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The Impact of Commodity Taxation on Product Variety: A Multi-category Investigation

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Abstract:

Excise taxes are one of the primary tools used to discourage consumption of socially undesirable or unhealthy products. When considering implementation of such taxes, the current policy and academic discussions have focused on potential outcomes due to price changes. In this paper, we document that price changes are only the immediate response to tax policy changes, and in the long run tax changes can impact product offerings. Using exogenous changes in tax rates from multiple empirical contexts; (1) the Korean soju market and (2) the U.S. cigarette market, we show that a tax increase is followed by a significant drop in number and variety of product offerings. In addition, the change in product assortments post-tax hinges critically on the nature of tax imposed. We find that specific taxes, as opposed to *ad valorem* taxes, lead to the exit of products with larger pack size. We conduct a simulation experiment and estimate that studies which do not consider assortment changes can result in a 9% upward bias in consumer welfare for large tax increases. Our findings have important policy implications for research examining the impact of taxes on market outcomes.

Keywords: Commodity tax, tax reform, ad valorem tax, specific tax, product variety, product size

Statements and Declarations:

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1 Introduction

Regulators utilize a variety of policy tools to discourage consumption of socially undesirable products such as tobacco, alcohol and gambling. Policies range from simple provision of information (e.g. nutrition labelling) to active social marketing to raise awareness, restrictions on advertising by firms, and imposing bans on public consumption. Arguably the most utilized and effective economic tool to curb consumption of 'sin' products is raising costs of consumption by imposing taxes. According to the WHO, the majority of countries impose taxes on tobacco and alcoholic products.[1] More recently, there has been substantial interest in extending similar counter-marketing efforts to food products that pose health risks such as sugary sodas and high fat food offerings. For example, a number of cities in the US and 34 countries globally have imposed taxes on sugar sweetened beverages (Global Food Research Program 2019). The goal of such pigovian taxes are to change consumer behavior by discouraging excessive consumption of unhealthy commodities and/or to shift their preference to more desirable alternatives. In addition, a well-designed tax system could generate substantial tax revenues.

Given their ubiquitous use as a policy tool, the question of how commodity taxes influence government revenues and consumer welfare has garnered interest from policymakers and academic researchers alike. For example, a recent policy report by the Task Force on Fiscal Policy for Health (2019) concludes that even though excise tax policies are highly effective, they remain an underutilized tool for curtailing unhealthy consumption of tobacco, alcohol and sugary beverages. Likewise, academic literature in marketing and economics demonstrates the large effects of tax intervention in influencing consumers' product choices and consumption (Adda and Cornaglia 2010, Hines 2007, Mytton et al 2012, Wang et al 2015), with many arguing for taxation as a potential nudge mechanism against obesity (Bollinger and Sexton 2018, Chouincard et al 2007, Dubois et al 2017, Griffith et al 2012, Khan et al 2016, Seiler et al 2020,

[1] According to the World Health Organization, 166 (135) out of 186 countries reported have a tobacco (alcohol) tax. See http://apps.who.int/gho/data/node.main-euro.A1181 for alcohol taxes and http://www.who.int/tobacco/economics/1globalregionaloverview.pdf for cigarette taxes.

Wang 2015). Yet another stream of literature focuses on the trade-off between reduced consumption and tax revenue (Hollenbeck and Uetake 2021, Miravete et al 2018) and designing of 'optimal' sin-tax policies taking into account interactions between the corrective and redistributive motives of commodity tax (Allcott et al 2019).

A common theme across policy papers and the extant academic literature is the focus on price as the primary causal link between taxes and market outcomes. That is, implementation of taxes leads to higher prices, which in turn lead to changes in consumer or firm behavior. This link is often presented as the "conceptual causal pathway" in assessing the impact of taxes by the Community Preventive Services Task Force[2] (see Figure 1 of Elder et al 2010). In this paper, we argue that this causal pathway is incomplete, reflecting an immediate or short-run response to the tax changes. In the long run, implementation of taxes can lead to changes in market structure as lower demand may trigger some firms to exit the market. Alternatively, firms may respond to changes in demand by altering the menu of product offerings.

In theoretical literature, how the tax changes will affect equilibrium product variety is largely ambiguous as the result depends on the shape and nature of consumer demand. On the one hand, Anderson et al (2001a) show that an increase in a tax rate will act as a marginal cost multiplier and therefore induce firms to exit the market (resulting in a lower level of product variety in the market). On the other hand, Constantatos and Sartzetakis (1999) suggest that, in a market with vertical differentiation, an increase in tax can lead to an increased number of lower quality manufacturers. With respect to per-firm product variety, a prediction has been made that an increase in tax rate creates distortion in the market by making high-cost products more expensive and thus could shift both demand and supply toward low-cost products (Cremer and Thisse 1994).

Our objective in this paper is to document empirically how taxes impact product variety in the market. Analyzing historical data from multiple empirical contexts with large changes in tax rates at the national level, we examine changes in firms' product assortments: we first look at the number of product options offered to the market, and then extend our analysis to the firm's decision on which products to make available in response to the tax change. Our empirical finding has an important implication for policymakers by looking at the changes in the behaviors of firms that would remain in the market.

2 Empirical Contexts

We seek to establish the causal relationship between the tax changes and market outcomes of firms' product decisions by studying multiple product markets, which saw sizeable changes in commodity tax rates. As the timing of

[2]The Community Preventive Services Task was established by the U.S. Department of Health and Human Services (DHHS) in 1996 to develop guidance on which community-based health promotion and disease prevention intervention approaches work and which do not work, based on available scientific evidence https://www.thecommunityguide.org/about/about-community-guide

changes in tax regime in these markets were largely driven by factors external to demand and supply of the focal products, the cases make the corresponding industries a useful laboratory in which to study the impact of exogenous tax changes on market outcomes of our interest. This section describes each market context and data for our analysis.

2.1 Korean Alcoholic Beverage Markets

First, we investigate a tax reform case in the Korean alcoholic beverage industry in 2000, with a focus on the soju market[3]. The Korean soju market has historically been highly regulated. Since 1977, the production has been limited to 10 local producers with production licenses in 11 geographic regions (9 provinces and 2 metropolitan cities, Seoul and Busan). The national market was composed of separate geographic markets with a protected local producer until 1992, and it has since become open to nation-wide competition allowing for free entry to regions. Because each local-based firm and some other firms from other regions compete in the regions, each geographic market still exhibits distinct product assortments available to local consumers. Details of this industry are provided in Web Appendix A.

Prior to the tax reform in 2000, the Korean government had levied its domestic soju products at a preferential rate (35%) compared to other distilled spirits and liquors because of its national popularity (the rates for whisky and beer were 100% and 130% respectively). The unbalanced tax rates between (largely domestic versus imported) product categories had been judged unfair by members of the WTO. Following complaints filed by the EU and the U.S., in July 1998, the WTO suggested the Korean government adjust the rates for these products as the unbalanced rates were viewed as a means of domestic market protection, which is against the GATT (The General Agreement on Tariffs and Trade). In October, the Korean government filed an appeal for the case but finally lost the case in February 1999. As the government was consequently forced to equate the tax rates for soju and whisky products, it finalized the plan for the tax reform for the overall alcoholic beverage industry in September 1999, which became effective as of January 2000: the government equalized the tax rates levied on soju and other liquors at 72% and to reduce the rate gap among the products, the tax rate for beer products decreased to 115%. This exogenous shock to the contemporary tax regime for alcoholic product categories provides us with an ideal natural experiment in which to study the effects of tax changes.

Producers of alcoholic beverages manage a broad product line, and the market is characterized by strong local branding and product differentiation. Hence, we can investigate the impact of the tax increase on the soju product variety offered to consumers in each geographic market. To account for heterogeneity across these geographic markets, we obtained regional-level retail data

[3]Soju is a traditional Korean liquor mostly made by diluting ethanol. It serves as the most widely consumed alternative in the overall alcoholic beverage industry in Korea: according to the Korean Alcohol and Liquor Industry Association, its market size by volume accounted for nearly 40% of the industry in 2011.

from Nielsen Korea spanning the period before and after the tax reform (1996 – 2005). The data contain bi-monthly product-level (identified with firms, brands and pack sizes) retail soju sales volume and value across 10 geographic regions.

