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The impact of the 1985 federal tax on distilled spirits on the per capita consumption of beer, wine and distilled spirits

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THE IMPACT OF THE 1985 FEDERAL TAX ON DISTILLED SPIRITS ON THE PER CAPITA CONSUMPTION OF BEER, WINE AND DISTILLED SPIRITS.

by

ZE'EV MEISELES

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1990

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1. Introduction

In 1985 the U.S. was faced with the following statistics: The approximate number of alcoholics 18 years and older was 10.5 million. The total number of people suffering from the negative effects of alcohol use was 17.7 million[1]. The data also reveals that alcohol problems are occurring in every socio economic group in the U.S. with american youths having the highest rates of illicit drug use in comparison to any other industrialized nation[2]. Alcohol is the no.1 drug problem among America's youth[3]. The number of adolescents who had experienced negative effects from the use of alcohol has been estimated at 4.6 million. Alcohol was more than twice as popular among college students as the second most popular leading drug, marijuana, and over five times as popular as cocaine[4].

On November 1, 1951, the federal government set an excise tax of $10.50 per proof gallon[5] on the purchase price of distilled spirits. This federal tax rate was held constant for thirty four years. On October 1,

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[1] Alcohol health and research world, spring 1987, vol. 2, Epidemiologic bulletin no. 15.

[2] Demographic trends, 1985, alcohol abuse and alcoholism 1985-1995, Gerald Williams, page 30.

[3] Congress of the United States, 1987, office of technology assessment, health technology case study 22.

[4] Institute for Social Research, 1987, university of Michigan, drug use among american high school students and other young adults.

[5] Proof gallon: standard U.S. gallon of 231 cubic inches at 60 degrees fahrenheit containing 50 percent by volume of ethyl alcohol (100 degrees proof).

1985, the federal government increased the excise tax rate to $12.50 per proof gallon on the purchase price of distilled spirits. The main purpose of this act was to raise tax revenue.

The specific aim of this project is to investigate empirically whether the effects of this federal tax have been felt on the consumption of alcoholic beverages.

In my research I will apply econometric time series models in an attempt to prove how effective the federal government has been in reducing the per-capita consumption of alcoholic beverages. In my analysis I will examine the effects of the federal excise tax on the distilled spirits industry as well as the effect on the closely substitutable alcoholic beverage industries, Namely, the beer and wine industries, which will be analized separately. The objective is to fit the best model that will accurately represent the consumption per capita of the specific industry with the minimum number of parameters.

The first step will be to fit a Multiplicative[6] Auto Regressive Moving Average Box Jenkin model for the per capita consumption of beer, wine and distilled spirits using monthly data for the U.S. as a whole for a long period prior to the October 1985 federal tax intervention set by the federal government. The pre-intervention period analyzed will be

[6] A model that has seasonal and non seasonal components is known as a multiplicative model.

January 1970 throughout September 1985[7]. These Multiplicative Box Jenkin models will then be extrapolated into the future for the period October 1985 through December 1988. Step two will be to compare the forecast of the pre-intervention models to the actual data. The difference between the actual and the forecast will show us the pure intervention effect.

As an alternative analysis a Multiplicative Box Jenkin Auto Regressive Moving Average model for the entire period of analysis January 1970 throughout December 1988 will be fit for each one of the alcoholic beverages. Later on I include an intervention component into these Multiplicative Box Jenkins models. The alternative approach measures the governments intervention directly and does not require a comparison of the prior models to the post-intervention models. This approach also takes into account not only the effective date of the intervention but also the specific shape and form of the intervention.

Later on I estimate separate conventional demand functions for beer, wine and distilled spirits for the entire period: January 1970 through December 1988. My explanatory variables to be used as regressors in the demand functions are: the relative price level of beer[8], the relative price of wine, the relative price of distilled spirits, real

[7] The effective date of the intervention was in fact one month prior to the amendment date of October 1, due to the fact that the governments plans to tax distilled spirits was widely recognized in advance.

[8] The relative price of a specific commodity is the nominal consumer price index of that specific commodity divided by the consumer price index of all items in the economy.

personal disposable income per capita[9], the unemployment rate, the legal drinking age and the portion of sixteen to twenty years old in the population.

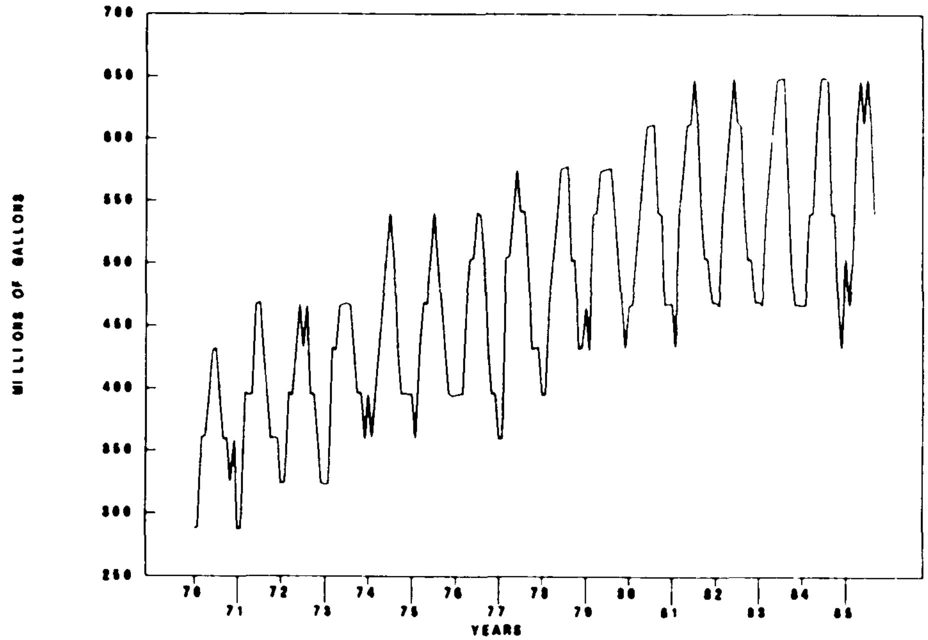
Finally the results obtained by conventional demand specifications will be compared to the Multiplicative Box Jenkins models in determining the effectiveness of the government tax intervention.

[9] Real per capita income is the nominal income divided by the consumer price index of all items in the economy.

