AN ABSTRACT OF THE DISSERTATION OF

Chayun Pipoblabanan for the degree of Doctor of Philosophy in Economics presented on November 26, 2008.

Title: Essays on Parametric and Nonparametric Estimation of Market Structure and Tax Incidence in the U.S. Brewing Industry

Abstract approved: ____

Victor J. Tremblay

This dissertation addresses two main issues involving alcohol markets. In the first, we employ both parametric and nonparametric methods to analyze the market structure and estimate the degree of market power in the U.S. brewing industry. In the nonparametric case, we use the variations in the excise tax to test whether behavior is consistent with that of a monopolist. Then, we calculate the "numbers equivalent," defined as the number of firms in a Cournot model that are consistent with market data. In the parametric case, we employ the new empirical industrial organization (NEIO) technique to estimate the degree of market power. This involves simultaneously estimating a market demand function with myopic addiction and an industry supply relation.

The results show that firm behavior in the U.S. brewing industry is not consistent with a cartel or a single monopolist. Both parametric and nonparametric methods provide consistent results which indicate that the U.S. brewing industry is quite competitive. Furthermore, we find that the degree of market power increases as concentration increases.

Second, we investigate the relationship between beer taxes and prices. As excessive alcohol consumption creates enormous negative externalities on society, various policies have been implemented by federal, state, and local governments to reduce alcohol use and its undesirable consequences. Because consumption falls with an increase in price, using higher excise taxes to raise prices is one policy that can be used. However, the effectiveness of such a policy depends on two issues: (1) how sensitive alcohol consumption is to a change in price, and (2) the degree to which prices respond to a change in taxes. In this study, we focus on the second issue. We estimate a reduced-form equation of the price of beer which is derived from a structural model developed in Chapter 2.

The results show that the federal tax on beer is over-shifted, while the state tax is not fully passed through. These results imply that a policymaker interested in reducing alcohol consumption should focus on raising the federal excise tax rate rather than depending on an uncoordinated policy by individual states to raise their state excise tax rates.

Essays on Parametric and Nonparametric Estimation of Market Structure and Tax Incidence in the U.S. Brewing Industry

by
Chayun Pipoblabanan

A DISSERTATION

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Presented November 26, 2008
Commencement June 2009

Doctor of Philosophy dissertation of Chayun Pipoblabanan

Presented on November 26, 2008.

APPROVED:

Major Professor, representing Economics

Chair of the Department of Economics

Director of the Economics Graduate Program

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Chayun Pipoblabanan, Author

ACKNOWLEDGEMENTS

I would like to express my sincerely thankfulness to several people who have helped me during my study at Oregon State University. First of all, I would like to express my deepest gratitude to my major professor, Dr. Victor Tremblay, for his valuable guidance and support during my research work. I would also like to thank Dr. Shawna Grosskopf, Dr. Carol Tremblay, Dr. Carlos Martins-Filho, and Dr. Chris Ward, for their worthy time serving on my committee. Their constructive comments and advices helped improve the quality of my dissertation.

I would like to extend my thanks to the Department of Economics, Oregon State University and Department of Economics, Kasetsart University for their financial support during my study. My thanks also go to the staff in economics: Barbra King, Laura Reylea, Lisa Duke, and Janet Knudson for their help and support.

Lastly, I would like to thank all of my family members who have always supported and encouraged me for all these years. Without their support, this dissertation could not have been completed.

CONTRIBUTION OF AUTHORS

Dr. Victor Tremblay provided ideas and assistance in writing this dissertation. Dr. Carol Tremblay assisted with data collection.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Essays on Parametric and Nonparametric Estimation of Market Structure and Tax Incidence in the U.S. Brewing Industry

Chapter 1

General Introduction

This dissertation addresses two main issues: estimating the degree of market power and analyzing the effect of excise taxes on prices. Data from the U.S. brewing industry are used to investigate both issues.

In chapter 2, parametric and nonparametric methods are used to estimate market structure and the degree of market power in the U.S. brewing industry. This is an important issue given that industry concentration has risen so dramatically. For example, the four-firm concentration ratio rose from 22.9 percent in 1953 to 92.8 percent in 2003, making tacit collusion and market power increasingly more likely. So in the first part of chapter 2, we employ the nonparametric method proposed by Ashenfelter and Sullivan (1987) to test the monopoly (perfect cartel) hypothesis. This method uses variations in the excise tax to assess whether firm reaction is consistent with that of a monopolist. Then, we calculate the numbers equivalent of firms which is used to identify the degree of market power that is consistent with the data.

In the second part of chapter 2, we use a parametric method to estimate the degree of market power. A market demand function with myopic addiction and an industry supply relation are estimated simultaneously. Demand and supply estimates are then used to identify the degree of market power. This analysis allows for a comparison of market power estimates using two methods. We find that the results from these two methods are consistent, indicating that there is at least a moderate amount of competition in the U.S. brewing industry.

In chapter 3, we investigate the relationship between beer taxes and prices. As excessive alcohol consumption is associated with several adverse consequences on society, policy-makers have implemented various polices aimed at reducing alcohol consumption and its undesirable effects. One policy is to increase the price of alcohol by raising excise taxes. However, the effectiveness of this tax policy depends on two issues: (1) how sensitive alcohol consumption is to a change in price, and (2) the degree to which prices respond to a change in taxes. In this study, we focus on the second issue. To do this, a reduced-form equation of the price of beer is derived from a structural model developed in chapter 2. We find that the effect of federal and state taxes on prices differs, perhaps because of bootlegging which occurs when consumers respond to an increase in a state or local excise tax by purchasing in neighboring areas where there is a lower excise tax and, therefore, price.

Chapter 2

Test of Market Structure: An Application to the U.S. Brewing Industry

2.1 Introduction

Profit maximization requires that a firm produces output where marginal cost equals marginal revenue. When a firm's demand function is downward sloping, price will exceed marginal cost and output will be allocatively inefficient. An output market is allocatively efficient when the market price equals long-run marginal cost, which is associated with competitive markets. Thus, the degree of competition in a market is an indicator of allocative efficiency in a market, assuming no externalities.

Empirical industrial organization economists have been concerned with measuring the degree of competition in markets and specifying its underlying determinants. The "competitiveness" of a market determines the extent to which price diverges from marginal cost with important implications for welfare and market efficiency. The Lerner index or price-cost margin is the traditional measure of a market's competitiveness, or market power, and is defined as the difference between price and marginal cost, divided by price. The main difficulty with using this measure is that while price is generally observable, marginal cost is not.

One method for estimating market power when marginal cost is unobservable is the new empirical industrial organization technique (NEIO), first developed by Appelbaum (1979, 1982) and summarized by Bresnahan (1989). This approach is based on the conjectural variations model and involves the estimation of the market demand function simultaneously with the supply relation. To identify the degree of market power using this approach requires that there are constant returns to scale or that the slope of the demand function pivots with an exogenous variable (Bresnahan, 1982).

There are several disadvantages with this method. First, it is data intensive. Data on price, output, input prices, and demand and cost shifters must be available. Second, the estimates and tests for market power can be biased when demand or cost functions are misspecified. Third, this method can only be applied in the case of homogeneous products.[1] Fourth, when using industry level data, the estimated supply relation does not correspond to the first-order conditions unless firms are symmetric (Bresnahan, 1989). For example, inference based on the conjectural variations is valid only if the behavior underlying the observed equilibrium is identical at the margin, and not just on average, to a conjectural variations game (Corts, 1999).

Another way to analyze market power is to evaluate the comparative static properties of a firm's first order conditions of profit maximization. This approach

[1] For measuring market power in differentiated products see Nevo (2001).

is less data intensive because demand and supply functions are not estimated. Sumner (1981) introduced this method and applied it to the cigarette industry by estimating the weighted-average price elasticity of demand facing firms. If the price elasticity of demand facing firm *i* is equal to the market price elasticity, the industry is purely monopolistic. If it is equal to $-\infty$, then the industry is perfectly competitive. Sumner rejected the hypothesis of pure monopoly (cartel) and the hypothesis of perfect competition.[2] Bulow and Pfleiderer (1983) demonstrate that Sumner's results are sensitive to assumptions about the functional form of the demand function, however.

In response, Sullivan (1985) developed a more general approach that avoided the main weakness with Sumner's method. He estimated the reduced-form functions of price and quantity based on the comparative statics properties of the market. With the Sullivan method, one can identify a lower bound on the numbers equivalent of firms.[3] His results showed that there was at least a moderately high level of competition in the cigarette industry.

Finally, Ashenfelter and Sullivan (1987) proposed a nonparametric measure of market structure based on the first-order condition for static profit maximization that equates marginal revenue with marginal costs. This is a nonparametric implementation of the Sullivan (1985) method where they used the

[2]The weighted-average price elasticity of demand facing firms was in the range of -13.5 to -34.5 which the industry demand elasticity was between -0.3 and -0.8.

[3] If this quantity is equal to some number *n*, then the industry must be at least as competitive as n firms playing a static Cournot game.

same set of data. Their results were consistent with Sullivan (1985) which showed that there was at least a moderate amount of competition in the cigarette industry. The main weakness with this approach is that it can be applied only when an excise tax is levied as it uses the variations in the excise tax to assess whether the firm's reaction is consistent to that of a monopolist.

The purpose of this chapter is to apply these techniques to the U.S. brewing industry because it is a concentrated industry. In 2000, there were 24 firms in the mass-producing sector of the industry, but it was dominated by three national brewers: Anheuser-Busch, Miller, and Coors. The domestic market share of these three leading producers was 88.9%. High concentration tends to yield high market power, but previous empirical studies showed that there was at least moderate competition in the U.S. brewing industry. For example, Tremblay and Tremblay (1995) used firm-level data from 1950-1988 to estimate the supply relation. They found that there was little market power in brewing through the 1980s. Using annual market level data from years 1953-1995, Denney et al. (2002) estimated simultaneously the demand function and supply relation and found that there is little market power.

In this paper, we will test the hypotheses of market power in the U.S. brewing industry by using both nonparametric and parametric methods. Because the excise tax on beer varies over time, we will employ the nonparametric method used by Ashenfelter and Sullivan (1987). In order to avoid the measurement problem associated with bootlegging between states, national data will be used in this study.[4] For the parametric method, a structural econometric model of addiction from a dynamic oligopoly game will be estimated to identify the degree of market power. This approach follows Denney et al. (2002).

This chapter is organized as follows. The next section (2.2) describes the method and empirical results using the nonparametric method. The method and results using parametric methods are reported in section 2.3, followed by a conclusion in the final section.

2.2 Nonparametric Test

Methodology

In this section, I summarize the Ashenfelter and Sullivan (1987) non-parametric method of testing market structure. Their tests are designed to investigate the response of monopoly output and price to an exogenous change such as the excise tax rate which is the marginal cost of business.

Assume a monopoly setting where the firm faces an upward sloping total cost function $C(q)$ and a downward sloping inverse demand function, $P(q)$, where q is firm output. Firm profit function is

$$\pi(q) = P(q)q - C(q).$$

[4] The study of Beard et al. (1997) showed the significant border-crossing effects in beer sales between the U.S. states.

At the profit maximizing output, q, the following condition holds:

(1) $$(q + \Delta q)P(q+ \Delta q) - C(q + \Delta q) \leq qP(q) - C(q) \qquad \text{for all } \Delta q \neq 0.$$

Equation (1) states that firm profit at the optimal output cannot increase for other levels of output. Rearranging terms we can write (1) as

(2) $$\Delta q P(q+ \Delta q) + q[P(q + \Delta q) - P(q)] \leq C(q + \Delta q) - C(q) .$$

With an excise tax of t, the cost function is $C(q) + tq$. Let $0 < t_0 < t_1$; let q_0 and q_1 be the corresponding profit maximizing levels of output, and let $p_0 = P(q_0)$ and $p_1 = P(q_1)$ be the corresponding monopoly price levels. When the excise tax rate is t_0, (2) implies that

(3) $$(q_1 - q_0)p_1 + q_0(p_1 - p_0) \leq t_0(q_1 - q_0) + C(q_1) - C(q_0).$$

Similarly, when the excise tax rate is t_1, (2) implies that

(4) $$(q_0 - q_1)p_0 + q_1(p_0 - p_1) \leq t_1(q_0 - q_1) + C(q_0) - C(q_1).$$

Adding (3) and (4) gives

(5) $$0 \leq (t_0 - t_1)(q_0 - q_1).$$

Since $t_0 < t_1$, it follows that

(6) $$q_1 \leq q_0.$$

As we have assumed a downward sloping marginal revenue function,[5]

(7) $$p_1 \geq p_0.$$

[5] Inverse demand $P(q)$ with negative slope, $dP/dq < 0$

$$TR = P(q).q$$
$$MR = (dP/dq)q + P$$
$$dMR/dq = (d^2P/d^2q)q + dP/dq + dP/dq < 0$$

As dP/dq is negative, d^2P/d^2q cannot be too large or demand cannot be too convex in the equilibrium's neighborhood.

Consequently, an increase in excise tax will result in price increase and quantity decrease. These are obviously testable propositions, although hardly unique to the monopoly model, and we offer empirical tests of them below.

Using (6) and the assumption that C is increasing, (3) implies that

(8) $$p_1(q_1 - q_0) + q_0(p_1 - p_0) \leq t_0(q_1 - q_0)$$

Alternatively, (8) can be written as

$$p_1q_1 - p_0q_0 \leq t_0(q_1 - q_0)$$

The decreased tax payments associated with the lower output level must be greater than the revenue loss from producing q_1 when the tax rate is t_0; otherwise the monopolist would have done better to produce q_1 when the tax rate was t_0. Then again, (8) may be written as

(9) $$\frac{-(q_1 - q_0)p_0}{(p_1 - p_0)q_0} \geq \frac{p_0}{p_1 - t_0}$$

or as

(10) $$\frac{-(p_1 - t_0)(q_1 - q_0)}{(p_1 - p_0)q_0} \geq 1$$

Expression (9) is an extension of the familiar rule that a monopolist will not produce on the inelastic portion of the demand curve. A generalization of (10) is given below.

