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Liberalization of the market for alcohol: Evidence from a Canadian province

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Abstract

We estimate demand and cost functions to determine the optimal policy to regulate the alcohol industry. Interestingly, we show that marginal and average costs may not be constant, as generally assumed in the literature on alcohol industry. A key policy implication from our estimates is that state monopoly is not necessarily the only means, let alone the best, both for maximizing revenue and reducing the social costs of alcohol consumption. Indeed, optimal taxation in a liberalized competitive market can yield a higher net social benefit. We also provide additional elasticities information on alcohol products.

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1 Introduction

Alcohol distribution and sale is one of the most heavily regulated industries in North America, and the forms of regulation vary greatly across jurisdictions. In some cases, regulation occurs through taxation in a private competitive market, while ownership and alcohol state monopolies apply in others. For example, the former prevails in Alberta (the only Canadian province with a fully privatized alcohol retail system) and in US 'license' states, whereas government monopolies control the liquor industry (retailing, wholesaling, or both) in US 'control' states and most of Canadian provinces. Moreover, the exact form of control varies from one context to another.[1]

In fact, variations in the forms of regulation have prompted questions on the role of governments in the control of alcohol distribution and sale. Especially, why and how should the alcohol industry be regulated? Unsurprisingly, answers to such normative questions in the public discourse are divisive and increasingly a matter of recurring debates in various jurisdictions and contexts, most often from an ideological perspective. For instance, as emphasized by Flanagan (2016), arguments for deregulation and privatization are essentially based on most common myths around alcohol: alcohol is just an ordinary product and should be treated as such; competition raises efficiency and lowers costs (prices); competition will somehow increase government tax revenue from alcohol sales. Meanwhile, critics of privatization constantly argue that it would lead to higher prices for consumers and cause governments to lose dividends from monopoly rent. Yet, government policies to control alcohol distribution and sale should be evidence based. The purpose of this paper is therefore to contribute to this complex debate on alcohol (de)regulation.

Essentially, alcohol regulation aims to generating tax revenue (e.g., J. P. Nelson, 2007; Seim & Waldfogel, 2013) and controlling alcohol consumption to internalize the associated external costs (e.g., T. Miller et al., 2006; Norstrom et al., 2010; Patra et al., 2011; Tyrfingsson et al., 2015).[2] An interesting question would then be to determine the best regulatory policy to achieve this dual goal. Specifically, are there some better alternatives to alcohol state monopolies? In a theoretical paper, Keutiben & Tatoutchoup (2019) showed that state monopolies could be inefficient for maximizing government revenue or net social benefit.[3] Actually, they emphasized that market demand and most importantly the industry cost structure are crucial for determining the optimal regulatory policy.

The objective of this paper is twofold. First, to estimate the demand and cost functions of the alcohol industry in the province of New Brunswick in Canada. Second, from the estimated parameters, to determine the optimal regulatory policy for controlling the distribution and sale of alcoholic beverages. More recently, using a loose measure of monopoly power, Zullo (2017) tested the effect of state monopolies on alcohol-related state income and pointed

[1] In all Canadian provinces, the wholesale distribution of alcohol is controlled by government monopolies which, except in Alberta, are also dominant retailers. Two provinces (New Brunswick and Prince Edward Island) operate full government retail monopolies while the remaining seven provinces have a mixed system involving both public and private firms, with public firms dominating the retail market. More details on the regulatory structure of alcohol sales in Canada can be found in Thomas (2012).

[2] A critical review of this literature can be found in J. Nelson & McNall (2016).

[3] Net social benefit is defined as the difference between government revenue and the external cost of alcohol consumption.

out that “in terms of income generation, state ownership of alcohol distribution and sales is preferable over a private market model featuring third-party state regulation.” Nonetheless, our approach is different as we clearly define monopoly power and, most importantly, our analysis is drawn on estimating demand and cost functions as underlined in Keutiben & Tatoutchoup (2019).

Our empirical analysis suggests that a “one-size-fits-all” approach to regulation must be abandoned and effective policies should be tailored to the specific characteristics of the case under consideration. Accordingly, optimal regulatory policy may vary from one context to another. For example, our empirical findings clearly suggest that the current state monopoly on alcohol distribution and sale in New Brunswick is inefficient, at least for wine and beer, both for generating tax revenue or internalizing the external costs of alcohol consumption. Likewise, it would be surprising that the fully privatized alcohol retail system in Alberta were optimal, given that it was implemented without any thorough evaluation.

The paper is organized as follows. Section 2 briefly sketches the theoretical framework while Section 3 provides the empirical estimation of market demand and cost functions. Section 4 uses the estimates to calibrate the parameters and discusses some policy implications. Section 5 concludes the paper.

2 Theoretical Framework

Consider a state-owned monopoly that produces a homogeneous good. Denote by $c(Q)$ and $P(Q)$ the cost function and the inverse market demand function respectively, where Q is the output produced. We analyze whether optimal taxation in a competitive market can be a better alternative to the state monopoly. Let $n \geq 2$ be the number of firms in the market after liberalization and entry.[4] For simplicity, we assume that firms are identical. Thus, the cost function of a given firm is $c(q) = C(Q)/n$, where $q = Q/n$ is a typical firm's output and Q is the aggregate output. Assume that the external cost of alcohol harm is linear in quantity consumed and denote by $s \geq 0$ its marginal cost.

Let's assume that under liberalization, the government uses a general class of linear taxation (τ, l), where $\tau \geq 0$ is the per-unit tax (a fixed dollar amount per unit of output) and l is a lump-sum transfer (license) from a given firm. For revenue maximization, any optimal alternative to the state monopoly is determined through a two-stage game. First, the government sets (τ, l, n), to solve:[5]

$$\begin{aligned} \max_{\tau,l,n} \quad G(\tau,l,n) &= n(\tau q + \theta l) - s(Q - Q^m) && (1) \\ \text{s.t} \quad nq &\geq Q^m && (2) \\ \pi^\tau(q,\tau,l) &\geq 0 && (3) \\ G(\tau,l,n) &\geq \pi^m. && (4) \end{aligned}$$

[4]We consider both the case where the state monopoly continues to produce and the case where it is dismantled.