2. Determination of the Proper Form by which the Consumption of Alcoholic Beverages will be Analyzed.

In time series analysis it is necessary to first plot the data. Let us begin with the absolute consumption level of beer.

ACTUAL CONSUMPTION LEVEL OF BEER



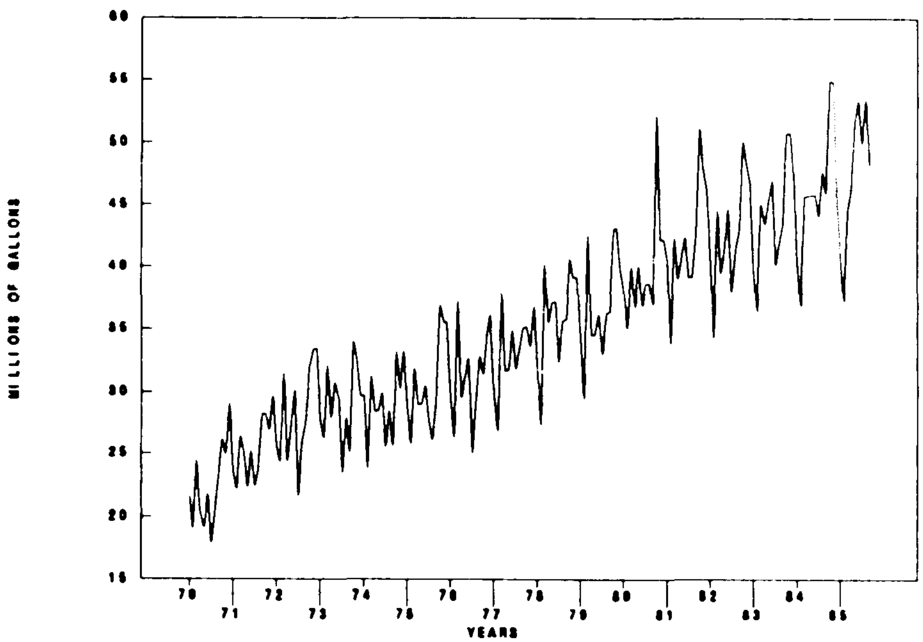
We immediately notice the following facts:

The actual level of beer consumption is trended especially during the seventies. That is, there is a systematic change in the level of beer consumption.

The actual level of beer consumption starts out at approximately three hundred millions gallons a month in 1970 and ends up at approximately six hundred million gallons a month in 1988.

Let us now examine the actual level of wine consumption.

ACTUAL CONSUMPTION LEVEL OF WINE



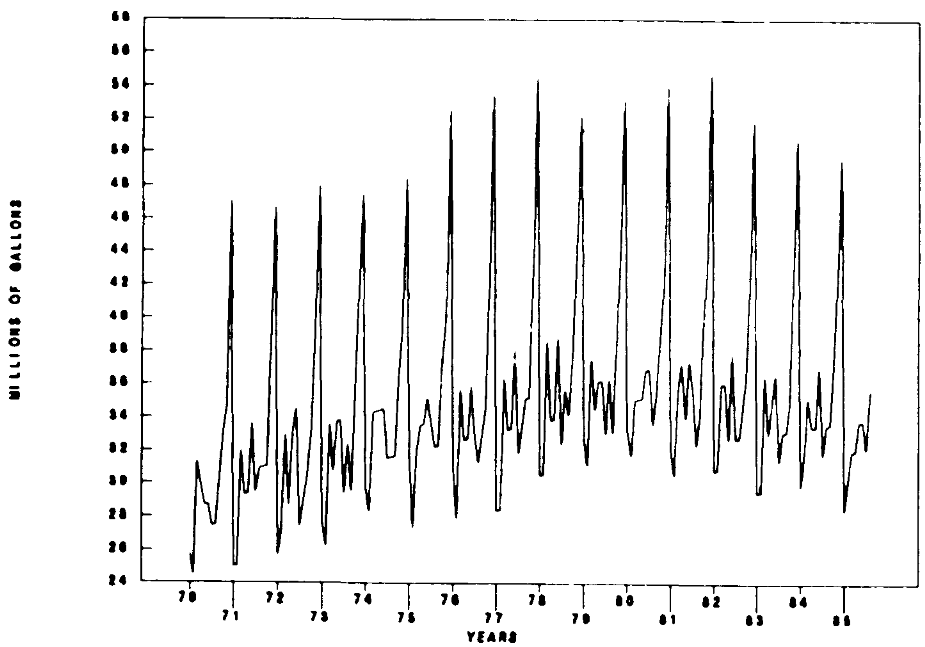
The following facts are evident:

The actual level of wine consumption is trended through the entire period.

The actual level of wine consumption starts out at approximately twenty millions gallons a month in 1970 and ends up at approximate fifty million gallons a month in 1988.

Let us now examine the actual level of distilled spirits consumption.

ACTUAL CONSUMPTION LEVEL OF SPIRITS



In examining the actual level of distilled spirits consumption the following facts are evident:

The actual level of distilled spirits consumption is trended through the entire period. Distilled spirits consumption tends to follow a cycle.

The actual level of distilled spirits consumption starts out at a low level of approximate twenty six millions gallons a month in 1970 and rises to a peak of up to approximately fifty two million gallons a month in 1979. Then through the eighty's the actual level falls continuously until it reaches a bottom level of approximately thirty million gallons a month.

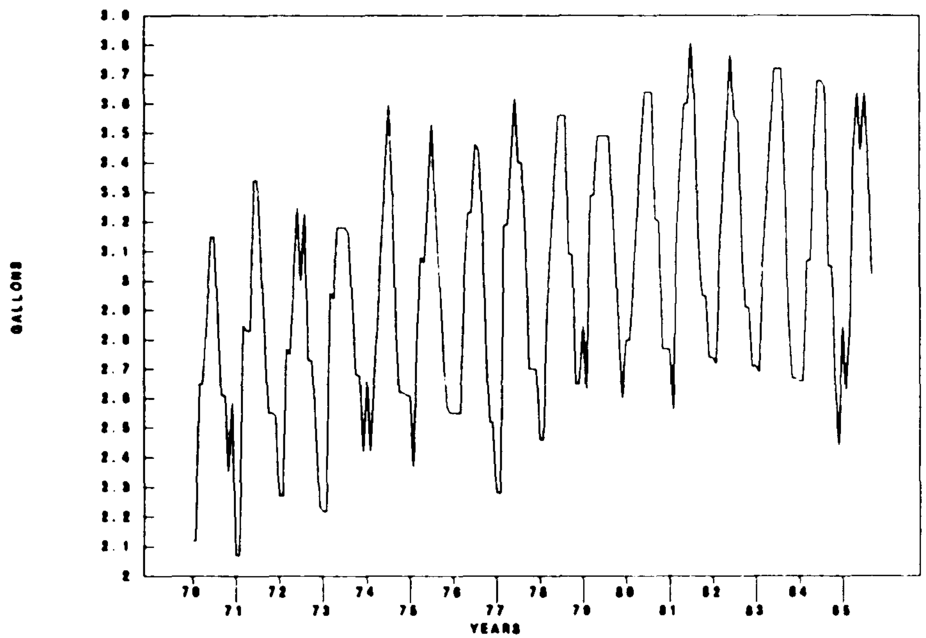
In order to eliminate the trivial trend which was evident in each one the alcoholic beverages, I had divided each industry's actual consumption level with the population sixteen years of age and over. This calculation gives us the per capita consumption of beer, wine and distilled spirits.

