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DEMAND SYSTEM ANALYSIS OF BEER IN THE U.S. MARKET

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DEMAND SYSTEM ANALYSIS OF BEER IN THE U.S. MARKET

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
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at the University of Kentucky

By

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ABSTRACT OF THESIS

DEMAND SYSTEM ANALYSIS OF BEER IN THE U.S. MARKET

The onset of the COVID-19 pandemic has stimulated remarkable changes in consumer purchasing and consumption behavior of food and beverages. This inherently raises the question of what the demand for beer differentiated by brands in the U.S. during the pandemic is? To answer this question, we used the recent Nielsen scanner data and employed the Linear Approximated Almost Ideal Demand System (LA/AIDS) model to jointly estimate the demand for the five major brands: Budweiser, Coors, Corona, Heineken, and Miller, as well as remaining brands combined. Our results suggest the sales of Corona and Heineken increased during the pandemic. After controlling price and expenditure endogeneity in the demand system, we find that consumers significantly become price sensitive for Heineken. As a result, there is a substitution between branded beers, but the strongest substitution is between Heineken and Corona. Our results also show a complementary relation between Heineken and Budweiser and Heineken and All-Other.

KEYWORDS: Beer, COVID-19, demand, endogeneity, elasticity

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03/07/2022

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DEDICATION

Dedicated to my son, Sejun Kafle

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CHAPTER 1. INTRODUCTION

1.1 Background

The onset of the COVID-19 pandemic has remarkably changed the behavior of consumers in two ways. First, the food buying behavior of consumers has changed from frequent buying to buying in bulk. In response to stay home orders, social distancing, and quarantine, consumers decreased the number of visits to the grocery store but increased the amount of food purchases per visit (Cranfield, 2020). The second change is the food consumption behavior as food away from home switched to food at home. Closures of workplaces, educational institutions, and flexible working from home kept people home more than before. A few studies recently carried out on demand for different foods during the pandemic. A study conducted by Aday and Aday (2020), using demand data in European countries due to COVID-19, shows that demand for fresh bread increased by 76 percent and frozen vegetables by 52 percent in the week when the pandemic was announced, and the demand for alcoholic beverages increased about twice one month after the pandemic announcement. The U.S. also experienced an increase in demand for beverages by 18 percent in March 2020, one month after the pandemic, followed by a 7.5 percent increase in April (U.S. Census Bureau, 2020).

Understanding beverage buying during the pandemic can help beverage retailers and beverage manufacturers who must quickly adapt to the constantly changing environment. The U.S. beer market provides an interesting case to study against this backdrop. The beer industry is one of the nation’s largest and most impactful industries (Beer Institute, 2017). In 2020, the U.S. beer industry sold 204.8 million barrels of beer, out of which 82 percent of all beer was domestically produced and 18 percent was imported from different countries (NBWA, 2020). According to the Beer Institute (2017), the beer industry alone is 1.9 percent of the total U.S. gross domestic product (GDP), contributing $350 billion annually. The same data shows the beer industry in the U.S. generated nearly 2.23 million American jobs, and the industry pays more than $63 billion in tax for the production and sale of beer and other malt beverages. This equals more than 41 percent of the retail price paid for these products by consumers. Given this background, two important research questions arise. First, what is the demand for beer during such an uncertain and unavoidable situation as the pandemic? Second, what are the demand relations for beer differentiated by brand[1] type? We aim to answer these questions by examining the own- and cross-price elasticities of beer categorized by brand in the Linear Approximated Almost Ideal Demand System (LA/AIDS) framework. We used a recent Nielsen scan track weekly data to obtain dollar sales, unit sales, and unit price of the major two imported brands: Corona and Heineken, and the major three domestic brands: Budweiser, Coors, and Miller, as well as the remaining brands combined, which we will name hereafter as All-Other. These five major brands represent half of the top ten selling beers in the U.S. for 2019 (Vinepair, 2019). Then, we jointly estimated the demand for six beer categories and addressed the price and expenditure endogeneity in the demand system. To the best of our knowledge, the time discrepancy for demand system analysis within the U.S. beer sector is more than 20 years, and we fulfill this significant gap by estimating the demand system of major beer brands using the recent scanner data from 2017 to 2020.

[1] The dictionary meaning of a brand is the impression of a product held by real or potential consumers.

1.2 Research Objectives

The broad objective of this research is to study the demand for beer in the U.S. market. This is addressed in terms of two specific objectives. The first specific objective is to study the demand for six different beer brands in the U.S. during the pandemic. Under this objective, we analyze the effect of the COVID-19 pandemic on the purchase of six beer categories. To achieve this objective, we include the COVID-19 variable as a demand shifter in the Linear Approximated Almost Ideal Demand System model and examine whether the COVID-19 variable is positively or negatively associated with a specific beer brand. The second specific objective is to understand the demand relations of different beer brands. In particular, we estimate the substitution or complementary relations between different beer brands. Additionally, cross-price elasticities also allow us to identify the strongest substitution and complimentary beer brands.

This research indicates that the retail-level sales of Corona and Heineken surged after the COVID-19 outbreak in the U.S. We also find the compensated own-price elasticities in the range of -0.195 to -1.464. Compensated cross-price elasticities suggest a substitution between branded beers, but the strongest substitution is between Heineken and Corona. Our results also show a complementary relation between Heineken and Budweiser and Heineken and All-Other. The results from this study can potentially benefit the beer industry in the form of production and pricing during a less predictable situation of the pandemic. Our empirical findings can also benefit policymakers in predicting the demand-side response of a tax change on imported and domestic beer brands.

1.3 Structure of the Thesis

The remainder of this thesis is organized as follows. The second chapter presents the literature review. Section 2.1 provides the background of beer, beer import, beer production, and major beer brands in the U.S. Section 2.2 presents the demand for food and alcoholic beverage during the pandemic. Section 2.3 captures the findings of previous literature on the price elasticities of different alcoholic products.

Chapter three describes the Linear Approximated Almost Ideal Demand System model. We also present the formulas for various elasticities estimation procedures and discuss the demand system analysis's price and expenditure endogeneity problems. To address the price endogeneity issue in the model, we created two types of instrumental variables (i) neighboring states' average price (ii) lagged prices.

Chapter four consists of sources of data and a description of major variables used in the model.

We then move to chapter five and discuss the LA/AIDS model results. First, we estimate parameters from the AIDS model and then we emphasize elasticities estimates in greater detail. Finally, we further discuss the endogeneity test and quantify bias.

We end the thesis in chapter six by drawing conclusions and submitting policy recommendations and pointing limitations of this research.

CHAPTER 2. BACKGROUND AND LITERATURE REVIEW

This chapter consists of three subsections. In the first subsection, we provide the background of beer, imports of beer in the U.S., major beer brands in the U.S. market, and domestic beer production in the U.S. market. The second subsection consists of the demand for food and beverage during the pandemic, and the third subsection describes findings of previous literature on the elasticities of beer.

2.1 Background of Beer

Beer is a fermented alcoholic product that combines water, malt, hops, and yeast. Beer is the most popular alcoholic beverage in the world. It is widely consumed all over the world and is associated with many activities and traditions. American beer dates back to the early to the mid-seventeenth century. As reported by the Alcohol and Tobacco Tax and Trade Bureau (TTB, 2020), there are 6,406 brewery facilities operating in the U.S. They sold 204.8 million barrels of beer in 2019. Beer Industry is one of the most impactful industries in the U.S. and pays $63 billion in tax (Beer Institute, 2017). Tax on beer depends on alcohol content, place of production, size of the container, and place of purchase, so the U.S. has different tax rates in different states. Based on tax information provided by Statista (2022), the tax rate in different states of the U.S. is presented in figure 2.1 below. Tennessee has the highest excise tax rates in the U.S., with 1.29 dollars per gallon of beer, whereas Wyoming taxed the beer the least at 2 cents per gallon.

