5}$$

ε_{ijt} is the independent and identically distributed extreme value error term and ζ_{ijt} is drawn from the distribution such that $\tilde{\varepsilon}_{ijt}$ follows the extreme value distribution. The parameter ρ governs the nesting structure, bounded between zero and one, with values closer to one indicating a higher degree of substitutability within nests. Nests are defined as single malt Scotch, blended Scotch, single malt Irish, blended Irish, and the outsde good. At $\rho = 1$, consumers will substitute only to products within the same nest, while at $\rho = 0$, consumer's substitution will be determined by the other parameters in the indirect utility function, i.e., the model collapses to the mixed logit model.

Finally, the parameters α_i and β_i can be decomposed into a mean value, observed heterogeneity by demographics, and unobserved heterogeneity:

$$\begin{pmatrix} \log(\alpha_i) \\ \\ \beta_i \end{pmatrix} = \begin{pmatrix} \alpha \\ \\ \beta \end{pmatrix} + \Pi D_i + \Sigma \nu_i, \quad \nu_i \sim N(0, I_{K+1})$$

I make the common assumption that the price coefficients α_i follow the lognormal distribution, which bounds the price coefficients to be negative. For the demographic component D_i, individuals are split into four bins of household income smaller than \$45,000, between \$45,000 and \$70,000, between \$70,000 and \$100,000, and greater than \$100,000. The demographics will interact by Π to allow the (dis)utility from price to vary by income bin. The ν_i term is drawn from the standard normal distribution with variance to be estimated and interacts with price and proof. This will induce heterogeneity in preferences for prices and the proof of a product, but not in the preference for a particular bottle size or other characteristics.

I define the potential outside market as the market of whiskey and calculate market shares as liters of ethanol equivalent[8]. For example, an 80 proof 750ml bottle of scotch will contain 300ml of ethanol. Defining the potential market as the market of whiskey has the drawback in that it makes the prices of non-Scotch and non-Irish whiskies to be non-strategic. For example, if high-end Bourbon prices fell drastically, the model would not capture the substitution of Scotch drinkers to Bourbon. But the benefit of this definition of the market is that through the PLCB data, I can calculate the market size without assumptions.

I decompose the indirect utility term into

$$U_{ijt} = \delta_{jt}(x_j, \xi_{\tilde{j}}, \xi_t, \Delta\xi_{jt}; \beta) + \mu_{ijt}(x_j, p_{jt}, D_i, \nu_i; \Pi, \Sigma) + \tilde{\varepsilon}_{ijt} \tag{6}$$

[8]The "standard serving" associated with the consumption of alcohol is often defined in terms of alcohol consumed (one can of beer is equal to a glass of wine and a shot of liquor).

where

$$\delta_{jt} = x_j\beta + \xi_{\tilde{j}} + \xi_t + \Delta\xi_{jt} \tag{7}$$

$$\mu_{ijt} = [p_{jt}, x_j] * (-\exp(\Pi D_i + \Sigma\nu_i)) \tag{8}$$

The conditional probability that consumer i chooses product j in market t is then

$$s_{ijt} = \frac{\exp((\delta_{jt} + \mu_{ijt})/(1-\rho))}{\exp(I_{ig}/(1-\rho))} \frac{\exp(I_{ig})}{\exp(I_i)}$$

with the McFadden (1978) inclusive values defined as

$$I_{ig} = (1-\rho)\ln \sum_{j=1}^{J_g} \exp((\delta_{jt} + \mu_{ijt})/(1-\rho))$$

$$I_i = \ln\left(1 + \sum_{g=1}^{G} \exp(I_{ig})\right)$$

for product set J_g of each nest. Thus product j's shares in market i are then simulated as

$$\hat{s}_{jt} = \frac{1}{N_t} \sum_{i=1}^{N_t} \frac{\exp((\delta_{jt} + \mu_{ijt})/(1-\rho))}{\exp(I_{ig}/(1-\rho))} \frac{\exp(I_{ig})}{\exp(I_i)} \tag{9}$$

Identification and Estimation

The arguments for identification and the estimation procedure are based on the procedure outlined in Berry (1994) and Berry et al. (1995). I utilize the NielsenIQ Consumer Panel Data as micro moments to identify the demographic interactions with prices (Conlon and Rao 2023). I draw the income distribution from the NielsenIQ Consumer Panel Data, where I assign panelists into one of four income bins {< \$45,000, \$45,000 - \$70,000, \$70,000 - \$100,000, \$100,000 <}. I then calculate the average purchase price of Scotch by each income bin and add these micro moments to match with the model predictions (Petrin 2002). I exclude the coefficient on the lowest income bin for identification (the mean price coefficient

$\bar{\alpha}$ will be the lowest income bin's mean price coefficient).

The variation in the data that identifies the unobserved heterogeneity in product characteristics is the exogenous shifts in the product characteristics and the corresponding changes in shares, which the distribution of consumer heterogeneity must rationalize. To identify the exogenous changes in prices, I instrument price with three instruments: the first is an indicator variable for the tariff, which is credibly uncorrelated with the structural error term $\Delta\xi_{jt}$ due to the nature of the tariffs but correlated with the price. The tariff serves as an ideal cost shock for "tracing out" the demand curve. For my second instrument, I match each product to the data of wholesale liquor prices in New York state and use the corresponding wholesale price in New York (the prices that suppliers charge to wholesalers in New York) as an instrument for retail prices in Pennsylvania. The identifying assumption behind this instrument is that wholesale prices in New York would reflect cost shocks that affect Pennsylvania as well while being uncorrelated with any demand shocks in Pennsylvania. This is similar to the argument for "Hausman instruments," and as such, is susceptible to the same threats to identification as discussed in Nevo (2001). For example, if there is an unobserved demand shock that leads manufacturers to charge higher prices to both Pennsylvania and neighboring New York, retail prices in Pennsylvania and wholesale prices in New York would be correlated. However the inclusion of period fixed effects and brand fixed effects mitigates such concerns as identification relies on wholesale prices in New York being uncorrelated with $\Delta\xi_{jt}$, the product-specific deviation from brand and period fixed effects. Unless the correlated demand shocks in both markets are brand-period specific, these instruments would satisfy the exclusion restriction. Finally, the third instrument is a dummy variable indicating whether a product is offered on sale or not. The PLCB does adjust prices according to an unknown method to maximize profits on most of their products, but for many products (absent some cost shock) PLCB's listed prices stay constant throughout the entire period. Most of the price variation is due to temporary price reductions and promotions, which are scheduled by the manufacturer or PLCB several months in advance, and thus, the identification holds as long as the sales are not correlated with $\Delta\xi_{jt}$, the product specific deviation from brand and period fixed effects. Using promotions as an instrument also risks attributing stock-piling behavior for elastic demand, but Seim and Waldfogel (2013) also study the Pennsylvania liquor market and find no correlation between consumers' distances to store and changes in sales, suggesting that stock-piling behavior is weak.

