The Demand for Alcoholic Beverages in New Brunswick, Canada: A Cointegration Analysis

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Alcohol consumption has raised a triad of social, economic and medical issues for policy makers. The Commission of Inquiry Into the Non-medial Use of Drugs (LeDain Commission 1973) concluded that misuse of alcohol is a serious social problem second only to drug usage and that the cost of excessive consumption is largely passed on to other people instead of alcohol consumers themselves. On the other hand, "sin taxes" on alcoholic beverages provide substantial government revenues, accounting in New Brunswick for approximately 1.8% of provincial revenues in 1996. Therefore, alcoholic beverage taxation and control has been an important policy goal for both provincial and federal governments, even though policy makers may not fully understand the factors affecting the demand for alcohol.

Accordingly, the literature on the demand for alcoholic beverages is extensive and growing, with a wide range of econometric models being applied in various parts of the world. Most studies, such as those by Walsh and Walsh (1970), Johnson and Oksanen (1974, 1977), McGuinness (1980), Duffy (1983), Adrian and Ferguson (1987), Godfrey (1988), and Johnson et al (1992) have followed the traditional single-equation estimation techniques. Others, such as those by Clements and Johnson (1983), Jones (1989), Selvanathan (1988, 1991), Alley et al (1992), Amoako-Tuffour and Leblanc (1995), and Andrikopouloset al (1997) have adopted the system-wide analysis employing variants of the Rotterdam or the Almost Ideal Demand System (AIDS). The results have been mixed even among those by the same authors (Johnson and Oksanen, for example) due primarily to the methodological differences.

With the exception of Johnson et al (1992), all these studies have a common feature. They did not incorporate recent advances in time-series analysis that allow the investigation of the long-run equilibrium relationship between economic variables using cointegration techniques. It is now accepted that all series should be pre-tested for the presence of unit roots, i.e. non-

stationarity. If one or more series are non-stationary then the regression is spurious and it is not possible to attach any meaning to the significance tests of the parameters.[1] Preliminary data analysis indicated that most our data series are non-stationary. Accordingly, the purpose of this paper is to use the recently developed cointegration techniques and error correction mechanism (ECM) to estimate the demand for alcoholic beverages for the province of New Brunswick over the period 1955-94. The study adopts the single-equation instead of the system-wide approach because alcohol sales and pricing are totally controlled by government agencies in Canada, implying that prices can be treated as exogenous, and the single-equation approach is justified.[2]

The cointegration procedure has been adopted by Johnson et al (1992) for Canada. Using annual data from 1956 to 1983, they estimated the short-run and long-run demand for alcoholic beverages for each province of Canada. The explanatory variables included are own price, the legal drinking age on alcohol consumption and income. For New Brunswick, they found a long-run price elasticity of -0.56, 0.21 and 0.00 for beer, spirits and wine respectively and a long-run income elasticity of 1.23, 1.00 and 0.81. Their short-run price elasticities were -0.81, -1.84 and -0.54 and income elasticities were 1.19, 1.44 and 0.01 for beer, spirits and wine respectively. However, these results are problematic since all the short-run price elasticities were larger than the long-run elasticities and the long-run price elasticities for spirits and wine were positive suggesting possible model mis-specification.[3]

In light of this, we extend Johnson et al (1992) by employing a larger and newer data set (1955-94), a more complete list of explanatory variables (own price, income, prices of substitutes, unemployment rate and demographics) and three alternative cointegration tests to look for evidence of long-run relationships. An accurate estimation of effects of prices, income and demographics on alcohol consumption is important for policy makers because they may serve as instruments to control usage.