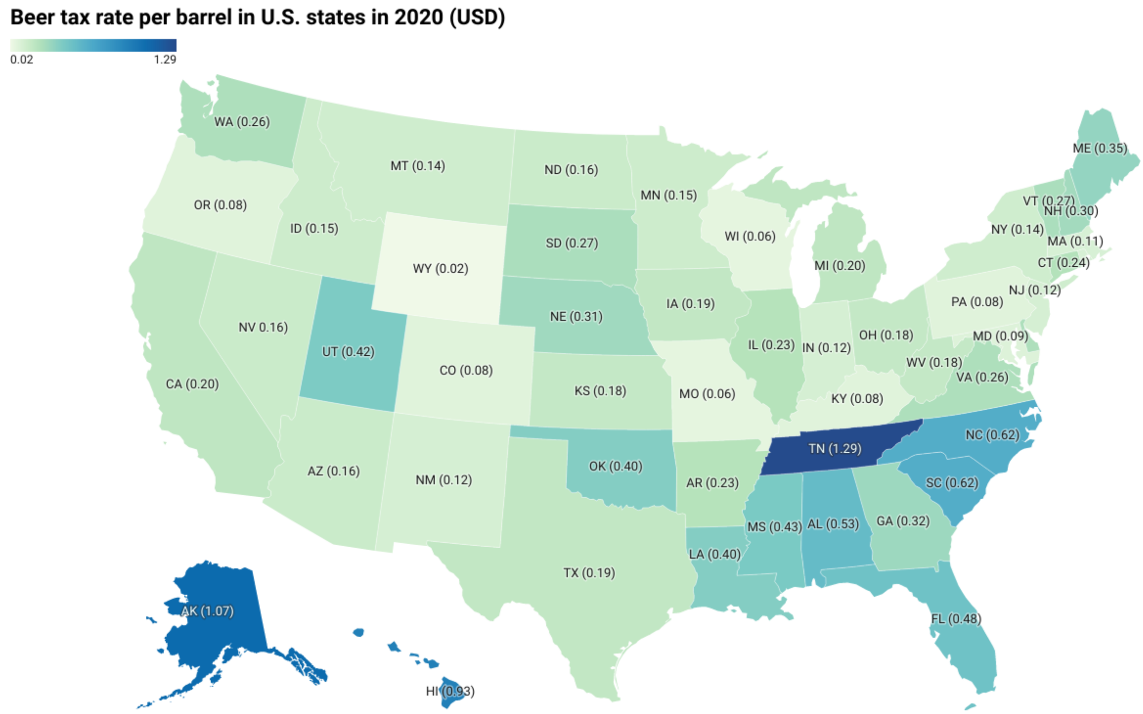


Figure 2.1 Beer tax rate per barrel in U.S. states in 2020 (USD)
Source Statista, 2022

2.1.1 Beer Import in the U.S.

The U.S. imports beer from different countries, the major ones being Mexico, Netherlands, Belgium, Ireland, and Canada. Among these countries, Mexico dominated the U.S. beer market. The value of beer imported from Mexico has increased from 2010 to 2020, as shown in Figure 2.2. The leading Mexican beer brands sold in the U.S. are Corona, Modelo Especial, and Dos Equis (Statista, 2021). The value of beer imports from the Netherlands ranks second, which slightly decreased from 946 million dollars in 2010 to 807 million dollars in 2020. Beer imports from Belgium, Ireland, and Canada rank in the third, fourth, and fifth positions.

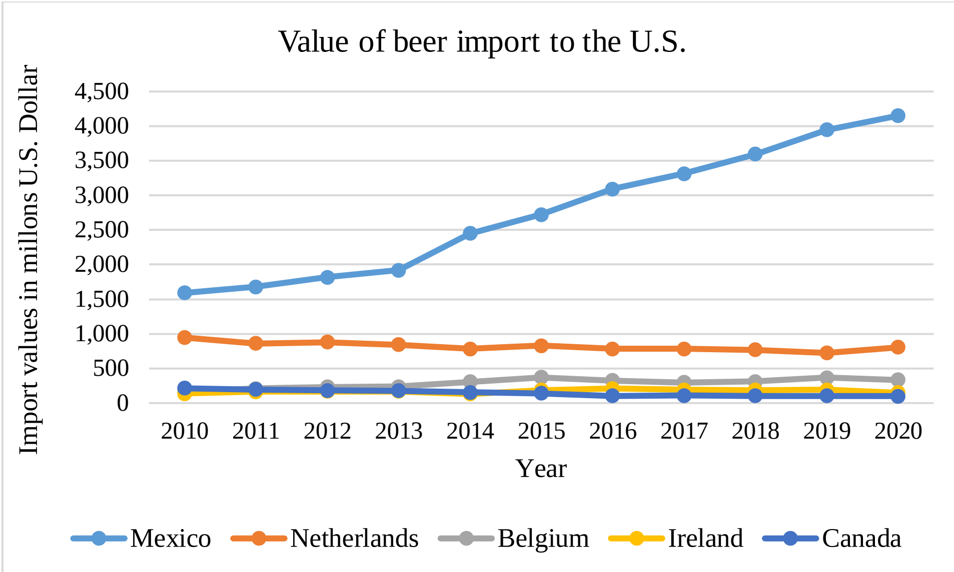


Figure 2.2 Value of beer imports to the U.S. from five major countries
Source: USDA, Foreign Agricultural Service 2021

2.1.2 Major Beer Brands in the U.S. Market

Information on the major beer brands in the U.S. is presented in Table 2.1 below. Bud Light ranked in the leading position, reaching sales of 24.9 million barrels in 2018 and a market share of 14.3 percent. Anheuser-Busch InBev is the leading parent company. Out of twenty listed major brands in the table below, nine brands are from Anheuser-Busch InBev. Other parent companies are Molson Coors Brewing Company, Grupo Modelo/Constellation Brands, Heineken International, D.G. Yuengling and Son Inc, Pabst Brewing Company, and Grupo Modelo/Heineken International. The Blue Moon has the largest alcohol content having 5.9 percentage alcohol by volume (ABV). Bush Light and Keystone Light have relatively low alcohol content of 4.1 ABV. Among the top twenty beer brands, fifteen brands originate in the U.S., five from Mexico, Netherlands or Belgium.

Table 2.1 Summary of top twenty selling brands in the U.S. in 2018

S.N.	Brands	Percentage ABV	Parent company	Origin	Sales in millions of barrels	Market share (Percentage)
1	Bud Light	4.2	Anheuser-Busch InBev	USA	24.9	14.3
2	Coors Light	4.15	Molson Coors Brewing Company	USA	14.9	7.2
3	Miller Lite	4.2	Molson Coors Brewing Company	USA	12.6	6.1
4	Budweiser	5.0	Anheuser-Bush InBev	USA	11.3	5.5
5	Michelob Ultra	4.2	Anheuser-Busch InBev	USA	8.8	4.3
6	Corona Extra	4.6	Grupo Modelo/Constellation Brands	Mexico	8.6	4.2
7	Modelo Especial	4.6	Grupo Modelo/Constellation Brands	Mexico	8.1	4
8	Natural Light	4.2	Anheuser-Busch InBev	USA	6.7	3.3
9	Busch Light	4.1	Anheuser-Busch InBev	USA	6.2	3.3
10	Busch	4.3	Anheuser-Busch InBev	USA	4.2	2
11	Heineken	5.0	Heineken International	Netherlands	3.8	1.8
12	Keystone Light	4.1	Molson Coors Brewing Company	USA	3.5	1.7
13	Miller high life	4.6	Molson Coors Brewing Company	USA	3.4	1.7
14	Stella Artois	5.2	Anheuser-Busch InBev	Belgium	2.7	1.3
15	Bud Ice	5.5	Anheuser-Busch InBev	USA	2.5	1.2
16	Natural Ice	5.9	Anheuser-Busch InBev	USA	2.3	1.1
17	Yuengling Lager	4.4	D.G. Yuengling &Son, Inc	USA	2.3	1.1
18	Pabst Blue Ribbon	4.8	Pabst Brewing Company	USA	2.2	1.1
19	Blue Moon	5.40	Molson Coors Brewing Company	USA	2.1	1.0
20	Dos Equis	4.2	Grupo Modelo/Heineken International	Mexico	1.9	0.9

2.1.3 Domestic Beer Production in the U.S.

The United States is the second biggest producer of beer after China (Statista, 2021). Figure 2.3 shows the domestic beer production (sales) in barrels. We obtained this information from the TTB statistical report (TTB, 2021). This trend shows that domestic beer production has been gradually declining after peaking in 2012 due to increased competition from imported beer. Total domestic beer production in 2010 was 181 million barrels, whereas in 2020, the production slightly decreased to 180 million barrels.