The consumer heterogeneity for bottle-proof and the outside good is identified by the exogenous changes in the product choice sets across markets and the correlation between the shares and characteristics of the remaining products. The nesting parameter ρ is identified by the change in each nest's shares of the total inside market as products are added and dropped from the choice set. Thus, the number of products in each nest will be added as instruments to identify the nesting parameter.

I also utilize differentiation instruments from Gandhi and Houde (2019). Namely, I utilize the local and interacted form of the differentiation IVs, using exogenously predicted prices and bottle categories. These IVs capture the crowdedness of the product space for each product, as in "how many similarly priced own-firm and rival-firm bottles are there to mine?".

Defining the set of instruments as $Z = [z_1, \ldots, z_M]$, I define the population moment conditions as $E[Z'\omega(\theta)]$ where $\theta = [\beta, \Pi, \Sigma, \rho]$ are the parameters to be estimated and $\omega(\theta)$ is an error term defined as the unobserved mean valuation $\Delta\xi_{jt}$. Specifically, using Equation 7, I derive

$$\omega(\theta) = \delta_{jt} - x_j\beta - \xi_{\tilde{j}} - \xi_t$$

The δ_{jt} comes from matching the predicted shares to the market shares, $\hat{s}_{jt}(\delta_{jt}, \theta) = s_{jt}$, and can be inverted numerically with the dampening term from Grigolon and Verboven (2014). Then, the GMM estimate is

$$\hat{\theta} = \arg\min \omega(\theta)' Z A^{-1} Z \omega(\theta)$$

for the appropriate weighting matrix A.

I simulate my consumers with 1000 Halton draws from the standard normal distribution, with income bins randomly assigned according to the distribution from the NielsenIQ Consumer Panel Data for 2019 and 2020 in Pennsylvania, and estimate the feasible efficient two-step GMM using a non-linear search over the parameters.

Model of Supply

There are F firms each producing a subset J_{ft} of products in each period t. Firm f's profit function in market t (ignoring t subscripts), assuming constant marginal costs, and normalizing the market size to one, is

$$\Pi_f = \sum_{j \in \mathcal{J}_f} (p_j - mc_j) s_j(\mathbf{p}) - FC_f \tag{10}$$

where $\mathcal{J}_f$ is the firm's product set, mc_j is product j's marginal costs, $s_j(\mathbf{p})$ is the market share of product j as a function of market prices $\mathbf{p}$, and finally FC_f is the fixed cost of firm f. I then define the ownership elasticity matrix Ω as in Nevo (2001), where

$$\Omega_{jr} = \begin{cases} -\partial s_r / \partial p_j & \text{if } \exists f : r, j \subset \mathcal{J}_f \\ 0 & \text{otherwise} \end{cases} \tag{11}$$

Thus, the markup equation results,

$$p - mc = \Omega^{-1} s(\mathbf{p}) \tag{12}$$

Estimation Results

The results of the estimation are presented in Table 5. For the price variable, as stated previously, the mean coefficient ($\bar{\alpha}$) is not separately identified from the demographic price coefficients. The demographic coefficients by income bin are in the expected order (for the lognormal distribution), becoming more and more negative as income increases. There is significant heterogeneity within each income bin as well, as indicated by the random coefficient on prices, and suggests a large overlaps in price sensitivities between the income bins. The consumers seem to prefer larger bottle sizes, as well as have little heterogeneity in preference for bottle-proof and the outside good (captured by the coefficient on the constant term). The nesting parameter is estimated to be 0.76, indicating that consumers generally prefer to substitute to other products in the same category in response to a price change. The nesting parameter may be particularly relevant later when considering the welfare impact of the tariffs as it indicates that consumers may not be inclined to substitute to the blended Scotch, Irish, or the outside good. Table 6 presents the micro moments to be matched and their model predicted values. Overall the model predictions tend to be higher than the survey results, perhaps due to the sales of high priced products in the Pennsylvania data but not observed in the smaller survey sample.

The elasticities from the model are plotted for all products in Figure 7. All of the own price elasticities are negative and elastic, and we observe that there is a positive relation between prices and elasticity. Higher priced products are purchased more by price insensitive consumers, and since elasticity is calculated as a weighted mean of individual consumer purchase probabilities, the elasticities become decrease as prices increase. These elasticities also imply higher markups for the high-priced products, in line with the theory of vertical and horizontal product differentiation.

5 Markup Adjustments and Welfare

Markups Adjustment

Using the demand estimates, I can estimate a "super-elasticity" of demand for each product by taking the percentage change in the elasticity divided by the percentage change in prices.