2.2 U.S. Cigarette Market

As a second case study, we look for empirical evidence from the U.S. cigarette market. In April 2009, the largest federal cigarette excise tax increase in history went into effect, bringing the combined federal and average state excise tax for cigarettes to 2.21 dollar per pack (The federal tax on cigarettes increased by 156% from 0.39 to 1.01 dollar per pack). The stated objective of this increase was to raise tax revenue to fund the Children's Health Insurance Program approved by President Obama. This program was designed for states to insure low-income children who are not eligible for Medicaid and cannot afford private insurance.[4]

Given the trigger and the magnitude of this tax rate change, this case also serves as a good empirical context in which to study the market outcomes in response to the tax changes. For the empirical analysis of the case, we make use of data from Nielsen Academic dataset from the University of Chicago. We observe weekly sales volume, price, and promotion of UPCs in approximately 25,000 stores across the US. Our analysis for this market is based on data from 2007 to 2011.

3 Empirical Results

In this section, we document changes in product assortments in the two product markets. For the Korean soju market, we consider 10 years to capture not only the immediate but also longer term effects of the tax reform. For the cigarette market, we focus on two years before and after the tax increase. With respect to the overall retail market volume and prices, both product markets saw an immediate increase in retail prices and a reduction of sales volume after the tax hike (The detailed figures are presented in Web Appendix B.). While this aspect of the tax effects has been the focus of previous literature, in this paper we focus on the tax effects on product variety in the markets.

3.1 Impact of Taxation on Product Variety: Number of Products

We begin by investigating changes in the number of product options offered in each product market. As a common measure across product categories, we look at the number of product variants offered to the market. In the soju market, we define a product variant as a unique combination of firm, brand and pack size available in our data. For cigarette product variants, we consider UPCs. As firms' product assortment decisions were made at a larger geographic

[4]U.S. Department of the Treasury Alcohol and Tobacco Tax and Trade Bureau, Statistical Report – Tobacco, Washington D.C. 2010

level (regional for soju and national for cigarettes), this naturally limits the appropriate granularity of the analysis.

To summarize changes in the number of product options in each geographic soju market after the tax reform, we consider two additional measures beyond a single measure of the total number of products. In each geographic market, the local-based firm and some other firms from the other regions compete and each local firm has a distinctly high market share in their base region. While the total number of firms is fixed nationwide, individual firms can enter and exit each region freely. The number of competing firms in the geographic markets, therefore, could vary in each year. While the total number of product variants (produced by all active firms) represents the overall product assortment currently available in each geographic market, this number is likely to have been lower when some firms chose to exit the markets after the higher tax rate was enforced. To understand further whether the tax changes influenced individual firms' decisions on product assortment (offered to each geographic market), we compute the number of active brands and products offered by individual firms which continued to operate throughout the entire observation period until 2005.[5] Through these measures, we attempt to document the changes in the product variety offered by each firm after accounting for the changes due to firms' decisions on market entry and exit.

In the cigarette market, we have access to more detailed UPC level sales data yet the information on the manufacturers is missing. In addition to the total number of UPCs, therefore, we count the number of available brands in the market. As a third measure of product variety, we operationalize the number of cigarette UPCs in a similar manner to the soju market using the brand information: given the significantly larger number of brands in the cigarette market, we look at the number of the total UPCs offered by brands that had been available throughout the entire observation period.[6]

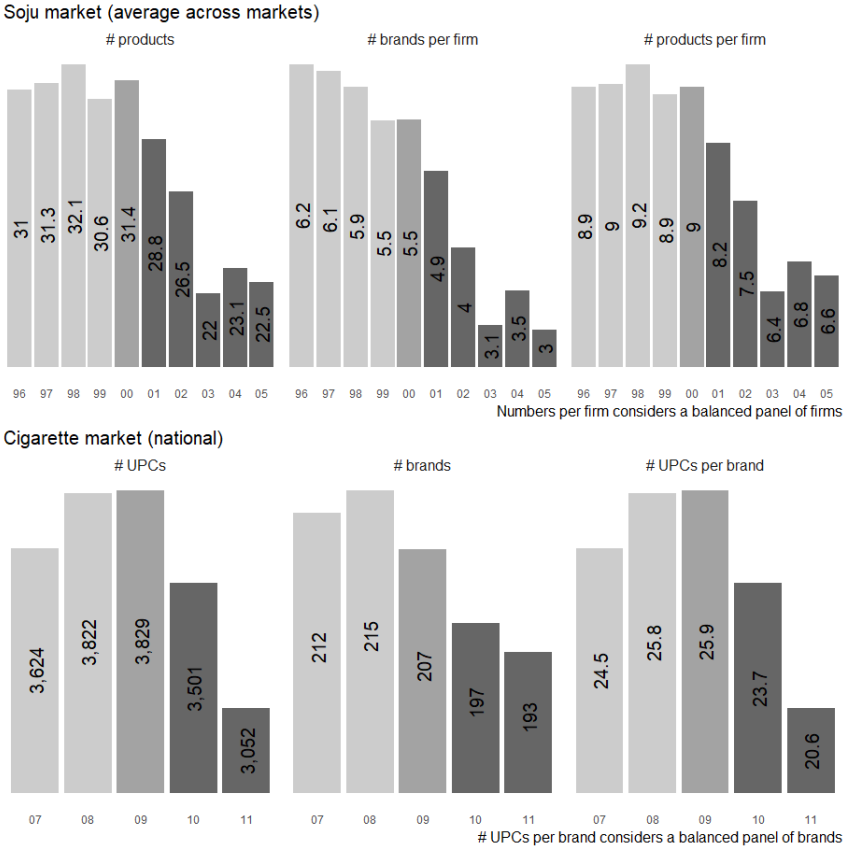
Figure 1 summarizes the time-series pattern of every measure of product variety in the two product markets. The top panel in Figure 1 presents the measures from the soju market, each averaged across 10 geographic regions. Across all measures, we observe that the numbers decreased after the tax increase. The chart in the first column represents changes in the total number of active soju products offered by all active firms and we observe that this number decreased after the tax reform. After accounting for changes in the number of firms in each market, we present the number of per-firm brands in the middle column and the number of per-firm products in the right column. Here, we find that after the tax increase, individual firms which remained in the market reduced their product assortment.[7]

[5] We first define an active product as one with more than 1,000 unit volume (liter) sales in any bi-monthly period. On average, this volume represents 0.01 share point in the geographic market. A brand is defined active in a market if it has at least one active product.

[6] In the soju market, there were few brands that satisfy this condition.

[7] In this market, we also find that the firms exited the market and hence, the observed reduction in the overall soju product variety in the geographic markets had been driven in part by market exits made by individual firms. In Web Appendix C, we report more detailed market-level data including the number of firms.

Fig. 1 Soju and Cigarette Product Variety: Time-Series Patterns



The patterns from the cigarette market are shown in the bottom panel of Figure 1. All three measures of product variety also decreased in this market after the tax increase in 2009: the total number of available UPCs decreased not only because there were fewer brands offered to the market but also each brand was sold in fewer UPC variants. Consistently in both product markets, we find that these changes in product variety do not necessarily come immediately after the policy change. In the soju market, with the longer period of observation, the presented patterns suggest that the firms stabilize the number of brands within 3 to 4 years of the tax change.

As a statistical test of these data patterns, for each product category, we run the following logit regression on whether each product variant (a UPC, product or a brand) is active in each year, and to see if there is any significant change in their probability of remaining active after the tax increase:

$$P(y_{jmt} = 1) = \frac{exp(\beta_S 1^{year=policychange} + \beta_L 1^{year>policychange} + \alpha_{jm})}{1 + exp(\beta_S 1^{year=policychange} + \beta_L 1^{year>policychange} + \alpha_{jm})}, \quad (1)$$

where $P(y_{jmt})$ refers to the probability that each corresponding product option j is offered to consumers in a geographic market m (a total of 10 geographic markets for soju and a national market for cigarettes) at each annual time-period t (from 1996 to 2005 for soju and from 2007 to 2011 for cigarettes). α_{jm} captures the corresponding product-market fixed effects and these variables are considered control variables. The parameters of our interest are β_S and β_L. β_S represents any immediate change to the dependent variable at the year of the change in tax policy (i.e., during the policy transition period), while β_L represents the long-term changes in the variable after the policy change. If β_S is zero, therefore, the interpretation would be that the new policy did not affect the variable immediately.