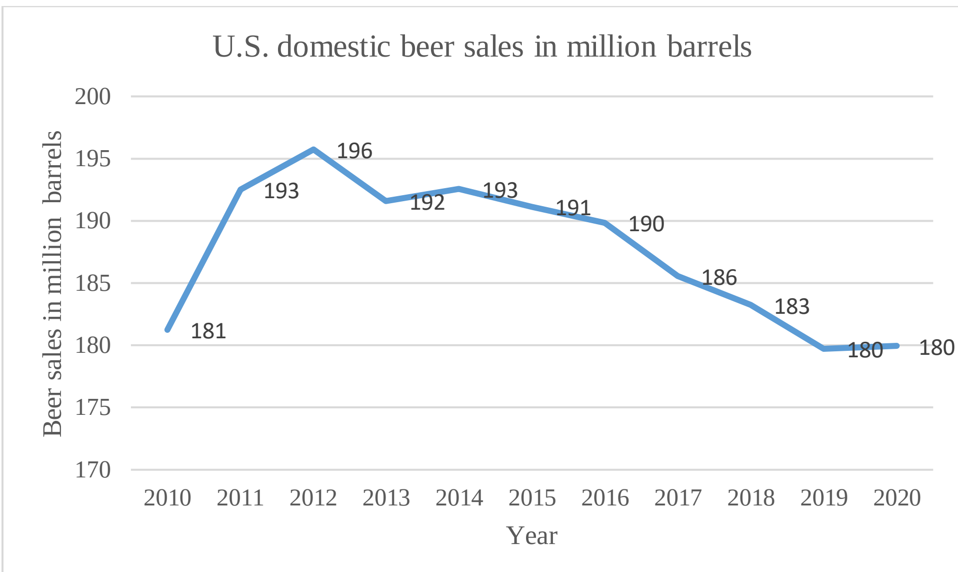


Figure 2.3 U. S. domestic beer sales in barrels
Source TTB, 2021

2.2 Demand for Food and Beverages during the COVID-19 Pandemic

One of our specific objectives is to study the demand for different beer brands during the pandemic. It is worth discussing the findings of previous literature on the purchase of food and beverages during the pandemic. Recently, few studies have attempted to look at food and beverage purchases during the COVID-19 pandemic in the U.S. and other countries.

Chenarides et al. (2020) conducted an online survey in two major cities in the U.S.; Detroit and Phoenix. They found that consumers tended to purchase more groceries than normal during their grocery visits. Similarly, Pollard, Tucker and Green (2020) used a subset (n=1540) of a nationally representative, a probability-sampled panel of 6000 U.S. adults ages 18 years and older to compare alcohol consumption in 2020 (May 28 to June 16) to 2019 (April 29 to June 9). They concluded that the frequency of alcohol consumption increased during the pandemic. Additionally, Grossman, Benjamin-Neelon, and Sonnenschein (2020) conducted a cross-sectional online survey with a convenience sample of U.S. adults over 21 years in May 2020. A total of 832 respondents were taken, and participants reported the perceived increase in their current alcohol intake compared to pre-COVID-19. Furthermore, data on U.S. food and beverages sales obtained from the U.S. Census Bureau show that the purchase of food and beverages in the U.S. increased after the COVID-19 outbreak compared to six months prior to the pandemic outbreak. The Center for Disease Control and Prevention (CDC) reported the first case of COVID-19 in the U.S. in late January 2020. Comparing sales of food and beverages six months before COVID-19 and six months during COVID-19 in figure 2.4 below show the increased purchase of food and beverages after January 2020.

Figure 2.4 U.S. food and beverages store sales
Source: U.S. Census Bereau, 2022

2.3 Previous Literature on Elasticities of Alcoholic Products

The existing economics and public health literature show several studies on demand relations of alcoholic beverages. Most of these studies combine all alcohol consumption into a single category-beer or, at best, disaggregate beer, wine, and spirit into distinct categories. However, there is no study on demand analysis of imported and domestic beer brands in the U.S. The effect of price changes in demand for alcoholic products is usually presented in price elasticities. Table 2.2 summarizes the literature on the own-price elasticities of alcohol products. Baltagi and Griffin (1995) assessed the demand for liquor in the U.S. using panel data from 43 states. They used the data from 1959 to 1982 and applied the three regression models: traditional OLS, Within, and GLS. They reported that short-run own-price elasticity is -0.20 and long-run own-price elasticity is -0.69. Similarly, Edward, Moran, and Nelson (2001) examined the demand for beer, wine, and distilled spirits using quarterly data from 1970 to 1990 and estimated the own-price elasticity of beer as -0.27 and the income elasticity of beer as -0.67. Nelson (2003) also carried out a study on the substitution effect of several restrictive alcohol regulations, including advertising bans on billboards, bans on price advertising, state monopoly control of retail stores, and changes in the minimum legal drinking age using a panel of 45 U.S. states for the period from 1982 to 1997. He used a generalized least-squares model and reported that beer's own-price elasticity ranges from -0.16 to -0.18; however, the demand for beer is unaffected by income. Similarly, Trolldal and Ponicki (2005) examined the demand for spirits, wine, and beer using panel data from 1982 to 1999 from 50 states. They found own-price elasticity for beer was -0.24. A few years later, Goel and Saunoris (2018) studied seasonal U.S. beer demand using quarterly data from 2009 to 2015 for all 50 U.S. states. They used a simple linear demand model and found that the own-price elasticity for beer was -0.120 and income elasticity was 0.186. They also concluded that there is a substitution between beer and wine. Toro-González, McCluskey, and Mittelhammer (2014), using Dominick's scanner dataset from 1991 to 1997, analyzed the demand for beer as a differentiated product by type: craft beer, mass-produced beer, and imported beer. They found own-price elasticity -0.177 and income elasticity 0.580. In addition, Rojas and Peterson (2008) did a brand-level study using supermarket scanner data from 1988 to 1992. They used the metric method and the results found that own-price elasticities range from -3.726 to -3.201 and cross-price elasticity 0.053. The high own-price elasticities at the brand level make sense because there is high substitution between brands and consumers can switch from one beer brand to another.

Table 2.2 Previous literature on the own-price elasticity of alcohol products in the U.S.

Alcohol products	Authors	Data period	Own-price elasticity
Spirits	Baltagi and Griffin (1995)	1959 to 1982	-0.20
Beer, wine, and spirits	Edward, Moran, and Nelson (2001)	1970 to 1990	-0.27
Beer	Nelson (2003)	1982 to 1997	-0.16 to -0.18
Beer, wine, and spirits	Trolldal and Ponicki (2005)	1982 to 1999	-0.243
Beer	Goel and Saunoris (2018)	2009 to 2015	-0.120
Mass, craft and imported beer	Toro-Gonazalez, McCluskey, and Mittelhammer (2014)	1991 to 1997	-0.177
Beer at brand level	Rojas and Peterson (2008)	1988 to 1992	-3.726 to -3.201

A review of previous literature shows that this study makes three important contributions to the literature. First, unlike other studies, we are explicitly modeling the demand for imported and domestic beer brands. This allows us to determine if consumers substitute or complement brands when there are price changes. Second, we address price and expenditure endogeneity using the instrumental variables approach. Third, except for Goel and Saunoris (2018), most previous studies used data for years prior to 2000. However, Goel and Saunoris did not use the demand system. Finally, different from previous studies, our study examines the demand for beer using recent data covering the COVID-19 period, which enables us to capture an idea on the demand for beer during the pandemic.