If we would just continue to analyze the actual levels of consumption, we would be ignoring one of the most natural features of the time series and that is, the population growth over the entire period.

Let us now examine the new naturally detrended series.

Let us start with the per capita consumption of beer :

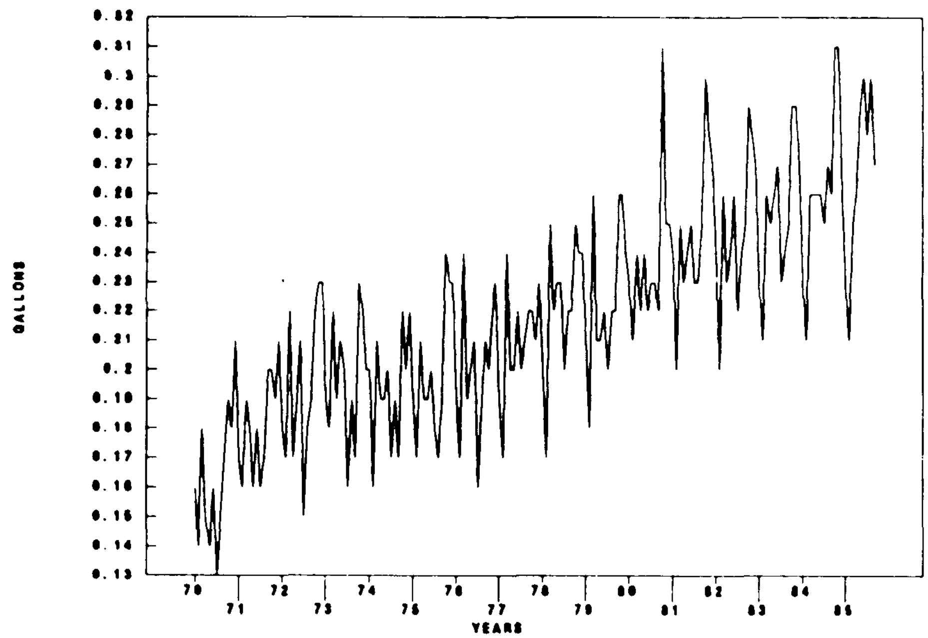
PER CAPITA CONSUMPTION LEVEL OF BEER



Although we have removed the natural trivial trend from the consumption of beer we still have not removed all of the trends that exist in the series. It is obvious that the series is trended upward in the seventies and downward in the eighties.

Let us examine the per capita consumption of wine:

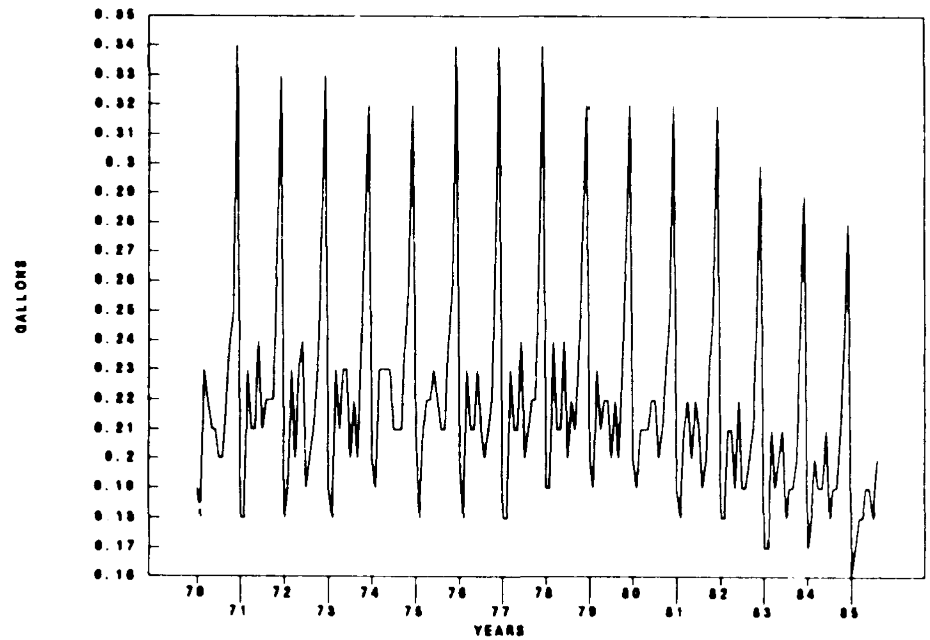
PER CAPITA CONSUMPTION LEVEL OF WINE



It is clear that the wine series is not completely detrended. This series is very strongly trended upward up until 1981 and trended downward thereafter.

Let us examine the per capita consumption of distilled spirits:

PER CAPITA CONSUMPTION LEVEL OF SPIRITS



The per capita consumption of distilled spirits is not completely detrended as well. In particular we notice how the series is sharply trended downward throughout the eighties.

3. Determination of Stationarity

In order to model the per capita consumption of the alcoholic beverages using the technic developed by Box and Jenkins, it is, absolutely necessary to first stationarize these series. It is technically possible to model the per capita series without obtaining stationarity first, however, in that case, the entire estimation process will become absolutely meaningless. The estimation process set up by Box and Jenkins is statistically correct only when we are dealing with stationrized series.