Table 1 presents the estimates from the logit regressions of every measure of product variety. Consistent with the data patterns, we confirm that the bulk of the tax effect on product variety occurred in the long run. The reported long-term tax effect is robust to the addition of product-specific fixed effects (The soju market results are robust to region-product-specific fixed effects). Overall, our results from the two product markets show that the tax increase led to a reduction in product variety in the market. In addition, in the Korean soju market, we observe that such a decrease in product variety is attributed to a firm's stronger incentive to leave the market as well as to produce fewer products when high taxation is implemented. Both actions could be driven by a decrease in the overall profit in the presence of higher taxation. Anderson et al (2001a) show in their theoretical model that an increase in tax will act as a marginal cost multiplier and therefore induce firms to exit the market (resulting in a lower level of product variety in the market).

3.2 Impact of Taxation on Product Variety: Product Sizes

We now turn to the effect of taxes on the firm's decision on which products (as opposed to how many) to make available in the market in response to the tax change. In particular, we focus on the tax effects on product variants with varying pack sizes – whether the firms have a higher incentive to reduce their assortment in smaller versus larger sizes. As to soju product pack sizes, most soju manufacturers offered their flagship brands in both small and large sizes and the industry standard for the small size lay around 350ml. In our data, the vast majority of the retail sales volume came from either small sized products in a range between 0.3 and 0.4 liter or 1.8 liter bottles (79.4% and 17.7% respectively during the period of our observation). Hence, we define soju product variants with their size greater than 0.4 liter as larger sized items. In the cigarette data, we investigate the tax effect on single versus multipack UPCs.

Table 1 Soju and Cigarette Product Variety: Logit Regression Estimates

1. Soju Market

	Dependent Variables: $y_{jmt} \in \{0,1\}$					
	(I) Products		(II) Brands per Firm*		(III) Products per Firm*	
	Coefficients	*SD*	*Coefficients*	*SD*	*Coefficients*	*SD*
Year of Tax Increase	0.011	(0.097)	0.093	(0.156)	0.222**	(0.110)
year > 2000	−0.523***	(0.060)	−1.024***	(0.099)	−0.355***	(0.067)
Controls:						
Market×Brand FE	No		Yes		No	
Market×Product FE	Yes		No		Yes	
# Obs.	7,140		2,660		5,400	

*Notes: Measures per firm consider a balanced panel of (active) firms.

2. Cigarette Market

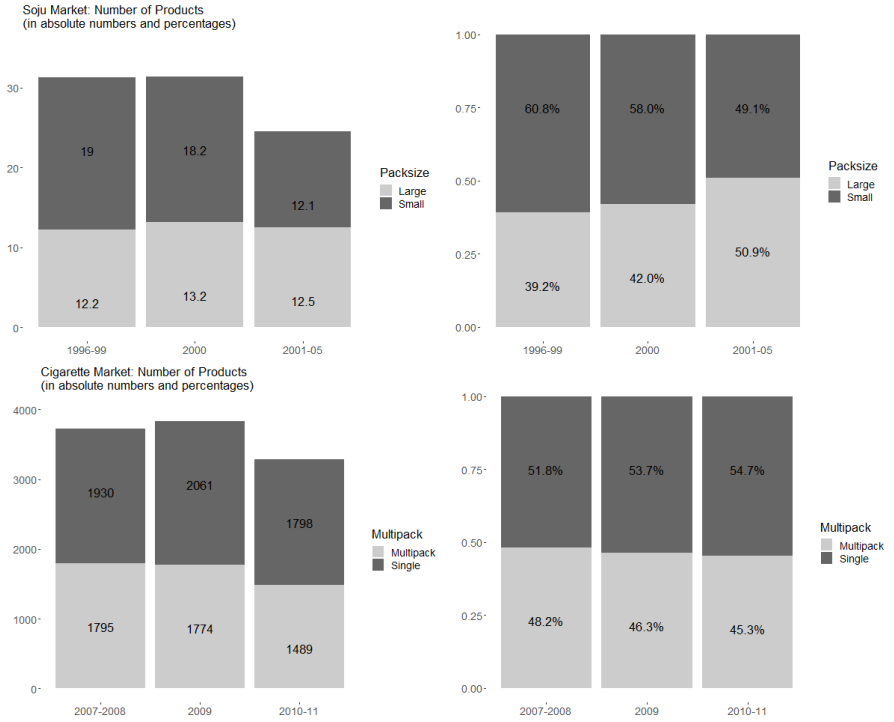
	Dependent Variables: $y_{jt} \in \{0,1\}$					
	(I) UPCs		(II) Brands		(III) UPCs per Brand*	
	Coefficients	*SD*	*Coefficients*	*SD*	*Coefficients*	*SD*
Year of Tax Increase	0.209***	(0.054)	−0.269	(0.249)	0.178***	(0.060)
year > 2009	−0.812***	(0.044)	−0.771***	(0.207)	−1.029***	(0.048)
Controls:						
Brand FE	No		Yes		No	
UPC FE	Yes		No		Yes	
# Obs.	13,885		595		11,615	

*Notes: UPCs per brand consider a balanced panel of (active) brands.

Figure 2 presents changes in the number of product variants in each size group before and after the tax increase in the soju and cigarette markets. Interestingly, the two product markets exhibit an opposite trend with respect to the tax effects on product assortment in pack sizes. While the reduction in product assortment took place mostly among smaller-sized variants in the soju market, in the cigarette market, multipack items reduced disproportionally more. As a result, the share of larger items increased in the soju market (from 39.2% to 50.9%) and decreased in the cigarette market (from 48.2% to 45.3%).

To test these diverging patterns statistically, we run a logit regression similar to that presented in Equation (1). In addition to the variables corresponding to the policy change - year of tax increase and time after the tax increase -, we interact these variables with a new variable indicating whether each product variant belongs to larger pack size group. This specification allows us to test whether there were any significantly different tax effects depending on the pack size of the products. The top panel in Table 2 confirms the statistical significance of the observed patterns in Figure 2: The estimates confirm the overall reduction of product assortment following the tax increase yet the magnitude of the effects varied significantly by pack size. In the soju market, the tax increase had a stronger negative impact on the availability of smaller-sized products while the opposite was true in the cigarette market.

Fig. 2 Soju and Cigarette Product Variety: By Packsize



What could potentially drive this diverging tax effects on pack sizes in the two product markets? We note that the Korean alcohol tax is levied in proportion to the price of the product (i.e., *ad valorem* taxation) while the tax for cigarettes in the U.S is charged per unit of a product irrespective of price or quality of the product (i.e., specific taxation). Theoretical predictions of how tax changes will affect equilibrium product variety in the market depend largely on the types of taxation. In the literature of the optimal tax design, these two forms of taxation have often been compared with respect to their impact on the market equilibrium and the resulting revenue for the firms and the government (Anderson et al 2001b, Delipalla and Keen 1992, Hamilton 1999, Keen 1998, Kroft et al 2021, Skeath and Trandel 1994).

The distinction between these two types of taxation may account for varying product assortment in small and large pack items as the tax hike in each form would have different implications on the amount of discount consumers could expect from larger pack items. Under the *ad valorem* taxation, the tax changes in proportion to the final consumer price do not necessarily alter the nature of volume discount. On the other hand, as in the cigarette market, when higher tax is charged per pack, there is less room for manufacturers to

Table 2 Soju and Cigarette Product Variety by Product Size

1. Estimates from Product-level Logit Regression

	Dependent Variables: $y_{jmt} \in \{0,1\}$			
	(I) Soju Market Products		(II) Cigarette Market UPCs	
	Coefficients	*SD*	*Coefficients*	*SD*
Year of Tax Increase	−0.109	(0.130)	0.467***	(0.075)
Year of Tax Increase×Larger Packsize*	0.270	(0.195)	−0.539***	(0.107)
year >Year of Tax Increase	−1.020***	(0.084)	−0.482***	(0.060)
(*year* >Year of Tax Increase)×Larger Packsize	1.067***	(0.121)	−0.679***	(0.088)
Controls:				
Market×Product FE	Yes		Yes	
# Obs.	7,140		13,945	

*Notes: "Larger Packsize" denotes soju products with packsize greater than 400ml and cigarette products in multi-pack carton. Cigarette market regression is at the national level (y_{jt}) and do not include market fixed effects.