TABLE 1 Variable Definitions

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VARIABLE	DEFINITION (all variables except K1 or K2 are in logs)
B	Per adult beer consumption
S	Per adult spirits consumption
W	Per adult wine consumption
BP	The price of beer
SP	The price of spirits

WP	The price of wine
G1	Per capita real GDP
R1	Proportion of people aged between 15 and 34 in the total adult population
R2	Proportion of people aged 65 and over in the total adult population
U	The unemployment rate
K1	Strike dummy in year 1977
K2	One period lagged dummy of K1

The paper is organized as follows. Data and estimation procedure are explained in the second section. Empirical results are presented in the third section. Diagnostic checks for heteroskedasticity, autocorrelation, and model specification are also provided in this section. The fourth section discusses and compares our results with the literature. The final section concludes.

Data and Methodology

This study uses annual data for the period 1955-1994 for the province of New Brunswick, Canada. Following the traditional single-equation approach, the dependent variables are annual consumption of beer, wine, and spirits (in litres) per adult (15 years and over). Independent variables, which are defined in Table 1 for convenience, include prices, income, demographic variables, unemployment rate and a strike dummy which occurred in 1977. Specifically, prices, deflated by the consumer price index, are tax inclusive. The price indices are obtained by dividing total dollar sales by total volume of sales. Since all of the variables were entered in log-form, the coefficients which are expected to have a negative sign are elasticity measures. Per capita GDP (gross domestic product) of New Brunswick, deflated by the consumer price index (CPI) is used as our income variable. The demographic data consists of two variables with R1 representing the proportion of total adult population aged 15 to 34, i.e. the active drinking group, and R2 representing the group aged 65 and over, i.e. the passive drinking group. Accordingly, variable R1 is expected to have a positive sign and variable R2 is expected to have a negative sign. We choose the unemployment rate in New Brunswick as a proxy of the socioeconomic condition in New Brunswick. Concerning this variable, there are opposing arguments in the alcohol literature. On the one hand, the National Alcohol Survey of 1989 indicates that people are more willing to consume alcohol when they have jobs, suggesting a negative relationship between alcohol demand and the unemployment rate. On the other hand, the unemployed may be addicted to alcohol for psychological reasons, suggesting a positive relationship.

Results from past empirical work are inconclusive. A strike dummy variable and its lagged dummy variable are also included as in Johnson et al (1992) for New Brunswick. Detailed data sources and construction are given in the data Appendix.

As mentioned above, preliminary data analysis using the Augmented Dicky-Fuller (ADF) unit root tests shows that all series are non-stationary. In particular, while R1 and R2 are second-difference stationary (i.e., I(2)), all other series are first-difference stationary (i.e., I(1)). Accordingly, to avoid spurious regression we proceed by first exploring the long-run demand function for each alcoholic beverage category and then adopting the error-correction mechanism to estimate the short-run equations.

Empirical Results

For each alcohol category, two equations were estimated: a long-run cointegrating equation and a short-run error correction (EC) equation. The equations were estimated in log-log form over the period 1955-94. Accordingly, all parameter estimates including those using the first-differenced variables can be interpreted as elasticities. Since there are considerable weaknesses associated with the Engle-Granger method of cointegration testing (Harris 1995), we investigate our cointegrating relationships by using three cointegration tests, namely the traditional Engle-Granger test (1987), the Johansen test (Johansen 1988) and the Leybourne and McCabe test (Leybourne and McCabe 1992).[4]

Table 2 shows the result of cointegration tests and the long-run demand equations for beer, wine and spirits. Notice that t-statistics are not reported for the cointegrating equations, but are reported later for the error-correction equations due to the fact that the distributions of OLS coefficient estimates in a static regression model such as the long-run demand equations typically take non-standard forms even when the series are co-integrated (Banerjee et al 1993). Consequently, t-statistics can not be used for a significance test. The judgement about which variables to include was based on the effect of excluding them on the cointegration tests (Ferguson and Peeris 1995).