It is necessary to transform each one of the original per capita consumption series into a new series that exhibits a constant mean, constant variance and an autocorrelation function that dies out relatively fast. The autocorrelation function is a measure of dependency among two per capita consumption points k time units apart. The autocorrelation coefficient measures the degree by which a value of the series above or below the mean at time t is likely to be followed by a value of the series above or below the mean k time observations later.

The autocorrelation function formula is:

$$r_k = \frac{\sum_{t=1}^{t=n-k} (z_t-\overline{z})(z_{t+k}-\overline{z})}{\sum_{t=1}^{t=n} (z_t-\overline{z})^2}$$

The autocorrelation function is the covarience of the series between time t and time k divided by the variance of the series.

The specific aim here is to form a new series that can be described as having a joint normal probability distribution in which its values are independent of the time of origin. It is also necessary to assume that the new series is ergodic which implies that if our sample size would increase infinitely we would find our sample to be a consistent estimate of the population at large.

As common with most business time series all of the three per capita alcoholic beverages turned out to be non stationary. All three series were non stationary with regards to the mean. The mean of the beer series rises up until 1981 and falls thereafter. The mean of the wine series rises up until 1981 and falls thereafter. The mean of the distilled spirits series is stationary up until 1981 and falls thereafter. With regards to stationarity in the variance only wine exhibited nonstationarity.

The variance around the mean in the beer series was about a half a million gallons throughout the entire period. The variance around the mean in the wine series increased throughout the entire period. That is, the wine series clearly can be characterized as exhibiting homoskedasticity. The variance around the mean in the early seventies was about 0.02 million gallons a month where as, the variance around the mean in the eighties reached 0.1 million gallons. The variance around the mean of the distilled spirits series was fairly constant. It was found to be approximately 0.1 million gallons throughout the entire period.

In analyzing the autocorrelations it is necessary to examine the shape of the autocorrelations function as well as the absolute numerical size of the values themselves. Let us concentrate on the first forty four lags of the autocorrelation function. We will examine the correlations of the series starting from one lag apart all the way to forty four lags apart.

The marginal significant level is equal to:

$$\cdot = \frac{2}{\sqrt{n}}$$

The marginal significant level is represented by • and n is equal to the sample size. Whenever the autocorrelations exceed this critical value they are considered to be significant.

The Q statistic measures the overall autocorelation among the first forty four lags. The Q statistics is known as the Box Perice Statistic as is given by the following formula:

$$Q = n \sum_{i=1}^{i=L} r_i^2$$

n is the sample size.

r Sub i is the autocorrelation at lag i.

Let us examine the autocorrelation functions:

Autocorrelation function of the per capita beer consumption

for the period January 1970 through September 1985:

```
==============================================================================
      autocorrelations           partial autocorrelations          ac      pac
==============================================================================
|              . |**********  |           . |**********  | 1  0.782  0.782
|              . |*******     |        ****| .           | 2  0.500 -0.286
|              . |**          |        ****| .           | 3  0.172 -0.300
|            ***| .           |       *****| .           | 4 -0.196 -0.393
|         ******| .           |           . | .           | 5 -0.436 -0.022
|        *******| .           |           . |*.          | 6 -0.528  0.063
|          *****| .           |           . |*****       | 7 -0.406  0.353
|             **| .           |           . |***         | 8 -0.156  0.206
|              . |**          |           . |****        | 9  0.181  0.293
|              . |******      |           . |**          |10  0.497  0.126
|              . |**********  |           . |****        |11  0.732  0.270
|              . |*********** |           . |*****       |12  0.850  0.355
|              . |*********   |           . | .          |13  0.712 -0.014
|              . |******      |           . | .          |14  0.450 -0.018
|              . |**          |           . | .          |15  0.131 -0.000
|            ***| .           |           . |*.          |16 -0.193  0.061
|         ******| .           |           . | .          |17 -0.424 -0.025
|        *******| .           |          **| .           |18 -0.526 -0.173
|          *****| .           |           . | .          |19 -0.402  0.033
|             **| .           |           . | .          |20 -0.154  0.005
|              . |**          |           . | .          |21  0.153 -0.019
|              . |******      |          .*| .           |22  0.453 -0.096
|              . |*********   |          .*| .           |23  0.663 -0.051
|              . |**********  |           . |**         |24  0.769  0.141
|              . |********    |          .*| .           |25  0.640 -0.068
|              . |*****       |           . |*.          |26  0.404  0.056
|              . |*.          |          .*| .           |27  0.099 -0.078
|            ***| .           |           . |*.          |28 -0.201  0.069
|          *****| .           |           . | .          |29 -0.404  0.038
|        *******| .           |          .*| .           |30 -0.505 -0.042
|          *****| .           |          .*| .           |31 -0.399 -0.042
|             **| .           |           . | .          |32 -0.162  0.025
|              . |*.          |          .*| .           |33  0.114 -0.060
|              . |*****       |           . | .          |34  0.400  0.027
|              . |********    |          .*| .           |35  0.595 -0.079
|              . |*********   |          .*| .           |36  0.667 -0.076
|              . |*******     |           . | .          |37  0.566 -0.003
|              . |****        |          .*| .           |38  0.330 -0.083
|              . |*.          |           . | .          |39  0.050 -0.010
|            ***| .           |           . | .          |40 -0.214  0.007
|          *****| .           |          .*| .           |41 -0.409 -0.046
|         ******| .           |           . | .          |42 -0.492 -0.012
|          *****| .           |           . | .          |43 -0.393 -0.004
|             **| .           |          .*| .           |44 -0.189 -0.077
==============================================================================
Q-statistic (44 lags) 1713.360                  S.E. of Correlations     0.072
```