	Mean Utility	Random Coeff	Demographic Interactions (Π)			
	(β)	(Σ)	<\$45K	\$45K - \$75K	\$75K - \$100K	>\$100K
Price	2.423 (2.758)	2.508 (0.897)	-	-0.825 (2.941)	-3.955 (1.279)	-4.926 (1.201)
Proof	-0.020 (0.032)	0.013 (0.018)				
Constant	-0.159 (3.197)	3.069 (2.341)				
375 ML	-1.266 (0.174)					
750 ML	-					
1000 ML	0.015 (0.044)					
1750 ML	0.813 (0.108)					
Nesting Parameter (ρ)						
0.764 (0.022)						

Table 5: Demand Model Estimates

Micro Moments		
Moment	Value	Estimated Value
$E[p_j\|inc1]$	\$26.79	\$25.60
$E[p_j\|inc2]$	\$28.18	\$32.42
$E[p_j\|inc3]$	\$31.85	\$38.08
$E[p_j\|inc4]$	\$37.47	\$41.08

Table 6: Micro Moments

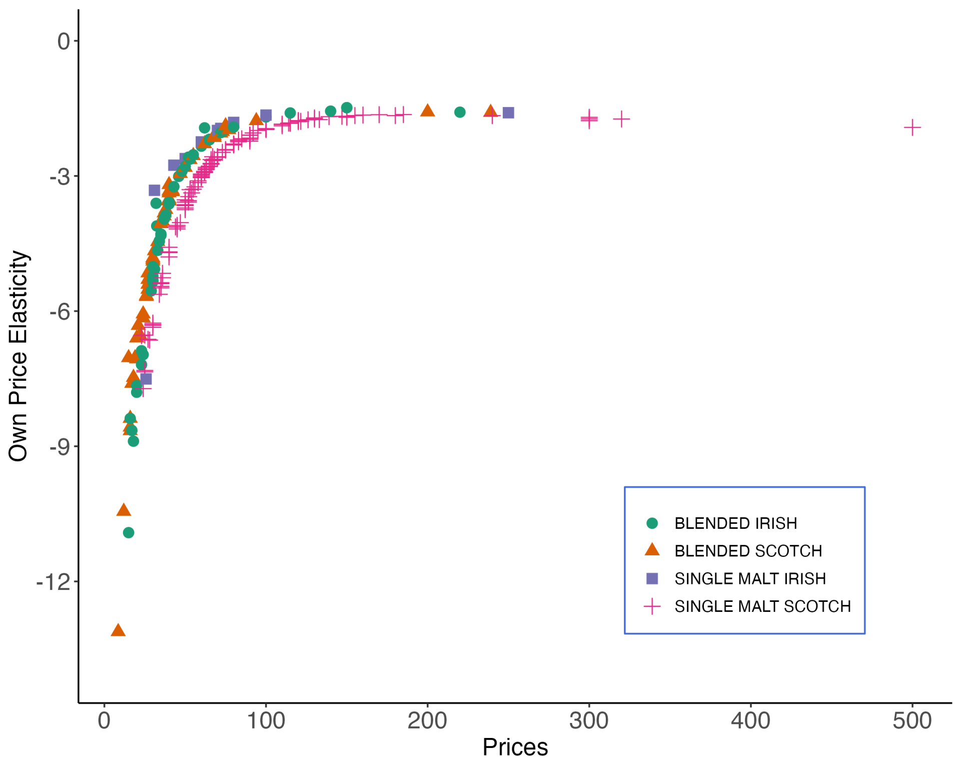
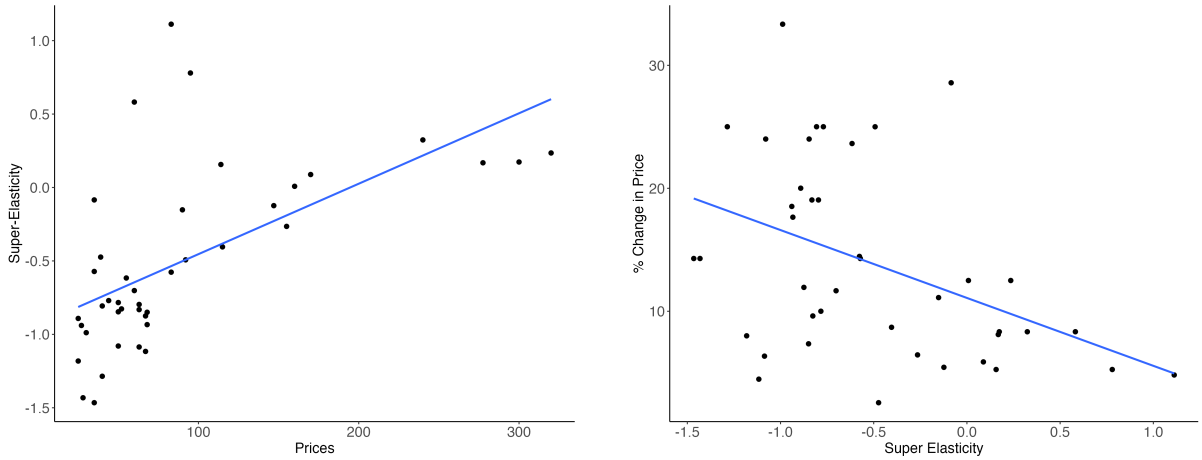


Figure 7: Own Price Elasticity

The super-elasticity serves as a measure of the demand curvature, as it shows the elasticity of elasticity with respect to prices. Using the *observed* prices in October 2019 and March 2021, I calculate each products respective price elasticites in each period and calculate the super-elasticities. For products sold in both October 2019 and March 2021, Figure 8a plots the prices of products in October 2019 against the calculated super-elasticities and the accompanying Figure 8b plots the super-elasticities against observed percentage increase in prices. The scatter plot and the fitted regression line in Figure 8a indicate a positive correlation between prices and super-elasticities, suggesting that for a percentage price increase, the demand elasticities increased (in magnitude) more for higher priced goods. Many of the lower priced products in fact have negative super-elasticities, indicating that the demand became *less* elastic by March 2021. Figure 8b shows that, as theory predicts, products for which demand became less elastic exhibit higher changes in prices compared to those products for which demand became more elastic. These plots show that the patterns of pass-through



(a) Prices vs Super-Elasticity (b) Super-Elasticity vs Price Changes

Figure 8: Passthrough and Super-Elasticity (October 2019 - March 2021)

observed in the data can be explained by the curvature of the demand, namely, more convex for lower-priced products and concave for higher-priced products.