In the case of perfect competition, price is taken as exogenous, and a firm will select q so that,

(11) $$\Delta q P(q+\Delta q) \leq C(q+\Delta q) - C(q)$$

or we can write (11) as

$$P(q+\Delta q) \leq \frac{[C(q+\Delta q) - C(q)]}{\Delta q}.$$

Comparing (11) with (2) suggests the way to measure monopoly power analogous to that considered in Bresnahan (1982). Bresnahan shows that

(12) $$\Delta q P(q+\Delta q) + \beta q(P(q+\Delta q) - P(q)) \leq C(q+\Delta q) - C(q) \quad \text{for all } \Delta q,$$

where β is an index of monopoly power. When $\beta = 0$, the market is perfectly competitive, and $\beta = 1$ for the case of monopoly. The intermediate values of β index different oligopoly equilibria.

In the special case of the two excise taxes t_0 and t_1, (12) implies

(13) $$p_1(q_1 - q_0) + \beta q_0(p_1 - p_0) \leq t_0(q_1 - q_0) + C_0(q_1) - C_0(q_0)$$

For β strictly between 0 and 1, one cannot guarantee that $q_1 \leq q_0$ and $p_1 \geq p_0$, but this is certainly the most plausible case. When $q_1 \leq q_0$ and $p_1 \geq p_0$ do hold, (13) implies that

(14) $$\beta \leq \frac{-(p_1 - t_0)(q_1 - q_0)}{(p_1 - p_0)q_0}$$

which is a generalization of (10). Inequality (14) shows which values of the monopoly index β are consistent with the data corresponding to any two tax rates and then provides a nonparametric method to calculate that index.

Inequality (14) is related to the bound found in Sullivan (1985) for the conjectural variations model. Let there be n firms with increasing cost functions $C_1(q_1),\ldots,C_n(q_n)$ and let the industry price be given by $P(q_1+\ldots+q_n)$, where $P(q)$ is a decreasing function and $q_1,\ldots,q_n$ are the outputs of each firm. Then, in the case of an excise tax, t, the firms' first order conditions imply that

$$p[q(t)] + q_i(t)p'[q(t)][1+\alpha_i(t)] - t = c_i'[q_i(t)] \qquad \text{or}$$

$$p(t) - t + q_i(t)\,\frac{p'(t)}{q'(t)}\,[1+\alpha_i(t)] = c_i'[q_i(t)]$$

where $p'[q(t)] = dp/dq_i$, $p'(t) = dp/dt$, $q'(t) = dq/dt$, and $\alpha_i = \sum_{j\neq i} dq_j / dq_i$ is the i^{th} firm's conjectural variation.

If marginal cost is greater than zero, for all firms in the industry, then it follows from the above equation that

$$q_i(t)p'(t)+ (p(t) - t)q'(t)/(1+\alpha_i(t)) \geq 0$$

Adding these over all firms implies that

(15) $$q(t)p'(t)+(p(t)-t)q'(t)n(t) \geq 0$$

where the quantity $n(t) = \sum_{i=1}^{N} \frac{1}{(1+\alpha_i(t))}$ can be thought of as the numbers equivalent of firms, since, in the Cournot case where all α_i are zero, it reduces to N. In a perfectly competitive market, the $\alpha_i \to -1$, and $\sum_{i=1}^{N} \frac{1}{(1+\alpha_i(t))} \to \infty$, while in a cartel pricing scheme where $\alpha_i \to N\text{-}1$ would imply $\sum_{i=1}^{N} \frac{1}{(1+\alpha_i(t))} = 1$. Thus the numbers equivalent is a meaningful scale on which to measure the level of competition in an industry.

If $t_1 > t_0$ then (15) implies that

$$(16) \qquad \int_{t_0}^{t_1} [q(t)p'(t) + (p(t)-t)q'(t)n(t)]dt \geq 0$$

If $p'(t) \geq 0$ and $q'(t) \leq 0$ for all t then, since $0 \leq q(t) \leq q_0 = q(t_0)$ and $0 \leq p_0 - t_1 = p(t_0) - t_1 \leq p(t) - t$ for t between t_0 and t_1, we have

$$(17) \qquad \int_{t_0}^{t_1} [q(t)p'(t) + (p_0 - t_1)q'(t)n(t)]dt \geq 0$$

Thus the mean value theorem implies that for some $\tilde{t}$ between t_0 and t_1

$$(18) \qquad n(\tilde{t}) \geq \frac{q_0(p_1 - p_0)}{-(q_1 - q_0)(p_1 - t_0)}$$

The right hand side of (18) is a finite difference form of the lower bound on the numbers equivalent estimated in Sullivan (1985). It will be used to identify which indices of market power are consistent with data from the U.S. brewing industry. Since the right hand side of (18) is equal to the reciprocal of the right hand side of (14), when the data imply the rejection of conjectural variations models with numbers equivalents less than some number N, then they also imply the rejection of models with monopoly index β greater than $1/N$.

As mentioned previously, an important prediction of the monopoly model follows from condition (8), which shows that revenue loss from producing q_1 when tax rate is t_0 must be less than the decreased tax payments associated with the lower output level. The number of observations that are consistent with this prediction will be counted. In order to get the precise conclusion whether the producers in the U.S. brewing industry form a cartel, we need to test the hypothesis related to the expression in (8).

Let $z = (p_1q_1 - p_0q_0) - t_0(q_1 - q_0)$, and assume that $\{z_i\}$ is independently and identically distributed (iid.).

The null and alternative hypotheses are as follow;

H_0: $z = 0$

H_1: $z < 0$.

If z_i follows the normal distribution, we can test this hypothesis by using a *t*-test. If not, then the *t*-test may not be valid. When distributional assumptions are suspect, there are at least two nonparametric methods that can be used as alternatives to *t*-test, namely the sign test and the Wilcoxon signed-rank test. The sign test is used to test the null hypothesis that the median of a distribution is equal to some value. The only requirement of this test is that the scale of measurement should be ordinal, interval or ratio. The sign test uses only information about element positions relative to the assumed median (higher or lower). The test does not utilize information about their values, so it makes this test less powerful if compare to the Wilcoxon signed-rank test, as the latter uses information about the elements' rank. However, the scope of the Wilcoxon signed-rank test is limited by distribution which is required to be symmetric relative to the median.

With the aim of using the more powerful Wilcoxon signed-rank test, we need to check whether the distribution of this random variable is symmetric. The Rosenblatt-Parzen kernel estimator will be used to perform the nonparametric density estimation. In this study, we will use the Gausian kernel choice. The bandwidth is selected according to the method proposed by Sheather and Jones (1991) as this method has become very popular and seems to give good performance in simulation studies (Pagan and Ullah, 1999). If the distribution is not symmetric, the sign test will be used to test the monopoly hypothesis.

Before going on to use condition (18) to see whether or not the oligopoly models are consistent with the data, it is necessary to check conditions (6) and (7), since these are assumed in its derivation. Conditions (6) and (7) show the response of quantity and price to the change of tax rate. If tax rate increases, a decrease in consumption and an increase in price are expected. Next, the number equivalent of firms as in expression (18) is computed. In calculating the number equivalent of firms, only observations in which condition (6) and (7) hold will be counted.

The crucial assumptions under these tests are 1) the total cost function *C(q)* is upward sloping, 2) the marginal revenue function *MR(q)* is downward sloping, and 3) there are no other demand and cost changes at the time of the tax change.

Data and Result

The data include 51 annual observations from 1953 through 2003 for the U.S. brewing industry. They consist of the excise tax rate, output, and price (see Appendix 2.2 for data definitions and sources). Measurement procedures for each variable are as follows:

The excise tax variable is the sum of the average state excise tax and federal excise tax per barrel[6] of beer (dollars). Output is per capita beer consumption (barrels) which is the total beer industry consumption divided by the total U.S. population aged 18 years and older. The per capita consumption is used instead of the aggregate consumption in order to avoid the demand changes caused by an increase in population. Price data are unavailable. A proxy for price is obtained as follows. First, the average price per case of 24 12-ounce cans of beer in 2000 is weighted by average price of leading product categories.[7] Next, the price per barrel in year 2000 is approximated by multiplying the average price

[6] 1 barrel = 31 gallons = 13.778 cases of 24 12-ounce cans = 124 quarts = 3,968 ounces.
[7] Using the information from Tremblay and Tremblay (2005), we calculated the price per case using market share information from table 6.1 (p.138) and the price per case of 24 – 12 ounce cans from table 7.1.(p.167).

per case of 24 12-ounce cans of beer in 2000 by 13.778 (number of cases per barrel). Then, the nominal price of beer for the other years is generated by using the consumer price index of beer. In order to reflect the real direction of tax and price (by getting rid of the effect of inflation), both tax and price data were converted to real terms by using the consumer price index.

In nominal terms, the average state excise tax rate of beer consumption gradually increased over time, averaging 2.55% each year during the studied period, 1953-2003. On the other hand, the federal excise tax of beer consumption remained unchanged at $9 per barrel during the period of 1953-1990. There was a 100% increase in federal excise tax in 1991; the tax jumped from $9 to $18 per barrel (see Figure 2.1). However in real terms, the excise tax decreased on average 3.28% during the periods of 1953 – 1990, and decreased on average 2.28% from 1991 to 2003 (see Figure 2.2).

The aggregate beer consumption grew on average 2.23% each year during 1953-1990. The increase in federal excise tax was followed by a huge decrease in aggregate beer consumption in the U.S. from 193.257 million barrels in 1990 to 186.366 million barrels in 1995, a 3.56% reduction in beer consumption from 1990.

The prediction of the monopoly model as in expression (8) can be checked easily. In its derivation, we retained the hypothesis that the same demand and cost functions applied to each pair of years considered. The failure of the prediction for two given points can be attributed to either a rejection of the monopoly model or to a shift in the demand or cost functions. In this study, the focus is on the monopoly model. Since it is desirable to be able to interpret failures of the predictions as failures of the model, considerable care must be taken in choosing which pairs of points to apply the tests.

The prediction of the simple monopoly model summarized in expression (8) is presented in Table 2.1. The accuracy of the model is truly poor in this case. Of the 50 changes, the monopoly prediction (8) was correct only 22% of the time. In order to test the hypothesis about monopoly, the density distribution of z is estimated as show in Figure 2.3. We can see that the distribution of z is symmetric, so the Wilcoxon signed-rank test is preferred to the sign test. Testing the monopoly hypothesis is similar to testing whether the expected value of z is less than zero. Appendix 2.1 shows the proof that the expected value of the estimation of z is equal to its sample mean. The results of the monopoly hypothesis tests are presented in Table 2.2. The sign test and Wilcoxon signed-rank test statistics indicated that we cannot reject the null hypothesis at 0.05% significant level. The median of z is greater than zero which is strong evidence against the monopoly hypothesis.

Before using (18) in order to see whether or not other oligopoly models are consistent with the data, we first need to check whether output and price change in the same direction as they do in condition (6) and condition (7). This is important because equation (6) and (7) are used in the derivation of (18). Conditions (6) and (7), which are also predictions of the monopoly model, state that when the tax rate increases (decreases), the quantity consumed should fall (rise) and the price should rise (fall). The results are given in the first three columns of Table 2.1. For the entire sample, the joint prediction of both conditions is correct only 38% of the time. The prediction of condition (7) is correct 76% of the time, while condition (6) is correct only 44% of the time. The last column of Table 2.1 shows that the monopoly model's predictions are correct only 8 times or 16%.

The failure of the monopoly model's predictions might be the result of measurement error. In most of the cases considered above, the change in the real tax rate was due to changes in the consumer price index. Given that many of these changes were slight, a better test would be to restrict the analysis to a subset of cases where there were more significant changes. The second row in Table 2.1 presents the prediction results for subgroups where there was *an increase* in the real tax rate (from the previous year); the third row displays results where there was *a decrease* in the real tax rate (from the previous year). The performance of the model is better in the case of tax decrease than in the case of tax increase.

From the assumption about the downward sloping marginal revenue curve, conditions that forecast (6) and (7) should be predicted correctly. One reason that might explain the failure of this prediction comes from the treatment of the tax rate in years in which more than one tax prevailed. To avoid this result, pairs of points separated by one year were considered. This method helped to remove measurement error from the tax data although it allowed any instability in the cost or demand functions to more heavily influence the results. The last three rows in Table 2.1 give the results for all of these "Skip Year Changes." As the table shows, the prediction of conditions (6) and (7) improves while the prediction of condition (8) is less precise. The density distribution of z in the case of "Skip Year Changes" is estimated as shown in Figure 2.3. The distribution of z is not symmetric, so we use the sign test to test the monopoly hypothesis. As we can see from table 2.2, we failed to reject the null hypothesis. This implies that firms in the U.S. brewing industry did not behave as a collective monopoly.

An alternative approach would be to consider tax changes that are substantial. Table 2.3 considers changes greater or less than 5%. The results are similar to those of Ashenfelter and Sullivan (1987) using the change in the tax rates. As the magnitude of the tax change increased, (6) and (7) tended to have the correct sign more frequently. When the percentage of the tax change is greater than five percent, the predictions are correct 73% and 59% of the time in the case of consecutive years and skip year changes, respectively. As can be seen in the general case, when the increase in tax rate is significant, it will be associated with an increase in price and a decrease in sale of beer. In addition, the prediction of (8) was also more successful as the tax change became larger.

Table 2.4 displays the extent to which other oligopoly models with higher numbers equivalents are consistent with the results for the "Consecutive Years" and the "Skip Year Changes" cases. The test in equation (18) has only been applied to pairs of years in which conditions (6) and (7) hold. Table 2.4 shows that models with numbers equivalents in excess of 5 or 6 are consistent with this sample. We can conclude that simple conjectural variations models can be rejected unless they represent at least a moderate amount of competition.