TABLE 2 Long-run Demand Equations and Cointegration Tests

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	Beer	Wine	Spirits
Intercept	-0.744	-0.028	1.665
BP	-1.322	-1.103	--
SP	-0.050	0.302	-1.445
WP	1.060	0.202	1.030

G1	0.663	0.538	0.179
DR1	-4.880	--	-4.450
DR2	--	--	18.69
Ajusted R^2	0.963	0.846	0.903
F-statistic	169.02	44.87	60.42
Cointegration Test			
Engle-Granger	-3.26	-3.17	-3.79
Critical Value at 5%	-4.70	-4.41	-4.70
Johansen	98	68.4	113
Critical Value at 5%	94	68.5	94
LM	0.09	0.12	0.10
Critical Value at 5%	0.11	0.14	0.11

Note: 1. The null hypothesis for the Engle-Granger and Johansen tests is no cointegration while for the LM test it is cointegration.

The cointegration test results are reported in the last three rows of Table 2. For the beer equation, we found strong evidence from the Johansen test and the LM test that beer consumption, prices of beer, spirits and wine, income and the young population are cointegrated, although the Engle-Granger test fall short of the critical value at the 5% level of significance (-4.7). Similarly, based largely on the Johansen and LM cointegration tests, we conclude that, at the 5% significance level, wine consumption, wine price, spirits price and income are cointegrated and that spirits consumption, spirits price, wine price, income, young and old population are cointegrated.

With respect to the long-run demand for beer, column 2 of Table 2 shows that in addition to own price and income variables, the prices of substitutes and demographic variables are significant in determining the long-run demand for beer. In particular, own-price elasticity is -1.32 in the long-run. The cross elasticity of the demand for beer with respect to the price of wine is 1.05, indicating that wine is an important substitute for beer. The long-run income elasticity is 0.663. The demographic variable DR2, the ratio of people aged 65 and over to the total adult population, has a negative impact on beer consumption. Finally, the cross elasticity of beer demand with respect to the price of spirits, although negative, is very close to zero. Therefore, spirits are poor substitutes for beer.

For the long-run demand for wine, the result is somewhat disappointing since own price elasticity is positive. While this result contradicts with theory, it is consistent with Johnson et

al (1992) using New Brunswick data. They explain a positive own price elasticity as indicating that the commodity is totally unresponsive to price.

Still puzzled by the results, we regress wine consumption against own price alone and find that the coefficient for wine price is -1.106, with an R^2 of only 0.08. This suggests that changes in wine price do not explain the variation in the demand for wine very well. This may be so since wine prices fluctuate most drastically among the three alcohol categories.[5] The average price index that we have used might not be able to fully capture the variation in demand. On the other hand, the income variable is very significant in the wine equation. Both spirits price and beer price are insignificant at the 5% level of significance, indicating that both of them are poor substitutes for wine. Furthermore, the demographic variables do not play a role in the long-run consumption of wine.

Turning to the long run demand for spirits, column 3 of Table 2 shows that own price elasticity is -1.445 in the long-run. As in the beer equation, wine is a close substitute for spirits. The demand for spirit is income inelastic in the long-run. In addition, both of the demographic variables play a significant role in the long-run demand for spirits with the predicted signs. Spirits, with the highest alcohol content, are supposed to have the largest effect on health. Hence older people tend to drink less spirits or switch to other categories such as wine. In contrast, the positive coefficient of DR2 indicates that the young population is the most active group in spirits consumption.

Having cautiously concluded the cointegrating relationships for beer, wine and spirits, we proceed to the second stage analysis which involves estimating the short-run demand functions based on the cointegrating relationships. Table 3 reports the short-run demand elasticities for beer, wine and spirits.[6]

In Table 3, the ECM component is the lagged residual from the long-run cointegrating equation reported in Table 2. Its coefficient measures how the residual in the last period will affect consumption change in the current period. Thus, one minus the coefficient measures the speed of convergence of alcohol demand to its long-run equilibrium level. For the beer equation, the coefficient is around 0.53, this means about 47% of the difference between the short and long-run consumption level will be eliminated within one year. In addition, the beer equation shows a short-run price elasticity of -1.238, which is not different from -1 at the 5% level of significance. Wine is a significant substitute for beer in the short-run. Spirits are insignificant, indicating that spirits are poor substitutes for beer. The demand for beer is also income inelastic in the short-run. Furthermore, the demographic variable DR1 is not significant

in the short-run though appears in the long-run equation. Finally, the squared term of BPS is introduced due to a model specification test explained later.