Autocorrelation function of the per capita wine consumption

for the period January 1970 September 1985:

```
=====================================================================
      autocorrelations        partial autocorrelations      ac     pac
=====================================================================
|            . |*********   |       . |*********   | 1  0.687  0.687
|            . |********    |       . |***         | 2  0.593  0.229
|            . |*******     |       . |**          | 3  0.548  0.153
|            . |******      |      .*| .           | 4  0.444 -0.043
|            . |********    |       . |*****       | 5  0.586  0.421
|            . |********    |       . |*.          | 6  0.580  0.101
|            . |*******     |       . |*.          | 7  0.562  0.090
|            . |******      |    ****| .           | 8  0.437 -0.287
|            . |******      |       . |*****       | 9  0.480  0.368
|            . |******      |       . | .          |10  0.493 -0.020
|            . |*******     |       . |****        |11  0.544  0.302
|            . |**********  |       . |****        |12  0.743  0.286
|            . |*******     |   *****| .           |13  0.501 -0.379
|            . |******      |      .*| .           |14  0.440 -0.109
|            . |*****       |      **| .           |15  0.382 -0.119
|            . |****        |       . |**          |16  0.326  0.164
|            . |******      |      .*| .           |17  0.469 -0.069
|            . |******      |      .*| .           |18  0.442 -0.042
|            . |******      |       . |*.          |19  0.452  0.049
|            . |****        |      .*| .           |20  0.330 -0.052
|            . |*****       |       . |*.          |21  0.349  0.058
|            . |*****       |       . | .          |22  0.374 -0.007
|            . |*****       |       . |*.          |23  0.410  0.084
|            . |********    |       . |**          |24  0.585  0.117
|            . |*****       |      .*| .           |25  0.386 -0.102
|            . |****        |      .*| .           |26  0.332 -0.047
|            . |****        |      .*| .           |27  0.269 -0.069
|            . |***         |       . | .          |28  0.227  0.033
|            . |*****       |      .*| .           |29  0.353 -0.068
|            . |****        |       . |*.          |30  0.333  0.046
|            . |*****       |       . | .          |31  0.364  0.037
|            . |***         |      .*| .           |32  0.234 -0.072
|            . |***         |       . | .          |33  0.251  0.035
|            . |****        |       . |*.          |34  0.296  0.089
|            . |****        |       . | .          |35  0.309 -0.003
|            . |******      |       . | .          |36  0.469  0.012
|            . |****        |      .*| .           |37  0.298 -0.041
|            . |***         |      .*| .           |38  0.227 -0.064
|            . |**          |       . |*.          |39  0.189  0.067
|            . |**          |      .*| .           |40  0.156 -0.039
|            . |****        |       . | .          |41  0.270  0.017
|            . |***         |      .*| .           |42  0.258 -0.059
|            . |****        |       . | .          |43  0.285  0.021
|            . |**          |       . |*.          |44  0.171  0.045
=====================================================================
 Q-statistic (44 lags) 1464.242          S.E. of Correlations  0.072
```

Autocorrelation function of the per capita consumption of distilled spirits for the period January 1970 throughout August 1985:

```
========================================================================
        autocorrelations          partial autocorrelations     ac     pac
========================================================================
|          .  |***           |        .  |***          | 1  0.216  0.216
|           **|  .           |         ***|  .         | 2 -0.187 -0.246
|           .*|  .           |        .  |  .          | 3 -0.077  0.029
|           .*|  .           |          **|  .         | 4 -0.113 -0.163
|          .  |  .           |        .  |*.           | 5 -0.016  0.048
|          .  |***           |        .  |**           | 6  0.227  0.186
|          .  |  .           |          **|  .         | 7 -0.031 -0.168
|           .*|  .           |        .  |*.           | 8 -0.095  0.049
|           .*|  .           |          **|  .         | 9 -0.086 -0.135
|          ***|  .           |          **|  .         |10 -0.222 -0.172
|          .  |***           |        .  |*****        |11  0.206  0.354
|          .  |************  |        .  |***********  |12  0.894  0.845
|          .  |**            |         ***|  .         |13  0.178 -0.209
|           **|  .           |          .*|  .         |14 -0.173 -0.046
|           .*|  .           |          **|  .         |15 -0.100 -0.119
|           **|  .           |        .  |*.           |16 -0.125  0.082
|          .  |  .           |          .*|  .         |17 -0.014 -0.084
|          .  |**            |          **|  .         |18  0.181 -0.181
|           .*|  .           |        .  |*.           |19 -0.043  0.067
|           .*|  .           |          .*|  .         |20 -0.089 -0.056
|           .*|  .           |          .*|  .         |21 -0.114 -0.043
|          ***|  .           |        .  |**           |22 -0.216  0.168
|          .  |***           |          .*|  .         |23  0.194 -0.064
|          .  |**********    |        .  |*.           |24  0.804  0.084
|          .  |**            |        .  |  .          |25  0.170  0.038
|           **|  .           |        .  |  .          |26 -0.163 -0.016
|           **|  .           |        .  |  .          |27 -0.123 -0.023
|           **|  .           |        .  |  .          |28 -0.116  0.007
|          .  |  .           |          .*|  .         |29 -0.032 -0.099
|          .  |**            |        .  |  .          |30  0.138 -0.021
|          .  |  .           |        .  |  .          |31 -0.036  0.029
|           .*|  .           |        .  |  .          |32 -0.090  0.011
|           **|  .           |        .  |  .          |33 -0.134 -0.028
|          ***|  .           |        .  |*.           |34 -0.199  0.039
|          .  |**            |          .*|  .         |35  0.153 -0.115
|          .  |*********     |        .  |  .          |36  0.718  0.022
|          .  |**            |          .*|  .         |37  0.156 -0.066
|           **|  .           |        .  |  .          |38 -0.175 -0.026
|           **|  .           |        .  |  .          |39 -0.134  0.002
|           .*|  .           |        .  |  .          |40 -0.110 -0.038
|           .*|  .           |        .  |  .          |41 -0.061  0.005
|          .  |*.            |        .  |  .          |42  0.107  0.009
|          .  |  .           |        .  |  .          |43 -0.035 -0.026
|           **|  .           |          .*|  .         |44 -0.119 -0.087
========================================================================
 Q-statistic (44 lags)  518.723          S.E. of Correlations   0.073
```

From analyzing the autocorrelation functions we reinforce what we already know. That is that All three per capita series are in fact not stationary. All three series do not die out fast. In all three cases we see large and significant autocorrelations for seasonal and nonseasonal lags.