There are frequent failures of condition (6) in which the quantity is expected to fall after the increase in excise tax. There are at least three explanations for this failure. First, the maintained hypothesis that there is no shift in demand functions may be wrong; the per capita income of the U.S. increases over time, on average 1.82% over the period of 1953-2003. As income is one of the factors that determine the demand for beer consumption, an increase in income will result in an increase in consumption. Second, the fact that beer is an alcoholic beverage that can be addictive means that although the price of beer increases, consumption may not decrease in the short run. Finally, the assumption that there is no shift in the cost function may not be true. Tremblay (1987), Kerkvliet et al. (1998), and Xia and Buccola (2003) indicated some statistical evidence supporting the hypothesis that the U.S. brewing industry experienced considerable technological change and productivity growth in the second half of the twentieth century. If we can find the methods that take these factors into account, we can perform a more accurate test of the monopoly model.

2.3 Parametric Estimation

Methodology

In this section, we will employ the NEIO approach to estimate the degree of market power exerted by the U.S. brewing industry. The supply relation and the market demand for the U.S. brewing industry will be specified and the degree of market power will be estimated.

As alcohol consumption is addictive, an increase in current consumption increases the degree of addiction and also market demand in the next period. Thus, the problem related to a firm's decision in the brewing industry is dynamic. In this study, the structural econometric model of addiction from a dynamic oligopoly game following the work of Denney et al. (2002) is employed to investigate the issue of market power. Their methodology is as follows.

Assume that n firms compete in discrete time periods. A firm's problem is to choose the output level in each period to maximize its discounted stream of current and future (after-tax) profits. In this set up, the inverse market demand for beer in period t, $p_t(Q_t, \varphi_t, z_t)$, is a function of current consumption, Q_t, the degree of addiction, φ_t, and a vector of exogenous variables, z_t. Because of addiction, an increase in Q_t leads to an increase in φ_{t+1} and market demand in the next period. Firm i's unit cost in period t, $c_t(w_t, x_t, T_t)$, is a function of a vector of input prices, w_t, the quantity of a fixed input, x_t, and a control variable for the state of technology, T_t. As stated above, firm i's problem in time period $t = 0$ is to choose the output level (q_{it}) in each period to maximize its discounted stream of current and future (after-tax) profits, Π_0, which is

(1) $$\Pi_0 = \sum_{t=0}^{\infty} \delta^t [p_t(Q_t, \varphi_t, z_t)\, q_{it} - c_t(w_t, x_t, T_t)\, q_{it} - (\tau^f_t + \tau^s_t) q_{it}],$$

subject to the constraints on the structure of the dynamic updating rule regarding addiction, on the initial value of addiction, and on output feasibility. δ is the discount factor ($0 \leq \delta < 1$), τ^f is the federal excise tax rate, and τ^s is the average state excise tax rate.

Assuming a solution exists, the firm's problem can be solved recursively using dynamic programming methods.[8] Let the value function, defined as $V_t = \sup_{q_i} \Pi_t$, be the maximized value of the objective function of the problem in period t. The Bellman equation for this problem in period k ($0 < k < \infty$) is:

(2) $$V_k = \max\, [p_k(Q_k, \varphi_k, z_k)\, q_{ik} - c_k(w_k, x_k, T_k)\, q_{ik} - (\tau^f_k + \tau^s_k) q_{ik} + V_{k+1}],$$

subject to the constraints described above. Because of addiction, an output change in period k will affect the optimal path of output in future periods. The

[8] See Novshek (1993) for a more complete description of dynamic programming techniques.

Bellman equation shows that the firm must trade off today's net returns with the present value of future net returns (V_{k+1}) which can be seen from the firm's first order condition:

$$(3) \qquad [p_k - \theta_i q_{ik} - c_k(\cdot) - (\tau^f_k + \tau^s_k)] + \frac{\partial V_{k+1}}{\partial q_{ik}} = 0,$$

The bracketed term is the standard first-order condition to the firm's static problem in the absence of addiction. The markup or market power parameter, $\theta_i = -(\partial p/\partial Q)\Theta$, where $\Theta = (\partial Q/\partial q_i)$, will be positive when market power is present.[9] The last term on the left-hand side of equation (3) describes the impact of change in current output on the value function of the next period. In the static model, when θ is greater than zero, the equilibrium price exceeds marginal cost. With addiction, the firm might lower the price of output today or set it below marginal cost, because this will increase addiction and future profits. Thus, the price-cost margins or Lerner index underestimates the degree of market power in markets with addiction.

The supply relation in equation (3) can be rewritten in aggregate form following Bresnahan (1989)[10] as:

$$(4) \qquad [p_t - \theta Q_t - c_t(\cdot) - (\tau^f_t + \tau^s_t)] + \sum_{i=1}^{n} \frac{\partial V_{t+1}}{\partial q_{it}} = 0,$$

[9] In a monopoly setting, $\Theta = 1$ and $\theta = -(\partial p/\partial q) > 0$. In competition or simple Bertrand setting, $\Theta = \theta = 0$.

[10] The supply relation for an industry can be estimated by imposing the assumptions that product is homogeneous, marginal cost is the same for all firms and all firms behave in the same way $\theta_i = \theta$. The market power parameter is a measure of average industry conduct.

Rearranging (4), we will get the dynamic version of the industry supply relation as:

(5) $$p_t = c_t(\cdot) + \tau^f_t + \tau^s_t + \theta Q_t - \sum_{i=1}^{n} \frac{\partial V_{t+1}}{\partial q_{it}},$$

where Q_t is industry output and the last term is the effect of a change in current output on the aggregate value function in the future. Similar to the static case, exerted market power increases with an increase in θ.

Both the market demand function and the industry supply relation are needed in order to estimate the market power variable. Similarly to Denney et al. (2002), a linear market demand function is specified as:

(6) $$Q_t = \alpha_0 + \alpha_1 p_t + \alpha_2 p_t^{Cola} + \alpha_3 p_t^{Spirits} + \alpha_4 Inc_t + \alpha_5 Q_{t-1} + \alpha_6 Dem_t + \varepsilon_{t,D},$$

where p^{Cola} is the price of cola, $p^{Spirits}$ is the price of spirits, *Inc* is disposable income, *Dem* is a demographics variable represented the proportion of population who are 18 years old or older, and ε_D is an additive error term. The lag consumption variable is included to characterize addiction by letting $\varphi_t = Q_{t-1}$. This assumes a partial adjustment (or myopic model of addiction) as a rational addiction model is not identified with time-series data when price and output are endogenous (Chaloupka, 1991).

For the marginal cost function, as in Denney et al. (2002), the Generalized Leontief functional form, in which costs are assumed to be a function of two variable input prices (labor and materials), one fixed input (capital), and a time trend to control for technological change (T), is used. The cost function is generated as follows:

(7) $$c_t = \beta_1 w_t^L + \beta_2 w_t^M + \beta_3 (w_t^L\, w_t^M)^{1/2} + \beta_4 K_t + \beta_5 T_t,$$

where w^L is the price of labor, w^M is price of materials, and K is the quantity of capital.

To obtain the supply relation as in equation (5), we require the additional structure on the dynamic effects described in the first order condition. Following Roberts and Samuelson (1988) and Jarmin (1994), aggregate dynamic effects that occur in future periods are simplified by using a constant, λ_0. The dynamic industry supply relation can be written as:

(8) $$p_t = \beta_1 w_t^L + \beta_2 w_t^M + \beta_3 (w_t^L\, w_t^M)^{1/2} + \beta_4 K_t + \beta_5 T_t + \lambda_0 + \lambda_1 \tau^f_t + \lambda_2 \tau^s_t + \theta Q_t + \varepsilon_{t,S},$$

where ε_S is an additive error term.

Equations (6) and (8) will be estimated simultaneously.

Data and Results

Data on 51 observations at the industry level from 1953-2003 are used. The list of variables, their mean values, and their standard deviations are presented in Table 2.5. A description of these data and their sources can be found in Appendix 2.2.

As the system of simultaneous equations in (6) and (8) contain a lagged endogenous variable, and as the disturbances are assumed to follow an autoregressive process, the Two-Stage Least Squares (2SLS) estimator would give inconsistent estimates. The efficient two-step estimator proposed by Hatanaka (1976) is used in order to get consistent and asymptotically efficient estimates. The first step is to use the proper instruments (the non-stochastic exogenous variables and their lags) to get consistent estimates of the structural coefficients and then calculate the correlation coefficients (ρ) from the consistent set of residuals. The second step is computing Feasible Generalized Least Squares (FGLS) estimates on the modified structural equation. In additional, we also use the Lagrange Multiplier Test to test for the second order autocorrelation. However, the test result doesn't detect the second order autocorrelation problem.

Table 2.6 presents the empirical results from both market demand and supply relation estimation. In the demand equation, all parameter estimates have the expected signs. The price of spirits, the income variable and the demographics variable are statistically insignificant, but all of their signs are correct. There might be a multicollinearity problem in demand equation. We find that these three variables (p^{Spirit}, *Inc* and *Dem*) are highly correlated with lag of quantity (Q_{t-1}).[11] Demand has a negative slope (the coefficient of p is negative),

[11] Correlation between Q_{t-1} and p^{Spirit} is-0.9950, correlation between Q_{t-1} and *Inc* is 0.9425 and correlation between Q_{t-1} and *Dem* is 0.9737.

cola and spirit are substitutes for beer (the coefficients of p^{Cola} and p^{Spirit} are positive), and beer is a normal good (the coefficient of *Inc* is positive). The coefficient of the lag of output is positive and significant which provides the evidentiary support for the presence of addiction. The price, cross-price, and income elasticities are calculated by using the means of each variable. The short-run and long-run elasticity estimates are reported in Table 2.7. These elasticity estimates are within the ranges found in six previous studies (except for the cross-price elasticity of spirits which is lower than that range), which are reviewed in Tremblay and Tremblay (2005).[12]

For the supply relation, all of the parameter estimates have the expected signs and are statistically significantly different from zero except the coefficients of total capacity (*K*) and *Q*. An increase in input prices will increase the output price. The significance of the time trend (*T*) variable indicates that technological change has reduced prices, consistent with Tremblay (1987), Kerkvliet et al. (1998) and Denney et al. (2002). Both federal and state excise taxes have a positive impact on the supply price.

The market power parameter is positive but statistically insignificant; its value is close to zero, $\theta = 0.0000932$. Using the slope of inverted demand, we can calculate that Θ is equal 0.0510. This implies that the conjectural variation

---

[12] The price elasticity of demand ranges from -0.142 to -0.889, the cross-price of elasticity for spirits ranges from 0.140 to 0.285, and the income elasticity ranges from -0.545 to 0.760.

estimate is close to Bertrand at -0.9490, so the degree of exerted market power in the brewing industry appears to be very low. This result is consistent with the work of Tremblay and Tremblay (1995) and Denney et al. (2002), and consistent with the fact that accounting profit rates are low in the brewing industry compared to the manufacturing sector as a whole.[13]

As concentration in brewing industry increased during the 1980s, it is possible that the degree of market power might have increased. When concentration ratios are high, leading firms dominate following firms in term of size, and it might be possible for leading firms to dictate price and gain more economic profits. In this study, we employ dummy interaction terms, $Q_{53\text{-}83}$ and $Q_{84\text{-}03}$, to test whether the degree of market power is constant during the period of study.[14] The study period is divided into two periods, before and after the year 1984 when the 4-firm concentration ratio reached 80 percent. An industry is considered highly concentrated and market structure can tend toward monopoly when the four leading firms control more than 80 percent of total industry sales (Hirschey and Pappas, 1992). Table 2.8 presents the results when we include $Q_{53\text{-}83}$ and $Q_{84\text{-}03}$ in the supply relation. The results from our model are quite robust to this specification, as all estimated parameters have correct signs. Coefficients on the output variables for both periods are positive but statistically

---

[13] Brewers Almanac (1998) indicated that the average profit-to-sales ratio is 2.723 percent for the brewing and 4.823 percent for all manufacturing during the 1960-1994 time periods.

[14] $Q_{53\text{-}83} = D_{53\text{-}83}*Q$ where $D_{53\text{-}83} = 1$ if year < 1984, otherwise $= 0$ and
$Q_{84\text{-}03} = D_{84\text{-}03}*Q$ where $D_{84\text{-}03} = 1$ if year ≥ 1984, otherwise $= 0$.

insignificant. A Wald test indicates that the degree of market power is higher in the period after 1984 (at the .10 level of significance).

2.4 Conclusion

In this paper, we estimate market structure and the degree of competition in the U.S. brewing industry. The results are divided into two parts: nonparametric and parametric.

In the nonparametric part, by following the testing method of Ashenfelter and Sullivan (1987), our results indicate that the monopoly hypothesis serves as a poor predictor of the effect of excise tax changes on beer prices, sales, and revenues. When we separated data into subgroups by using the size of the tax change, we find that as the magnitude of the tax change increases, the prediction of the monopoly model tends to be more accurate. The estimates of numbers equivalent suggest that there is at least a moderate amount of competition in the U.S. brewing industry.

Improper controls are one of the important factors that can influence test results. We need to consider the alternatives that address this problem. As there are many changes in both demand and cost functions during the period of study, if we can modify the test in a way that captures these factors, then our test will be more accurate.

We also measure market power using parametric methods. Our estimation results for both the demand function and the supply relation are well-behaved, and we find supporting evidence for addiction. The results indicate that the brewing industry is quite competitive. The results also show that the degree of monopoly power is significantly higher after the mid-1980s when the concentration ratios increased.

The results from both nonparametric and parametric approaches are consistent, as we did not find any evidence of collusion between producers (perfect cartel) in the U.S. brewing industry. However, the U.S. brewing industry seems to be very competitive (close to Bertrand) when we use the parametric method, while the nonparametric method indicates that there is at least a moderate amount of competition in the U.S. brewing industry .