CHAPTER 3. METHODOLOGY

This section discusses the Linear Approximated Almost Ideal Demand System (LA/AIDS) specification that supports our study. We also provide estimation procedures of expenditure elasticity and compensated and uncompensated own- and cross-price elasticities. Finally, we briefly present the price and expenditure endogeneity.

3.1 The Linear Approximated Almost Ideal Demand System (LA/AIDS)

We used the Linear Approximated Almost Ideal Demand System (LA/AIDS) model developed by Deaton and Muellbauer (1980). The LA/AIDS model has a flexible, functional form that provides an arbitrary first-order approximation of any demand system. Additionally, it satisfies the axioms of choices and aggregation across consumers and allows for testing or imposing theoretical restrictions. Therefore, it has been widely used in empirical demand system analysis both for alcoholic and non-alcoholic beverages [see Duffy (1995), Nelson and Moran (1995) for alcoholic and Zheng and Kaiser (2008), Kim and Zheng (2017) for non-alcoholic]. We adopted the AIDS model and notations from Zheng and Kaiser (2008) as follows:

$$w_{it} = a_i + b_i \ln\left(\frac{Y_t}{P_t}\right) + \sum_{j=1}^{6} c_{ij} lnp_{jt} + d_i lnBlack_t + e_i lnHisp_t + f_i lnAsian_t + g_i lnCOVID\_19_t + \alpha_s + \alpha_m + \alpha_y + \varepsilon_{it} \quad (1)$$

Where w_{it} is the conditional budget share of product *i* in period *t*,

$w_{it} = p_{it} q_{it} / Y_t$, and

P_t denotes Stone's geometric price index $lnp_t = \sum_{i=1}^{6} w_{it} \ln p_{it}$.

a_i through g_i are the parameters to be estimated and ε_{it} is the error term for item *i* in year *t*.

i indexes the six beer brands in order Budweiser, Coors, Corona, Heineken, Miller, and All-Other. Modeling six brands of beer in a demand system allows us to identify and evaluate all possible pairwise substitution and complementary relationships between the six brands. The system we estimated is conditional on U.S. expenditure on different beer brands as a group with the implicit assumption that beer brands are a weakly separable group.

Alcoholic beverage literature has shown that many other factors, such as socioeconomic characteristics, could affect demand for alcohol products (Ornstein and Hanssens, 1985). Therefore, we consider the importance of demographic groups in the demand system and include different racial groups such as the percentage of the Black, Hispanic, and Asian population. We also included COVID-19 as a dummy variable to account for the association between the COVID-19 pandemic and beer sales. FIPS, month, and year fixed effects reflecting state, month, and year-specific unobserved demand determinants, respectively are incorporated in the demand system. Thus, we have six separate models for each of the six brands of beer to be applied to empirical data to estimate parameters.

The consumer theory implies a set of restrictions on the demand system including adding up, homogeneity, and symmetry.

$$\sum_{i=1}^{6} b_i = \sum_{j=1}^{6} c_{ij} = \sum_{i=1}^{6} d_i = \sum_{i=1}^{6} e_i = \sum_{i=1}^{6} f_i = \sum_{i=1}^{6} g_i = 0 \qquad (2)$$

$and\ \sum_{i=1}^{6} a_i = 1$ (Adding up)

$\sum_{j=1}^{6} c_{ij} = 0$ (Homogeneity for all i)

$c_{ij} = c_{ji}$ (Symmetry for all i and j)

Estimates from the AIDS model are used to calculate elasticities. Several elasticities definitions and formulas have appeared in the literature for the AIDS (Alston, Foster and Gree, 1994) and we adopted these formulas from Zheng and Kaiser (2008) to estimate own-price, cross-price, and expenditure elasticities as follows;

Expenditure elasticity measures the percent change in quantity demanded beer when total U.S. peoples' expenditure on alcohol increase by 1 percent, holding all other demand factors constant. Expenditure elasticity (E_i) is calculated as

$$E_i = 1 + b_i/w_i \qquad (3)$$

If b_i is significantly different from zero and positive, expenditure elasticity is elastic. If b_i is negative, expenditure elasticity is inelastic. If b_i is 0, expenditure elasticity is unitary.

Compensated own-price elasticity of demand is defined as the percentage change in the quantity demanded of a beer brand, *i* that results from a 1 percent change in the price of that brand, keeping everything else constant. Slutsky price elasticity is compensated own-price elasticity and is calculated as

$$E_{ii}^{c} = -1 + c_{ii}/w_i + w_i \qquad (4a)$$

Compensated cross-price elasticity of demand between *i* and *j* is defined as the percent change in the demand for brand *j* when the price of brand *i* changes by 1 percent, keeping everything else constant. Cross-price elasticity is calculated as

$$E_{ij}^{c} = c_{ij}/w_i + w_j \qquad (4b)$$

Lastly, **Cournot price elasticity** is uncompensated and is calculated as

$$E_{ii}^{u} = -1 + c_{ii}/w_i - b_i \qquad (5)$$

3.2 Price and Expenditure Endogeneity

Price and expenditure endogeneity are the most common econometric issues in the demand system analysis of differentiated products (Dhar, Chavas, and Gould, 2003). Price endogeneity occurs when price affects the quantity of beer sales, and the quantity of beer sales can also affect the price, resulting in simultaneous equation bias. Similarly, expenditure endogeneity occurs in the simultaneity of deciding the quantity demanded each beer brand and the total expenditure on beer. Endogeneity leads to biased and inconsistent demand parameter estimates, which will cause invalid policy recommendations (Dhar, Chavas, and Gould, 2003; Hovhannisyan and Bozic, 2017). Thus, we must account for the endogeneity problem to get unbiased and consistent demand estimates.

One of the approaches to account for the endogeneity problem is using instrumental variables. We created two different categories of instruments to account for price endogeneity. First, neighboring states' average price to instrument for the price of each beer brand in a given market. This type of instrument was also used by standard literature on demand system analysis of the ready-to-eat cereal in the U.S. by Hausman (1996). Our rationale for using these instrumental variables is based on the argument that neighboring states' price is correlated with the current state's prices. Still, it is not correlated with the quantity demand of beer brands. Using the U.S. map, we identified neighboring states for each state and estimated the average neighboring states' price from our Nielsen scanner data. A list of the neighboring states is provided in Appendix I. Second category of instruments are lagged values of potentially endogenous price which was also used by Goel and Saunoris (2018) to study the demand for beer in the U.S. Villas-Boas and Winer (1999) also applied lagged prices as instruments in estimating demand for different brands of yogurt and ketchup. We use three distinct sets of lagged prices to instrument beer brands' prices. Specifically, the first set of instruments includes lagged monthly prices. The second set of instruments comprises lagged quarterly prices, and the third set of instruments entails lagged yearly prices. We expect that each of these instruments affects the current beer price (relevance) and the quantity demand of beer only through beer price (exclusion restriction). Following the standard literature of Hausman (1996), our ideal choice of instruments for this study will be neighboring states' average prices, although we discuss both categories of instruments. Moving to instrumental variable to account for expenditure endogeneity, we use log income per capita as an instrument for expenditure endogeneity, which was also used by Zheng and Kaiser (2008) on estimating nonalcoholic beverage demand in the U.S.