2. Estimates from Linear Regression on Price per Volume

	Dependent Variables: $ln(Price_{mjt})$			
	(I) Soju Market		(II) Cigarette Market	
	Coefficients	*SD*	*Coefficients*	*SD*
Larger Packsize	−0.344***	(0.013)	−0.279***	(0.014)
Year of Tax Increase	0.158***	(0.016)	0.164***	(0.015)
Year of Tax Increase×Larger Packsize	0.020	(0.023)	0.026	(0.023)
year >Year of Tax Increase	0.212***	(0.012)	0.206***	(0.013)
(*year* >Year of Tax Increase)×Larger Packsize	0.009	(0.016)	0.085***	(0.019)
Controls:				
Market×Brand FE	Yes		Yes	
# Obs.	2,793		17,858	

*Notes: Price variables ($Price_{mjt}$) for soju and cigarette products are post-tax price per liter and post-tax price per 20 sticks respectively. Cigarette market regression is at the national level.

offer discount from larger pack bundles. This is due to the fact that any possible discount expected per unit of volume (i.e., a pack of cigarette) would be offset by the additional tax burden borne per that unit of volume.

To investigate this aspect further, we look at the relative difference in price per unit volume between small and large items (unit volume is 1 liter and 20 sticks in the soju and cigarette markets respectively). We computed the difference for each brand and once the relative price is computed for every brand, we average these differences across brands in each product market. We divided price per volume of large products by that of small products, and the computed percent difference, therefore, summarizes the average amount of discount that consumers could expect from choosing larger items of a given brand. In the soju market, the discount from larger items was maintained after the tax increase (from 73.3% in 1996-99 to 70.6% in 2001-2005). In the cigarette market, however, the price per pack offered by single pack items and multi pack items became closer and after the tax increase we see that discount from larger pack items became almost non-existent (from 85.1% in 2007-08 to 96.8% in 2010-11).

Table 2 (in the bottom panel) also confirms this observed pattern by regressing price per unit volume of each product variant over the period of our observation. First, the estimates show that there was a general price discount from a larger pack. By time variables indicating the policy changes (the year of tax increase and years after), the model also captures price hikes following the tax increase. Our main interest in the regression is to identify whether there was any significantly different price reaction to the tax increase depending on the pack size of the items. While we do not find any significant difference between pack sizes in the soju market, in the cigarette market, there was a significant increase in price per unit volume for larger items. This different price reaction to the tax increase may account for why larger (multipack) cigarette products are more likely to be discontinued after the tax increase. This finding from the cigarette market under specific taxation is consistent with the recent finding from a study of the impact of soda taxes in Philadelphia (Seiler et al 2020), where they document a significantly larger reduction in sales of large pack sizes in stores.[8]

4 Concluding Remarks

When it comes to a case of sin taxes, our results indicate that an increase in commodity taxes has two effects that could discourage consumption of the commodity: price increases and variety decreases. Most extant discussions by researchers and policy makers on the implementation of new tax regimes have focused on their effects via final consumer price changes, and they treat product variety offered by multi-product firms as fixed. These approaches have overlooked another important causal pathway of the tax effects: the effect of tax changes on product variety decisions made by individual firms. To the best of our knowledge, this paper provides the first empirical evidence of the impact of taxation on a firm's decisions on product variety. Through a series of analyses of the Korean soju and U.S. cigarette markets, we document consistently the negative impact of a tax hike on the product variety. Furthermore, we find that larger-sized products are more likely to be discontinued after the tax increase under the specific (as opposed to *ad valorem*) taxation. Consistent with this result, we note that 30 out of 35 OECD countries adopt specific taxation for alcoholic beverages.

Given the frequent changes of tax regime for various product markets, our findings could be extended to other relevant cases where we observed sizable tax changes (e.g., an alcohol tax increase in Kentucky in 2009) or the introduction of new tax (e.g., soda tax in some U.S cities such as Berkeley in 2015 and Philadephia in 2017). While in the present study we investigate the consequences of multiple tax changes made at the national level, future research can consider the extent to which individual firms adjust their product assortment decisions in response to these state- or city- level taxes.

[8]They note that the assortment carried by individual stores varied in the data, and our finding suggests that this may reflect in part the impact of the tax increase on the supply side assortment changes.

In Web Appendix D, we extend our analysis to other two product markets which were also affected by the Korean alcohol tax reform - beer and whisky (the tax rates for beer and whisky decreased from 130% to 115% and from 100% to 72% respectively). We find some empirical evidence of an increase in the number of active brands in both markets.[9] This result strengthens the credibility of our main finding as they confirm that the observed tax effects are symmetric depending on the direction of a tax change: as taxes increase (decrease), firms reduce (increase) their product variety.

Prior research findings focusing on one effect (e.g., price effects), therefore, should be understood as partial equilibrium outcomes and to consider the results under the full equilibrium, one should evaluate these long-term changes. While our data do not have sufficient granularity to estimate a structural model of firms' assortment decisions and consumers' product choices, to understand the economic consequences of the documented tax effects, we consider a simulation of a firm's optimal pricing and assortment decisions in Web Appendix E. In the simulation, we estimate for large tax increases that the studies disregarding assortment changes can have a 9% upward bias in estimated consumer welfare. To add more empirical relevance to our simulation results, the finding of potentially lower demand quantity when accounting for the assortment changes is consistent with a recent action made by the Mayor of Philadelphia lowering revenue expectations from soda taxes by 15 percent in 2018.[10]

[9]The analysis assumes that the three categories are independent on the demand-side. The assumption takes into consideration that these products exhibit distinct characteristics with respect to product attributes (e.g., production process and alcohol by volume), customer base (e.g., distribution of age and gender), and consumption patterns (e.g., seasonality). In particular, the issue of substitutability between soju and beer had been under legal scrutiny for a merger case in 2006 in Korea and the Korea Fair Trade Commission concluded that the two product markets are separate (Korea Fair Trade Commission. Decision on Hite-Jinro Merger. KFTC Decision No. 2006-009).