Figure 2.1
Nominal Beer Prices, State Taxes, Federal Taxes and Total Taxes of the US Brewing Industry: 1953-2003

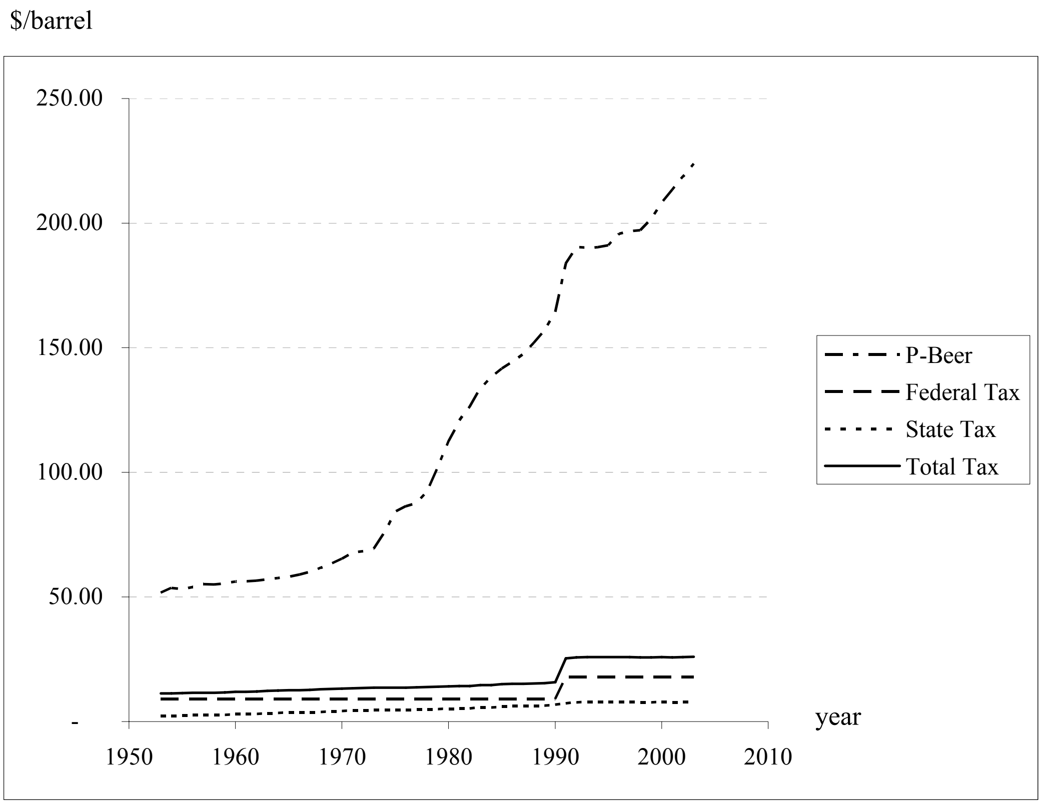


Figure 2.2
Real Beer Prices, State Taxes, Federal Taxes and Total Taxes of the US Brewing Industry: 1953-2003

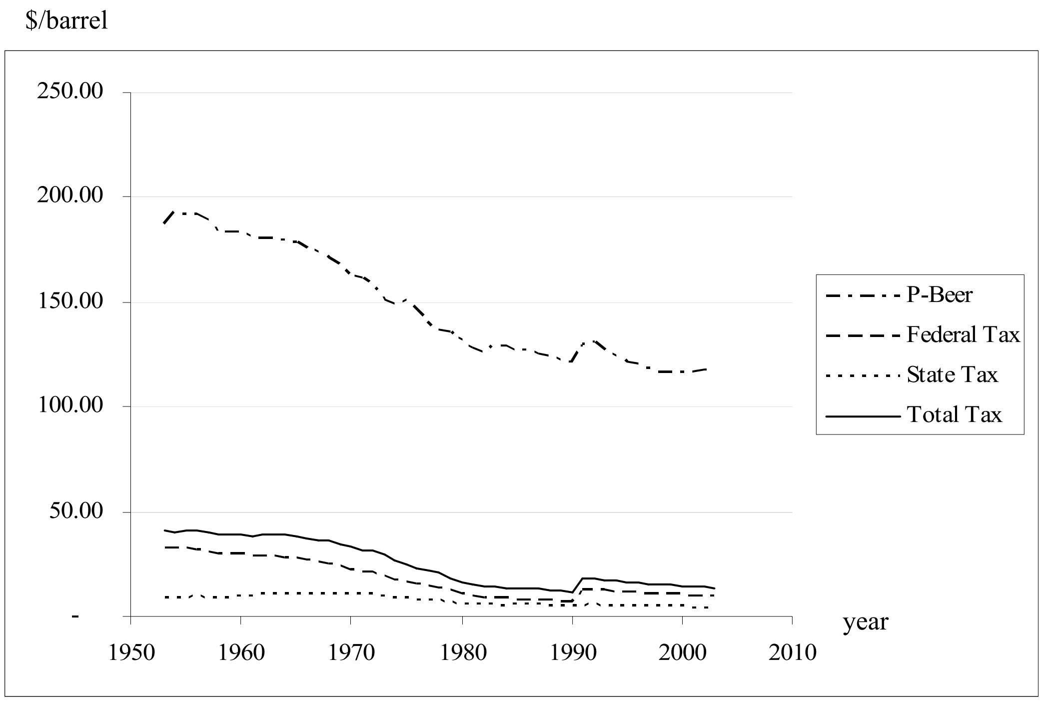
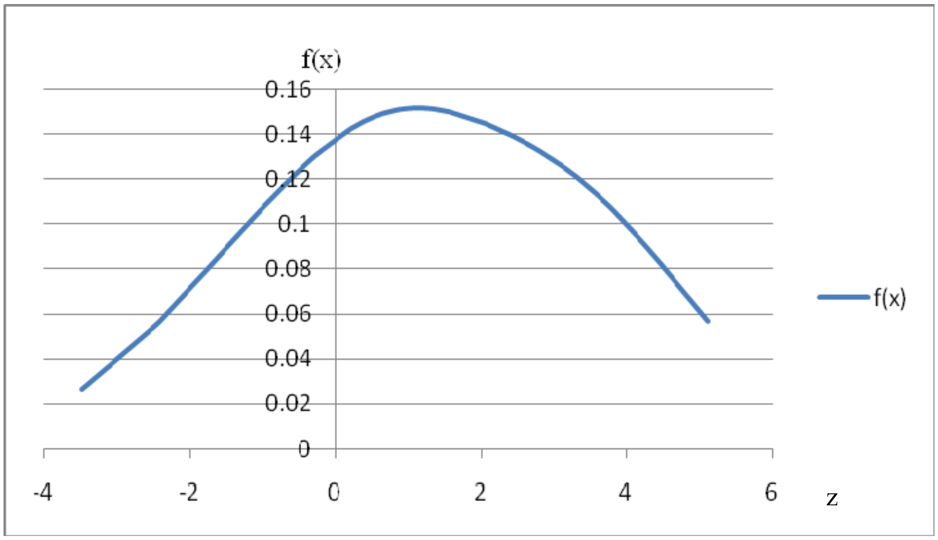
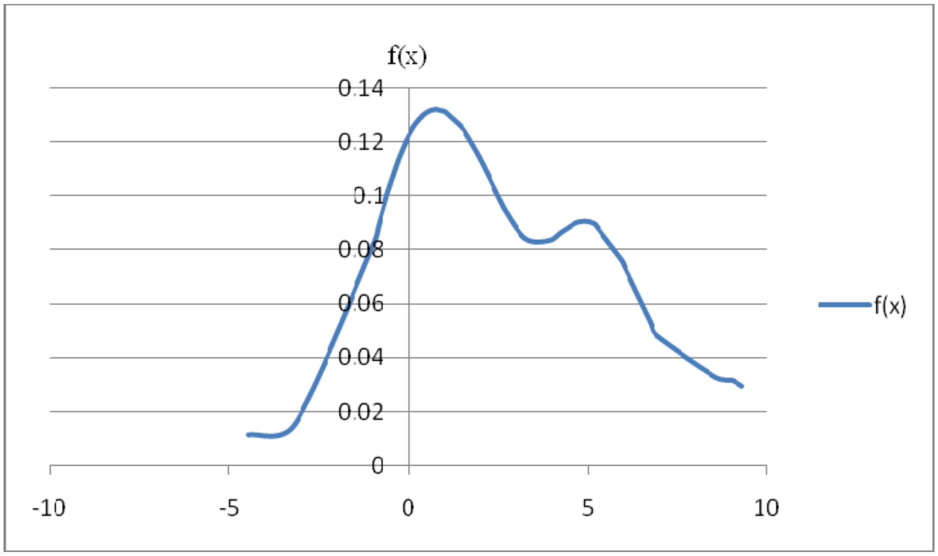


Figure 2.3
Density Estimation of *z*

a) Consecutive Years



b) Skip Year Changes



Note: Kernel choice: Gausian
Bandwidth choice: Sheather and Jones method

Table 2.1
Tests of the Predictions of the Monopoly Model about Changes in Quantity, Price, and Revenue

Data From	Number Cases	Percentage Predictions Correct				
		$\Delta q \leq 0$[a]	$\Delta p \geq 0$[b]	(6) – (7)[c]	(8)[d]	(6) – (8)[e]
Consecutive years	50	0.44	0.76	0.38	0.22	0.16
Increase	5	0.20	0.40	0.20	0.00	0.00
Decrease	45	0.47	0.80	0.40	0.24	0.18
Skip Year Changes[f]	49	0.57	0.82	0.53	0.20	0.16
Increase	7	0.57	0.43	0.43	0.29	0.14
Decrease	42	0.57	0.88	0.55	0.19	0.17

Notes: [a]Prediction tested is expression (6): Quantity consumed will decline.
[b]Prediction tested is expression (7): Price will increase.
[c]Test of joint prediction that quantity declines and price increases.
[d]Prediction tested is expression (8): Total revenue will fall by more than the product of the lower tax rate and the change in quantity.
[e]Test of the joint prediction that quantity, price and revenue all change in accordance with the monopoly model.
[f]Pairs of data points separated by one year.

Table 2.2
Hypothesis Testing of Monopoly Prediction

Test Method	Consecutive Years		Skip Year Changes	
	Test-statistic	p-value	Test-statistic	p-value
Sign test[a]	3.2527	0.9998	3.7143	1.0000
Wilcoxon Signed-Rank test[b]	3.6393	0.9999	4.7747	1.0000

Note:

H_0: $z = 0$

H_1: $z < 0$.

where $z = (p_1q_1 - p_0q_0) - t_0(q_1 - q_0)$.

[a]The large-sample approximation is based on the asymptotic normality of sign statistic B, where B is the number of possitive z s. The test-statistic B^* is defined as

$$B^* = \frac{B - (n/2)}{\{n/4\}^{1/2}}$$

When H_0 is true, B^* has an asymptotic $N(0,1)$ distribution as n tends to infinity. H_0 will be rejected if $B^* < z_\alpha$.

[b]The large-sample approximation is based on the asymptotic normality of Wilcoxon signed rank statistic T^+, where T^+ is the sum of the positive signed ranks. The test-statistic T^* is defined as

$$T^* = \frac{T^+ - \left\{\frac{n(n+1)}{4}\right\}}{\{n(n+1)(2n+1)/24\}^{1/2}}$$

When H_0 is true, T^* has an asymptotic $N(0,1)$ distribution as n tends to infinity. H_0 will be rejected if $T^* < z_\alpha$.

Table 2.3
Tests of the Predictions of the Monopoly Model about Changes in Quantity, Price, and Revenue: Disaggregation by Percentage of Tax Change

Data From	Number Cases	Percentage Predictions Correct				
		$\Delta q \leq 0$[a]	$\Delta p \geq 0$[b]	(6) – (7)[c]	(8)[d]	(6) – (8)[e]
Consecutive years	50					
$\Delta t < 5\%$	39	0.33	0.72	0.28	0.21	0.15
$\Delta t \geq 5\%$	11	0.82	0.91	0.73	0.27	0.18
Skip Year Changes[f]	49					
$\Delta t < 5\%$	22	0.50	0.73	0.45	0.18	0.14
$\Delta t \geq 5\%$	27	0.63	0.89	0.59	0.22	0.19

Notes: [a]Prediction tested is expression (6): Quantity consumed will decline.
[b]Prediction tested is expression (7): Price will increase.
[c]Test of joint prediction that quantity declines and price increases.
[d]Prediction tested is expression (8): Total revenue will fall by more than the product of the lower tax rate and the change in quantity.
[e]Test of the joint prediction that quantity, price and revenue all change in accordance withthe monopoly model.
[f]Pairs of data points separated by one year.

Table 2.4
Tests of the Predictions of Alternative Oligopoly Models

Numbers Equivalent	Percent Consistent With Numbers Equivalent[a]	
	Consecutive Years	Skip Year Changes
	$\Delta q \leq 0$ $\Delta p \geq 0$ (19 Cases)	$\Delta q \leq 0$ $\Delta p \geq 0$ (26 Cases)
n = 1	0.42	0.35
n = 2	0.68	0.73
n = 3	0.77	0.77
n = 4	0.84	0.88
n = 5	0.89	0.92
n = 6	0.89	0.96
n = ∞	1.00	1.00

Note: [a]Consistency denoted that expression (18) holds for the indicated value of n and thus that the changes in quantity and price are consistent with that value for the numbers equivalent of firms.

$$n \geq - q_0 (p_1 - p_0) / (q_1 - q_0) (p_1 - t_0)$$

Table 2.5
Description of the Variables and Data for the U.S. Brewing Industry

Variable	Description (Units)	Mean (Std. Dev.)
Q	Quantity of beer consumed (thousands of 31-gallon barrels)	149,751 (43,968)
P	The real price per barrel of beer (in 1982 dollars)	147.93 (26.86)
p^{Cola}	Index of the price of cola (equals 100 in 1982)	88.51 (8.22)
$p^{Spirits}$	Index of the price of spirits (equals 100 in 1982)	142.40 (49.88)
Inc	Real disposable income (billions of dollars)	1,967.97 (1,008.97)
Dem	Proportion of the population aged 18 and over	0.70 (0.04)
w^l	Price of labor (wage per barrel in thousands of dollars)	10.40 (4.24)
w^m	Price of materials (cost per barrel in thousands of dollars)	33.93 (4.18)
K	Beer industry capacity (million of barrels)	180.21 (40.27)
T	Time trend (1953 = 1)	26 (14.87)
tax	Sum of federal and average state excise tax (dollars per barrel)	24.94 (11.06)
τ^f	Federal excise tax rate (dollars per barrel)	17.61 (8.94)
τ^s	Average state excise tax rate (dollars per barrel)	7.33 (2.42)

All dollar values are measured in real terms (1982 dollars).