TABLE 3 Short-Run Demand Equations, ECM Two Stage Models and Diagnostics

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	Beer	Wine	Spirits
BP	-1.128	0.031	0.021
	(-7.285)	(0.143)	(0.060)
WP	0.946	-0.054	0.638
	(5.11)	(0.208)	(1.449)
SP	-0.073	0.184	-1.125
	(-0.375)	(0.663)	(-2.513)
G1	0.287	0.168	0.292
	(3.459)	(1.357)	(1.686)
DR2	--	--	5.697
			(1.884)
Srike Dummy	-0.108	-0.120	-0.118
	(-4.362)	(-3.493)	(-1.958)
BPS	4.791	--	--
	(4.350)		
Lagged Dependent Variable	0.199	0.347	0.144
	(2.331)	(2.491)	(1.160)
ECM Component	-0.235	-1.951	-2.867
	(-4.831)	(0.556)	(0.583)
Adjusted R^2	0.835	0.556	0.583
Diagnostics			
Breusch-Pagan	9.574	5.704	2.68
p-value	0.296	0.680	0.593
Breusch-Goldgrey	0.06	0.015	2.26
p-value	0.799	0.903	0.133
RESET	0.004	0.620	0.593
p-value	0.952	0.440	0.450

Note: 1. All variables are in first difference and t-statistics are in parentheses.

For the wine equation, the speed of adjustment is around 0.765, implying that about 76.5% of the difference between the short and long-run consumption level will be recovered within one year. This is much higher than that for beer or spirits. One possible explanation for this interesting result is that there are more substitutes in the wine category than in the beer or spirits categories which could speed up the adjustment process. The short-run own-price

elasticity, although negative, is insignificant. In addition, both spirits and beer are poor substitutes for wine, indicating that there is no close substitute for wine. This is possible because within the wine category prices differ so much across different brands that much of substitution occurs within the category. Wine is also income inelastic in the short-run. Finally, demographic variables are not significant in affecting the short-run demand for wine.

Turning to the short-run demand for spirits, we find that the speed of adjustment is around 0.48, which is slightly higher than that of beer. The short-run own price elasticity is -1.125, not significantly different from -1 at the 5% level. Although not significant, the coefficient of wine price suggests that wine is a substitute for spirits. Spirits are income inelastic in the short-run. The insignificance of beer price suggests that beer is a poor substitute for spirits in the short-run. The demographic variables are not significant in the short-run demand for spirits at the 5% level of significance.

Finally in Table 3 are the results of several diagnostic tests performed to check model adequacy for the short-run equations with the Breusch-Pagan test for hetroscedasticity, the Breusch-Goldfrey test for autocorrelation and the Ramsey RESET test for model specification. The results show that each of the three short run equations passes the diagnostic tests. It should be noted that for the beer equation excluding BPS, the price of beer squared, the Breusch-Pagan test indicates heteroskedasticity and the Ramsey RESET test shows model mis-specification. When the term BPS is added, the model passes both tests as shown in Table 3.

Discussion

Recent advances in time-series analysis have cast doubt on the value of regression results in demand analysis of alcoholic beverages due to non-stationary time series. This study has attempted to apply the new econometric techniques to the New Brunswick data to derive more accurate elasticity measures. To our knowledge, Johnson et al (1992) was the only other Canadian study employing the cointegration techniques to estimate the demand for alcoholic beverages. Using data for all 10 Canadian provinces, they find that elasticity estimates vary greatly across provinces from virtually very inelastic to very elastic for each alcoholic category. Specifically, they find that beer demand is generally price inelastic across provinces; wine demand can be elastic or inelastic in different provinces and can be changing from the short to the long-run. It is particularly noteworthy that they obtain positive long-run own price elasticities in spirits model for most of the provinces in Canada. Their income elasticities vary from inelastic to elastic in different regions.