CHAPTER 4. DATA DESCRIPTION

This study uses data from multiple sources. We use the Nielsen scan track scanner data to obtain retail-level data on dollar sales, unit sales, and unit price for six brands of beer, namely Budweiser, Coors, Corona, Heineken, Miller, and All-Other from 28 U.S. states (states are shown in Appendix II) for xAOC[2] channel. The xAOC combines channels from food, drug, club, dollar, and military stores and mass merchandisers. To assess the demand for beer during the pandemic, we obtained the weekly scanner data directly from the Nielsen company from January 1, 2017 through July 11, 2020. A total observation for this study from the xAOC channel for each beer brand is 5,152 (28 states with 184 weeks). We obtained the quarterly data on total personal income and the population above 18 years old from the U.S. Census Bureau. Then we divided total personal income by population above 18 years old to calculate income per capita. To get insights into how beer consumption relates to racial differences, we assembled data on annual estimates of the percentage of Black, Hispanic, and Asian people from the ACS (2020). Finally, regarding the variable to capture the effect of the pandemic on beer sales, we obtained the weekly positive case data of COVID-19 as a dummy variable from the COVID-19 U.S. state policy database (CUSP, 2021). Data analysis is done by using Stata version 15.

The variable definitions and descriptive statistics on the key variables used in the analysis are reported in Table 2. Comparing the retail price of six categories of beer in the U.S. shows that Corona is the most expensive brand, having a retail price of $13.13, followed by Heineken $11.58 and Coors $11.52. Similarly, Miller ranks in the fourth position

[2] xAOC is a Nielsen term which stands for extended all outlets combined.

($10.82), followed by Budweiser ($10.29) and All-Other ($9.45), respectively. A brand's per capita beer consumption is calculated by dividing the total quantity of the brand sale by the total population above 18 years old. All-Other beer has the highest per capita consumption, followed by Budweiser, Miller, Coors, Corona, and Heineken. Similarly, the budget share in total expenditure for All-Other is highest, followed by Budweiser, Miller, Coors, Corona, and Heineken respectively. Among race groups in our data, the percentage of White population is highest (72.961), followed by the percentage of Black population (15.084), the percentage of Hispanic population (13.588) and the percentage of Asian population (4.231). In addition, we created COVID-19 as a dummy variable and takes 1 if there was a positive case in the week and 0 otherwise.

Table 4.1 Variable definitions and summary statistics (N=5152)

Variable	Description	Mean	Min	Max	Std. Dev.
p1	Retail price for Budweiser	10.290	6.434	14.767	1.392
p2	Retail price for Coors	11.521	6.111	15.793	1.651
p3	Retail price for Corona	13.128	10.149	17.129	0.974
p4	Retail price for Heineken	11.584	6.964	15.502	1.311
p5	Retail price for Miller	10.819	5.027	15.32	1.468
p6	Retail price for All-Other	9.448	6.373	13.081	0.978
q1	Per capita Budweiser consumption	0.022	0.001	0.080	0.012
q2	Per capita Coors consumption	0.008	0.000	0.032	0.004
q3	Per capita Corona consumption	0.006	0.0003	0.023	0.004
q4	Per capita Heineken consumption	0.002	0.000	0.010	0.002
q5	Per capita Miller consumption	0.009	0.000	0.039	0.005
q6	Per capita All-Other	0.069	0.003	0.232	0.034

w1	Budget share for Budweiser	0.191	0.059	0.327	0.058
w2	Budget share for Coors	0.079	0.042	0.187	0.028
w3	Budget share for Corona	0.063	0.021	0.172	0.024
w4	Budget share for Heineken	0.025	0.009	0.071	0.013
w5	Budget share for Miller	0.089	0.017	0.213	0.037
w6	Budget share for All-Other	0.553	0.427	0.795	0.073
White	Percentage of population that is White	72.961	54.5	86.9	9.386
Black	Percentage of population that is Black	15.084	1.800	38.000	9.677
Hisp	Percentage of population that is Hispanic	13.588	2.900	39.700	10.528
Asian	Percentage of population that is Asian	4.231	0.900	14.800	2.969
COVID-19	Dummy variable	0.107	0	1	0.309

CHAPTER 5. ESTIMATION AND RESULTS

In this section, first we provide the parameter estimates from LA/AIDS model. Then we compare elasticity estimates accounting endogeneity using instrumental variables (endogenous model) and without accounting endogeneity (exogenous model). Next, we present the results of the price and expenditure endogeneity test. Finally, we quantify the endogeneity bias.

5.1 Parameter Estimates

The model is estimated in Stata using the quaids command introduced by Poi (2012). The estimated parameters are then used to calculate the required elasticities. However, the quaids post estimation command does not provide the significance level of elasticities, so we use the aidsdills command developed by Lecocq and Robin (2015) to get elasticities with their respective standard errors and level of significance. Aidsills uses Blundell and Robin's (1999) iterated linear least-square (ILLS) estimator.

The LA/AIDS model parameter estimates are reported in Table 5.1 and Table 5.2 below. All of the own-price coefficients for all six beer equations are statistically significant. Twelve of the fifteen cross-price coefficients are statistically significant. The first demographic variable, the percentage of Hispanic population, is positively associated with Budweiser, Coors, Heineken, and Miller, whereas it is negatively associated with All-Other. Similarly, our second demographic variable is the percentage of Asian population, which is positively associated with Budweiser, Coors, and Miller, whereas it is negatively associated with Corona, Heineken and All-Other. Further, the third demographic variable, the percentage of Black population, is positively associated with Corona and Miller, whereas it is negatively associated with All-Other. Our final demand shifter variable is COVID-19, which is positively associated with Corona and Heineken, whereas it is negatively associated with Coors and Miller. These findings show that sales of Corona and Heineken increased during the pandemic.

Table 5.1 Price coefficients estimation from LA/AIDS model

Equations	Price coefficients					
	Ci1	Ci2	Ci3	Ci4	Ci5	Ci6
Budweiser	-.009***					
	(.003)					
Coors	.008***	-.015***				
	(.001)	(.001)				
Corona	.0116***	-.0002	-.013***			
	(.002)	(.001)	(.003)			
Heineken	-.001	-.002***	.017***	-.005***		
	(.0007)	(.0005)	(.0008)	(.0006)		
Miller	.014***	-.010***	.0003	.002***	-.010***	
	(.001)	(.001)	(.001)	(.0005)	(.001)	
All-Other	-.023***	.019***	-.016***	-.011***	.003*	.028***
	(.003)	(.002)	(.003)	(.001)	(.002)	(.006)

* p<0.05, ** p<0.01, *** p<0.001. Standard errors appear in parentheses

Table 5.2 Demographic coefficient estimation from LA/ AIDS model

Equations	Intercept a_i	Expenditure b_i	%Hispanic d_i	% Asian e_i	% Black f_i	COVID-19 g_i
Budweiser	.042***	-.021***	.0009***	.0004***	-.0001	.00003
	(.004)	(.003)	(.0001)	(.0001)	(.0001)	(.00006)
Coors	.001	-.013***	.0007***	.0003***	.00004	-.0001***
	(.003)	(.002)	(.00008)	(.00008)	(.00007)	(.00003)
Corona	.079***	-.009***	-.0001	-.0003***	.0005***	.0002***
	(.002)	(.002)	(.0001)	(.0001)	(.00009)	(.00005)
Heineken	.003***	-.0008	.00009**	-.00007**	-.00003	.00003*
	(.0008)	(.0007)	(.00004)	(.00003)	(.00003)	(.00001)
Miller	.0150***	-.015***	.0004***	.0009***	.0001**	-.00007**
	(.0018)	(.001)	(.00008)	(.00007)	(.00006)	(.00003)
All-Other	.858***	.060***	-.002***	-.001***	-.0005***	-.00007
	(.008)	(.005)	(.0003)	(.0003)	(.0002)	(.0001)

* $p<0.05$, ** $p<0.01$, *** $p<0.001$. Standard errors appear in parentheses.