Table 2.6
U.S. Brewing Industry Demand Function and Supply Relation Parameter Estimates

Variable	Demand Function		Supply Relation	
	Parameter Estimate	Wald test	Parameter Estimate	Wald test
Intercept (x 10^5)	1.0153[b]	4.2515		
p (x 10^2)	-5.4708[a]	9.1937		
p^{Cola} (x 10^2)	1.4268[c]	1.8104		
p^{Spirit} (x 10^2)	0.3856	0.0774		
Inc	0.2703	0.0230		
Q_{t-1}	0.6814[a]	20.8916		
Dem (x 10^4)	1.4348	0.0418		
Intercept (x 10^2)			1.0362[a]	12.7429
w^L			9.6767[a]	6.7397
w^M			2.7327[a]	6.0845
$(w^L w^M)^{1/2}$			-9.7076[a]	5.8611
K			-0.0411	1.2422
T			-0.5292[b]	4.4264
τ^f			1.5456[a]	17.3883
τ^s			1.3835[c]	1.8525
Q (x 10^{-5})			9.3200	0.3126
Wald Test[d]	13,189.47[a]		88,874.47[a]	

Note: Estimation Method: IV estimation and applied FGLS
All dollar values are in 1982 dollars.
[a]Significant at the 0.01 level.
[b]Significant at the 0.05 level.
[c]Significant at the 0.10 level.
[d]This test is a joint test of the hypotheses that all the coefficients except the constant term are zero.

Table 2.7
Own-Price, Cross-Price, and Income Elasticity Estimates

Variable	Elasticity Estimates	
	Short Run	Long Run
Own price	-0.5404	-1.6962
Cross-price, beer-cola	0.0843	0.2647
Cross-price, beer-spirits	0.0367	0.1151
Income	0.0036	0.0112

Table 2.8
U.S. Brewing Industry Demand Function and Supply Relation Parameter Estimates with Separate Output Variables by Period

Variable	Demand Function		Supply Relation	
	Parameter Estimate	**Wald test**	**Parameter Estimate**	**Wald test**
Intercept (x 10^5)	1.0153[b]	4.2515		
p (x 10^2)	-5.4708[a]	9.1937		
p^{Cola} (x 10^2)	1.4268[c]	1.8104		
p^{Spirit} (x 10^2)	0.3856	0.0774		
Inc	0.2703	0.0230		
Q_{t-1}	0.6814[a]	20.8916		
Dem (x 10^4)	1.4348	0.0418		
Intercept			97.4964[a]	14.7734
w^L			12.4151[a]	5.5649
w^M			3.8216[a]	5.8729
$(w^L w^M)^{1/2}$			-12.8559[b]	5.1300
K			-0.0506[b]	3.3829
T			-0.4916[a]	11.0141
τ^f			1.3011[a]	28.3019
τ^s			2.3978[b]	3.0275
$Q_{53\text{-}83}$ (x 10^{-5})			5.1373	1.1524
$Q_{84\text{-}03}$ (x 10^{-5})			8.2670	1.5578
Wald Test	13,189.47[a]		357,366.60[a]	

Note: Estimation Method: IV estimation and applied FGLS
All dollar values are in 1982 dollars.
[a]Significant at the 0.01 level.
[b]Significant at the 0.05 level.
[c]Significant at the 0.10 level.
[d]This test is a joint test of the hypotheses that all the coefficients except the constant term are zero.

Appendix 2.1

This appendix shows the proof that the expected value of the estimation z is its sample mean.

Let $z = (p_t q_t - p_{t-1} q_{t-1}) - t_{t-1}(q_t - q_{t-1})$.

In this study, we estimate the density of z by employing the Rosenblatt-Parzen kernel estimator. The Gaussian kernel is used as the kernel choice and the bandwidth is selected according to the method proposed by Sheather and Jones (1991).

The Kernel Estimator

$$\hat{f}(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x_i - x}{h}\right)$$

For the symmetric kernel,

$$\hat{f}(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right)$$

Let $\quad \hat{\mu} = \int_{-\infty}^{\infty} \hat{f}(x) x dx$

$$\hat{\mu} = \int_{-\infty}^{\infty} \frac{1}{nh}\sum_{i=1}^{n} \hat{K}\left(\frac{x - x_i}{h}\right) x dx$$

Do the change of variable, let $\psi = \dfrac{x - x_i}{h}$, then $x = x_i + h\psi$, and $dx = hd\psi$

$$\hat{\mu} = \frac{1}{nh}\sum_{i=1}^{n} \int_{-\infty}^{\infty} K(\psi)(x_i + h\psi) h d\psi$$

$$\hat{\mu} = \frac{1}{n}\sum_{i=1}^{n}\left\{x_i \int K(\psi)d\psi + h\int \psi K(\psi)d\psi\right\}$$

If $\int \psi K(\psi)d\psi = 0$, and $\int K(\psi)d\psi = 1$

Then $\hat{\mu} = \frac{1}{n}\sum_{i=1}^{n} x_i + 0$

$$\hat{\mu} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

The proof shows that the expected value of the population mean is the sample mean.

Appendix 2.2

The data consist of 51 annual observations covering the period 1953 – 2003. Measurement procedures and data sources for all variables are as follows.

The Demand Function Variables:

Beer consumption is measured in 31 gallon barrels and is taken from *Brewers Almanac* (various issues). All the price data (prices of beer, cola, and whiskey) are measured by price indexes (equaling 100 in 1982) which are obtained from *CPI Detailed Report*. Disposable income is obtained from *Statistical Abstract of the United States*. The demographics variable is defined as the proportion of the population aged 18 years and over. The population figures come from *Statistical Abstract of the United States*.

The Supply Relation Variables:

The price of labor is defined as total production wages per barrel in the brewing industry. The price of materials is defined as the cost per barrel of materials. Both input prices are obtained from *Brewers Almanac* (various issues). Capital is measured as the total brewing capacity, and is obtained from *Brewers Digest, Buyers Guide and Brewery Directory* (various issues). Federal and average state beer taxes per barrel are obtained from *Brewers Almanac* (various issues).

All money figures in our regression analysis are in 1982 dollars. The prices of beer, cola, spirit, state tax, and federal tax are deflated by Consumer

Price Index. Both prices of labor and materials are deflated by the Producer Price Index. Disposable income is deflated by GDP deflator. Both price indexes and GDP deflator are obtained from *Statistical Abstract of the United States*.

All these data are sited in Tremblay and Tremblay (2005).

Chapter 3

Estimating Tax Incidence

3.1 Introduction

Although consuming alcohol in moderation can improve health and increase longevity (Brewers of Europe, 2004), excessive alcohol consumption does cause various adverse consequences to society. Alcohol contributes to injuries resulting from motor-vehicle accidents, fires, falls, and drowning. Alcohol also is associated with violent behavior such as child abuse, homicide, suicide and sexual assault. In addition, excessive alcohol consumption can lead to many health problems such as digestive diseases, certain cancers, mental disorders, and cardiovascular disease (Centers for Disease Control and Prevention, 2008).

In 2000, there were approximately 85,000 deaths attributed to excessive alcohol consumption in the United States, making alcohol the third leading cause of preventable death (behind tobacco, poor diet and physical inactivity) in the nation (Mokdad et al., 2004). In 2003, 30% of fatal traffic crashes were alcohol related (Chen and Yi, 2007), 28% of these accidents involved intoxicated drivers ages 16-24, and there were over 4 million emergency room visits for alcohol-related conditions (Mc Caig and Burt, 2005).

Harwood (2000) found that the economic cost of alcohol abuse in the United States was $184.6 billion in 1998. This cost of alcohol abuse includes health care expenditures (treatment, prevention, research, and training), lost productivity (loss of earnings from death, illness, and alcohol-related crime) and other effects on society (motor vehicle crashes, crime, and fire destruction). In 2001, the data released from the Minnesota Department of Health (2006) shows that the annual economic cost associated with alcohol use was over $900 per person in the state. As reported in The Annual Catastrophe of Alcohol in California, the economic cost of alcohol use is $38.4 billion annually, which is about $1,000 per California resident. This can translate to a cost of $2.80 per drink,[15] which is substantially higher than the average excise tax per drink of $0.08 (Marin Institute Report, 2008).

As alcohol consumption creates enormous negative externalities on society, a Pigovian tax can increase efficiency when the price plus the tax reflects the full social cost (private cost + external cost) of the product (Varian, 1992). Tremblay and Tremblay (2005) calculated the external cost of consuming a six-pack of 12-ounce containers of beer. They found that the net external cost[16] of

---

[15] A drink or standard serving is equivalent to one 12-ounce container of regular beer (at 5 percent alcohol by volume), one 6-ounce glass of wine (at 10 percent alcohol by volume), one 5-ounce glass of wine (at 12 percent alcohol by volume), and one 1.5-ounce shot of distilled spirits (80 proof, 40 percent alcohol by volume).

[16] The net external cost combined the health-care cost, lost productivity from death and illness, cost from crime, and other impacts, then subtracted the possible benefit from moderate beer consumption which will reduce the total cost of cardiovascular disease.

consuming a six-pack of beer is approximately \$1.52 - \$2.28, which is more than three times the excise tax rate (\$0.47). This suggests that beer taxes are too low and beer consumption is too high from society's perspective. The study by Kenkel (1996) suggested that the optimal tax on alcohol should be more than 100 percent of the net-of-tax price.

Given the high social cost associated with alcohol consumption and abuse, federal, state and local governments have implemented other policies to reduce alcohol use. To deter teenage and young adult drinking, all states raised the minimum legal drinking age to 21 years of age by July 1988. To discourage alcohol abuse, alcoholic beverage containers must contain warning labels, which describe the dangers of drinking and driving, consuming alcohol when pregnant, and excessive alcohol use. This policy began in November 1989. The Alcohol Traffic Safety Act of 1983 eased the standards required for arresting and convicting drunk drivers and also imposed more severe penalties on drunk driving. Many states and counties have taken on policies that control where and when alcohol can be sold. These polices require servers to become trained and/or licensed; servers are also held accountable for adverse drinking related actions of the patrons they serve (Chaloupka et al., 2002).

Although economic analysis suggests that alcohol taxes are too low, over the last six decades, real tax rates have actually fallen as they were not routinely increased to compensate for the effects of inflation. The most recent increase in the federal excise tax on alcohol took place in 1991. The beer tax was increased from \$9 to \$18 per barrel (or \$0.29 to \$0.58 per gallon). Table 3.1 shows that more than 30 states have not raised nominal beer tax rates since 1990. According to law of demand, taxes that increase the price of alcohol will result in lower alcohol consumption which may lead to less alcohol abuse.

Several studies have examined the effects of price on various forms of alcohol abuse. Increasing alcohol beverage prices or raising alcohol taxes will have significant effects on reducing adverse health effects (Cook and Tauchen, 1982; Grossman, 1993; Chesson et al., 2000), decreasing nonfatal and fatal motor vehicle crashes and other injuries (Young and Bielinska-Kwapisz, 2006; Mast et al., 1999; Chaloupka et al., 1993; Saffer and Grossman, 1987), lowering youth alcohol consumption (Coate and Grossman, 1988), lessening family violence (see Markowitz and Grossman, 2000; Markowitz and Grossman, 1998; Markowitz, 2000), and crime rate (Cook and Moore, 1993).

There are two main criticisms with these studies. First, the results disclose correlation between taxes and externalities, not causation. For example, federal or state governments might increase taxes in response to a loss of revenue as the alcohol consumption declines. Thus, it is possible that causality runs from lower sales (lower externalities) to higher taxes. Specification tests performed by Cook and Tauchen (1982) and Ohsfeldt and Morrisey (1997) showed that causality runs from taxes to cirrhosis and from taxes to work place injuries, however.

Another criticism is that there might be a third cause, such as culture and drinking sentiment, that explains the link between taxes and abuse. Convincing evidence of a third cause was found by Sloan et al. (1994), Mast et al. (1999), Dee (1999), Stout et al. (2000), and Young and Likens (2000). Tremblay and Tremblay (2005) showed the importance of state effects in explaining the relationship between beer taxes and alcohol-related outcomes by comparing the rates of per-capita ethanol consumption, liver disease, and alcohol-related traffic fatalities by state. They show that states with a large proportion of people who oppose alcohol consumption for religious reasons, such as Kentucky, Utah, and Alabama, have low alcohol consumption and low rates of liver disease. Utah and Kentucky also have low alcohol-related traffic fatality rates. In 2007, the Alabama beer tax was the highest in the nation. On the other hand, Nevada has the highest rate of alcohol consumption because of tourism and legalized gambling. In addition, states with significant alcohol production such as California, Colorado, Kentucky, Missouri and Wisconsin have very low tax rates. In order to fully understand the relationship between taxes and alcohol-related outcomes, researchers must control for these other variables.

As discussed previously, there are two main concerns related to alcohol tax policy. The first is what should be the optimal excise tax? The present excise tax is too low from society's perspective, as it does not cover the external cost of consuming alcoholic beverages. A Pigovian tax would be efficient and would equal the net external per unit cost of alcohol consumption. Another concern related to alcohol tax policy is the effectiveness of this tax policy in reducing alcohol's adverse consequences. This depends on two factors: how sensitive alcohol consumption and abuse are to the change in price, and how well prices respond to a change in taxes. In this paper, we are interested in investigating the relationship between beer taxes and prices. This relationship is of interest because a policy to raise taxes can be effective only to the extent that prices respond to taxes. If taxes have little effect on beer prices, the tax changes will not have much impact on alcohol related behavior.[17]

The extent to which higher excise taxes are passed through or lead to higher prices depends on such factors as market structure, demand conditions, and cost conditions. In the case of perfect competition, in the long run, after-tax prices will increase by the same amount as the tax for a constant-cost industry (see Figure 3.1a) and by less than the amount of the tax if the supply curve is upward sloping (see Figure 3.1b). Taxes can be over-shifted if the industry supply curve slopes downward, which could occur because of economies of scale and spillover effects (see Figure 3.1c). Quantity demanded falls after imposing a tax, which results in a higher average total cost assuming supply is not perfectly inelastic. A mathematic proof of the effect of excise tax on equilibrium price in the case of perfect competition can be found in Appendix 3.1.