The previous calculations is subject to the caveat that the other changes in the markets were occurring between October 2019 and March 2021, such as the introduction and exit of products, price changes in blended Scotch and Irish whiskies, changes in the outside good shares, and so on. Thus, to further isolate the effect of the tariffs on markups, I use the model to simulate the effects of a cost increase. Using the elasticity estimates, I recover the costs for each product in October 2019 through the markups equation in Equation 12. I then impose a 25% cost increase to single malt Scotch products only and re-compute the equilibrium prices and elasticities. Table 7 shows for a sample of best-selling single malt Scotch products the equilibrium prices and elasticities in October 2019, the newly estimated prices and elasticities, and the super-elasticities. Figure 9 plots the prices and super-elasticities for all single malt Scotch products. Once again, positive super-elasticities imply a (magnitude-wise) increase in elasticities for a percentage increase in price while negative super-elasticities imply the converse.

The plot shows a positive relationship between prices and super-elasticities. Thus, at the new equilibrium prices, holding all else fixed, elasticities increase for high-priced goods.

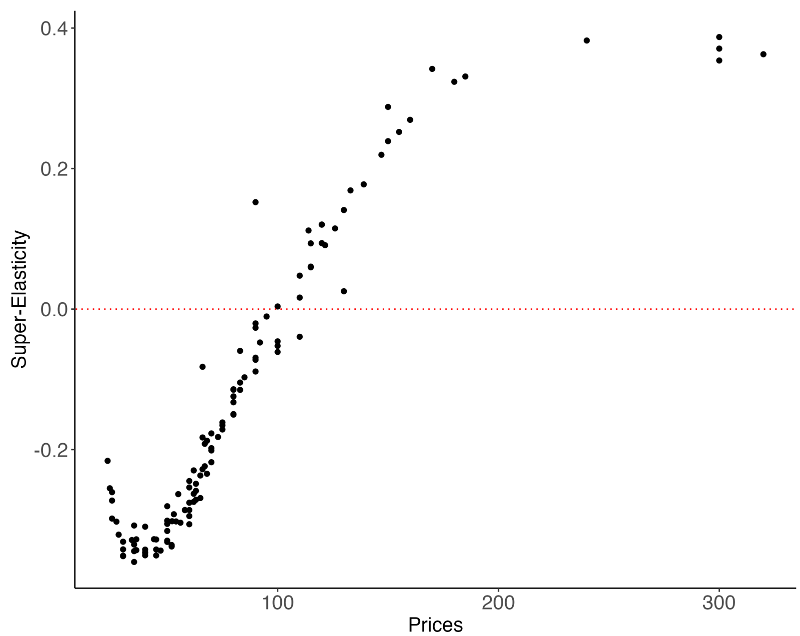


Figure 9: Model Simulated Super-Elasticities vs Original Prices

Product	Prices	New Prices	Elasticity	New Elasticity	Super-Elasticity
McClelland's Highland Single Malt Scotch	\$22.99	\$29.11	-6.54	-6.17	0.22
Loch Lomond Single Malt Scotch	\$24.99	\$31.67	-6.53	-6.08	0.26
The Glenlivet Speyside Single Malt Scotch Founders Reserve	\$39.99	\$52.21	-4.58	-4.09	0.35
Laphroaig Islay Single Malt Scotch 10 Year	\$49.99	\$65.30	-3.58	-3.23	0.32
Glenfiddich Single Malt Scotch 12 Year	\$49.99	\$65.37	-3.53	-3.20	0.30
The Glenlivet Speyside Single Malt Scotch 12 Year	\$52.99	\$69.89	-3.30	-3.00	0.29
The Macallan Highland Single Malt Scotch Double Cask 12 Year	\$59.99	\$79.45	-2.96	-2.69	0.28
The Balvenie Single Malt Scotch Doublewood 12 Year	\$62.99	\$83.00	-2.81	-2.59	0.25
The Macallan Highland Single Malt Scotch 12 Year	\$66.99	\$88.44	-2.57	-2.39	0.22
Oban Single Malt Scotch 14 Year	\$82.99	\$106.45	-2.20	-2.14	0.10
The Glenlivet Speyside Single Malt Scotch 18 Year	\$113.99	\$137.22	-1.83	-1.87	-0.11
Glenmorangie Highland Single Malt Scotch 18 Year	\$114.99	\$141.58	-1.82	-1.85	-0.06
Glenfiddich Single Malt Scotch 18 Year	\$114.99	\$141.66	-1.83	-1.85	-0.06
The Macallan Highland Single Malt Scotch Fine Oak 15 Year	\$125.99	\$153.02	-1.75	-1.80	-0.11
The Macallan Highland Single Malt Scotch 18 Year	\$319.99	\$372.12	-1.74	-1.84	-0.36

Table 7: Estimated Prices and Elasticities

This suggests downwards markups adjustment and consequently more absorption of the cost increase. On the other hand, demand for low-priced goods became *less* elastic at the new equilibrium prices, suggesting an upwards adjustment of the markups and more pass-through of the cost shock.

The advantage of looking at the model-estimated prices and elasticities is that I can isolate out the effects that are driving the patterns in the data. The shifting demographic composition of buyers for low-price and high-price goods appears to be driving this pattern. In Table 8, I examine the proportion of buyers in each income bin before and after the cost increases for two products from Table 7, Glenfiddich Single Malt Scotch 12 Year and Glenfiddich Single Malt Scotch 18 Year.