[5]The parameter θ identifies the market structure: $\theta = 1$ for oligopoly while $\theta = 0$ for perfect competition.

Second, given (τ, l), each firm chooses $q \geq 0$ so as to:

$$\max_q \pi^\tau(q, \tau, l) = p(Q)q - c(q) - \tau q - \theta l. \tag{5}$$

$Q^m > 0$ and $\pi^m > 0$ are monopoly output and profit respectively. Equation (2) says that (τ, l) must not reduce the degree of consumer satisfaction. Equation (3) says that firms should earn a nonnegative profit. Equation (4) says that (τ, l) must provide greater revenue to the government than dividend it collects under state monopoly. Conditions (2)-(4) are necessary for market liberalization. Keutiben & Tatoutchoup (2019) showed that liberalizing is a better alternative to state monopoly if and only if the monopoly quantity were in the range of output where there are diseconomies of scale. Additionally, they showed that post tax quantity will increase only if the social cost of consuming the good were below a threshold value. Interestingly, they emphasized that oligopoly is a better alternative to the state monopoly than perfect competition. Drawing on Keutiben & Tatoutchoup (2019), we solve the theoretical model using specific cost and demand functions. The solution sketched in the Appendix will be calibrated to determine the optimal market structure.

3 Empirical Framework

To determine the optimal regulatory policy, we need to estimate cost and market demand functions. Given the heterogeneity of alcoholic beverages, we follow the literature and the distinction made by the retailing sector to divide alcoholic beverages into three well known categories: wine, spirits and beer.

3.1 Econometric Specification

The cost function c^i of each product $i = w, s, b$ depends on Q^i, the total quantity of product i sold in the market.[6]

$$c_t^i = \beta_0^i + \beta_1^i Q_t^i + \beta_2^i (Q_t^i)^2 + \xi_{1t}^i, \; i = w, s, b; \; t = 1, ..., T. \tag{6}$$

Note that $c_t^i = C_t^i - Tax_t^i$, where C_t^i is the observed total cost including the time-varying per unit tax Tax_t^i on product i; β_0^i, β_1^i, β_2^i are coefficients to be estimated and ξ_{1t}^i are error terms. The subscript t refers to time, and T is the total number of observations. To be consistent with the properties of a cost function, we must have $\beta_0^i \geq 0$, $\beta_1^i \geq 0$ and $\beta_2^i \geq 0$. This functional form allows to test for quadratic specification ($\beta_2^i > 0$), linear specification with a fixed cost ($\beta_2^i = 0$) and constant returns to scale technology ($\beta_2^i = 0$ and $\beta_0^i = 0$).

To estimate the market demand function, we assume a linear specification:

$$Q_t^i = \delta_p^i P_t^i + X_t^i \alpha^i + \xi_{2t}^i, \; i = w, s, b; \; t = 1, ..., T. \tag{7}$$

The variable P^i is the market price of product i, δ_p^i is the parameter of interest, X^i is a $T \times k$ matrix of $k > 3$ control variables affecting the demand function, and ξ_{2t}^i are error terms.

[6] The superscripts w, s, b refer to wine, spirits and beer respectively.

The monopoly equilibrium price and quantity are simultaneously determined by:

$$P_t^i - Tax_t^i = \beta_1^i + (2\beta_2^i - 1/\delta_p^i)Q_t^i + \xi_{3t}^i,\ i = w, s, b;\ t = 1, ..., T; \tag{8}$$

where ξ_{3t}^i are error terms. Equation (8) is obtained by equalizing marginal revenue and full marginal cost, where the full marginal cost includes the time-varying per unit tax, Tax_t^i, on product i. Equation (8) is equivalent to the following constrained equation

$$\begin{aligned} P_t^i - Tax_t^i &= \delta_0^i + \delta_1^i Q_t^i + \xi_{4t}^i,\ i = w, s, b;\ t = 1, ..., T; \\ \delta_0^i &= \beta_1^i, \quad \delta_1^i = 2\beta_2^i - 1/\delta_p^i. \end{aligned} \tag{9}$$

Equations (6), (7) and (9) constitute a simultaneous equations model (SEM), where for each i, C^i, Q^i and P^i are endogenous variables; Tax^i and the set of variables X^i are exogenous.

3.2 Identification and Estimation

The order condition for identification of an equation requires that the number of excluded exogenous variables from the equation is at least greater than the number of right-hand side endogenous variables. Therefore, for each product i, the order condition for identification indicates that equation (6) of the cost function is overidentified, while equation (7) of the market demand is just identified. Indeed, in equation (6) we have $k-1$ exclusions, because the set of exogenous variables X^i excluded has $k-1 > 2$ elements (only the constant is not excluded). The same is true for equation (9). No exogenous variable is excluded in equation (7); however because of the restriction $\delta_1^i = 2\beta_2^i - 1/\delta_p^i$, this equation becomes exactly identified.

Although our three-equation system can be nonlinear in endogenous variables, for instance, if $\beta_2^i > 0$ in (6), it can still be estimated by Two-Stage Least Squares (2SLS).[7] To account for the restriction on parameters in equation (9) and to focus on long-run relationship between variables, we proceed as follows, for each product i.

Step 1: Regress each endogenous variable Q^i and P^i on exogenous variables (Tax^i and the set of variables X^i) to obtain the fitted values $\hat{Q}^i$ and $\hat{P}^i$ respectively.

Step 2: Estimate equation (6) by OLS substituting Q^i with $\hat{Q}^i$ to get $\hat{\beta}_0^i$, $\hat{\beta}_1^i$, and $\hat{\beta}_2^i$.