[10]https://www.inquirer.com/news/philly-soda-tax-revenue-spending-20190821.html

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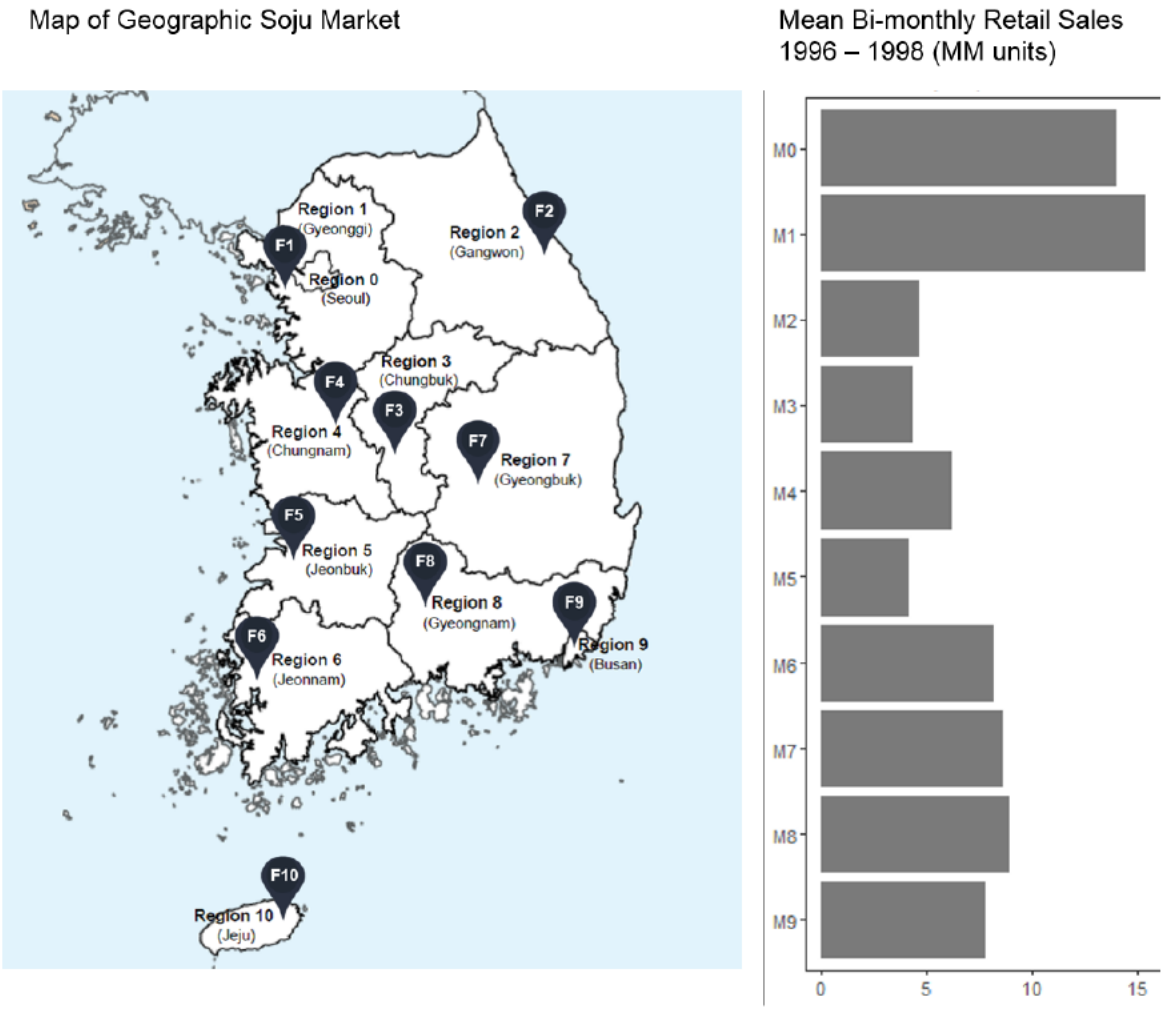
WEB APPENDIX A: A Summary of the Korean Soju Market

Historically, the Korean soju market operated under a degree of government regulation. The market competition for soju has been limited to 10 firms which originated as regional representative soju producers. In the 1970's, when there were more than 250 small-sized soju production sites nationwide, unhygienic operations and tax evasion by these producers became a concern for the government. The government consequently controlled the market supply by consolidating production sites in each of 11 regions based on which the production licenses were distributed (9 provinces and 2 metropolitan cities, Seoul and Busan). The government assigned one local producer to each geographic market and by 1977, there were only 10 producers nationwide. The leading producer was assigned to both Seoul and nearby Gyunggi province while the remaining 9 regions were allocated to 9 other local producers. Figure A.1 depicts the Korean map and the geographic soju market (11 regions and corresponding 10 local manufacturing firms). Since the market deregulation in 1992 (allowing for free entry to regions), the national soju market has been divided into a group of geographic markets in which a local-based firm and some other firms from the other regions compete.

To account for heterogeneity across these geographic markets with respect to their market structure, we make use of regional-level retail data from Nielsen Korea. While this study focuses on sales from the retail channel at the regional level, the soju manufacturers' domestic volume is shipped to other channels such as on-premises, exports, and supply for the military. Among these, the volume for exports and supply for the military are not subject to tax and are less relevant to the present analysis. It is also noteworthy that the absolute amount of the non-taxed volume was small compared to the rest (11.1% of the total shipment volume for the period 1997-

2002). Figure A.1 also presents the market size of each region with respect to the soju retail sales. The market data of Region 10 (Jeju island) and its local producer are not available due to their small size, and hence we exclude them from our analysis.

Figure A.1. Geographic Soju Market Overview

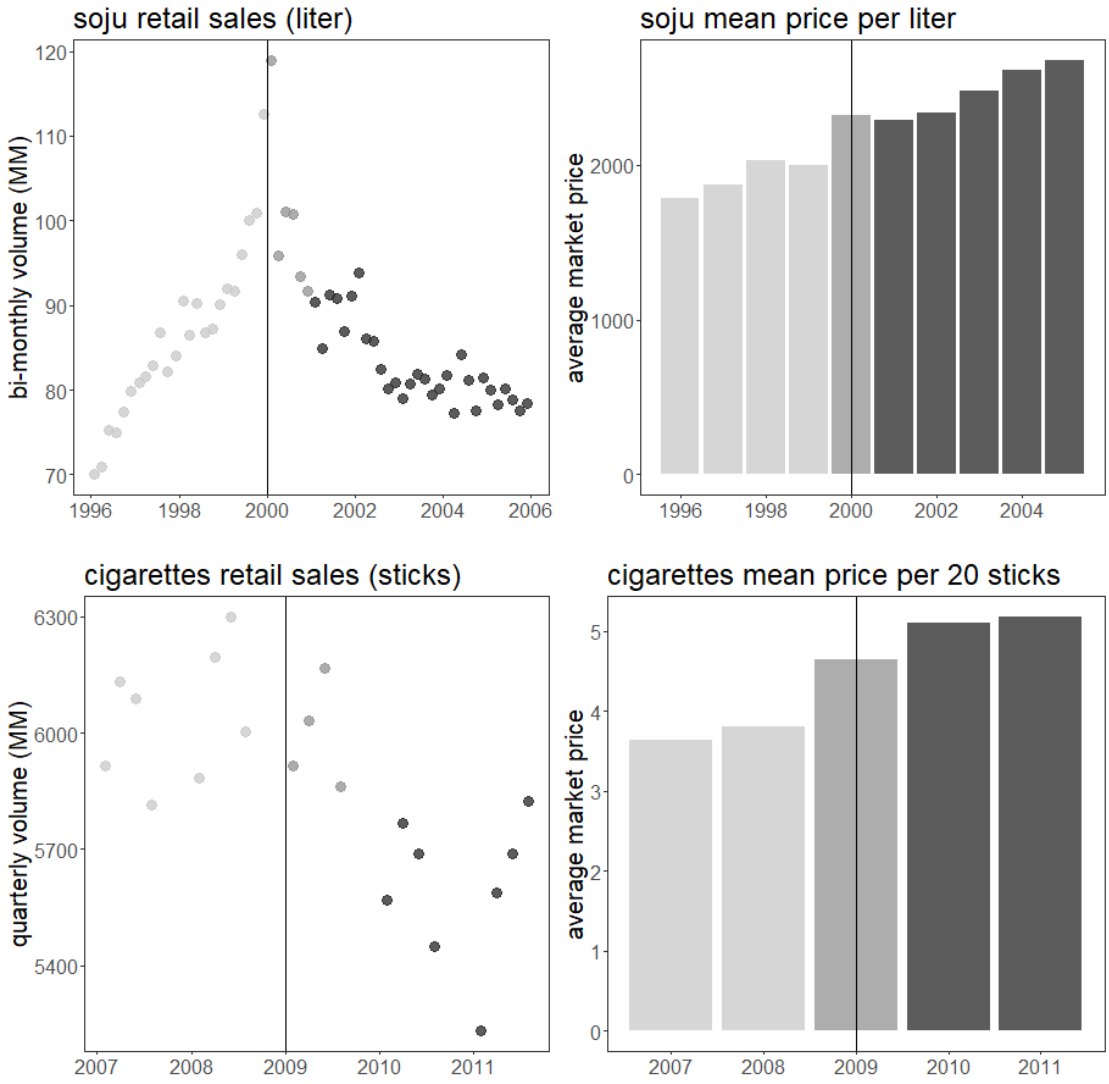


*Note: F1 - F10 represent local manufacturing firms; M0 - M9 represent geographic markets (regions).