		Original Share	Post Cost Increase Share	Change
	Income 1	1.05%	1.09%	0.04%
Glenfiddich	Income 2	0.97%	0.88%	-0.09%
12 Year	Income 3	14.34%	11.06%	-3.28%
	Income 4	83.64%	86.67%	3.03%
	Income 1	0.3%	0.16%	-0.14%
Glenfiddich	Income 2	0.05%	0.02%	-0.03%
18 Year	Income 3	3.34%	2.68%	-0.66%
	Income 4	96.31%	97.15%	0.84%

Table 8: Buyer Share by Income Bin

As these two products are from the same distillery and product line, with the only difference being the age, comparing these two products allows us to identify how the consumer composition differs initially and how it changes after a cost increase for products of different qualities. Income 1 through Income 4 represent the income bins $\{<$ \$45,000, \$45,000 - \$70,000, \$70,000 - \$100,000, \$100,000 $<\}$, respectively. The first column shows the proportion of buyers in each income bin at the original equilibrium price, and the second column for the new equilibrium price after the 25% cost increases. We can see that initially the Glenfiddich 18 has a higher share of high-income consumers, as expected for a premium product (\$114.99 vs \$49.99). But post cost increase, the buyer composition shifts substantially for the Glenfiddich 12 compared to the Glenfiddich 18; in particular, the proportion of highest-income consumers purchasing the Glenfiddich 12 increase by 3.03%. This increase in high-income buyers will shape the demand to be less elastic, despite the increase in price. On the other hand, for Glenfiddich 18, due to the higher proportion of Income 1 through Income 3 buyers substituting out compared to Income 4 buyers, the proportion of buyers shift towards Income 4 and shapes the demand for this product to be less elastic. However, in this case, the increase in price appears to outweighs the change in the curvature, i.e., the demand shifts inwards more than the curvature becomes less elastic, and on net, the price elasticity increases.

Welfare Analysis

I can estimate the welfare impact of the tariffs, both through the impact on variety and on prices. Following McFadden (1981) and Small and Rosen (1981), I estimate individual i's expected welfare in market t for single malt Scotch products $\boldsymbol{J}_t$ as

$$CW_i(\boldsymbol{p}_t, \boldsymbol{J}_t) = \frac{\log(1 + \sum_{j \in J_t}[V_{ijt}(\boldsymbol{p_t})])}{\alpha_i}$$

where $V_{ijt} = U_{ijt} - \tilde{\varepsilon}_{ijt}$. The compensating variation for a counterfactual product choice set and prices $(\boldsymbol{J}'_t, \boldsymbol{p}'_t)$ is then calculated as

$$CV_i = \frac{1}{\alpha_i} \times \frac{\log(1 + \sum_{j \in J'_t}[V_{ijt}(\boldsymbol{p'_t})])}{\log(1 + \sum_{j \in J_t}[V_{ijt}(\boldsymbol{p_t})])}$$

The welfare effects are calculated for a subset of the consumers, specifically consumers who have a non-zero purchase probability of single malt Scotch products. As there are several lower-income consumers who derive zero consumer surplus from single malt Scotch due to their extremely high price sensitivity, including these consumers into the welfare calculations would find zero effect of the tariffs on welfare for many lower-income consumers. Thus, the welfare results are calculated interpreted as the welfare effect of the tariffs on single malt Scotch buyers, not all consumers in the market for whiskey.

Price Effect

I first calculate the welfare change accounting for the differential tariff pass-through by quality and compare it to the baseline of uniform tariff pass-through. I start with the products and prices in October 2019 (the baseline from the difference in differences model) and calculate the increase in equilibrium prices due to the tariffs by March 2021 (the final month of the tariffs). I calculate welfare under two pass-through schemes, holding the products fixed. First, I impose a uniform price increase of 7.70% across all products regardless of price range. Second, I impose a heterogeneous price increase of 11.49%, 7.30%, and 4.19% for each product in each price bin of thirds, in increasing order of prices. The welfare effects of the first scheme is presented in the first column of Figure 9 and the second scheme in the second column. First, both results show that the low-income consumers lose more relatively to high-income consumers, which is expected as the low-income single malt Scotch consumers are the most price-sensitive. But going from uniform to the heterogeneous price effect exacerbates the welfare loss for all consumers. The increase in the welfare loss for the high-income consumers can be explained by examining the micro moments, which matched the average purchase price of high-income consumers to be $41.08; that is, even high-income consumers purchase the cheaper goods often, and thus the increase in price pass-through from 7.70% to 11.49% for the cheaper products hurt high-income consumers as well.

Variety Effect

For the product choice set, I simulate product exits using Monte Carlo simulations. First, I use a logit model to estimate the exit probability of each product, under two specifications: one with just category dummy variables (uniform effect) and one with category-price bin dummy variables (quality differential effect). The uniform effect predicts an exit probability of 26.6% for all single malt Scotches while accounting for quality, the exit probabilities become 8%, 20%, 41.2%, in increasing order of price bins. I then take Bernoulli draws for each product, according to its exit probabilities, 5000 times, for both schemes (uniform and heterogeneous).

The results are in Figure 10. The first column shows that assuming uniform exit probability across all products leads to the highest welfare loss for low-income consumers, as the uniform exit leads to largest decline in the range of products these consumers would substitute to, as compared to high income consumers who purchase a wider range of products. But once I simulate product exit with heterogeneous probabilities by quality, the magnitude of the welfare loss decreases for everybody and the order is reversed. The magnitude of the variety welfare effect is small because as discussed in the introduction, the low quality goods also tend to have the highest market shares, so when their exit probability decrease from 26.6% to 8% when going from uniform to heterogeneous exit probabilities, all consumers' welfare losses decrease. However, the order of the welfare loss is flipped, so that the high-income consumers see the higher welfare loss than the low-income consumers. This is the "progressiveness" of the tariffs, in that the high quality products that the high-income consumers purchasing are more likely to drop out of the market, predominantly hurting the high-income consumers more than the low-income consumers.