Step 3: Regress (without constant) $\hat{Pe}^i = \hat{P}^i - \hat{\beta}_1^i - Tax^i$ on $\hat{Q}^i$ from equation (9) to get $\hat{\delta}_1^i$ and thus $\hat{\delta}_p^i$, since $\hat{\delta}_1^i = 2\hat{\beta}_2^i - 1/\hat{\delta}_p^i$.

Step 4: From equations (7) and (9), derive the reduced form of the demand in terms of the structural parameters as

$$\hat{Q}^i = \frac{\hat{\delta}_p^i \hat{\beta}_1^i + \hat{\delta}_p^i Tax^i + X^i \alpha^i}{2(1 - \hat{\delta}_p^i \hat{\beta}_2^i)} + \frac{\xi_2^i + \hat{\delta}_p^i \xi_4^i}{2(1 - \hat{\delta}_p^i \hat{\beta}_2^i)}.$$

Then, regress by OLS $\hat{Y}^i = 2\hat{Q}^i(1 - \hat{\delta}_p^i \hat{\beta}_2^i) - \hat{\delta}_p^i \hat{\beta}_1^i - \hat{\delta}_p^i Tax^i$ on X^i to get parameters $\hat{\alpha}^i$.

Step 5: Cointegration test, if variables used to estimate cost and demand are nonstationary

[7] Strickland & Weiss (1976) used 2SLS to estimate a similar system and obtained unbiased and consistent estimators. 2SLS is used to correct the simultaneity bias in OLS.

and integrated of order 1. Following Engle & Granger (1987), we perform a stationarity test on the residuals of each model. If residuals are stationary, then there exists a long run relationship between the dependent and explanatory variables, thus validating the model.

3.3 Data

Table 1 – List of variables

Notation	Description	Unit	Data sources
Q^i	Total quantity of liquor i	Millions of litres	Table 10-10-0010-01
P^i	Market price of liquor i	\$/litre	Total sales/total quantity
C^i	Total cost of liquor i	Millions of dollars	Annual reports of ANBL
Inc	Disposable per capita income aged 19+	Thousands of dollars	Table 36-10-0229-01
Pop	Population	Thousands	Table 17-10-0005-01
$Pop19$	Population aged 19+	Thousands	Table 17-10-0005-01
$R35$	Growth rate of the population aged 35+	Percentage	Table 17-10-0005-01
$P65$	Proportion of population aged 65+	Percentage	Table 17-10-0005-01
$Urate$	Unemployment rate	Percentage	Table 14-10-0288-01
Tax^i	Tax per unit on i	\$/litre	Annual reports of ANBL

Tables are from Statistics Canada while taxes and sales data are from ANBL's annual reports spanning 1976-2016. The superscripts $i = w, s, b$ refer to wine, spirits and beer respectively.

The dataset includes annual observations from 1976 to 2016 with variables described in Table 1. The total cost of each product C^i equals the purchasing cost plus operating expenses. Since ANBL is a multi-product monopoly, operating expenses (salaries, rent, and other expenses) are only available for all products together. Therefore, we assume that operating expenses for each product are proportional to its sale share.[8] Control variables include the *per capita* disposable income (Inc), unemployment rate ($Urate$) and demographic variables (Pop, $Pop19$, $P65$, $R35$).[9] Summary statistics are presented in Table 2.

[8] C^i = purchase cost of product i + $weight^i *$ total operating expenses, where $weight^i = S^i/(S^w+S^s+S^b)$, S^i being the total sales of product $i = w, s, b$. All dollars values are converted in real values of 2002 using the consumer price index from Statistics Canada.

[9] Because of the ongoing debates regarding the exogeneity of the population in empirical Industrial Organization literature, we find necessary to test the exogeneity of all demographic variables using the Hausman test. We follow the Hausman procedure and for identification of equation (7) the lag of each demographic variable and the lag of own price are used as instruments. It follows from the results that we cannot reject the null hypothesis of the exogeneity of all demographic variables, including the population (we performed a F-test on the residuals of demographic variables obtained in the first stage of the Hausman procedure).

Table 2 – Summary statistics of data used in the estimation

Variables	Mean	Std. Dev.	Min	Max
Q^w(Millions of litres)	3.653	1.304	2.255	6.714
Q^s(Millions of litres)	3.202	0.5449	2.756	4.487
Q^b(Millions of litres)	48.87	2.960	43.90	55.06
P^w ($/litre)	9.610	1.016	7.909	12.10
P^s ($/litre)	26.74	2.026	24.12	30.10
P^b ($/litre)	3.462	0.2847	2.812	4.025
C^w (Millions of dollars)	21.65	9.749	11.79	47.11
C^s (Millions of dollars)	51.38	8.578	41.74	70.18
C^b (Millions of dollars)	102.1	12.33	71.52	119.1
Tax^w ($/litre)	1.259	0.303	0.746	1.748
Tax^s ($/litre)	3.514	0.850	2.129	5.649
Tax^b ($/litre)	0.464	0.134	0.225	0.692
Inc (Thousands of dollars)	17.10	3.175	12.38	22.47
Pop (Thousands)	737.7	19.82	689.5	757.4
$Pop19$ (Thousands)	537.1	54.32	419.6	605.9
$P65$ (%)	13.00	2.72	8.94	19.52
$R35$ (%)	1.616	0.642	0.541	2.634
$Urate$ (%)	11.32	1.876	7.50	15.20

Total number of observations = 41, except for $R35$ which is 40.