4. Obtaining Stationarity in the Variance

As shown earlier the per capita consumption of wine exhibits non stationarity in the variance around the mean. In order to obtain stationarity in the variance of the per capita wine I applied the natural logarithmic transformation. The logarithmic transformation is only a particular case out of many Box Cox power transformations that I could have chosen. The Box Cox transformation is given by the following formula:

$$y_t(\Gamma) = \frac{y_t^{\Gamma}-1}{\Gamma}$$

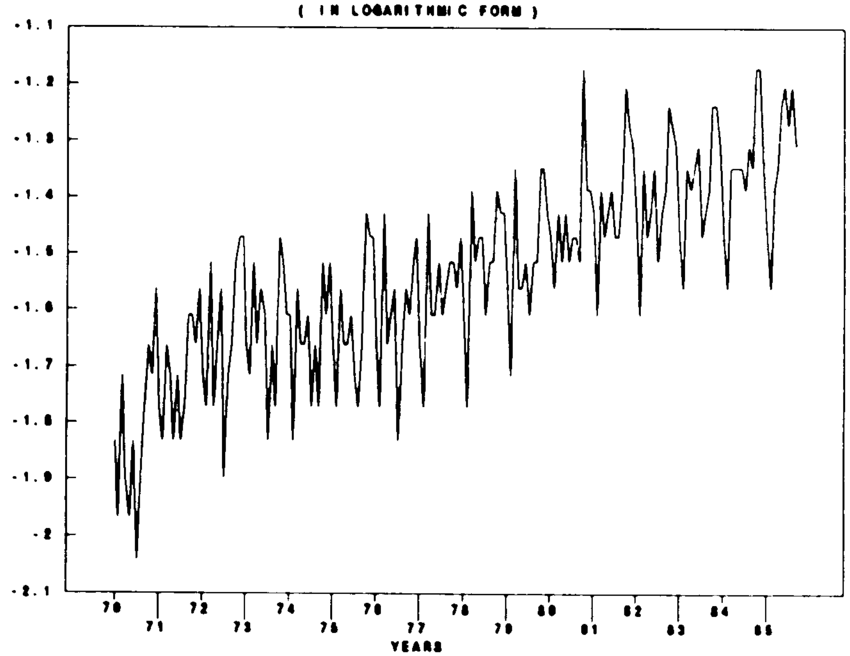
Whenever Γ is non zero we have a power transformation. However I chose the particular case where Γ is equal to zero which is essentially a logarithmic transformation. I chose the logarithmic transformation in particular over other transformations since this specific transformation controls for heteroskedasticity.

Let us take a look at what occurs when applying the logarithmic transformation to the per capita consumption of wine.

Consumption of per capita wine after being transformed into logarithms:

PER CAPITA CONSUMPTION LEVEL OF WINE

(IN LOGARITHMIC FORM)



The problem of homoskedasticity was very severe when we analyzed the per capita consumption of wine. Now after applying the logarithmic transformation we have compressed the scale so as to significantly diminish the problem of homoskedasticity.

It is important to note that the logarithmic transformation serves only for the sake of proper estimation of a multiplicative Auto Regressive Moving Average Box Jenkins wine model. Once this model has been estimated it will be necessary to back transform the wine series into its original form in order to evaluate the forecast values.

5. Obtaining Stationarity in the Mean and Autocorrelation

In order to stationrize all three per capita consumption series it was absolutely necessary to simply difference once and seasonally difference once. That is, if the original series is x sub t then the stationrized series is y sub t like so:

$$y_t = x_t - x_{t-1} - x_{t-12} + x_{t-13}$$

It does not alter the result whether we simply difference and then seasonally difference or if we first seasonally difference and then simply difference. In any event we lose the first thirteen observations. It is very important to determine the correct size of differencing to apply in order to achieve stationarity in the mean and in the autocorrelation. If one was to simply difference or seasonally difference more than once then this would damage the results in two ways. First we would be losing more observations. Secondly and much more important we would be introducing dependency among the observations that was not in existence and this would cause our results to be biased.

In order to prove that by simply and seasonally differencing once we have reached stationarity we must carefully examine the stationrized autocorrelation function. We must be able to show that by simply and seasonally differencing once we produce a series which has an autocorrelation function that dies out relatively fast for simple and seasonal lags. This is one way of assuring that we have achieved stationarity. From a mathematical point of view a stationrized series is one in which the value of the autocorrelation function approaches zero as the number of lags included in the autocorrelation function approach infinity.

Autocorrelation function of the sationrized beer series

for the period February 1970 through September 1985 :

```
==========================================================================
        autocorrelations          partial autocorrelations      ac      pac
==========================================================================
|        ******| .           |        ******| .          | 1 -0.440 -0.440
|            .*| .           |         *****| .          | 2 -0.103 -0.368
|             . |**          |            .*| .          | 3  0.153 -0.101
|            **| .           |           ***| .          | 4 -0.185 -0.253
|             . | .          |          ****| .          | 5 -0.009 -0.291
|             . |*.          |           ***| .          | 6  0.097 -0.225
|             . | .          |            **| .          | 7 -0.019 -0.176
|             . |*.          |            .*| .          | 8  0.038 -0.104
|             . | .          |            .*| .          | 9 -0.004 -0.096
|             . | .          |            .*| .          |10 -0.031 -0.089
|             . |***         |             . |*****      |11  0.237  0.371
|        ******| .           |           ***| .          |12 -0.473 -0.195
|             . |***         |            .*| .          |13  0.220 -0.060
|             . | .          |           ***| .          |14  0.011 -0.212
|             . | .          |             . | .         |15 -0.012  0.019
|             . |*.          |            .*| .          |16  0.078 -0.075
|             . | .          |            .*| .          |17 -0.025 -0.113
|            .*| .           |            **| .          |18 -0.073 -0.183
|             . | .          |            .*| .          |19  0.034 -0.105
|             . | .          |            **| .          |20 -0.015 -0.126
|             . | .          |             . | .         |21  0.027 -0.021
|             . | .          |            .*| .          |22  0.035 -0.042
|            **| .           |             . |*.         |23 -0.125  0.082
|             . |**          |             . | .         |24  0.182 -0.000
|            **| .           |            .*| .          |25 -0.151 -0.070
|             . |*.          |             . | .         |26  0.092 -0.010
|             . | .          |             . |*.         |27 -0.025  0.044
|            .*| .           |             . | .         |28 -0.062 -0.021
|             . |*.          |             . | .         |29  0.075  0.024
|             . | .          |            .*| .          |30 -0.014 -0.071
|            .*| .           |            **| .          |31 -0.092 -0.189
|             . |**          |             . | .         |32  0.154 -0.038
|            .*| .           |            .*| .          |33 -0.108 -0.108
|             . | .          |             . | .         |34  0.000 -0.013
|             . |***         |             . |***        |35  0.199  0.222
|          ****| .           |             . |*.         |36 -0.279  0.040
|             . |*.          |             . | .         |37  0.110 -0.011
|             . | .          |            .*| .          |38 -0.015 -0.060
|             . | .          |             . | .         |39 -0.027  0.000
|             . |*.          |             . | .         |40  0.072 -0.007
|             . | .          |             . | .         |41  0.004 -0.007
|             . | .          |             . | .         |42 -0.019  0.007
|             . |*.          |             . | .         |43  0.045 -0.037
|            .*| .           |             . |*.         |44 -0.081  0.067
==========================================================================
 Q-statistic (44 lags)  157.805            S.E. of Correlations  0.075
```