Their study also concluded that due to interprovincial differences the 10 demand equations should be estimated separately. Based on this, we estimated the New Brunswick demand for

beer, wine and spirits. For beer, we find that our short-run own price elasticity of -0.95 is close to theirs. While our long-run demand for beer is unit elastic (-1.21), theirs is inelastic. For spirits our estimates are -1.15 for the short-run and -1.54 for the long-run. These are consistent with Ornstein (1980) though inconsistent with Johnson et al (1992).

As in Johnson et al (1992), our results in the wine model are equally disappointing. Our own price elasticities are positive both in the short and long-run. While they explain the results as indicating that wine demand is very inelastic to own price, we suspect the lack of micro-level data for wine category where price varies greatly across brands has contributed to the counter-intuitive result.

With respect to income elasticity, our results show that the demand for alcoholic beverages is income inelastic in both the short and long-run, which is also inconsistent with Johnson et al for New Brunswick. This again could be explained by the omitted variable problem since they included fewer variables in their equations. It is also possible because we use per capita real GDP while they use per capita real disposable income as the income variable. In addition, there has been a general trend towards moderation in drinking in Canada during the sample period. While per capita income has been increasing in most of the sample period, alcohol consumption has been decreasing since the 1980s. Johnson et al (1992) use data in the sample period 1955-1983. Our additional data may suggest that the demand for alcohol is getting more income inelastic.

The results of cross-elasticities have been mixed and no general conclusion can be drawn. In their earlier studies Johnson and Oksanen (1974, 1977) find mixed results and the prices of substitutes were not included in their subsequent work (Johnson et al 1992) because they were insignificant. However, these studies might not be reliable due to spurious regression. Furthermore, in most of the previous studies little attention has been given to the direction of substitution. For example, wine can be a good substitute for beer while beer might not be a good substitute for wine. This can happen because for those people who want to find a substitute for beer, wine is the closest commodity that can be chosen. But it can be true that most people who care about wine might find that the best substitute is spirits. If this assumption is true, then the direction of substitution matters. Therefore, the fact that one category of alcohol is a substitute for another category while the opposite direction does not hold is possible, and the variables should not be dropped from the regression due to statistical insignificance.

In summary, we feel more confident in our results for three reasons. First, we included additional variables such as the prices of substitute and demographic variables in our study.

Since these variables were found to be significant, excluding them from the regression might lead to biased estimates in their studies. Second, in contrast with Johnson el al our results on own-price elasticities show that all the long-run elasticities are higher than the short-run elasticities. This is consistent with the standard theoretical predictions about the short and long-run elasticities of demand. Finally, our results of the cointegration tests are more reliable since we used three alternative tests and employed a larger and newer data set.

Conclusions

Alcohol, as a commodity whose consumption is highly related to the society's attitude, can have demand varying in different regions, cultures, and sample periods. Earlier Canadian studies (Adran and Ferguson 1987; Johnson et al 1992) have noted that since tax, pricing and sales decisions are made at the level of the individual province it seems preferable to estimate province-level equations.

The purpose of this paper has been to provide a thorough time-series analysis of the demand for alcoholic beverages (beer, wine and spirits) for the province of New Brunswick, Canada. Preliminary data analysis indicated that all our data are non-stationary, suggesting that the cointegration approach with the error correction mechanism should be employed to avoid spurious regression. Using three cointegration tests, namely the Engle-Granger cointegration test, the Johansen test, and the Leybourne and McCabe test, we concluded, based largely on the last two tests, that there exists a long-run demand function for each alcohol category (beer, wine and spirits). The fact that our data fail the Engle-Granger test but pass the other two tests suggests that the traditional unit root tests (i.e., the Engle-Granger test) may not be powerful enough when using small sample data, and additional tests are beneficial.