Here, we limit our interpretations of AIDS estimations only to the direction of association if the explanatory variable is negatively or positively associated with the budget share in six equations. As the literature suggests (e.g., Türkmen-Ceylan, 2019), calculation of elasticities using coefficients obtained from AIDS estimation is a more direct way of interpreting estimation output. We discuss various elasticities in the following subsection.

5.2 Compensated Own- and Cross-Price Elasticities

Estimated results for compensated own-price and cross-price elasticities are presented in Table 5.3. The upper panel and middle panel of Table 5.3 represent estimates from the endogenous models using neighboring states' average price and lagged price as instrumental variables, respectively. In contrast, the lower panel represents estimates from the exogenous model. Including three panels is to examine how accounting price endogeneity affects elasticity estimates. The diagonal entries represent the compensated own-price elasticities, and the non-diagonal entries represent the cross-price elasticities. An own-price elasticity of a beer brand measures the percentage change in consumption of that brand due to a 1 percent increase in its price while holding utility level, other prices, and other demand factors such as Black, Hispanic, Asian, and the COVID-19 dummy constant. Beginning with the estimation based on the endogenous model using neighboring states' average price as instrumental variables, own-price elasticities of Budweiser (-0.641), and All-Other (-0.195) are less than one, meaning that beer is inelastic, which is in line with the previous literature that demand for the addictive product is inelastic (John et al. 2019). Also, Goel and Saunoris (2018) concluded that the demand for beer is inelastic. However, our results show that Heineken has the highest own-price elasticity (-1.464) and a value greater than 1, followed by Miller (-1.454), Corona (-1.241), and Coors (-1.007), meaning that these brands are elastic, and the most elastic is Heineken.

Interestingly, Miller has the highest own-price elasticity in the endogenous model using lagged price as instrumental variables. An important point to note here is that the own-price elasticities of these three brands, Corona, Heineken, and Miller (in absolute terms) are larger after accounting for endogeneity. This finding is similar to the finding of Besanko, Gupta, and Jain (1998), who found higher own-price elasticities after addressing the endogeneity issue in studying demand relations of different yogurt brands. Overall, our results show the own-price elasticity of beer brands with neighboring states' average prices as instruments ranges from -0.195 to -0.641.

The compensated cross-price elasticities, E_{ij}^{c}, measure the percentage of change in demand for alcoholic beverage *i* with respect to a 1 percent change in beer brand *j* while holding utility level, other prices, and other demand factors such as Black, Hispanic, Asian, and the COVID-19 dummy constant. In the endogenous model using neighboring states' average price as instruments, cross-price elasticities estimate between four beer brands, such as Heineken and Budweiser, Heineken and Coors, Miller and Coors, and Heineken and All-Other are negative, whereas the remaining cross-price elasticities are positive. A negative cross-price elasticity implies that the relevant items tend to be complementary, while a positive elasticity implies that they tend to be substituted. Hence, our estimation shows that four pairs of beer brands, Heineken and Budweiser, Heineken and Coors, Miller and Coors, and Heineken and All-Other, are complements. The strongest complements are Heineken and Budweiser after Heineken and All-Other. Similarly, Heineken and All-Other are the strongest complements in the endogenous model using lagged prices as instrumental variables. However, Miller and Coors are the only complement brands in the exogenous model. In addition, cross-price elasticities help in the identification of the substitutes brands. Total of seventeen pairs of beer brands are substitutes. The top pair of price substitutes are Heineken and Corona (1.319) followed by Heineken and Miller (1.287). A 1 percent increase in the price of Corona increased the demand for Heineken by 1.319 percent, while a 1 percent increase in the price of Heineken increased the demand for Corona by 0.506 percent, holding other demand factors constant. This asymmetric cross-price elasticities of Corona and Heineken indicate that the demand for Heineken shows the strongest substitution response for the price of Corona. In contrast, the consumption of Corona is not as responsive to the price of Heineken. The second strongest substitute response is the demand for Heineken with the increase in the price of Miller. Similarly, the demand for Miller with the increase in the price of Budweiser (0.687) and the demand for Coors with the increase in the price of All-Other (0.622) rank on the third and fourth position, respectively. We also find Heineken and Corona as the top pair of price substitutes in the endogenous model using lagged price as instruments and exogenous models. Overall, the top pair of price substitutes remain the same in both endogenous and exogenous models. We also estimated expenditure and uncompensated price elasticities and discussed them in the following subsection.

Table 5.3 Comparison of price elasticities in endogenous and exogenous models

Panel (i): Compensated price elasticities using neighboring states average price as IVs						
Quantity	Budweiser	Coors	Corona	Heineken	Miller	All-Other
Budweiser	**-0.641*** **	0.111**	-0.019	-0.043	0.321***	0.271***
	(0.052)	(0.038)	(0.049)	(0.037)	(0.069)	(0.048)
Coors	0.277***	**-1.007*** **	0.360***	-0.091	-0.162	0.622***
	(0.080)	**(0.058)**	(0.074)	(0.056)	(0.104)	(0.074)
Corona	-0.058	0.434***	**-1.241*** **	0.506***	0.395*	-0.036
	(0.127)	(0.092)	**(0.117)**	(0.088)	(0.166)	(0.116)
Heineken	-0.334**	-0.285***	1.319***	**-1.464*** **	1.287***	-0.522***
	(0.118)	(0.086)	(0.109)	**(0.084)**	(0.158)	(0.108)
Miller	0.687***	-0.139**	0.281***	0.351***	**-1.454*** **	0.274***
	(0.061)	(0.045)	(0.057)	(0.043)	**(0.079)**	(0.057)
All-Other	0.093**	0.085***	-0.004	-0.023	0.044	**-0.195*** **
	(0.033)	(0.024)	(0.031)	(0.023)	(0.043)	**(0.031)**
Panel (ii): Compensated price elasticities using lagged prices as IVs						
Quantity	Budweiser	Coors	Corona	Heineken	Miller	All-Other
Budweiser	**-0.357** **	0.160	-0.216	-0.031	0.350	0.095

	(0.134)	(0.126)	(0.210)	(0.108)	(0.188)	(0.109)
Coors	0.397*	**-1.167*** **	0.409	0.056	-0.234	0.539***
	(0.190)	**(0.180)**	(0.300)	(0.153)	(0.267)	(0.155)
Corona	-0.640*	0.488	**-1.494** **	0.548*	0.236	0.863***
	(0.296)	(0.278)	**(0.465)**	(0.237)	(0.417)	(0.238)
Heineken	-0.237	0.172	1.397***	**-0.914*** **	0.293	-0.712***
	(0.216)	(0.203)	(0.338)	**(0.174)**	(0.304)	(0.177)
Miller	0.744***	-0.201	0.169	0.083	**-1.620*** **	0.824***
	(0.145)	(0.138)	(0.229)	(0.117)	**(0.202)**	(0.117)
All-Other	0.032	0.073	0.098	-0.032	0.130	**-0.301*** **
	(0.078)	(0.073)	(0.122)	(0.063)	(0.109)	**(0.063)**

Panel (iii): Compensated price elasticities in exogenous model

Quantity	Budweiser	Coors	Corona	Heineken	Miller	All-Other
Budweiser	**-0.834*** **	0.109***	0.130***	0.014	0.187***	0.394***
	(0.017)	(0.015)	(0.019)	(0.015)	(0.014)	(0.023)
Coors	0.264***	**-1.051*** **	0.081**	-0.001	-0.038	0.746***
	(0.028)	**(0.024)**	(0.031)	(0.024)	(0.023)	(0.036)
Corona	0.391***	0.100**	**-1.083*** **	0.315***	0.058	0.220***
	(0.043)	(0.037)	**(0.047)**	(0.037)	(0.035)	(0.056)
Heineken	0.110***	-0.004	0.798***	**-1.178*** **	0.217***	0.057
	(0.031)	(0.027)	(0.034)	**(0.027)**	(0.025)	(0.040)
Miller	0.403***	-0.034*	0.041*	0.061***	**-0.979*** **	0.507***
	(0.019)	(0.016)	(0.021)	(0.017)	**(0.016)**	(0.025)
All-Other	0.136***	0.106***	0.025*	0.003	0.081***	**-0.350*** **
	(0.012)	(0.010)	(0.013)	(0.010)	(0.010)	**(0.015)**

* p<0.05, ** p<0.01, *** p<0.001. Standard errors appear in parentheses.