Autocorrelation function of the sationrized wine series

for the period February 1970 through September 1985 :

```
------------------------------------------------------------------
     autocorrelations     partial autocorrelations     ac      pac
------------------------------------------------------------------
|   *******| .      |   *******| .      | 1 -0.507 -0.507
|        .*| .      |    ******| .      | 2 -0.106 -0.490
|         .|*****   |         .|*.      | 3  0.369  0.072
|     *****| .      |       ***| .      | 4 -0.405 -0.265
|         .|**      |        **| .      | 5  0.149 -0.151
|         .|**      |         .| .      | 6  0.160 -0.002
|      ****| .      |        .*| .      | 7 -0.301 -0.115
|         .|**      |        **| .      | 8  0.166 -0.146
|         .| .      |        .*| .      | 9  0.025 -0.109
|        **| .      |        **| .      |10 -0.174 -0.150
|         .|*****   |         .|***     |11  0.349  0.235
|      ****| .      |        .*| .      |12 -0.316 -0.113
|         .| .      |        **| .      |13 -0.004 -0.137
|         .|**      |       ***| .      |14  0.166 -0.246
|        **| .      |         .| .      |15 -0.124  0.027
|         .|*.      |        .*| .      |16  0.063 -0.051
|         .|*.      |         .| .      |17  0.060 -0.004
|        **| .      |         .| .      |18 -0.116  0.003
|         .| .      |        **| .      |19 -0.004 -0.134
|         .|**      |         .| .      |20  0.139 -0.020
|        .*| .      |         .|*.      |21 -0.078  0.084
|         .| .      |         .| .      |22 -0.011 -0.010
|         .|*.      |         .|**      |23  0.044  0.126
|        .*| .      |        .*| .      |24 -0.108 -0.082
|         .|*.      |        .*| .      |25  0.041 -0.108
|         .|**      |         .| .      |26  0.118 -0.026
|        **| .      |         .| .      |27 -0.163 -0.024
|         .|*.      |         .|*.      |28  0.093  0.064
|         .| .      |        .*| .      |29 -0.037 -0.104
|        .*| .      |         .| .      |30 -0.049 -0.027
|         .|**      |         .| .      |31  0.164 -0.023
|        .*| .      |         .| .      |32 -0.106  0.028
|        .*| .      |        .*| .      |33 -0.088 -0.072
|         .|*.      |        **| .      |34  0.103 -0.165
|         .| .      |         .|*.      |35  0.012  0.113
|        .*| .      |        .*| .      |36 -0.073 -0.069
|         .|**      |         .| .      |37  0.161  0.029
|        **| .      |         .| .      |38 -0.135  0.035
|         .| .      |         .|*.      |39 -0.002  0.063
|         .| .      |        .*| .      |40  0.023 -0.100
|         .| .      |         .| .      |41  0.038  0.017
|         .| .      |         .|**      |42  0.017  0.143
|        **| .      |        .*| .      |43 -0.140 -0.088
|         .|*.      |         .| .      |44  0.095 -0.021
------------------------------------------------------------------
 Q-statistic (44 lags)  225.662         S.E. of Correlations  0.075
```

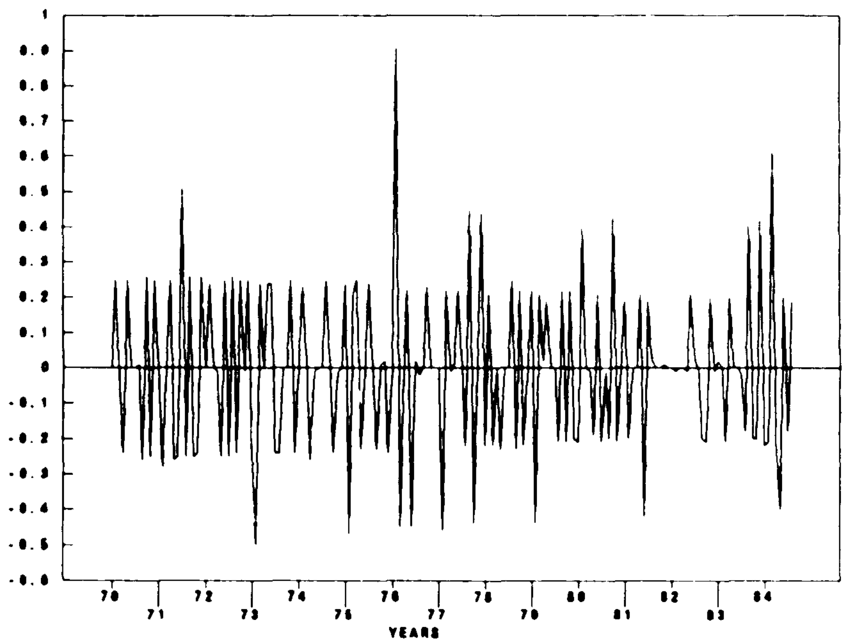
Autocorrelation function of the sationrized distilled spirits series

for the period February 1970 through September 1985 :