Net Effect

Finally, I estimate the welfare changes with both increased prices and decreased variety, with and without the quality differential effect. The results are presented in Figure 11. As summarized in the two previous subsections, once accounting for the quality differential effect, the price effect "decreases" everybody's welfare while the variety effect "increases" everybody's welfare, creating two opposing forces. On net, we observe that the three lower-income consumers welfare decreases even more relative to the uniform effects case, while the highest income consumers actually see an increase in their welfare relative to the uniform effects case. When going from the uniform to the heterogeneous effects, higher-income consumers see more of their purchased high-quality goods disappear from the market, but they are not as sensitive to the increase in pass-through for the low-quality goods (which are less likely to exit now) and thus see a decrease in the welfare loss. On the other hand, for lower-income consumers, they see more of their low-quality goods surviving but the increase in pass-through effect dominates as they are more price sensitive, and thus see an increase in the welfare loss.

These results suggest that accounting for the quality-differential effect of the tariffs is consequential as otherwise we might underestimate the welfare loss on low-income consumers and overestimate for high-income consumers, implying that the tariffs have a much more regressive effect than previously understood.

6 Conclusion

This paper studies the impact of tariffs on consumer goods, but with a novel focus on the differential effects by quality. Tariffs have many potential impacts on consumers and producers, and this paper explores whether product quality significantly modulates these impacts and how they affect consumers of varying income levels. My findings reveal the heterogeneity of tariff pass-through by product quality, disproportionately impacting lower-income consumers. Furthermore, tariffs resulted in a disproportionate reduction in the importation of higher quality goods, leading to higher welfare losses on higher-income consumers compared to low-income consumers, but the low price sensitivity of high-income consumers led to an overall muted impact of the tariffs for them.

This paper implies that assessing the welfare impacts of tariffs should consider all the multiple aspects in which tariffs affect consumers, mainly in prices and variety, but also the importance of matching consumer purchases and quality. That is, assuming a uniform impact of tariffs is innocuous as long as consumers are homogeneous, but once considering

Median Consumer Surplus Change (Price)		
	Uniform	Heterogeneous
<$45K	-52.56%	-66.09%
$45K - $70K	-41.33%	-53.84%
$70K - $100K	-16.21%	-22.60%
$100K <	-12.04%	-16.73%

Table 9: Consumer Surplus Change from Price Increase

Median Consumer Surplus Change (Variety)		
	Uniform	Heterogeneous
<$45K	-14.85%	-0.18%
$45K - $70K	-11.78%	-0.52%
$70K - $100K	-7.28%	-1.18%
$100K <	-6.95%	-1.25%

Table 10: Consumer Surplus Change from Variety Loss

Median Consumer Surplus Change (Price and Variety)		
	Uniform	Heterogeneous
<$45K	-59.94%	-66.13%
$45K - $70K	-48.56%	-54.03%
$70K - $100K	-22.55%	-23.90%
$100K <	-18.01%	-17.87%

Table 11: Net Consumer Surplus Change

how different consumers purchase different quality goods at different volumes, the tariff impacts may be much more regressive than previously understood. Furthermore, single malt Scotch in general is a premium product compared to other liquors, and thus the impact on low income consumers may be understated in this industry than other industries.

The mechanisms behind the markups adjustment are general and should extend to other differentiated products industries. However, future extensions to this study would include incorporating a supply model of endogenous product choice, which can be used to study the firm decisions in ceasing to import some products over others.

In conclusion, this study's findings encourage a more thorough consideration of the quality dimension when assessing the welfare impacts of tariffs, as trade policy impacts differ across consumers of different incomes due to heterogeneity in preferences.

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Appendix

A Robustness

A.1 Pennsylvania Monthly Level

The analysis of pass-through is conducted at the monthly level, as there may be concerns over whether the aggregation to the quarterly level masks any promotions or pre-trends. For example, the quarterly sticker price may mask the fact that a single malt Scotch product was going on promotions more often in order to compensate for the increase in prices due to the tariffs. Ignoring such effects would then overstate the impact of the tariffs.

Figure 10 plots the pooled regression, where all the observations as combined, and Figure 11 plots the regression where products are placed into thirds by price. As in the main specification, we can see that the pass-through rate is decreasing by prices.

A.2 Price Range Specification

For the difference-in-differences models where the products are split into thirds by price bin, the parallel trends may be violated due to difference in prices between single malt and blended Scotches. For example, the top third of single malt Scotches prices is much higher than the top third of blended Scotches. This poses a problem, for example, if the COVID-19 stimulus checks encouraged consumers to purchase more expensive bottles of liquor, so they would purchase single malt over blended, leading to a demand shock that violates parallel trends. Therefore, I run the difference-in-differences model where I split the single malt Scotch products into thirds by price, but use the blended Scotch products in the same price *range* as the controls for single malt in each bin. The results are presented in Figure 12, and in fact, the decreasing pass-through effect seems to be more pronounced than the main specification.

A.3 New York Wholesale Prices

In order to disentangle the effect of potential markup adjustments done by the retailer (the PLCB), I plot the change in prices for wholesale prices posted in the New York State Liquor Authority system (NYSLA). As the wholesale prices exhibit much fewer nominal rigidities at certain price points like in retail prices, studying the wholesale market also address the potential concern that higher pass-through rates for cheaper products are due to nominal rigidities (Conlon and Rao 2020).

Suppliers and manufacturers are required to post the prices at which they sell to wholesalers in each month, and thus should be more reflective of the absorption that is done by the producers. Figure 13 plots the evolution of wholesale prices, as estimated with Equation 1, once again split by three price bins. The pattern is similar in that the cheapest products exhibit the highest pass-through, which is decreasing as prices increase.