3.4 Estimation results

Before estimating the model, we perform stationarity tests for all variables included in our dataset. The results from three well known tests reported in Appendix (see Table A.1) show that $P65$ is $I(2)$ while all other variables are $I(1)$. Accordingly, first difference is applied for $P65$. Furthermore, F-tests of overall significance and the R-squared from stage one of 2SLS reported in Appendix (see Table A.2) show that the fitted values are very good predictors.[10]

Table 3 shows the estimation of cost functions. It follows from this table that the estimated cost function of wine is $\hat{c}^w(Q) = 0.595 + 3.17Q + 0.285Q^2$. The quadratic term $\hat{\beta}_2^w = 0.285$ is statistically significant at the 10% level. The R^2 of 0.968 means that the model explains 96.8% of the variation in the total cost of wine. Thus, the model provides a very good fit of data which is corroborated by the scatter plot presented in Figure 1.[11] Furthermore, the Residual Augmented Dickey Fuller test (Residual ADF test = -4.207) shows that the residuals of the regression are stationary at the 1% level. Therefore, the estimation of the cost function of wine is valid and suggests that the average total cost of wine is U-shaped.

The estimated cost function for beer exhibits constant returns to scale with the average

[10] To estimate the fitted values $\hat{Q}_t^i$ and $\hat{P}_t^i$ in step 1, lagged variables $\hat{Q}_{t-1}^i$ and $\hat{P}_{t-1}^i$ were used as instruments.

[11] We tested the linear specification. However, the intercept β_0^w, that represents the fixed cost were statistically negative, i.e., $\beta_0^w < 0$.

Table 3 – Estimation of cost functions

Parameter	Estimate	S.E.	t-statistic
		Cost function of wine	
$Const$	0.595	2.770	0.215
Q	3.317**	1.435	2.311
Q^2	0.285*	0.168	1.694
$R^2 = 0.968$	$R^2_{Adj} = 0.966$	Residual ADF test=-4.207***	Normality test: χ^2=3.898
		Cost function of spirits	
$Const$	19.185***	2.366	8.109
Q^2	2.034***	0.218	9.345
$R^2 = 0.697$	$R^2_{Adj} = 0.688$	Residual ADF test = -3.247***	Normality test: χ^2=8.114**
		Cost function of beer	
Q	1.640***	0.028	58.9
∓uncentered=0.988		Residual ADF test=-3.112***	Normality test: χ^2=9.109**

Significance Codes:‘ *** ’ 1%, ‘ ** ’ 5%, ‘ * ’ 10%.
Significance Codes:‘ ∓’ The uncentered R^2 does not measure the goodness of fit.

and marginal cost parameter significant at 1%.[12]

Table 3 also shows the selected model of the cost function of spirits for which the estimation is $\hat{c}^s(Q) = 19.185 + 2.034Q^2$. The quadratic term $\hat{\beta}_2^s = 2.034$ is statistically significant at the 1% level. The model explains 69.7% of the variability in the total cost of spirits, which represents a good fit of data as evidenced by the scatter plot provided in Appendix (see Figure A.1). The Residual Augmented Dickey Fuller test (Residual ADF test = -3.247) rejects the non-stationarity of residuals at the 1% level, thus validating the model. Accordingly, the cost function of spirits is quadratic and the average total cost is U-shaped. Finally, the estimated cost function of beer, $\hat{c}^b(Q) = 1.640Q$, exhibits constant returns to scale. The average and marginal cost parameter, $\hat{\beta}_1^b = 1.640$, is statistically significant at 1% level. The scatter plot is provided in Appendix (see Figure A.2).[13] The Residual Augmented Dickey Fuller test (Residual ADF test = -3.112) rejects the non-stationarity of residuals at the 1% level, meaning that cost and quantity are cointegrated and therefore have a long-run relationship. Therefore, the estimation of the cost function of beer is valid.

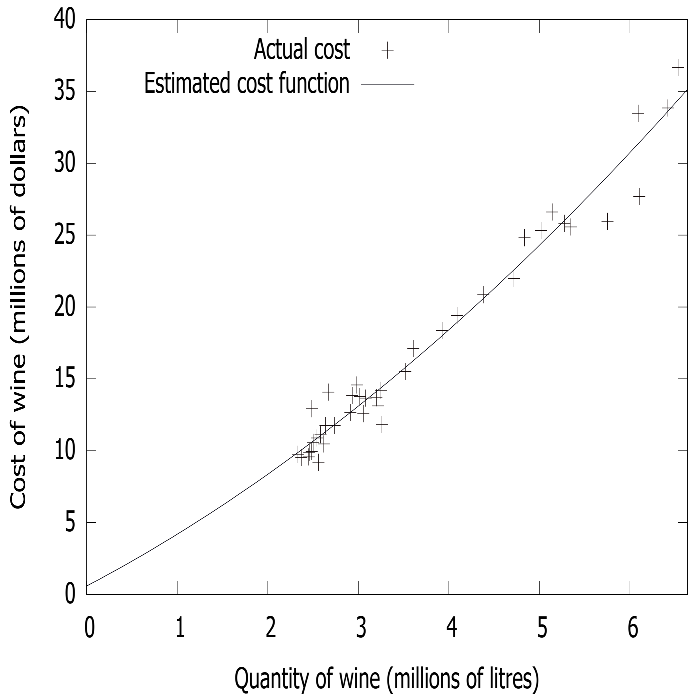
The estimation of demand functions is summarized in Table 4.[14] Coefficients of own price (in **bold**) are all significant at 1% with the expected negative sign. Meanwhile, own-price elasticities displayed in Table 5 clearly show that the monopoly maximizes its profit

[12]For the regression through the origin, the uncentered R^2 is used instead of the usual R^2. However, it does not measure the goodness of fit. The Residual Augmented Dickey Fuller test rejected the non-stationarity of residuals at 1%, meaning that cost and quantity are cointegrated and therefore have a long-run relationship.

[13]For the regression through the origin, the uncentered R^2 is used instead of the usual R^2. However, it does not measure the goodness of fit.

[14]In step 4, for the demand of beer, we used an estimator that is robust to heteroskedasticity and offers consistent standard errors and more efficient estimates compared to OLS. Residual ADF tests showed that variables are cointegrated, proving a long-run relationship and validating the regressions.