5.3 Expenditure and Uncompensated Price Elasticities

Table 5.4 compares expenditure and uncompensated own-price elasticities in endogenous and exogenous models. Elasticity estimates in the endogenous model with neighboring states' average price and lagged price as instruments are presented in columns i and ii, respectively, whereas elasticity estimates in the exogenous model are presented in column iii. Among six categories of beer in column i with neighboring states' average price as instruments, Miller and All-Other have the highest expenditure elasticity (1.057), suggesting that a 1 percent increase in alcoholic beverage expenditure increased consumption of Miller and All-Other by 1.057 percent among American people, holding other demand factors constant. However, in the endogenous model with lagged price as instruments in column ii, Corona has the highest expenditure elasticity (1.028) after All-Other (1.109). In both endogenous models, all the expenditure elasticities are positive and statistically significant, meaning that beer is a normal good, which is in line with the findings of previous studies. The uncompensated price elasticities in column i show that own-price elasticities ranged between -0.783 and -1.548. The uncompensated own-price elasticities are negative and in line with consumer theory. We note that ignoring expenditure endogeneity overestimates expenditure elasticity in Coors, Corona, and Heineken. Similarly, we get mixed results in uncompensated own-price elasticity.

Table 5.4 Comparison of elasticities in endogenous and exogenous models

	I. Neighboring states average price as IVs		ii. Lagged price as IVs		iii. Exogenous model	
Quantity	Expenditure elasticity	Uncompensated own-price elasticity	Expenditure elasticity	Uncompensated own-price elasticity	Expenditure elasticity	Uncompensated own-price elasticity
Budweiser	0.976***	-0.827***	0.842***	-0.516***	0.927***	-1.011***
	(0.023)	(0.050)	(0.033)	(0.133)	(0.004)	(0.017)
Coors	0.673***	-1.058***	0.613***	-1.214***	0.710***	-1.107***
	(0.036)	(0.058)	(0.049)	(0.179)	(0.006)	(0.024)
Corona	1.011***	-1.305***	1.028***	-1.560***	1.182***	-1.158***
	(0.055)	(0.117)	(0.073)	(0.465)	(0.009)	(0.047)
Heineken	0.662***	-1.480***	0.935***	-0.937***	0.952***	-1.202***
	(0.053)	(0.083)	(0.054)	(0.173)	(0.006)	(0.027)
Miller	1.057***	-1.548***	0.975***	-1.706***	0.929***	-1.061***
	(0.027)	(0.081)	(0.036)	(0.205)	(0.004)	(0.016)
All-Other	1.057***	-0.783***	1.109***	-0.922***	1.059***	-0.937***
	(0.014)	(0.031)	(0.019)	(0.061)	(0.002)	(0.015)

* p<0.05, ** p<0.01, *** p<0.001. Standard errors appear in parentheses.

5.4 Results of Price and Expenditure Endogeneity Tests

We undertook an endogeneity test for price and expenditure. The estimated Chi-square test statistic in the case of price endogeneity is 341.53, and for expenditure endogeneity is 11.31. We reject the null hypothesis that parameter estimates obtained without controlling for endogeneity are consistent and unbiased at 5 percent and 1 percent significance levels, respectively. This provides strong evidence of the endogeneity of price and expenditure. Next, we would like to simplify the discussion on price and expenditure endogeneity by quantifying bias.

5.5 Quantifying Bias in Compensated Price and Expenditure Elasticities

As suggested by Hovhannisyan and Bozic (2017), we quantified bias in compensated price and expenditure elasticities by estimating the percentage difference between the respective sets of elasticities estimates in exogenous and endogenous models as follows;

$$\Delta EL = \frac{100(\zeta^{Exog} - \zeta^{Endog})}{\zeta^{Exog}} \qquad (6)$$

Where, ζ^{Exog} and ζ^{Endog} are elasticities estimates from models without accounting endogeneity and with accounting endogeneity.

Table 5.5 presents the percentage difference between elasticity estimates from exogenous and endogenous models using neighboring states' average price as instrumental variables in the upper panel of the table and lagged price as instrumental variables in the lower panel of the table. Comparison of own-price elasticities in the exogenous and endogenous model using neighboring states' average price as instrumental variables show that the size of bias ranges from -48.519 to 44.286 for own-price elasticity of Miller and All-Other, respectively. The largest bias is found in Heineken and Coors (-7025). We also find ignoring bias underestimates expenditure elasticity in Budweiser (-5.286) and Miller (-13.778), while it overstates the estimates by 5.211, 14.467 and 30.462 percent for Coors, Corona and Heineken.

We find similar bias in comparing elasticity estimates in exogenous and endogenous models using lagged price as instrumental variables. The bias size ranges from -65.475 percent to 57.194 percent for own-price elasticity for Miller and Budweiser, respectively. The largest bias is found in the cross-price elasticity between Heineken and Coors (4400 percent). We also find that ignoring bias underestimates expenditure elasticity estimates by

4.952 percent and 4.742 percent in Miller and All-Other respectively. In comparison, it overstates the estimates by 9.169 percent, 13.662 percent, 13.029 percent, and 1.786 percent for Budweiser, Coors, Corona, and Heineken. Estimates of ΔEL show empirical evidence that price and expenditure endogeneity impact elasticity estimates, thus, we draw the conclusion for this paper based on the results after accounting price and expenditure endogeneity using neighboring states' average price as instruments.

Table 5.5 Percentage difference between elasticity estimates from exogenous and endogenous models

ii. Percentage difference between exogenous and endogenous using neighboring states as IVs

Quantity	Budweiser	Coors	Corona	Heineken	Miller	All-Other	Expenditure
Budweiser	23.141	-1.835	114.615	407.143	-71.659	31.218	-5.286
Coors	-4.924	4.186	-344.444	-9000	-326.316	16.622	5.211
Corona	114.834	-334	-14.589	-60.635	-581.034	116.364	14.467
Heineken	403.636	-7025	-65.288	-24.278	-493.088	1015.789	30.462
Miller	-70.471	-308.824	-585.366	-475.410	-48.519	45.957	-13.778
All-Other	31.618	19.811	116	866.667	45.679	44.286	0.189

ii. Percentage difference between exogenous and endogenous using lagged prices as IVs

Quantity	Budweiser	Coors	Corona	Heineken	Miller	All-Other	Expenditure
Budweiser	57.194	-46.789	266.154	321.429	-87.166	75.888	9.169
Coors	-50.379	-11.037	-404.938	5700.000	-515.789	27.748	13.662
Corona	263.683	-388.000	-37.950	-73.968	-306.897	-292.273	13.029
Heineken	315.455	4400.000	-75.063	22.411	-35.023	1349.123	1.786
Miller	-84.615	-491.176	-312.195	-36.066	-65.475	-62.525	-4.952
All-Other	76.471	31.132	-292.000	1166.667	-60.494	14.000	-4.721

CHAPTER 6. CONCLUSIONS, POLICY IMPLICATIONS, AND LIMITATIONS

This study is the first to analyze the demand for beer during the pandemic with a demand system approach using the LA/AIDS model. Unlike previous demand studies on beer in the U.S., this study has modeled the imported and domestic beer brands in the demand system using the recent state-level weekly Nielsen scanner data to examine the market demand for beer differentiated by brands. Our results show the retail-level sales of Corona and Heineken surged after the COVID-19 outbreak in the U.S. We find that the compensated own-price elasticities for Budweiser, Coors, Corona, Heineken, Miller, and All-Other are -0.641, -1.007, -1.241, -1.464, -1.454, and -0.195 respectively. Furthermore, it shows that the compensated own-price elasticity of Heineken (-1.464) is highest followed by Miller (-1.454), Corona (-1.241), and Coors (-1.007), meaning that these brands are elastic, and the most elastic is Heineken. Thus, if producers increase the price of the top branded beer such as Heineken, Miller, Corona, and Coors, U.S. consumers are more price-sensitive and will decrease their consumption of branded beer by a greater percentage than the price rise. Because of this, total revenue to U.S. Heineken, Miller, Corona, and Coors beer producers will fall if the price rises. This will be harmful to the U.S. Heineken, Miller, Corona, and Coors producing industry.