WEB APPENDIX B: Changes in Market Volume and Price

Figure A.2 presents retail sales and the average retail prices in the Korean soju and the U.S. cigarette markets over the period of our observation. In both markets, we observe that there was an immediate impact of the tax increase with increased retail prices and lower overall sales volume.

Figure A.2. Soju and Cigarettes Retail Market Volume and Price



WEB APPENDIX C: Changes in Product Variety by Geographic Soju Markets

Figure A.3 presents the raw data patterns in Figure 1 using the monthly (bi-monthly for soju) data. Albeit with more variation within short periods, we find that the observed patterns are generally consistent with those from annual figures. In addition, Table A.1 presents the measures by geographic region. We present the long-term changes by comparing the data of 1996-1999 (before the tax change) with those of 2001-2005 (after the tax change). The regional patterns are consistent with the aggregate pattern observed in Figure 1.

Figure A.4 presents three related measures of total product variety (the total number of firms, brands and products) in every geographic soju market before and after the tax reform. In the charts, bars represent the means of the measures before and after the reform, and the numbers printed represent differences in the means. The size of the bars represents the relative size (i.e., sales volume) of each market.

We find a robust pattern of reduction in the numbers after the tax increase. The observed decrease in the total number of firms indicates that the reduction in the product variety could have been driven in part by market exits made by individual firms. Nevertheless, we still observe that the firms which remained in the market after the tax reform reduced their product assortments.

Figure A.3. Soju and Cigarettes Product Variety: Time-Series Pattern

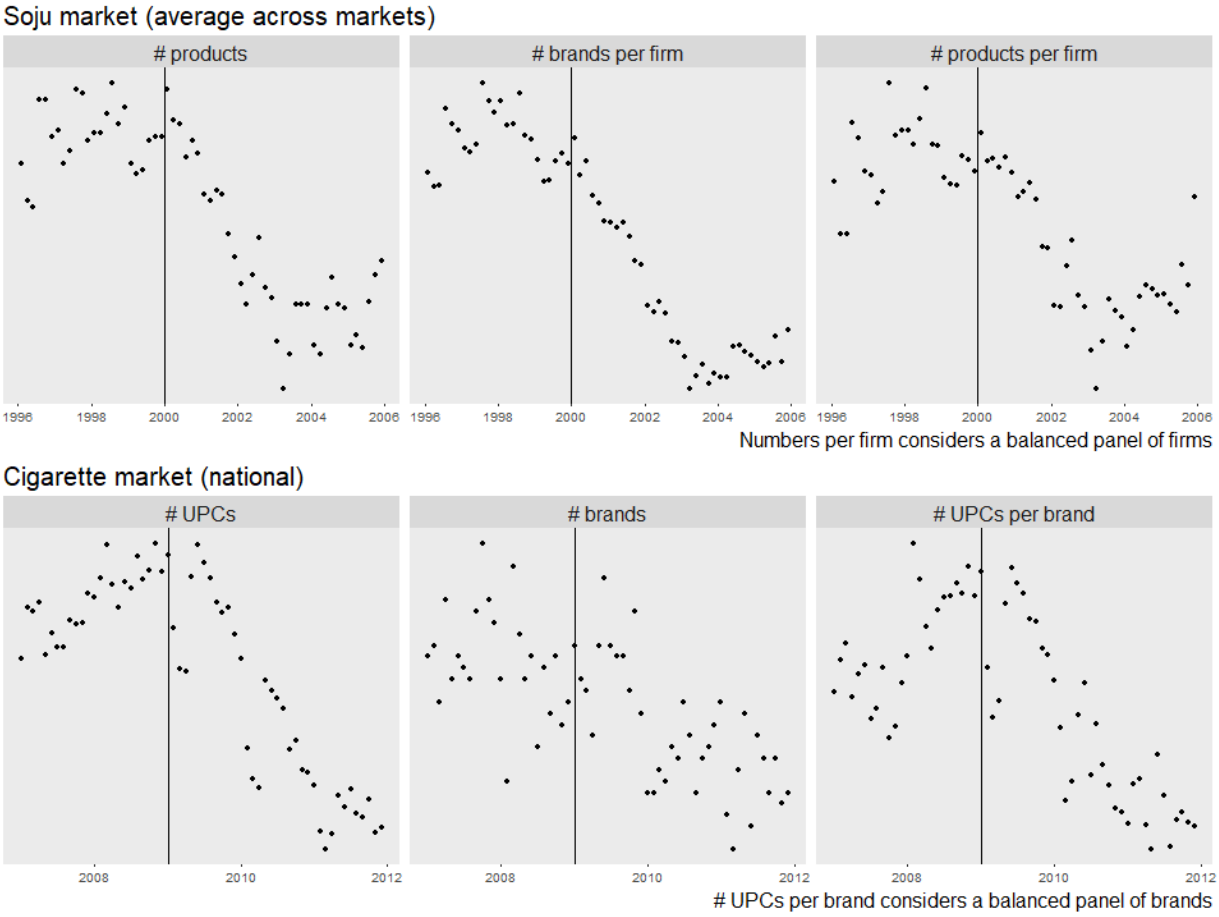
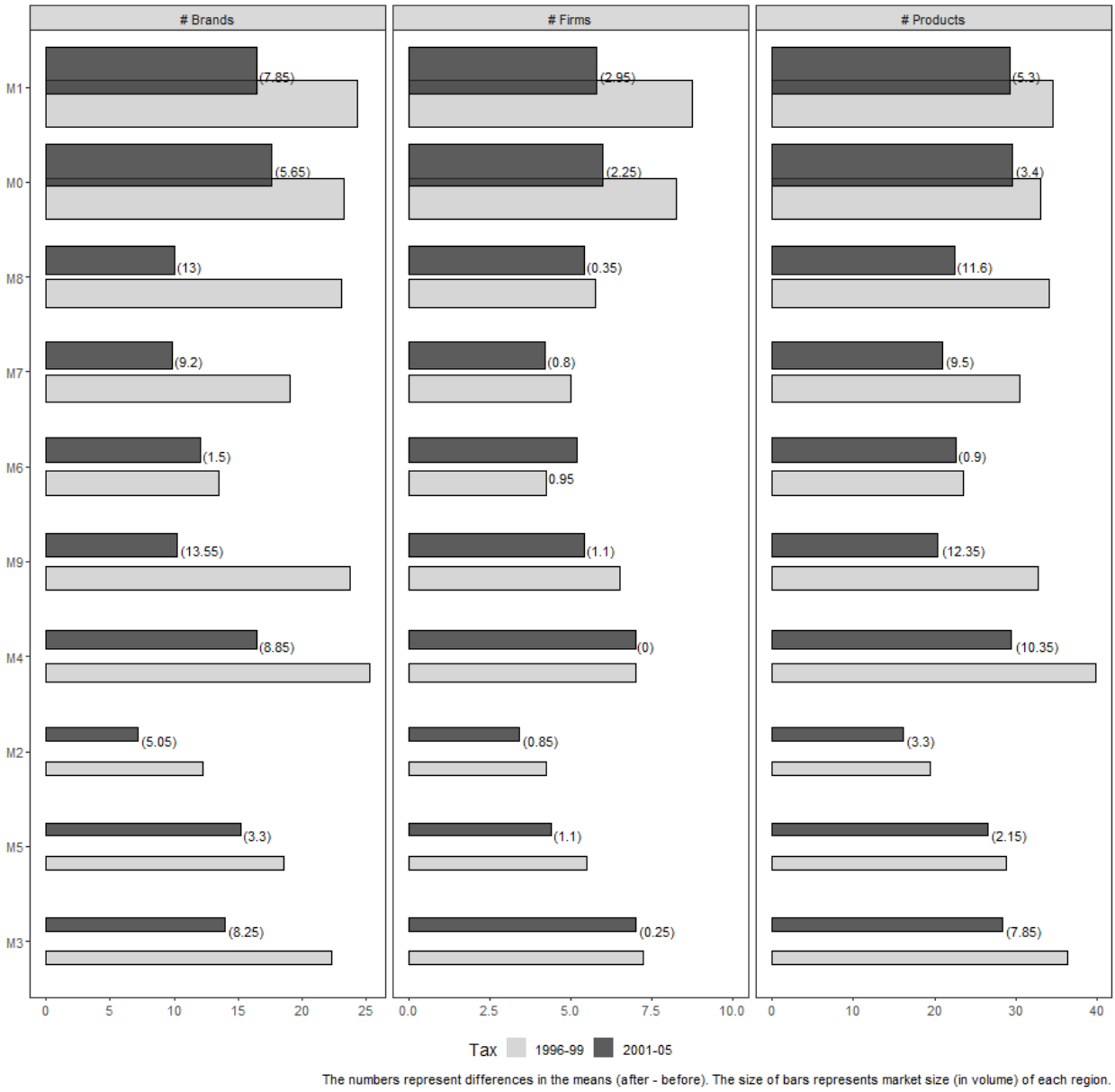