Figure 1 – Scatter plot of the cost function of wine



in the elastic part of the demand curve. Overall, our estimates of own-price elasticities are broadly in line with historical estimates reported by meta-analysis studies (J. P. Nelson, 2013; Fogarty, 2010; Gallet, 2007; Wagenaar et al., 2009). Besides, our own-price elasticity for beer is somewhat similar to the market own-price elasticities reported by N. H. Miller & Weinberg (2017) and N. H. Miller et al. (2019).[15]

[15] It is worth noting that N. H. Miller & Weinberg (2017) and N. H. Miller et al. (2019) also reported own-price elasticities for 13 brands of beer which, unsurprisingly and rightly, are substantially higher than the own-price elasticity for beer reported in Table 4.

Table 4 – Estimation of demand functions

	Dependent variables		
Explanatory Variables	Wine (Q^w)	Beer (Q^b)	Spirits (Q^s)
Constant	84.914***	250.602***	18.563***
	(20.445)	(19.107)	(1.847)
P^w	**-1.398*** **	-2.406**	0.202**
	(0.091)	(1.038)	(0.097)
P^b	-4.090***	**-35.875*** **	-1.378***
	(1.282)	(0.972)	(0.346)
P^s	0.457***	0.328	**-0.139*** **
	(0.132)	(0.378)	(0.003)
Inc	0.5611**	1.805**	0.104
	(0.246)	(0.771)	(0.087)
$R35$	-78.930	-681.525***	9.887
	(50.521)	(245.585)	(17.335)
Pop	-0.203***		
	(0.039)		
d_P65	256.542*	-3289.65***	54.599
	(132.364)	(510.52)	(45.892)
$Pop19$	0.110***	-0.112**	-0.019***
	(0.024)	(0.042)	(0.005)
$Urate$	0.205*	-1.200**	-0.0628
	(0.110)	(0.439)	(0.042)
Observations	40	40	40
R^2	0.978	0.839	0.947
R^2_{Adj}	0.973	0.796	0.937
F-stat	6.516***	22.794***	81.899***
Residual ADF test	-4.307***	-7.122***	-7.328***
Normality test	χ^2 =1.361	χ^2=15.104 ***	χ^2= 10.603 ***

Note that $R35$ and d_P65 were entered in the regression as ratios $\in$ (0,1), rather than in percentage.
Significance Codes: ‘ *** ’ 1%, ‘ ** ’ 5%, ‘ * ’ 10%.
Standard Errors in brackets.

4 Optimal market structure for alcohol

From the estimated cost and demand functions, we now calibrate the theoretical model to determine the optimal market structure for each beverage, using 2016, the last period in our dataset, as the benchmark year.[16] For context and to make it more clearly comprehensible,

[16]We used a sample size of 40 observations to estimate both the cost and demand functions. This sample size may be too small to estimate a simultaneous equations model. In such context, the estimates may be inconsistent if residuals are not normally distributed. Therefore, we ran normality tests on residuals (see χ^2 statistics in Tables 3 and 4). For wine, residuals of cost and demand functions are normally distributed, meaning that the estimates are unbiased and have robust standard errors. For spirits and beer, the null

Table 5 – Elasticities of Alcohol Products

Products	Own price elasticities	Income elasticities
Wine	-1.916***	0.558**
	(0.124)	(0.244)
Beer	-1.005***	0.632**
	(0.036)	(0.269)
Spirits	-1.015***	0.260
	(0.197)	(0.555)

Significance Codes:‘ *** ’ 1%, ‘ ** ’ 5%.
Standard Errors in brackets.

it's worth recalling briefly the main results from the theoretical analysis.[17]

- R1: If the state monopoly has diseconomies of scale or is producing in the range of output where there are diseconomies of scale, then the optimal regulatory policy is through taxation in an oligopoly market.
- R2: If the state monopoly has economies of scale or is producing in the range of output where there are economies of scale, then the optimal regulatory policy is to uphold the state monopoly.
- R3: In the case of constant returns to scale, optimal taxation in a privatized market yields the same outcome as the state monopoly.

4.1 Market structure for wine

Estimation shows that the average cost function for wine is U-shaped with its minimum at $\bar{Q}^w$=1.446 million litres. In the last four decades, the minimum quantity of wine sold by ANBL is 2.255 millions litres (see Table 2), meaning that the state monopoly is operating in the range of output where there are diseconomies of scale. Accordingly (see R1 above), the optimal market structure for wine is an oligopoly market with characteristics presented in Table 6. This would require the government to allow six firms in the wine market with an annual license fee of 1.554 million dollars per firm and a per-unit tax of \$5.243 per litre of wine.[18] This counterfactual plan suggests that government revenue would likely increase by 24.82% and total consumption of wine by 31.02%, while the price of wine would likely fall by approximately 12.5% to \$10.445 per litre.

Figure 2 illustrates the outcome of liberalization for revenue maximization (i.e., $s = 0$). While panel A shows that for $n \geq 2$, the quantity of wine sold under oligopoly is higher

hypothesis of the normality of residuals of cost and demand is rejected. Although 2SLS estimates are still unbiased in this case, they may not have minimum variance. Therefore, the results in the case of spirits and beer should be interpreted with due caution.