Comparing our own-price elasticities with other studies indicates that our own-price elasticity for All-Other is almost close to the own-price elasticity for beer found by Nelson (2003). Own-price elasticity is -0.195 for All-Other in our study and -0.16 to -0.18 for beer by Nelson (2003). Similarly, our own-price elasticity for All-Other is comparable with those obtained by Trolldal and Ponicki (2005). For example, our own-price elasticity is -0.195 and the own-price elasticity of Trolldal and Ponicki (2005) is -0.243. Compared to

All-Other category, the absolute value of own-price elasticity at the brand level except Budweiser is higher. Rojas and Peterson (2008) also found noticeably high magnitudes of the own-price elasticity of different beer brands. However, their own-price elasticity is higher (-3.726 to -3.201) than ours (1.007 to 1.464). The difference between their findings and ours is primarily due to their inclusion of many brands (65 different brands), whereas we include only six brands. In general, high own-price elasticity at the brand level is because of the high substitution rate among brands.

Results on the compensated cross-price elasticities give an interesting finding on demand for beer. The compensated cross-price elasticity shows the highest substitution effect between Heineken and Corona, followed by Heineken and Miller. Similarly, the compensated cross-price elasticities show a complementary relation between Heineken and Budweiser and Heineken and All-Other. A remarkable finding is that the expenditure elasticity of demand for Corona, Miller, and All-Other is elastic, implying that if U.S. peoples' total expenditure on beer increases, demand for Corona, Miller, and All-Other beer increases more than the demand demand for remaining branded beer.

Finally, elasticity estimates from this research are useful in policy simulation. Our estimates are conditional demand elasticities, which can be used to conduct policy simulation to investigate the effect on revenue due to an increase in tax on inelastic beer brands (Budweiser and All-Other) and elastic beer brands (Coors, Corona, Heineken, and Miller). In addition, the bottom-line implication of our result is that Coors, Corona, Heineken, and Miller producing breweries can increase their revenue by decreasing price because their own-price elasticity of demand is elastic. Similar arguments apply to Coors, Corona, Heineken, and Miller selling retailers.

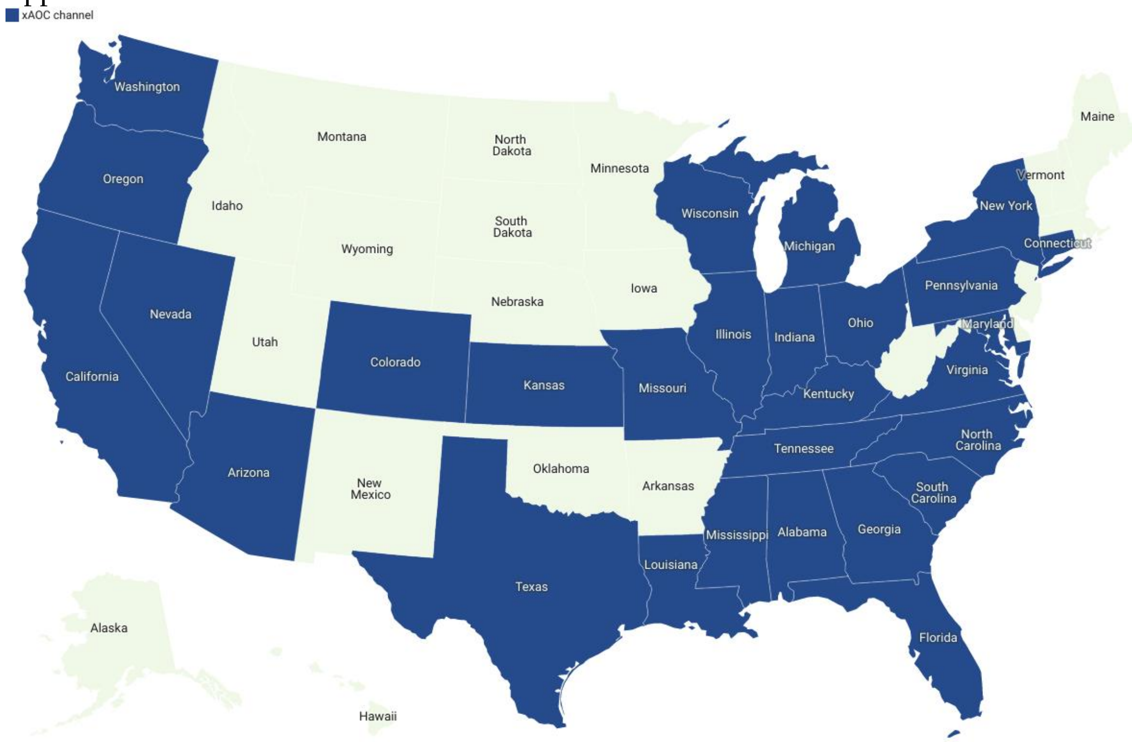
Although this paper is the first to look at the extent to which price determines the consumer choice of beer brands, two major limitations should be noted. First, the package size cannot be controlled, and we assume that the average size of the product sold in each brand is about the same. Second, the data are from the xAOC channel only. Therefore our results may not generalize to other channels for beer, such as convenience channels, liquor stores, and state drug channels. We note, however, that xAOC is an important outlet for beer, capturing sales at food, drug, mass merchandisers, club, dollar, and military stores. Thus, although our conclusions are strictly applicable only to consumers who purchase beer in xAOC channels, our results may have wider applicability.

APPENDICES

Appendix 1. List of neighboring states

Fips	States	Neighboring states
1	Alabama	Florida, Georgia, Mississippi, Tennessee
4	Arizona	California, Colorado, Nevada
6	California	Arizona, Nevada, Oregon
8	Colorado	Arizona, Kansas
9	Connecticut	New York
12	Florida	Alabama, Georgia
13	Georgia	Alabama, Florida, North Carolina, South Carolina, Tennessee
17	Illinois	Indiana, Michigan, Kentucky, Missouri, Wisconsin
18	Indiana	Illinois, Kentucky Michigan, Ohio
20	Kansas	Colorado, Missouri
21	Kentucky	Illinois, Indiana, Missouri, Ohio, Tennessee, Virginia
22	Louisiana	Mississippi, Texas
24	Maryland	Pennsylvania, Virginia
26	Michigan	Illinois, Indiana, Ohio, Wisconsin
28	Mississippi	Alabama, Louisiana, Tennessee
29	Missouri	Kentucky, Tennessee
32	Nevada	Arizona, California, Oregon
36	New York	Connecticut, Pennsylvania
37	North Carolina	Georgia, South Carolina, Tennessee, Virginia
39	Ohio	Indiana, Kentucky, Michigan, Pennsylvania
41	Oregon	California, Nevada, Washington
42	Pennsylvania	Maryland, New York, Ohio
45	South Carolina	Georgia, North Carolina
47	Tennessee	Alabama, Georgia, Kentucky, Mississippi, Missouri, North Carolina, Virginia
48	Texas	Louisiana
51	Virginia	Kentucky, Maryland, North Carolina, Tennessee
53	Washington	Oregon
55	Wisconsin	Illinois, Michigan

Appendix 2. xAOC channel in the U.S.



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