Table A.1. Geographic Soju Market Product Variety: Cross-Sectional Pattern

	# Products			# Brands per Active Firm			# Products per Active Firm		
	1996-1999	2000	2001-2005	1996-1999	2000	2001-2005	1996-1999	2000	2001-2005
M0	33.0	34.0	29.6	5.8	6.3	4.4	8.3	8.5	7.4
M1	34.5	37.0	29.2	8.1	7.7	5.5	11.5	12.3	9.7
M2	19.5	19.0	16.2	6.1	6.0	3.6	9.8	9.5	8.1
M3	36.2	40.0	28.4	3.7	3.8	2.3	6.0	6.7	4.7
M4	39.8	38.0	29.4	6.3	5.5	4.1	9.9	9.5	7.4
M5	28.8	35.0	26.6	4.6	5.0	3.8	7.2	8.8	6.7
M6	23.5	28.0	22.6	4.5	5.7	4.0	7.8	9.3	7.5
M7	30.5	24.0	21.0	6.3	5.0	3.3	10.2	8.0	7.0
M8	34.0	32.0	22.4	5.8	4.3	2.5	8.5	8.0	5.6
M9	32.8	27.0	20.4	7.9	6.0	3.4	10.9	9.0	6.8

Figure A.4. Geographic Soju Market Product Variety Before vs. After Tax Increase



WEB APPENDIX D: Analyses of the Korean Alcoholic Beverage Markets

D.1. Beer and Whisky Market Overview

Data. The main data for beer and whisky come from the Korean Alcohol and Liquor Industry Association (KALIA). The data contain every manufacturer's monthly domestic shipment

volume at the national level for each alcoholic beverage product category. The volume data are provided at the product level along with some product attributes such as brand and ABV (alcohol-by-volume). We complemented the data by conducting online research of brand launch by each firm. The sources of complementary research included news articles, company websites and product blogs. While the time period covered differs by product category, the data of both product categories contain the period 1997 to 2005 (Beer and whisky market data are available from 1997 and 1996 respectively.).

Table A.2 summarizes the market size for three years before and after the tax reform. It also presents the volume of imported products, which we obtained separately from KALIA. The data of imported products are available at the yearly- and category- level. Over the period from 2000 to 2002, the supply of imported products accounted for less than 2% of the total alcoholic beverage market. The main data of manufacturers' volume contain only the data of domestic production and, given the significance of domestic volume, we restrict the following analysis to the markets for domestic products. While the absolute volume of imported products was not substantial, it is noteworthy that the period saw a significant increase in this volume. The potential impact of this rapid expansion of imported products on the market competition might have differed across product categories. The expansion of the imported whisky products could have had a bigger impact on the competition within the category.

Beer market. The beer market had been characterized as a duopoly between OB beer (Firm 1) and Hite (Firm 2) since OB beer acquired the third small manufacturer, Cass in December 1999. They operate and compete nationally and we treat OB beer and Cass as one firm (Firm 1) merging their data for the entire period.

Whisky market. The market has grown in accordance with the national economic growth. In 2002, the market also saw an entry by a new firm. Before this new firm entered the market, the whisky market comprised 4 firms, of which the two biggest were joint ventures between Korean and international companies (Firm 1 with Allied Domecq and Firm 2 with Seagram). Firm 1 and 2 were later acquired by Pernod Ricard and Diageo in 2005 and 2002 respectively.

Table A.2. The Korean Alcoholic Beverage Market Summary

	Shipment Volume				
	Pre-Reform	%	*Post-Reform*	%	*Growth (%)*
Product Category	1997 - 1999		2000 - 2002		*Pre vs. Post*
Domestic Volume	7,388,125	99.2%	8,107,226	98.1%	9.7%
Soju	2,761,037	37.1%	2,866,465	34.7%	3.8%
Beer	4,374,662	58.8%	4,992,073	60.4%	14.1%
Whisky	29,257	0.4%	45,736	0.6%	56.3%
Others	223,169	3.0%	202,951	2.5%	−9.1 %
Imported Volume	57,112	0.8%	158,447	1.9%	177.4%
Soju	-		-		-
Beer	9,777	0.1%	35,029	0.4%	258.3%
Whisky	25,082	0.3%	54,066	0.7%	115.6%
Others	22,253	0.3%	69,352	0.8%	211.7%
Total Volume	7,445,237	100.0%	8,265,673	100.0%	11.0%

*Note: The unit of volume is a thousand liter.

D.2. Summary of Analysis Results

Although the tax rates levied on each product market were different for most of the period, all three markets experienced two levels - higher and lower - throughout the period. By pooling the data from three product categories under the higher or lower tax rate, we test whether the

market outcomes under these two levels of tax rate differed significantly. The two categories other than soju saw a tax "decrease" after the tax reform. The analysis assumes that the three products are independent on the demand side. This assumption takes into consideration that these products exhibit distinct characteristics with respect to product attributes (e.g., production process and alcohol by volume), customer base (e.g., distribution of age and gender), and consumption patterns (e.g., much stronger seasonality in beer consumption). According to a report by Gallup Korea (2000), soju was preferred to beer by 71.2% (37.5%) of male (female) consumers. With respect to age, while consumers in their 20s were indifferent between beer and soju, 74.5% of more mature consumers over age 50 preferred soju. These large differences in their major customer demographics had been attributed to the differences in alcohol content and prices. During the time of our observation, ABV for soju and beer ranged 21-25% and 4-5% respectively. It is also noteworthy that most whisky products had alcohol by volume over 40%. The three products also differ largely in price (the price of soju is much lower than that of beer or whisky).

Figure A.5 presents the yearly pattern of the number of brands in the beer and whisky markets over a time window from 1997 to 2002. The beer market shows an increase in the

Figure A.5. The Number of Beer and Whisky Brands: Cases of a Tax Decrease

number of brands from 11.5 during 1997-98 to 13.6 during 2001-02. The right panel highlights an increase in the number of active whisky brands after the tax decrease (from 8.2 to 10.1). The differences in both markets are significant at the 1% level in t-tests.

For the regression analysis, we create a dummy variable corresponding to higher tax periods in each product category; for the beer and whisky markets, the higher tax period corresponds to the years before 2000. We run a series of regressions to identify the tax effect on the firms' product variety decisions (the number of brands by firm). As a simple test, we treat the year 2000 as the policy transition period and exclude them from each regression. The unit of analysis is at a firm level and the model includes firm-specific fixed effects in addition to year-specific fixed effects. We also run regressions over a narrower time window from 1997 to 2003.

Table A.3 summarizes the results. Per-firm variety exhibits significantly distinct levels before and after the tax reform, and directions are consistent across product categories: The firms produce fewer brands under a high tax rate.

Table A.3. The Level of Tax and Product Variety

	Dependent Variable: Number of Brands per Firm			
	1997 - 2003 (N=90)		1996 - 2005 (N=142)	
Covariates	*Parameter*	*SD*	*Parameter*	*SD*
Intercept	2.618***	(0.379)	6.183***	(0.312)
Higher Tax Rate	−1.035***	(0.223)	−1.202***	(0.182)
Controls:				
Firm-Specific Effects	✓		✓	
Year-Specific Effects	✓		✓	
R^2	0.759		0.781	

*** Significant at 1% level

WEB APPENDIX E: ECONOMIC IMPLICATIONS

We present a simulation study of a firm's optimal pricing and assortment decisions to derive the economic implications of taxation when firms are allowed to change their product assortments. We consider a case of a specific tax, as in the cigarette market in the United States, under three supply side scenarios: (a) Baseline: we estimate the optimal prices and assortments without a tax, (b) Tax without Assortment Changes: we fix the assortments from the baseline scenario and estimate the optimal prices with a tax (pass-through of taxation), (c) Tax with Assortment Changes: we assume that the firm can change the assortment and prices after a tax is implemented.