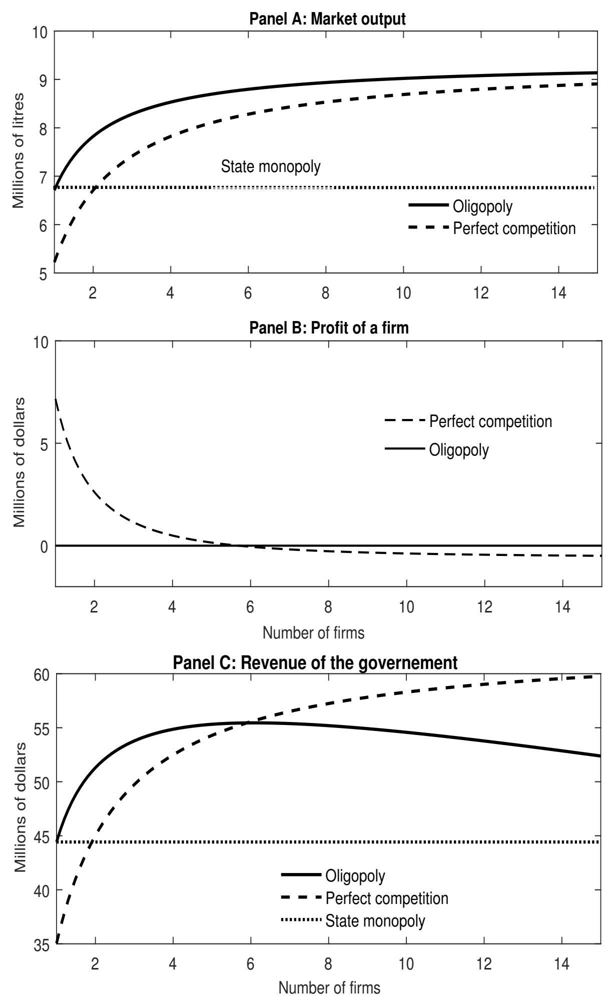
[17]See Proposition 1 and Proposition 3 in Keutiben & Tatoutchoup (2019).

[18]It's worth recalling that $\bar{Q} = \sqrt{\frac{\beta_0}{\beta_2}}$, $n_o^* = Q_o^*/\bar{Q} > 1$, $\tau_o^* = -(1 - 1/n_o^*)Q_o^*/\delta_p > 0$ and $l_o^* = -(Q_o^*/n^*)^2/\delta_p > 0$, where $Q_o^* = \frac{\delta_p(2\beta_2\bar{Q}+\beta_1)+a}{2}$, assuming only revenue maximization (i.e., $s = 0$). Refer to the solution of the theoretical model in the Appendix.

Table 6 – Optimal policy for wine: Oligopoly

Characteristics	Values
Number of firms	6
Per-unit tax	$5.243
License fee	$1.554 million
Change in the government's revenue	24.82%
Change in the quantity	31.02%
Change in the price	-12.48%
Change in Consumer surplus	71.87%

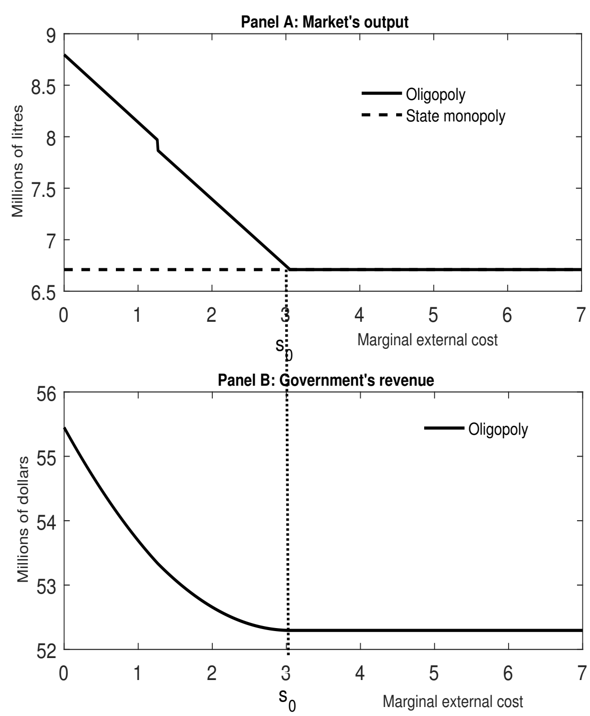
Figure 2 – Liberalization outcome for wine



than under perfect competition, it can be seen in panels B and C that in the long-run competitive equilibrium, where firms earn zero profit, the government collects the same revenue in oligopoly and perfect competition.

Accounting for the external cost of wine will not qualitatively change the results above if the marginal external cost of wine consumption is lower than the estimated threshold value $\hat{s}_0 = \$3$ per litre.[19] Optimal taxation would induce 5 or 6 firms in the market, depending on the value of the marginal external cost. However, if the marginal external cost is higher than $\hat{s}_0 = \$3$, the optimal mechanism with 5 firms operating in the market would give the same quantity as the state monopoly (see Figure 3) and government revenue would increase by 17.75%. For example, Rehm et al. (2006) estimated the total (direct and indirect) costs of alcohol consumption in New-Brunswick in 2002 to be 451.7 millions dollars. Based on this estimate, the external cost of wine consumption can be set at \$4.67 per litre.[20] Given that $s = \$4.67$ is above the threshold $\hat{s}_0 = \$3$, it would be optimal to have an oligopoly market with 5 firms. Indeed, even if the consumer surplus would not change, this would considerably increase government revenue (18% higher). This clearly shows that liberalization does not depend on the external cost of alcohol, but on cost and demand functions.

Figure 3 – Impact of the social cost of alcohol



4.2 Market structure for spirits

The estimated cost function for spirits is also U-shaped (see Table 3) with its minimum at $\bar{Q}^s = 3.071$ millions litres. The monopoly quantity estimate is $\hat{Q}^{sm} = 2.709$ millions

[19]Recall that $s_0 = (2Q^m - 2\beta_2\delta_p\bar{Q} - \delta_p\beta_1 - a)/\delta_p$. Refer to to the solution of the theoretical model in the Appendix.

[20]To calculate the external cost of wine, we account for both the total consumption in 2002 and the standard measurement of the alcohol content of drinks (alcohol per volume).

litres which is in the 95% confidence interval of the value of 2016 (= 2.970). Hence, for spirits, we consider that the state monopoly is operating in the range of output where there are economies of scale. Accordingly (see R2 above), it is optimal to maintain the state monopoly. This result is valid both for maximizing revenue and net social benefit.