There is potential concerns over pre-trends in the New York data, as we can reject the null of zero effect for the three quarters preceding the tariffs. The apparent pre-trends here can be attributable to wholesale prices being much more responsive to the tariffs (as manufacturers can change their listing prices at will), and thus the normalization to the 4th quarter of 2019 (the tariffs began in October 2019) is not innocuous. The normalization to the 4th quarter of 2019 was valid in the Pennsylvania data as, whether to contracting or monopsony power of the PLCB, the retail prices did not respond as immediately to the tariffs. From the graphs it is apparent that normalization to the third quarter of 2019 would eliminate these pre-trends.

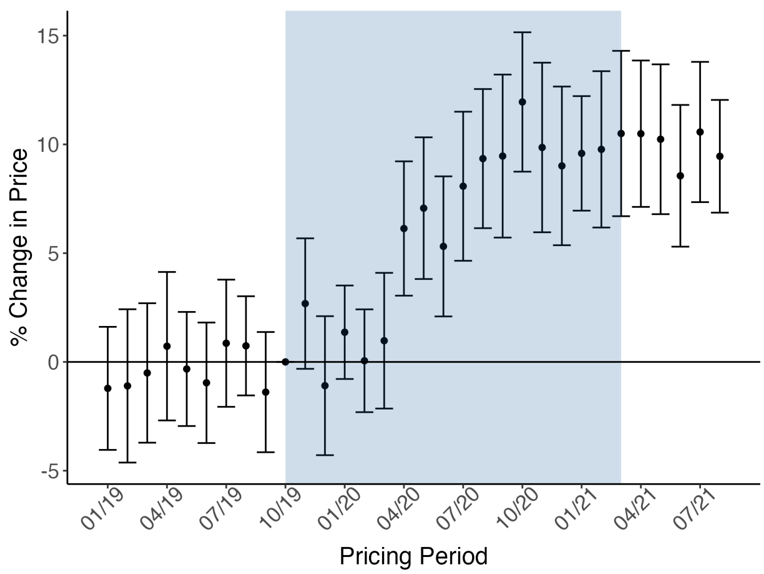
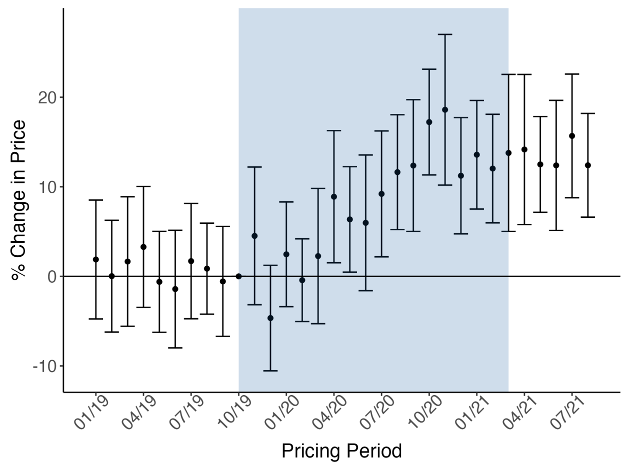
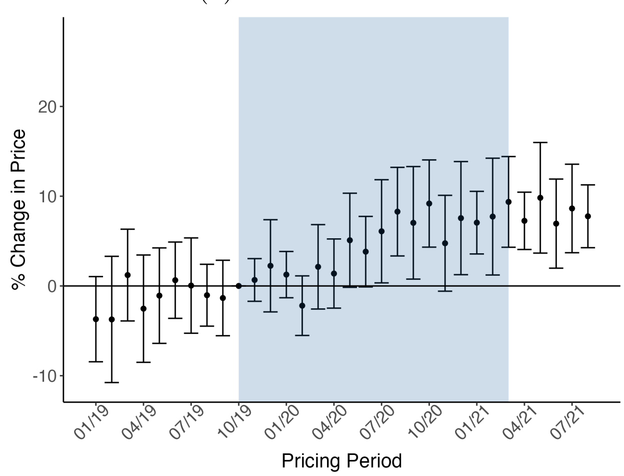


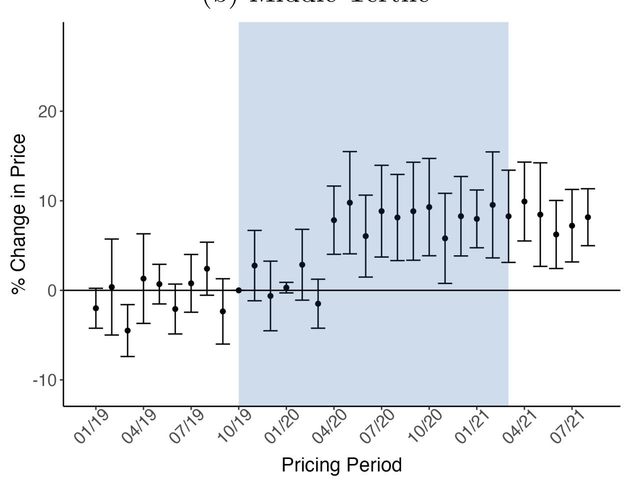
Figure 10: Monthly Price Changes in Pennsylvania