[17] If higher excise taxes have significant effect on moderate drinkers but little or no effect on alcohol abusers, however, then higher taxes could lower social welfare (Manning et al., 1995).

In the case of monopoly, the pass through rate depends on both marginal cost and demand. The per unit tax will always over-shift to consumers if marginal cost is constant and demand displays constant elasticity (see Figure 3.2a). However, the price will rise by half of the tax rate, if the firm's marginal costs are constant and the monopolist faces a linear demand curve (see Figure 3.2b). A mathematic proof of the effect of excise tax on equilibrium price in the case of monopoly can be found in Appendix 3.2.

Stern (1987) employed the conjectural variations model to investigate the possibility of the over-shifting of taxes in the case of imperfect competition. By assuming that all firms are identical and marginal cost is constant in a Generalized-Cournot model, Stern found that taxes can be over-shifted if $p\varepsilon'/\varepsilon$ is less than one, where ε is the elasticity of demand and the prime denotes its derivative with respect to price. But the tax incidence is shared between consumers and producers if demand is linear. Besley (1989) examined a similar model[18] and found that taxes can be over-shifted if the demand function is convex. A mathematic proof of the effect of excise tax on equilibrium price in the case of imperfect competition can be found in Appendix 3.3.

There has been little empirical work on the relationship between alcohol taxes and prices. Barzel (1976) regressed the retail price per case of distilled spirits on the tax per case and wholesale price (net of tax) for distilled spirits in

[18] Assuming identical firms, the inverse demand function is twice continuously differentiable and has a negative slope, and the cost function is increasing and twice continuously differentiable.

New York State in 1971. He found that the tax coefficient was greater than one, but not statistically significant. Young and Biellnska-Kwapisz (2002) ran regressions in which the price of a per gallon of pure ethanol was the dependent variable, and the independent variables were the combined state and federal excise tax rate and state and time specific fixed effects. They also found that prices rise significantly more than the increase in excise taxes. Denney et al. (2002) estimated a demand function and a supply relation for the U.S. brewing industry. They used parameter estimates of the model to simulate the effect of a one dollar increase in the federal and the state excise tax rate per barrel. They found that an increase in federal excise taxes causes a greater increase in price than an increase in the state excise tax. But, both federal and state taxes were not fully passed through to consumers. Kenkel (2005) investigated the tax incidence on beer, wine and spirits in Alaska; he did telephone surveys of Alaskan retail establishments licensed to serve alcohol. After the tax hikes on October 1, 2002, he found that the mean and median pass-through rates for beer, wine and spirits were substantially over one. For many brands of beer the mean and median pass-through rates were about 2. For on-premise wine and on-premise spirits the pass-trough rates are close to 4. These results suggested that alcohol taxes were more than fully passed through to prices.

As can be seen, the empirical evidence on the extent to which alcohol taxes are over-shifted is mixed and very limited. In this study, the tax incidence of federal and state taxes will be estimated and compared by using reduced-form equations, which are derived from the structural model developed in chapter 2.

3.2 Methodology

In this paper, the effectiveness of federal and state taxes on price will be examined. This is done by deriving the equilibrium price from the market demand function and the supply relation.

As described in chapter 2, the market demand is defined as:

$$(1) \qquad Q_t = f(p_t\, ,\, p_t^{Cola},\; p_t^{Spirits},\, Inc_t\, ,\, Q_{t-1}\, , Dem_t,\,)$$

where Q is quantity demanded, p, p^{Cola}, and $p^{Spirits}$ are the price of beer, cola and spirits, respectively. *Inc* is disposable income. *Dem* is a demographics variable defined as the proportion of population who are 18 years old or older. To characterize myopic addiction, the lag Q_{t-1} term is added.

The dynamic industry supply relation is obtained as follows. Each firm is assumed to maximize its discounted stream of current and future (after tax) profit. Each first order condition is solved for price, and these conditions are aggregate over all firms to get the industry supply relation:

$$(2) \qquad p_t = f(MC_t(w_t^L, w_t^M, K_t\, ,\, T_t)\, ,\, tax\, ,\, Q_t)$$

where w^L, and w^M are a price of labor and materials, *tax* is a per unit excise tax which is the sum of federal and the average state excise tax. K is a quantity of capital. T is a time trend, which controls for technological change.

The reduced form of this system is obtained by solving equations (1) and (2) simultaneously for price. This produces the following expression:

(3) $p_t = f(p_t^{Cola}, p_t^{Spirits}, Inc_t, Q_{t-1}, Dem_t, MC_t(w_t^L, w_t^M, K_t, T_t)\ tax)$

Assuming that $MC = \alpha_0 + \alpha_1 w^L + \alpha_2 w^M + \alpha_{3,}(w^L w^M)^{1/2} + \alpha_4 K + \alpha_5 T$, and (3) can be approximated by a linear specification, the reduced–form statistical model is:

(4) $$p_t = \pi_0 + \pi_1 p_t^{Cola} + \pi_2 p_t^{Spirits} + \pi_3 Inc_t + \pi_4 Q_{t-1} + \pi_5 Dem_t + \pi_6 w_t^L$$
$$+ \pi_7 w_t^M + \pi_{8,}(w_t^L w_t^M)^{1/2} + \pi_9 K_t + \pi_{10} T_t + \pi_{11} tax_t + e_t$$

where the π's are reduced from parameters and e_t is an addictive error term.

The coefficient π_{11} shows the net effect of a unit increase in the excise tax. This allows us to determine whether taxes are under- or over-shifted. For example, there is over-shifting if π_{11}>1 and under-shifting if π_{11}<1.

In general, one would anticipate the same tax incidence for a dollar increase in the federal and a dollar increase in the state tax rate. However, due to the possibility of bootlegging across states, and because state taxes are not the same and changes by state are not uniform, one might expect that federal excise tax will be a more effective policy to reduce alcohol abuse. Both results from Barnett, Keeler, and Hu (1995) and Denney et al. (2002) show that in cigarette industry and brewing industry, respectively, an increase in federal excise taxes causes a greater increase in price than the same increase in the average state tax rate.

In order to compare the effectiveness of federal and state excise taxes, the *tax* variable in equation (4) will be separated into federal excise tax (τ^f) and state excise tax (τ^s). The reduced–form statistical model of price becomes:

$$(5) \qquad p_t = \pi_0 + \pi_1 p_t^{Cola} + \pi_2 p_t^{Spirits} + \pi_3 Inc_t + \pi_4 Q_{t-1} + \pi_5 Dem_t + \pi_6 w_t^L$$
$$+ \pi_7 w_t^M + \pi_{8,} (w_t^L w_t^M)^{1/2} + \pi_9 K_t + \pi_{10} T_t + \pi_{11} \tau_t^f + \pi_{12} \tau_t^s + e_t$$

The coefficients π_{11} and π_{12} in equation (5) will show the net effect of beer price to one unit increase of federal and state beer taxes, respectively.

3.3 Data and Results

The reduced-form equations are estimated using annual industry data from 1953-2003. The data sources and descriptions are presented in Appendix 2.2 and in Table 2.5 from the previous chapter. The reduced-form equation in (4) is assumed to follow a first order autoregressive process. With a lagged dependent variable and autoregressive disturbances, the ordinary least squares (OLS) estimator is inconsistent and the feasible generalized least squares (FGLS) estimator is also inconsistent as the estimate of correlation coefficient (ρ) comes from OLS estimates. In this study, we employ the method suggested by Hatanaka (1974) to estimate this reduced-form equation. Hatanaka has devised an efficient two-step estimator based on the concept of instrumental variables. In the first step, the technique of instrumental variables is used to get the consistent estimator of ρ. In the second step, all variables are transformed by using this consistent estimator of ρ before using FGLS.

The empirical results are reported in Table 3.2. The estimation results of equation (4) when the federal and state taxes are combined are presented in the second column. All parameter estimates have expected signs, but some of them are statistically insignificant from zero. The positive and significance of p^{Cola} and p^{Spirit} indicates that soft drinks and spirits are substitutes for beer as a rise in their prices cause an increase in demand and a rise in price of beer. Beer price rises with an increase in income (*Inc*), suggesting that beer is a normal good. Due to addictive behavior, an increase in previous period consumption also leads to a rise in price of beer. The price of beer also increases with demographics variable (*Dem*) as the increase in the proportion of the population age over 18 years old will increase demand and results in an increase in the price. A rise in wages and material prices will result in an increase in beer price, but at a decreasing rate. An improvement in technology and total industry capacity reduces the cost of production and also the price of beer.

The estimated excise tax coefficient is 1.35 and is statistically significant from zero. The hypothesis that the excise tax is over-shifted (H_0: $\pi_{11} = 1$ against H_1: $\pi_{11} > 1$) is tested and the results show that the null hypothesis is rejected at 0.10 significant level. This implies that the excise tax is over-shifted. The finding that the tax is over-shifted is consistent with the study of Young and Biellnska-Kwapisz (2002) and Kenkel (2005).

The third column in Table 3.2 presents the results from equation (5) when we separate the federal excise tax and weighted average state excise tax. All parameters estimated are stable, as their signs remain the same as in column two. The federal excise taxes have a greater effect on the price of beer than state excise taxes. The estimated tax coefficient for the federal tax is 1.45 and is statistically significant from zero. The hypothesis that federal tax is over-shifted (H_0: $\pi_{11} = 1$ against H_1: $\pi_{11} > 1$) is tested and the results show that the null hypothesis is rejected at 0.05 significant level. This implies that federal tax is over-shifted. On the other hand, the estimated state tax coefficient is 0.66, but it is not statistically different from zero which suggests that the state tax is not fully passed though. This result is similar to the finding of Denney et al. (2002) as the equilibrium price of beer is more responsive to a federal than to state excise taxes. However, they did not find evidence that the federal excise tax is over-shifted.

In general, one would anticipate that the tax incidence should be the same for a dollar increase in the federal and a dollar increase in the state tax rate of every state. Bootlegging across states might be a good explanation why prices increase more in response to an increase in federal taxes than to state and local taxes. As state excise tax increases are not coordinated, some consumers will respond by shopping in neighboring states where there is a lower excise tax rate.

The opportunities for cross-border shopping are much more limited for a federal tax increase, however. Thus, the price effect of a tax increase in a single state is likely to be small relative to a federal tax rate increase.

In this study, the increase in state tax represents an increase in the weighted average state excise tax rate. If each state increases its tax rate by the equal amount at exactly the same time, we would expect the same response as an increase in federal tax. In reality, tax rates differ by state and change at different times. As of April 2004, the average excise tax rate of beer was \$0.24 per gallon, Wyoming had the lowest tax rate at \$0.02 per gallon while Alaska set the highest tax rate at \$1.07 per gallon (Table 3.1).

3.4 Conclusion

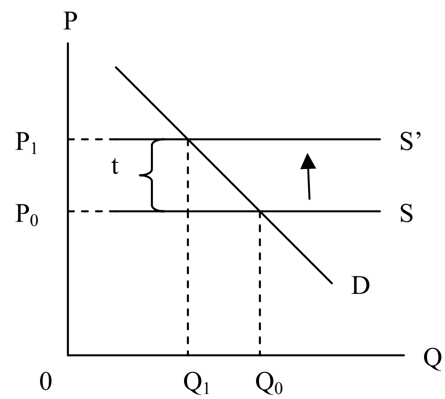
In this paper, we examine the effect of federal and state taxes on price in the U.S. brewing industry. This is accomplished by deriving the equilibrium price from the market demand function and the supply relation and estimating the resulting reduced-form price equation. We find that the federal excise tax for beer is over-shifted. That is, the price of beer will increase more than the increase in the federal excise tax rate. On the other hand, the state excise tax is not fully passed through, consumers and producers share the tax burden.

Consistent with the results of Denney et al. (2002), consumers bear a greater tax burden when excise taxes are increased at the federal level. Consistent with Young and Biellnska-Kwapisz (2002) and Kenkel (2005), the result of this chapter confirms that the federal excise tax is over-shifted.

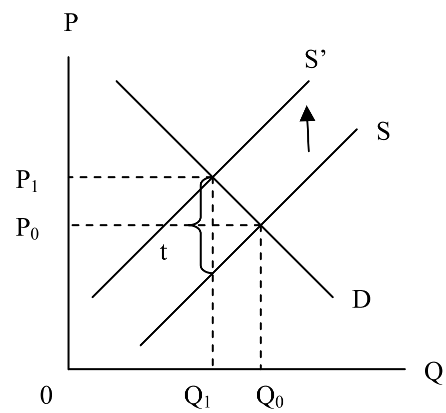
The policy implications from this study are clear. If the goal of society is to reduce total beer consumption, a policy that raises the federal excise tax rate will be more effective than an uncoordinated policy by individual states to raise their state excise tax rates.