4.3 Market structure for beer

For beer, the estimated cost function displayed in Table 3 exhibits a constant returns to scale technology. Therefore, each of the three market structures (monopoly, oligopoly and perfect competition) would generate the same outcome (see R3 above). However, a private competitive regime would likely be the best alternative because it would give incentives to firms to innovate and reduce costs (prices).[21]

5 Concluding Remarks

This paper estimated demand and cost functions to determine the optimal policy to regulate the alcohol industry, thereby contributing to the ongoing complex policy debate regarding the dismantling of alcohol state monopolies. Using sales data on three well known categories (wine, spirits and beer) from ANBL, our estimates suggest that marginal and average costs may not be constant, as generally assumed in the literature on alcohol industry. Some key insights for policy implementation can be drawn from our empirical findings.

Foremost, alcohol state monopolies are not necessarily the only way, let alone the best, to achieve the dual objective of generating tax revenue and reducing the social costs of alcohol consumption. Indeed, our empirical findings clearly suggest that the current state monopoly on alcohol distribution and sale in New Brunswick is inefficient, at least for wine and beer, both for generating tax revenue and internalizing the external costs of alcohol consumption. Specifically, our counterfactual analysis suggests that optimal taxation in an oligopolistic market for wine would likely increase government revenue while yielding a higher net social benefit.

However, our results also suggest that a “one-size-fits-all” approach to regulation must be abandoned and effective policies should be tailored to the specific characteristics of the case under consideration. For example, our estimates suggest to uphold the state monopoly for spirits sale and to allow free competition for beer. Nevertheless, this recommendation should be considered with due caution, given our small sample size (only 40 observations). Indeed, when the sample size is small (less than 50 observations), residuals may not be normally distributed and estimates inconsistent. This is precisely the case of spirits and beer for which the null hypothesis of the normality of the residuals of cost and demand estimates was rejected. In this case, although 2SLS estimates are still unbiased, they may not have minimum variance.

Overall, the main message from our counterfactual analysis is that optimal regulatory policy may vary from one context to another and a thorough evaluation should be required.

[21] It is worth noting that this conclusion is only valid if, somehow, there is no price coordination in the market post-liberalization, which is far from impossible as documented in N. H. Miller & Weinberg (2017) and N. H. Miller et al. (2019).

Therefore, it would not be surprising that the fully privatized alcohol retail system in Alberta were sub-optimal, given that it was implemented without any thorough evaluation. Future research could help clarify this.

Appendix

Solution of the theoretical model

Optimal mechanism under imperfect competition: $\theta = 1$

Let the linear market demand function be $Q = a + \delta_p P$ so that $P(Q) = (Q - a)/\delta_p$ with $\delta_p < 0$ and $a > 0$. The cost function is $c(Q) = \beta_0 + \beta_1 Q + \beta_2 Q^2$. The objective function is $G_o(Q, n) = (1/\delta_p - \beta_2/n)Q^2 - (\beta_1 + s + a/\delta_p)Q - n\beta_0 + sQ^m$. For any given value of n,

$$Q_o(n) = \frac{a + \delta_p(\beta_1 + s)}{2(1 - \beta_2\delta_p/n)}. \tag{A.1}$$

Case 1: $\beta_2 > 0$. Then,

$$Q_o^* = \begin{cases} \frac{\delta_p(2\beta_2\bar{Q}+\beta_1+s)+a}{2} & \text{if } s < s_0, \\ Q^m & \text{if } s \geq s_0. \end{cases}$$

$n_o^* = Q_o^*/\bar{Q} > 1$, $\tau_o^* = -(1 - 1/n_o^*)Q_o^*/\delta_p > 0$ and $l_o^* = -(Q_o^*/n^*)^2/\delta_p > 0$, where $s_0 = (2Q^m - 2\beta_2\delta_p\bar{Q} - \delta_p\beta_1 - a)/\delta_p$ and $\bar{Q} = \sqrt{(\beta_0/\beta_2)} = q_o^*$.

Case 2: $\beta_2 = 0$. First if $\beta_0 = 0$, $Q_o^* = Q^m$ (note that $s_o = 0$). Second, if $\beta_0 > 0$, we have a natural monopoly.

Optimal mechanism under perfect competition: $\theta = 0$

Firm's profit and government revenue become respectively $\pi^\tau = \beta_2(q - \bar{Q})(q + \bar{Q})$ and $G_c(Q, n) = (1/\delta_p - 2\beta_2/n)Q^2 - (a/\delta_p + \beta_1 + s)Q + sQ^m$.

$$Q_c(n) = \frac{a + \delta_p(\beta_1 + s)}{2(1 - 2\beta_2\delta_p/n)}. \tag{A.2}$$

Case 1: $\beta_2 > 0$. In the long-run, firm's profit is zero ($q = \bar{Q}$). Note that for any $n > 1$, $Q_o(n) > Q_c(n)$.
Case 2: $\beta_2 = 0$. Same results as under imperfect competition ($\theta = 1$).