Our analysis focuses on the following three economic measures: First, we look at the difference in the number of products sold between scenarios (c) and (a), and this is comparable to our main empirical results. Second, we look at the change in demand (or tax revenue generated as the tax revenue is the tax rate multiplied by the demand quantity in case of a specific tax) between scenarios (c) and (b). This second measure considers the important public policy implications of taxation as it will show the potential bias in prior studies that focus only on the tax effect due to price changes. Third, we consider economic welfare loss of taxation.

Demand assumptions. We consider a demand from a discrete choice (mixed logit) model with 10 products, and we assume a utility structure of consumer *i* from option $j \in [1,10]$ as the following: $u_{ij} = \alpha_{ij} - P_j + \epsilon_{ij}$; with utility from an outside option as $u_{i0} = \epsilon_{i0}$. We assume that ϵ_{ij} follow i.i.d. Type I extreme value distribution. For heterogeneity across consumers, we assume $\alpha_{ij} \sim N(\alpha_j, \sigma)$. In each simulation we consider a draw of α_j and σ from uniform [0,1] distributions. Finally, we assume full information, where all consumers know their valuations and the firm knows α_j and σ.

Supply assumptions. We assume a constant marginal cost for each product (c_j), also drawn from a uniform [0,1] distribution. Then as a fixed cost, we assume \$0.05 for each product added to the assortment. Given these assumptions, the firm determines the final assortments and prices by considering the profit maximizing prices for all 1,024 possible assortments and then finding the profit maximizing assortment.

When adding a tax to the problem, we consider the impact of a large (\$1) or a small (\$0.1) specific tax applied to all products that are sold. We run 500 Monte Carlo simulations, in each of which we consider a different draw of α_j, σ and c_j. For each we compare the optimal prices and assortments under the 3 scenarios described above.

Economic welfare. We follow Small and Rosen (1981) to calculate the change in economic welfare between any two scenarios, A (with the final assortment J^A and prices P_j^A) and B (with J^B and prices P_j^B): $\Sigma_i \ln\{\Sigma_{J^A} \exp(\alpha_{ij^A} - P_{j^A})\} - \Sigma_i \ln\{\Sigma_{J^B} \exp(\alpha_{ij^B} - P_{j^B})\}$. We first estimate the welfare loss of taxation by comparing the welfare between scenarios with and without a tax. Then we report how these estimates differ when the firm's product assortment changes are not considered. We note that the current measure of welfare does not account for other potential sources of social welfare gain (loss) due to consumption of healthier (less healthy) options or amount.

Simulation Results. The results are presented in Figure A.6. The top chart shows the distribution of the number of products sold with a \$0.10 (left) or \$1.00 (right) specific tax, or without a tax. We find that with a large tax there are likely to be fewer products in the market. With a large tax, the mean number of products offered reduces from 4.56 without a tax to 3.63 with a tax. This difference is much smaller (0.02) with a small tax. 32% of simulations with a

large tax and 93% of simulations with a small tax had no change in products offered. This suggests that the assortment changes are most relevant with large changes in the tax rates.

The bottom chart shows the implication (or bias) of not considering the assortment changes when evaluating the tax effects on the economic welfare and tax revenue (or demand). Specifically, we first compute the tax effect on economic welfare (by comparing economic welfare between (a) and (b), and (a) and (c)) and estimate the difference of these effects: {(welfare loss with assortment changes/ welfare loss without assortment changes)-1} The distribution of the estimated difference is presented in the chart. By definition, there is no difference when there is no change in the resulting product assortment with a tax. However, when the firm changes its product assortment following the implementation of tax, we find a large difference (between 10% - 20%) in the economic consequences of taxation. Overall (including the zeros), the average bias in the estimated tax revenue without accounting for the firm's assortment decisions is -8.6%, and the average bias in the estimated economic welfare of a tax is -9.0% (the biases are much smaller with the lower tax rate).

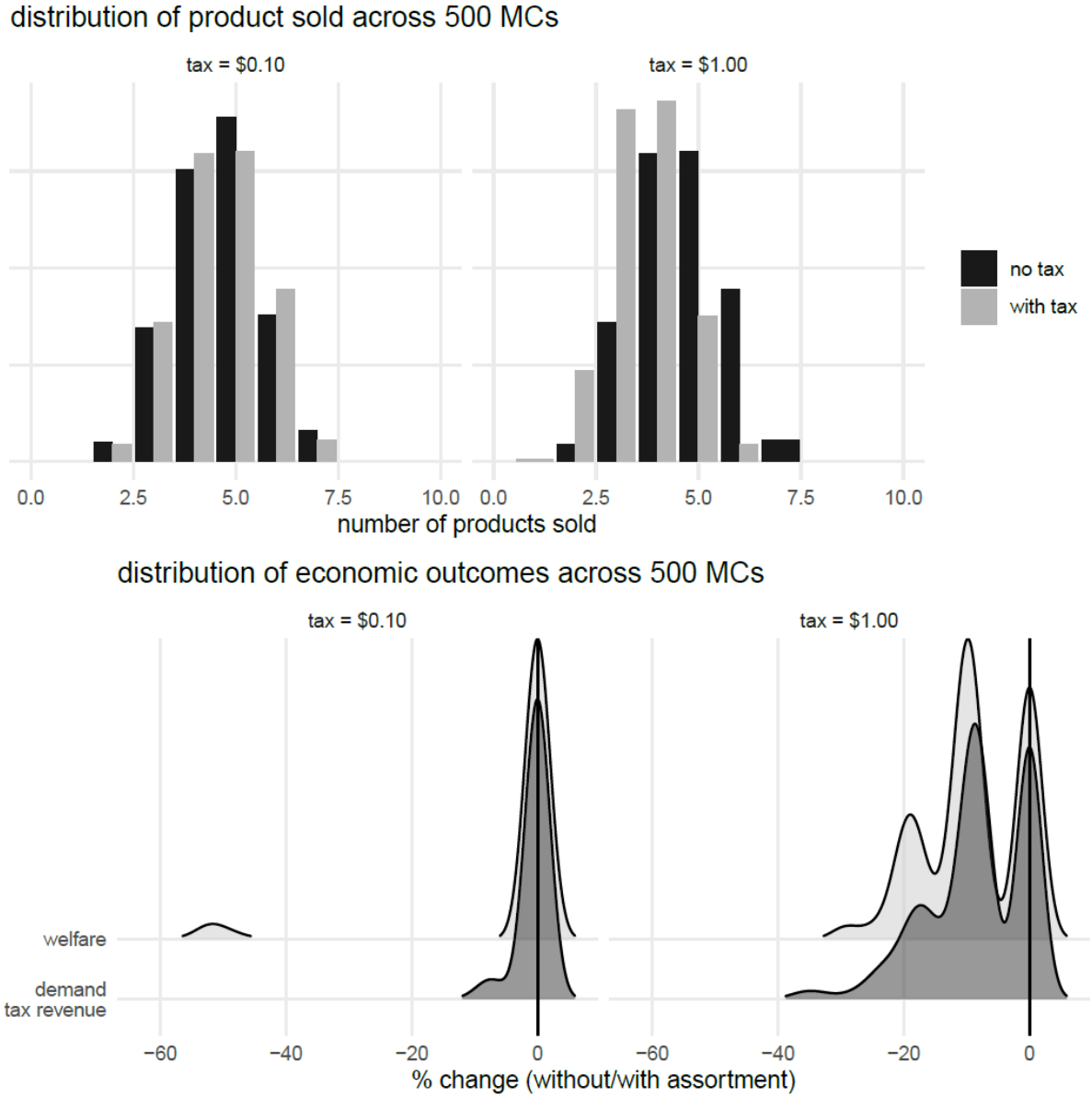



Figure A.6. Impact of Taxation: Simulation Results