Figure 3.1
Effects of Excise Taxes in Perfectly Competitive Market

a. Constant cost industry



b. Increasing cost industry



c. Decreasing cost industry

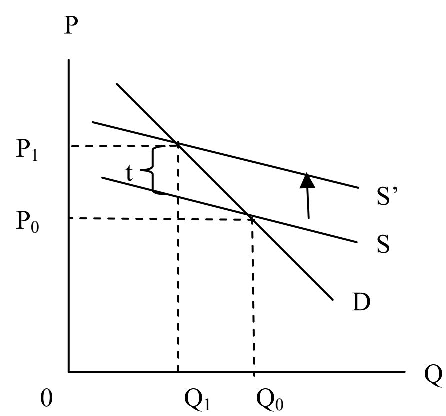
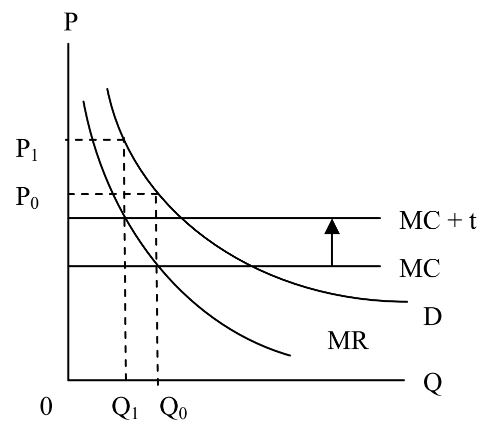


Figure 3.2
Effects of Excise Taxes in Monopoly Market with Constant Marginal Cost

a. Constant elasticity demand curve



b. Linear demand curve

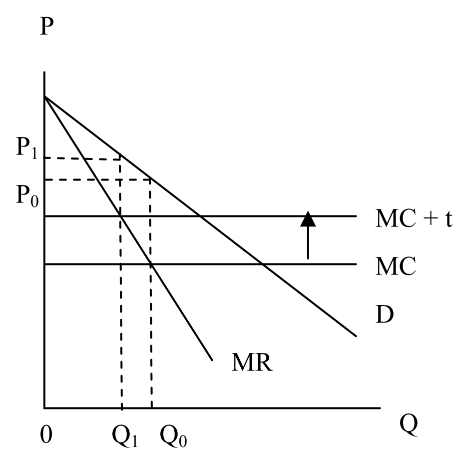


Table 3.1
Year when States Last Raised Beer Taxes (April 20, 2004)

($/gallon)

State	Current beer-tax rate [rank]* ($ per gallon)	Taxes last raised	State	Current beer-tax rate [rank]* ($ per gallon)	Taxes last raised
Wyoming	0.02 [1]	1935	Minnesota	0.15 [18]	1987
Pennsylvania	0.08 [4]	1947	Oklahoma	0.40 [41]	1987
Louisiana	0.32 [39]	1948	South Dakota	0.27 [36]	1988
Idaho	0.15 [18]	1961	Connecticut	0.20 [29]	1989
Georgia	0.48 [45]	1964	District of Columbia	0.09 [8]	1989
Michigan	0.20 [29]	1966	Rhode Island	0.10 [11]	1989
West Virginia	0.18 [23]	1966	Delaware	0.16 [20]	1990
North Dakota	0.16 [20]	1967	California	0.20 [29]	1991
North Carolina	0.53 [47]	1969	New Hampshire	0.30 [37]	1991
South Carolina	0.77 [49]	1969	Montana	0.14 [16]	1992
Wisconsin	0.06 [2]	1969	New Jersey	0.12 [13]	1992
Missouri	0.06 [2]	1971	Ohio	0.18 [23]	1993
Maryland	0.09 [8]	1972	New Mexico	0.41 [42]	1993
Massachusetts	0.11 [12]	1975	Virginia	0.26 [33]	1993
Colorado	0.08 [4]	1976	Washington	0.26 [34]	1997
Oregon	0.08 [4]	1977	Hawaii	0.92 [50]	1998
Indiana	0.12 [13]	1981	Florida	0.48 [45]	1999
Vermont	0.27 [35]	1981	Illinois	0.19 [26]	1999
Alabama	0.53 [47]	1982	Arkansas	0.23 [32]	2001
Kentucky	0.08 [4]	1982	New York	0.13 [15]	2001
Arizona	0.16 [20]	1983	Alaska	1.07 [51]	2002
Texas	0.19 [27]	1984	Tennessee	0.14 [16]	2002
Iowa	0.19 [27]	1986	Nebraska	0.31 [38]	2003
Maine	0.35 [40]	1986	Nevada	0.16 [20]	2003
Mississippi	0.43 [44]	1986	Utah	0.41 [42]	2003
Kansas	0.18 [23]	1987			

Note: *Ranked from lowest to highest
Source: in Factbook on State Beer Taxes, from The Beer Institute and state revenue department

Table 3.2
Reduced-form Estimations of Price Equation in the U.S. Brewing Industry

Variable	Equation (4) combined tax	(5) separated tax
Constant	6.5353 (0.0199)	-13.4027 (0.1330)
p^{Cola}	0.2194[a] (5.8992)	0.3067[a] (8.4336)
p^{Spirit}	0.2074[b] (2.7762)	0.2319[b] (3.3375)
Inc	0.0033 (0.3278)	0.0034 (0.4729)
Q_{t-1} (x 10^{-5})	16.3380 (1.5631)	6.9140 (0.2673)
Dem (x10^2)	0.6035 (0.5688)	1.0153[b] (3.0381)
w^L	6.0847[b] (4.6768)	3.1814 (0.4172)
w^M	1.6330[b] (3.4404)	0.8325 (0.3636)
$(w^L w^M)^{1/2}$	-6.0757[b] (4.4097)	-3.1342 (0.3875)
K	-0.0093 (1.5259)	-0.0035 (0.0120)
T	-0.7696 (0.0788)	-0.6924 (1.5124)
Tax	1.3514[a] (30.5434)	
τ^f		1.4505[a] (30.2278)
τ^s		0.6602 (0.2728)
Wald Test[c]	288.60[a]	1,903.43[a]

Note: Estimation Method: IV estimation and applied FGLS, the figures in parentheses are Wald-statistics.
[a]Significant at the 0.01 level
[b]Significant at the 0.05 level
[c]This test is a joint test of the hypotheses that all the coefficients except the constant term are zero.

Appendix 3.1

The Effect of Excise Tax on the Equilibrium Price in Perfect Competition

This analysis follows Bishop (1968).

At equilibrium, demand price, P_D, is equal supply price, P_S, plus a per unit tax, t.

$$P_D(q) = P_S(q) + t \qquad \text{or} \qquad P_D(q) - P_S(q) - t = 0$$

Let $\quad f(q, t) = P_D(q) - P_S(q) - t = 0$

The effect of a change in an excise tax on equilibrium price can be derived using implicit function theorem[19],

$$\frac{dq}{dt} = -\frac{\partial f / \partial t}{\partial f / \partial q} = \frac{1}{P_D' - P_S'} \; \frac{dq}{dt} = -\frac{\partial f / \partial t}{\partial f / \partial q} = \frac{1}{P_D' - P_S'}$$

where P_D' and P_S' are slope of demand and supply curve, respectively.

Multiplication by $\frac{dP_D}{dq} = \frac{dP_D}{dq} P_D'$, we get

$$\frac{dp}{dt} = \frac{P_D'}{P_D' - P_S'}.$$

For stability of equilibrium, $P_D' - P_S' < 0$, an increase in excise tax will result in an increase in price. The tax will have a proportional effect on the price when $P_S' = 0$ (constant cost case). The tax will be over- (under-) shifted when $P_S' < (>) 0$.

[19] In order to use implicit function theorem, the objective function $f(q,t)$ must be concave and differentiable in the neighborhood of q^*, and the change in t must be infinitesimally small. If these assumptions are violated, we can use the monotonicity theorem (see Tremblay and Tremblay, 2008).

Appendix 3.2

The Effect of Excise Tax on the Equilibrium Price in Monopoly

This analysis follows Bishop (1968).

The monopolist's profit function is

$$\Pi = R(q) - C(q) - tq$$

where *R(q)* and *C(q)* are firm's total revenue and total cost.

The first-order condition for firm profit maximization:

$$\Pi' = R' - C' - t = 0$$

The second-order condition is

$$\Pi'' = R'' - C'' < 0.$$

Using implicit function[20], as applied to the first-order condition, we get:

$$\frac{dq}{dt} = \frac{1}{R'' - C''}$$

Multiplication by $\frac{dp}{dq} = p'$ gives result:

$$\frac{dp}{dt} = \frac{p'}{R'' - C''}.$$

This is always positive, since p' as define above and $R'' - C''$ are both negative.

[20] In order to use implicit function theorem, the objective function, $\Pi = R(q) - C(q) - tq$, must be concave and differentiable in the neighborhood of q^*, and the change in t must be infinitesimally small. If these assumptions are violated, we can use the monotonicity theorem (see Tremblay and Tremblay, 2008).

In the case of linear demand curve and constant marginal cost, $R'' = 2p'$, and $C''= 0$, we get:

$$\frac{dp}{dt} = \frac{p'}{2p' - 0} = \frac{1}{2}.$$

We can derive the effect of excise tax in the case of constant elasticity and constant marginal cost. For example, inverse demand is given by $p = kq^{-1/\varepsilon}$. Its elasticity is $\frac{dq}{dp}.\frac{p}{q} = -\varepsilon$, with $\varepsilon > 1$.[21] We can calculate that:

$$\frac{R'}{p} = \frac{R''}{p'} = \frac{\varepsilon - 1}{\varepsilon}.$$

Then we get,

$$\frac{dp}{dt} = \frac{p'}{R''} = \frac{\varepsilon}{\varepsilon - 1},$$

which is always greater than one as ε is greater than one.

[21] The first order condition for monopolist's profit maximization implies that $P\left(1 - \frac{1}{\varepsilon}\right) = MC$, for $MC > 0$, so ε has to be greater than 1.

Appendix 3.3

The Effect of Excise Tax on the Equilibrium Price in

a Generalized-Cournot Model

This analysis follows Stern (1987).

Let firm i produces output q_i. Q_{-i} represents the output of other firms in the industry. Total output of all firms in the industry is $Q = Q_{-i} + q_i$. Assuming constant marginal cost (c_i), firm i's profit (π_i) is

(1) $$\pi_i = p(Q)q_i - c_i q_i - tq_i$$

where t is a per unit tax.

The firm's first-order condition of profit maximization is

(2) $$\frac{d\pi_i}{dq_i} = p(Q) + q_i\left(\frac{dp}{dQ}.\frac{dQ}{dq_i}\right) - c_i - t = 0$$

Rearranging terms, abbreviating $p(Q)$ as p, yields

(3) $$p\left\{1 + \left(\frac{Q}{p}.\frac{\partial p}{\partial Q}\right)\left(\frac{\partial Q}{\partial q_i}.\frac{q_i}{Q}\right)\right\} - c_i - t = 0 \text{, or}$$

(4) $$p\left\{1 - \frac{1}{\varepsilon}\frac{\partial Q}{\partial q_i}s_i\right\} - c_i - t = 0$$

where ε is the elasticity of demand, and s_i is firm i's market share, $\frac{\partial Q}{\partial q_i}$.

Follow Stern (1987), assume that the reactions of other firms to a small change in firm i's output satisfies

$$\frac{\partial Q_{-i}}{\partial q_i} = \frac{\partial (Q - q_i)}{\partial q_i} = \alpha\left(\frac{Q - q_i}{q_i}\right)$$

$$\frac{\partial (Q_{-i} - q_i)}{\partial q_i} s_i = \frac{\partial Q_{-i}}{\partial q_i} s_i + \frac{\partial q_i}{\partial q_i} s_i = \alpha\left(\frac{Q - q_i}{q_i}\right) s_i + s_i = \alpha + (1-\alpha)s_i$$

Substitute this into the (4), and rearrange the equation, we get

(5) $$p\left\{1 - \frac{(\alpha + (1-\alpha)s_i}{\varepsilon}\right\} - c_i - t = 0 \; p\left\{1 - \frac{(\alpha + (1-\alpha)s_i}{\varepsilon}\right\} - c_i - t = 0$$

Adding and dividing by the number of active firms, n, we get

(6) $$p\left(1 - \frac{\gamma}{\varepsilon}\right) - c - t = 0$$

where $c = \sum_i c_i / n$ and $\gamma = \alpha + (1-\alpha)/n$. Assume that all firms in the market are identical.

The condition for positive outputs, requires, $\varepsilon > \gamma$.

Applying the implicit function theorem to (6)[22], we can get the effect of excise tax change on price as

(6) $$\frac{dp}{dt} = \frac{1}{\left(1 - \frac{\gamma}{\varepsilon} + \frac{F\gamma}{\varepsilon}\right)}$$

[22] In order to use implicit function theorem, the objective function, $\pi_i = p(Q)q_i - c_i q_i - tq_i$, must be concave and differentiable in the neighborhood of q^*, and the change in t must be infinitesimally small. If these assumptions are violated, we can use the monotonicity theorem (see Tremblay and Tremblay, 2008).

where $F = \frac{p\varepsilon'}{\varepsilon}$ $F = \frac{p\varepsilon'}{\varepsilon}$ and ε is the elasticity of demand and the prime denotes the derivative with respect to price.

According to Seade (1980), stability of the generalized-Cournot equilibrium requires that $F > 1 - \frac{\varepsilon}{\gamma}$ $F > 1 - \frac{\varepsilon}{\gamma}$ or $1 - \frac{\gamma}{\varepsilon} + \frac{F\gamma}{\varepsilon} > 0$, as a result, imposing a tax will cause an increase in price. The tax will be over-shifted if F is less than one.

If demand has constant elasticity, constant ε implied that $F = 0$, the tax will be over-shifted. In the case of linear demand, $Q = a - bp = b(p^* - p)$, where $p^* = a/b$ is the price which gives zero demand, the elasticity of demand is equal to $p/(p^* - p)$ and $F = p^*/(p^* - p)$; equation (5) can be written as

$$p = \frac{1}{1+\gamma}(c+t) + \frac{\gamma}{1+\gamma}p^* .$$

So $\frac{dp}{dt} = \frac{1}{1+\gamma}$, which is less than one if γ is positive; consumers and producers will share the tax burden.

Chapter 4

General Conclusion

This research investigates two important issues involving alcohol markets. Chapter 2 examines market structure and estimates market power in the U.S. brewing industry, a classic issue in industrial organization. Assuming no externalities, the degree of market power can be used as an indicator of allocative efficiency in a market. We present two methods to analyze market structure and estimate the degree of market power.