Stationarity tests

Table A.1 – Stationarity tests

	ADF		**Phillips-Perron: Z_ρ**		**DF-GLS**	
Variables	Level	1st diff	Level	1st diff	Level	1st diff
C^w	2.068	-2.429**	3.097	-22.158***	-0.490	-3.234*
C^s	-1.593	-4.392***	-5.047***	-26.892***	-2.136	-3.666**
C^b	-3.462***	-3.814***	-6.914	-31.530***	-2.173	-5.101***
Q^w	1.709	-2.675***	2.262	-35.137***	-1.611	-3.236*
Q^s	-1.589*	-3.890***	-4.240	-55.632***	-1.014	-3.093*
Q^b	-2.975**	-4.012***	-9.118	-47.946**	-2.454	-4.168***
P^w	-0.195	-4.757***	-1.075	-43.004***	-1.880	-6.690***
P^s	-2.542	-4.296***	-6.754	-30.366***	-1.855	-4.436***
P^b	-1.884	-5.895***	-4.594	-38.169***	-2.645	-5.545 ***
Tax^w	-1.966	-5.475***	-4.786	-27.617***	-2.027	-5.325***
Tax^s	-1.897	-5.731***	-6.379	-34.985***	-1.715	-5.838***
Tax^b	-1.826	-5.603***	-4.549	-33.171***	-1.496	-5.766***
Inc	0.386	-5.288***	0.205	-30.534***	-1.880	-5.186***
Pop	-2.608*	-2.644***nd	-3.019	-14.072**	-1.379	-3.830***
$Pop19$	-3.869**	-1.737*nd	-1.700	-6.409	-1.224	-3.821***
$P65$	1.400	-1.549	1.602	-0.983	-2.814	-1.179
$R35$	-1.027	-3.853***	-0.936	-20.045***	-1.509	-5.151***
$Urate$	-1.415	-5.061***	-4.684	-33.681***	-2.539	-4.652 ***

Critical value for test statistic: ‘ *** ’ 1%, ‘ ** ’ 5%, ‘ * ’ 10%.
‘nd’: Stationary without a drift.

F-tests and R-squared from the first stage of 2SLS

Table A.2 – F-tests and R-squared from the first stage of 2SLS

	Quantities ($\hat{Q}$)		Prices ($\hat{P}$)	
Products	F-Statistic	R^2	F-Statistic	R^2
Wine	265.93***	0.98	29.71***	0.91
Spirits	76.04***	0.96	47.22***	0.92
Beer	10.61***	0.76	28.10***	0.89

Critical value for test statistic: ‘ *** ’ 1%, ‘ ** ’ 5%, ‘ * ’ 10%.

Scatter plots of spirits and beer

Figure A.1 – Scatter plot of the cost function of spirits

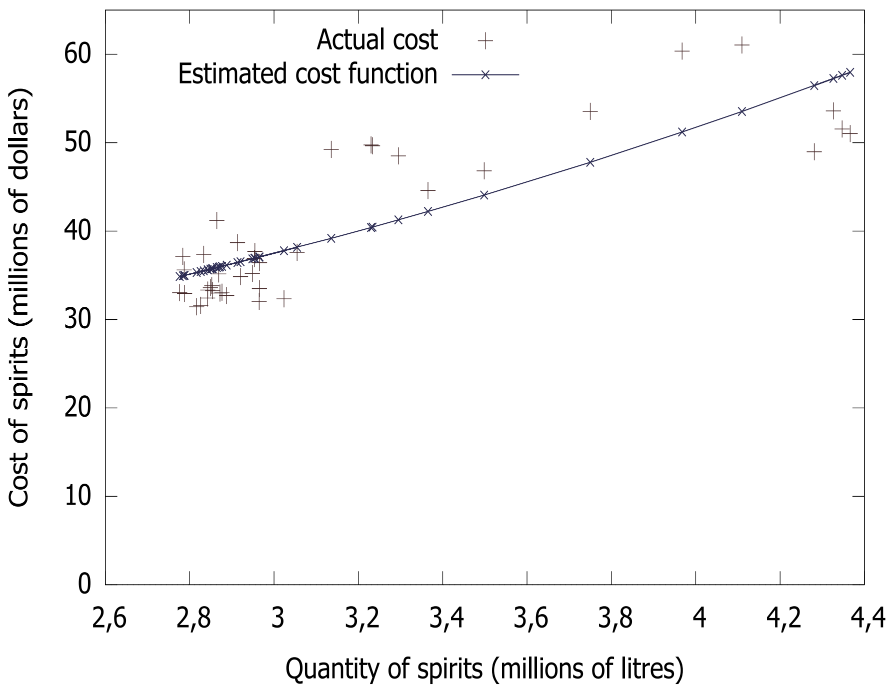
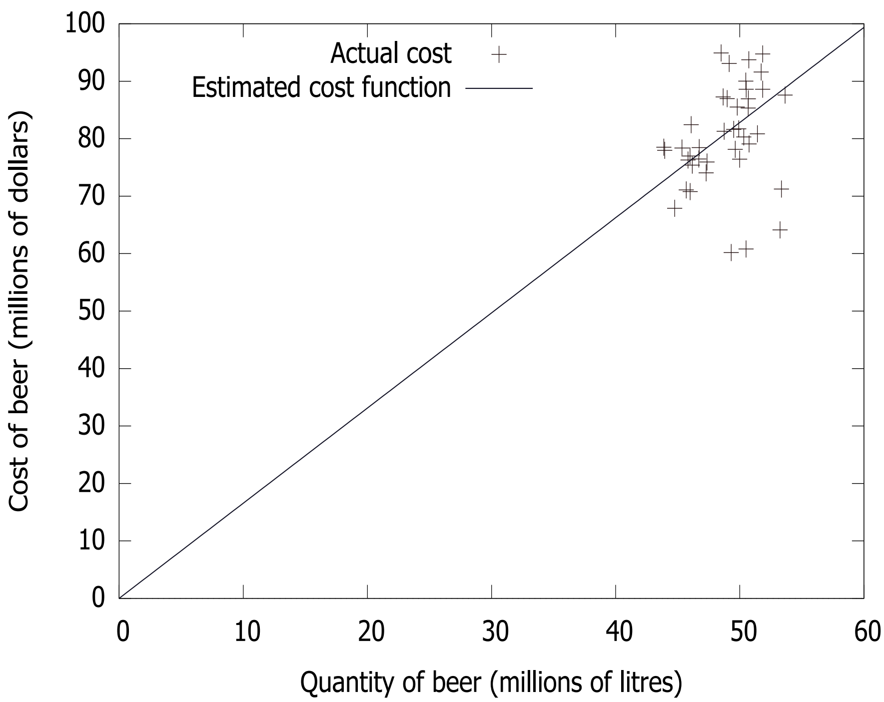


Figure A.2 – Scatter plot of the cost function of beer



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