Our estimation results from the cointegration relationships indicate that in addition to the traditional own price and income variable, substitute prices and demographic composition play an important role in driving the demand for alcoholic beverages in New Brunswick. Thus, omitting some of these variables may not only bias the estimates but also fail cointegration tests. The results from the error correction models show that these variables along with a strike dummy also explain the short-run demand for alcohol.

Summarizing our main results, we find for the province of New Brunswick that the demand for beer is price unit-elastic in both the short and long-run, that the demand for wine is price inelastic in both the short and long-run, and that the demand for spirits is price unit-elastic in the short-run but elastic in the long-run. We also find that the demand for all three alcoholic beverages is income inelastic in both the short and long-run in New Brunswick. With respect to substitution, we find that wine is a good substitute while spirits are poor substitutes for beer,

that both beer and spirits are poor substitutes for wine, and that wine is a good substitute but beer is a poor substitute for spirits at least in the short-run. This suggests that the degree of substitution and even the direction of substitution can be different among the three alcoholic beverages. Within one category of alcohol one type may be a very close substitute for another. But among the three categories, the degree of substitution might be different. A person who is addicted to spirits might find wine is the only interesting substitute.

The policy implications of our results are twofold: First, if the policy purpose is to control alcohol usage in New Brunswick, the most effective policy is to increase the spirits tax since spirits are the most price-elastic in the long-run. However, if the objective is to raise revenue at minimum cost, then increasing the wine tax will be most effective because wine is price-inelastic. Our results on income and demographic effects on alcohol consumption may also be important for analysing the need for and the effectiveness of potential control policies in New Brunswick. Finally, the methodology proposed in this paper can be applied to other provincial data to derive more accurate demand elasticities for policy purpose.

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Appendix

Data Sources and Construction

Consumption

Total consumption data (in thousand litres) are obtained from Statistics Canada (63-202, SDDS 1726 STC), March 31, 1955 to March 31, 1994. We adjust them from a fiscal year basis to a calendar year basis by following Johnson et al (1992):

$$CONS_{(CALENDER\ T)} = 0.25 * CONS_{(MARCH31,\ T)} + 0.75 * CONS_{(MARCH31,\ T+1)}$$

Expenditure

Total expenditure data (in thousand dollars) are obtained from Statistics Canada (63-202, SDDS 1726 STC), March 31, 1955 to March 31, 1994. We adjust them with the same formula as in consumption. This expenditure includes the direct price plus the Goods and Service Tax but excludes Provincial Sales Tax.

Population

Population data for fiscal years from June 1, 1955 to June 1, 1971 are obtained from Statistics Canada (91-502: population 1921-1971, Revised Annual Estimates of Population by Sex and Age Group, Canada and the Provinces). They are adjusted to a calendar year basis following Johnson et al.'s formula:

$$POP_{(CALENDER,T)} = 0.42 * POP_{(MARCH31,T)} + 0.58 * POP_{(MARCH31,T+1)}$$

Fiscal year data from July 1, 1971 to July 1, 1994 are obtained from Statistics Canada (SDDS 3604 Demography Division), and adjusted to a calendar year basis based on the following formula:

$$POP_{(CALENDER,T)} = 0.5 * POP_{(MARCH31,T)} + 0.5 * POP_{(MARCH31,T+1)}$$

Consumer Price Index

Data for the period 1955 to 1978 are from Statistics Canada (62-002) for Saint John, because data for New Brunswick are not available in that period. Data for 1979 to 1994 are from Statistics Canada (62-010, SDDS 2301 STC) for New Brunswick.

Sales Taxes

Provincial sales tax rates are obtained from the provincial government of New Brunswick. In particular, tax rates are listed as follows: January 1955 to December 1966, 3%; January 1967 to March 1969, 6%; April 1969 to April 1983, 8%; May 1983 to May 1985, 10%; June 1985 to 1994, 11%.

Income

Per capita GDP is obtained from Statistics Canada (13-213 SDDS 1902 STC) for the years 1961 to 1994.

The Unemployment Rate

The unemployment rate is obtained from Statistics Canada (13-213 SDDS 1902 STC) for the years 1966 to 1994.