Nonparametric analysis, following Ashenfelter and Sullivan (1987), shows that firm behavior in the U.S. brewing industry is not consistent with the cartel hypothesis. In addition, the numbers equivalent of firms suggests that there is at least a moderate amount of competition in the U.S. brewing industry.

The nonparametric results are valid only if demand and costs are stable. However, the results from previous studies and the results from the parametric part of the study indicate that the U.S. brewing industry experienced considerable technological change and productivity growth, so the maintained hypothesis that costs are constant may be untrue. If we can modify the test in a way that can capture these changes, then the test will be more reliable.

Given this problem, we also measure the degree of market power using parametric methods. The structural econometric model of addiction is derived from a dynamic oligopoly game. We estimate a market demand and a dynamic industry supply relation simultaneously using the method proposed by Hatanaka (1976). The estimation results suggest that the U.S. brewing industry is quite competitive which is consistent with the results from the nonparametric method and from previous studies. We also find that the degree of market power is higher when concentration is higher.

In chapter 3, we study the relationship between beer taxes and prices using a reduced-form equation derived from the structural model in chapter 2. Consistent with most previous studies, the federal excise tax for beer is over-shifted, which means that price of beer increases more than an increase in the tax. On the other hand, the state excise tax is not fully passed through. There are at least two reasons for this outcome: bootlegging across states because of the difference of tax rates between states, and an uncoordinated state tax policy. The results imply that, in order to decrease alcohol's adverse consequences, a policymaker should focus on increasing the federal excise tax rather than depending on an uncoordinated policy by individual states to raise their state excise tax rates.

References

Appelbaum, E. (1979). "Testing price taking behavior". *Journal of Econometrics, 9*(3), 283-294.

Appelbaum, E. (1982). "The estimation of the degree of oligopoly power". *Journal of Econometrics 19*(2-3), 287-299.

Ashenfelter, O., and Sullivan, D. (1987). "Nonparametric tests of market structure: An application to the cigarette industry". *The Journal of Industrial Economics 35*(4), 483-498.

Barnett, P., Keeler, T., and Hu, T,. (1995). "Oligopoly structure and the incidence of cigarette excise taxes*".* *Journal of Public Economics, 57*(3), 457-470.

Barzel, Y. (1976). "An alternative approach to the analysis of taxation". *Journal of Political Economy 84*(6), 1177-1197.

Beard, T., Gant, P., and Saba, R. (1997). "Border-Crossing sales, tax avoidance, and state tax policies: An application to alcohol". *Southern Economic Journal 64*(1), 293-306.

Besley, T. (1989). "Commodity taxation and imperfect competition: A note on the effects of entry". *Journal of Public Economics 40*(3), 359-67.

Bishop, R. L. (1968). "The effects of specific and ad valorem taxes". *The quarterly Journal of Economics 82*(2), 198-218.

Bresnahan, T. (1982). "The oligopoly solution concept is identified". *Economic Letters*, *10*(1-2), 87-92.

Bresnahan, T. (1989). Empirical studies on industries with market power. In R. Schmalensee and R. Willig (Eds), *Handbook of Industrial Organization: Vol.2.,* 1011-1057. Amsterdam: North-Holland.

Brewers Almanac. (various issues). United States Brewers Association.

Brewers Digest, Buyers Guide and Brewery Directory, (various issues).

Brewers of Europe. (2004). *The benefits of moderate beer consumption* (3rd ed.). Retrieved May 20, 2008, from http://www.brewersofeurope.org/docs/publications/pdf-Mei04.pdf

Bulow, J., and Pfleiderer, P. (1983). "A note on the effect of cost changes on prices". *Journal of Political Economy*, *91*(1), 182-185.

Centers for Disease Control and Prevention, Department of Health and Human Services. (2008). *Quick Stats General Information on Alcohol Use and Health*. Retrieved May 20, 2008 from http://www.cdc.gov/alcohol/quickstats/general_info.htm

Center for Science in the Public Interest: Alcohol Policies Project. (2004). *Factbook on State Beer Taxes*. Retrieved April 25, 2008 from http://cspinet.org/booze/taxguide/040802BeerReport.pdf

Chaloupka, F. J. (1991). "Rational addictive behavior and cigarette smoking". *Journal of Political Economy 99*(4), 722-742.

Chaloupka, F. J., Grossman, M., and Saffer, H. (2002). "Effects of price on alcohol consumption and consequences". *Alcohol Research & Health* 26(1), 22-34.

Chaloupka, F. J., Saffer, H., and Grossman, M. (1993). "Alcohol-control policies and motor-vehicle fatalities". *Journal of Legal Studies 22*(1), 161–186.

Chen C. M., and Yi H. (2007). Trends in alcohol-related morbidity among short-stay community hospital discharges, United States, 1979-2005. National Institutes of Health, National Institute on Alcohol Abuse and Alcoholism. *NIAAA Surveillance Report #80.* Retrieved March 28, 2008, from http://pubs.niaaa.nih.gov/publications/surveillance80/HDS05.pdf

Chesson, H., Harrison, P., and Kassler, W. J. (2000). "Sex under the influence: The effect of alcohol policy on sexually transmitted disease rates in the United States". *Journal of Law and Economics 43*(1), 215–238.

Coate, D., and Grossman, M. (1988). "Effects of alcoholic beverage prices and legal drinking ages on youth alcohol use". *Journal of Law and Economics 31*(1), 145–171.

Cook, P. J., and Moore, M. J. (1993). "Economic perspectives on reducing alcohol-related violence". In: Martin, S.E., ed. *Alcohol and Interpersonal Violence: Fostering Multidisciplinary Perspectives*. NIAAA Research Monograph No. 24, NIH Pub. No. 93–3496. Bethesda, MD: National Institute on Alcohol Abuse and Alcoholism, 193–212.

Cook, P. J., and Tauchen, G. (1982). "The effect of liquor taxes on heavy drinking". *Bell Journal of Economics 13*(2), 379–390.

Corts, K.S. (1999). "Conduct parameters and the measurement of market power". *Journal of Econometrics, 88*(2), 227-250.

Dee, T. S. (1999). "State Alcohol Policies, Teen Drinking, and Traffic Fatalities". *Journal of Public Economics 72*(2), 289-315.

Delipalla, S., and O'Donnell, O. (2001). "Estimating tax incidence, market power and market conduct: The European cigarette industry". *International Journal of Industrial Organization 19*(6), 885-908.

Denney, D., Lee, B., Noh, D. W., and Tremblay V. (2002). "Excise taxes and imperfect competition in the U.S. brewing industry". Working Paper, Department of Economics, Oregon State University.

Godfrey, L. (1978). " Testing against general autoregressive and moving average error models when the regressors include lagged dependent variables". *Econometrica*, *46*(6), 1293-1301.

Grossman, M. (1993). "The economic analysis of addictive behavior". In: Hilton, M.E., and Bloss, G., (Eds.), *Economics and the Prevention of Alcohol-Related Problems,* 91–123. NIAAA Research Monograph No. 25, NIH Pub. No. 93–3513. Bethesda, MD: National Institute on Alcohol Abuse and Alcoholism.

Harwood, H. (2000). *Updating estimates of the economic costs of alcohol abuse in the United States: Estimates, update methods, and data.* Report prepared by The Lewin Group for the National Institute on Alcohol Abuse and Alcoholism.

Hatanaka, M. (1974). "An efficient two-step estimator for the dynamic adjustment model with autoregressive errors". *Journal of Econometrics, 2*(3), 199-220.

Hatanaka, M. (1976). "Several efficient two-step estimators for the dynamic simultaneous equation model with autoregressive disturbances". *Journal of Econometrics, 4*(2), 189-204.

Hirschey, M., and Pappas, J.L. (1992). *Fundamentals of Managerial Economics (4 ed.).* The Dryden Press.

Iwasaki, N., Seldon, B., Tremblay, V. J. (2009) "Brewing Wars of Attrition for Profit (and Concentration)". *Review of Industrial Organization* **33**:4, 263-279.

Jarmin, R. S. (1994). "Learning by Doing and Competition in the Early Rayon Industry". *Rand Journal of Economics, 25*(3), 441-454.

Kenkel, D. S. (1996). "New estimates of the optimal tax on alcohol". *Economic Inquiry 34*(2), 296-319.

Kenkel, D. S. (2005). "Are alcohol tax hikes fully passed through to prices? evidence from Alaska". *American Economic Review 95*(2), 273-277.

Kerkvliet, J R., Nebesky, W., Tremblay, C. H., and Tremblay, V. J. (1998). "Efficiency and technological change in the U.S. brewing industry". *Journal of Productivity Analysis 10*(3), 271-288.

Manning, W., Blumberg, L., and Moulton, L. (1995). "The demand for alcohol: The differential response to price". *Journal of health Economics 14*(2), 123-148.

Marin Institute Report. (2008). The annual catastrophe of alcohol in California. Retrieved July 25, 2008, from http://www.marininstitute.org/site/resources/reports/18-reports/98-the-annual-catastrophe-of-alcohol-in-california.html

Markowitz, S. (2000). "The price of alcohol, wife abuse and husband abuse". *Southern Economic Journal 67*(2), 279–303.

Markowitz, S., and Grossman, M. (1998). "Alcohol regulation and domestic violence towards children". *Contemporary Economic Policy 16*(3), 309–320.

Markowitz, S., and Grossman, M. (2000). "The effects of beer taxes on physical child abuse. *Journal of Health Economics 19*(2), 271–282.

Mast, B. D., Benson, B. L., and Rasmussen, D. W. (1999). "Beer taxation and alcohol-related traffic fatalities". *Southern Economic Journal 66*(2), 214–249.

McCaig L. F., and Burt C. W. (2005). "National hospital ambulatory medical care survey: 2003 emergency department summary". *Advance data from vital and health statistics; No 358*. Retrieved April 28, 2008, from http://www.cdc.gov/nchs/data/ad/ad358.pdf

Minnesota Department of Health. (2006). *The human and economic cost of alcohol use in Minnesota.* Retrieved May 2, 2008, from www.health.state.mn.us/divs/hpcd/chp/alcohol/pdf/final2004costfactsheet.pdf

Mokdad A. H., Marks J. S., Stroup D. F., and Gerberding J. L. (2004). "Actual causes of death in the United States, 2000". *Journal of American Medical Association, 291*(10), 1238–1245.

Nevo, A.((2001). "Measuring market power in the ready-to-eat cereal industry". *Econometrica, 69*(2), 307-342.

Novshek, W. (1993). *Mathematics for Economists*. New York: Academic Press.

Ohsfeldt, R. L., and Morrisey, M. A. (1997). "Beer taxes, workers' compensation, and industrial injury". *Review of Economics and Statistics 79*(1), 155-160.

Pagan, A., and Ullah, A. (1999). *Nonparametric Econometrics*. Cambridge University Press.

Panzar, C., and Rosse, J. (1987). "Testing for "monopoly" equilibrium". *Journal of Industrial Economics 35*(4), 433-456.

Roberts, M. J. and Samuelson L. (1988). "An empirical analysis of dynamic, non-price competition in an oligopolistic industry". *Rand Journal of Economics*, *19(2),* 200-220.

Saffer, H., and Grossman, M. (1987). "Beer taxes, the legal drinking age, and youth motor vehicle fatalities". *Journal of Legal Studies 16*(2), 351–374.

Seade, J. (1980). "The stability of Cournot revisited". *Journal of Economic Theory 23*(1), 15-27.

Sheather, S. J., and Jones, M. C. (1991). "A reliable data based bandwidth selection method for kernel density estimation". *Journal of the Royal Statistical Society, Series B, 53*(3), 683-690.

Sloan, F. A., Bridget A. R., and Cristoph M. S. (1994). "Tort liability versus other deterring careless driving policies". *International Review of Law and Economic 14*(1), 53-71.

Stern, N. (1987). "The effects of taxation, price control and government contracts in oligopoly and monopolistic competition". *Journal of Public Economics, 32*(2), 133-158.

Stout, E. M., Frank A. S., Lang L., and Hester H. D. (2000). "Reducing harmful alcohol-related behaviors: Effective regulatory methods". *Journal of Studies on Alcohol 61*(3), 402-412.

Sullivan, D. (1985). "Testing hypotheses about firm behavior in the cigarette industry". *The Journal of Political Economy*, *93*(3), 586-598.

Sumner, D. (1981). "The measurement of monopoly power: An application to the cigarette industry". *The Journal of Political Economy*, *89*(5), 1010-1019.

Tremblay, V. J. (1987). "Scale economies, technological change, and firm cost asymmetries in the U.S. brewing industry". *Quarterly Review of Economics and Business 27*(2), 71-86.

Tremblay, V. J., and Tremblay, C. H. (1995). "Advertising, price, and welfare: Evidence from the U.S. brewing industry". *Southern Economic Journal, 62*(2), 367-381.

Tremblay, V. J., and Tremblay, C. H. (2005). *The U.S. Brewing Industry: Data and Economic Analysis*. The MIT Press.

Tremblay, V. J., and Tremblay, C. H. (2008). *The Neglect of Monotone Comparative Statics Methods*. Working paper.

United States. Bureau of the Census. (various issues). *Statistical Abstract of the United States.* U.S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census.

United States. Office of Prices and Living Conditions. (various issues). *CPI Detailed Report*. U.S. Department of Labor, Bureau of Labor Statistics.

Varian, H. (1992). *Microeconomic Analysis*. Norton.

Xia, Yin, and Buccola, S. (2003). "Factor use and productivity change in the alcohol beverage industries". *Southern Economic Journal 70*(1), 93-109.

Young, D. J., and Bielinska-Kwapisz, A. (2002). "Alcohol taxes and beverage prices". *National Tax Journal, 55*(1), 57-73.

Young, D. J., and Bielinska-Kwapisz, A. (2006). "Alcohol prices, consumption, and traffic fatalities". *Southern Economic Journal*, *72*(3), 690-703.

Young, D. J., and Likens, T. W. (2000). "Alcohol Regulation and Auto Fatalities". *International Law and Economics 20*(1), 107-126.