(a) Bottom Tertile

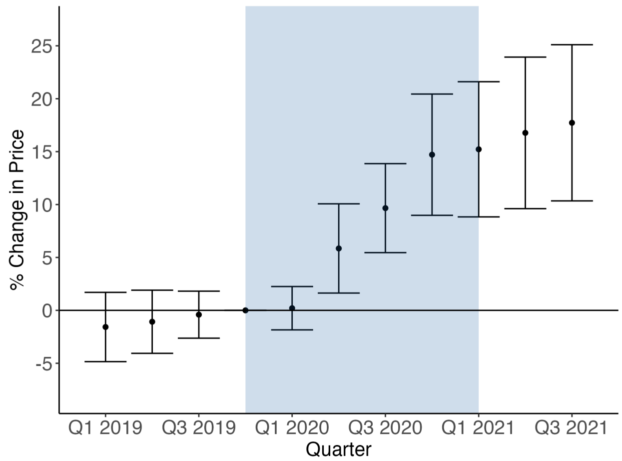


(b) Middle Tertile

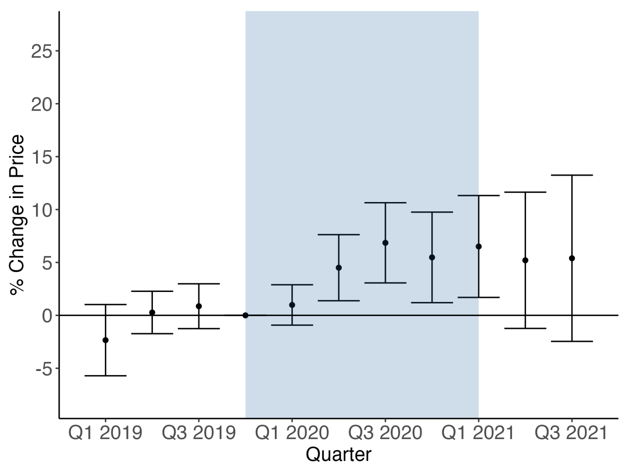


(c) Top Tertile

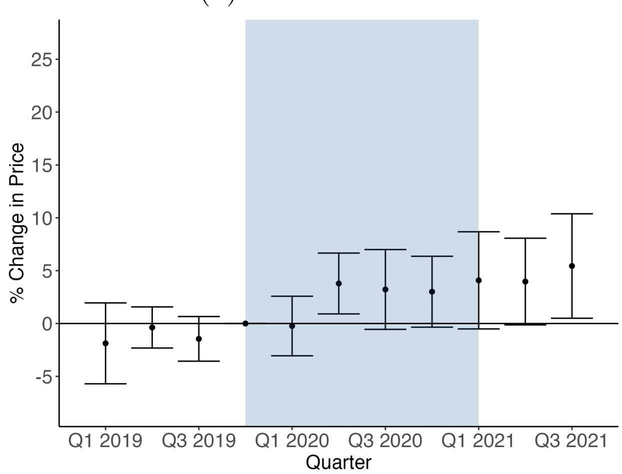
Figure 11: Percentage Change in Prices by Tertile (Monthly)



(a) Bottom Tertile

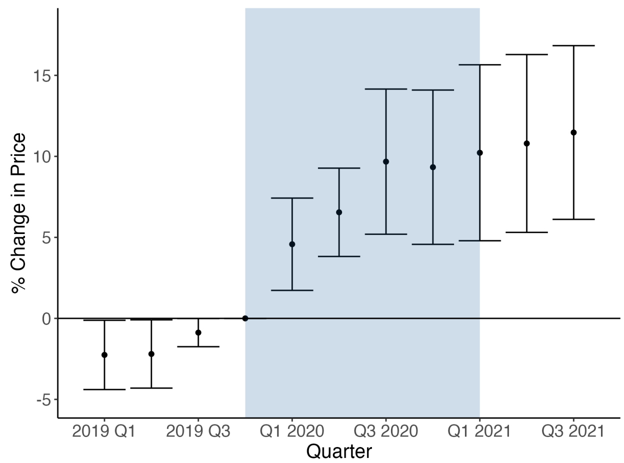


(b) Middle Tertile

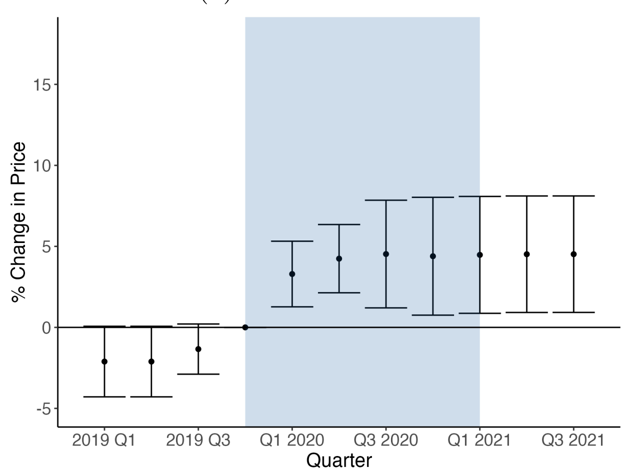


(c) Top Tertile

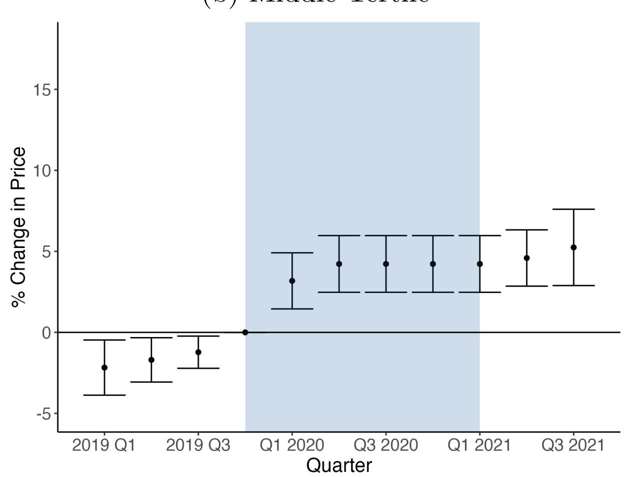
Figure 12: Percentage Change in Prices by Tertile (Price Ranges)



(a) Bottom Tertile



(b) Middle Tertile



(c) Top Tertile

Figure 13: Percentage Change in Prices by Tertile (New York Wholesale)