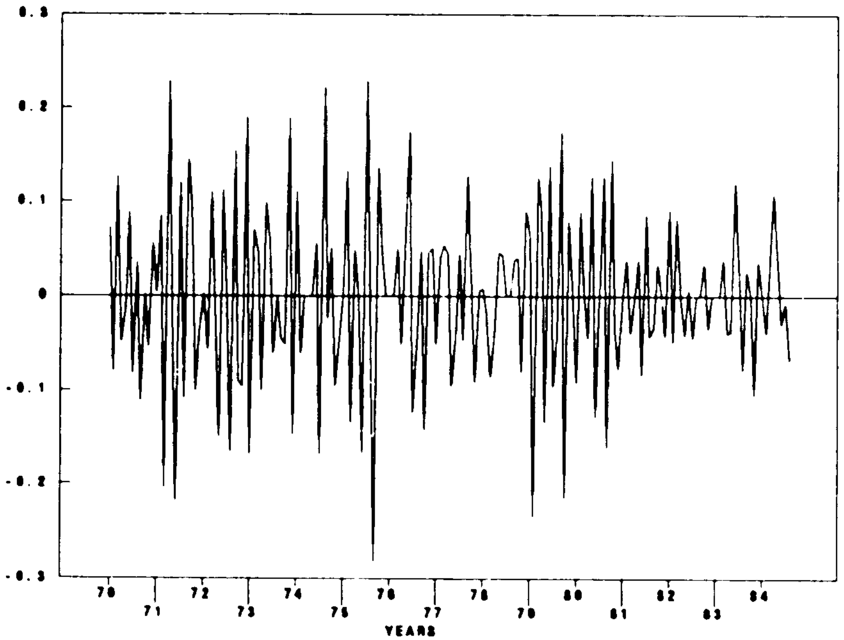
```
===========================================================================
       autocorrelations          partial autocorrelations          ac      pac
===========================================================================
|        *******|  .        |        *******|  .        | 1 -0.518 -0.518
|             **|  .        |        *******|  .        | 2 -0.148 -0.569
|              . |*****     |              . | .        | 3  0.396 -0.037
|           ****|  .        |             **|  .        | 4 -0.293 -0.141
|              . | .        |            ***|  .        | 5 -0.031 -0.210
|              . |***       |             .*|  .        | 6  0.251 -0.049
|            ***|  .        |              . | .        | 7 -0.199 -0.034
|              . | .        |             .*|  .        | 8 -0.026 -0.111
|              . |***       |              . |*.        | 9  0.218  0.038
|           ****|  .        |             **|  .        |10 -0.275 -0.168
|              . |***       |              . |**        |11  0.231  0.165
|              . | .        |              . |*.        |12 -0.021  0.099
|           ****|  .        |             **|  .        |13 -0.269 -0.161
|              . |***       |            ***|  .        |14  0.236 -0.212
|              . | .        |             .*|  .        |15  0.018 -0.061
|            ***|  .        |             **|  .        |16 -0.238 -0.174
|              . |****      |             .*|  .        |17  0.280 -0.040
|              . | .        |              . |*.        |18 -0.013  0.099
|           ****|  .        |              . | .        |19 -0.272  0.005
|              . |***       |             .*|  .        |20  0.259 -0.078
|              . | .        |              . |*.        |21 -0.013  0.043
|           ****|  .        |           ****|  .        |22 -0.301 -0.293
|              . |******    |              . |***       |23  0.464  0.228
|           ****|  .        |              . | .        |24 -0.290 -0.004
|             .*|  .        |              . | .        |25 -0.086 -0.029
|              . |****      |             .*|  .        |26  0.339 -0.048
|           ****|  .        |              . | .        |27 -0.277 -0.029
|              . |*.        |              . | .        |28  0.047  0.005
|              . |**        |              . |*.        |29  0.181  0.077
|           ****|  .        |             .*|  .        |30 -0.269 -0.043
|              . |*.        |             .*|  .        |31  0.039 -0.070
|              . |****      |              . |**        |32  0.321  0.138
|          *****|  .        |              . |**        |33 -0.378  0.116
|              . |**        |             .*|  .        |34  0.156 -0.047
|              . |**        |              . |*.        |35  0.135  0.095
|           ****|  .        |             .*|  .        |36 -0.334 -0.039
|              . |***       |              . |*.        |37  0.249  0.042
|              . | .        |              . | .        |38  0.028 -0.038
|            ***|  .        |              . |*.        |39 -0.199  0.105
|              . |**        |              . | .        |40  0.155  0.010
|              . | .        |              . | .        |41 -0.018 -0.034
|             **|  .        |             .*|  .        |42 -0.150 -0.094
|              . |***       |              . | .        |43  0.236 -0.006
|             .*|  .        |              . | .        |44 -0.096  0.009
===========================================================================
 Q-statistic (44 lags)  443.069          S.E. of Correlations  0.075
```

As a final proof of achieving stationarity with regards to the mean, variance and autocorrelation let us examine the plot of the stationrized series.

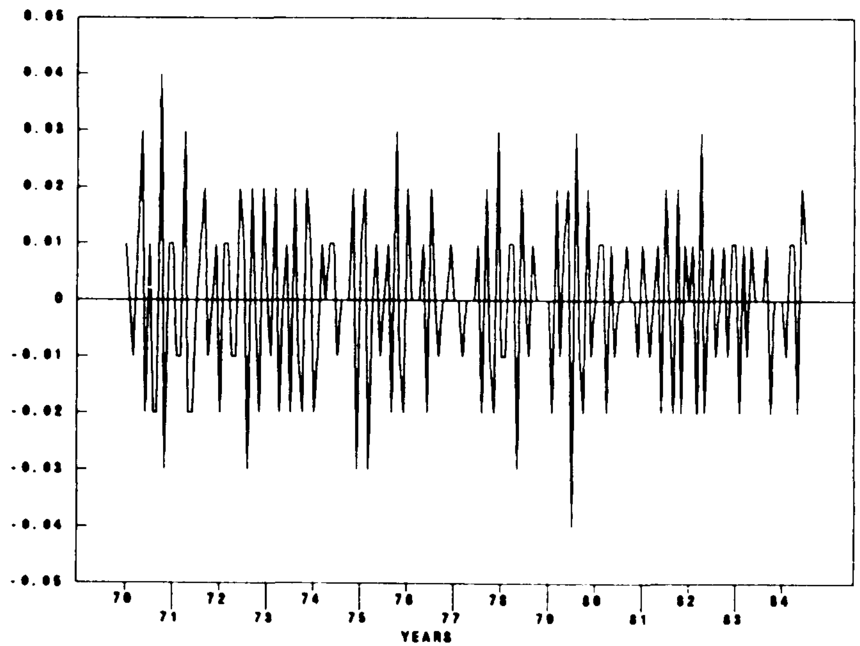
STATIONARY BEER



STATIONARY WINE



STATIONARY DISTILLED SPIRITS



A brief examination of all three plots clearly indicates once again what we already know. All three series, once simply and seasonally differenced, achieve stationarity in the mean and autocorrelation.

The purpose of differencing is solely for the sake of estimation. Once a model is estimated and identified the series must be integrated back into the original form in order to produce a forecast for the post-intervention period.

6. Identification of the Pre-Intervention Multiplicative Autoregresive Moving Average Box Jenkins Models.

The objective here is to identify the best model with the minimum number of parameters that can adequately represent the basic features of the consumption per capita of the specific alcoholic beverage to be analyzed. The models chosen will attempt to explain only the most regular patterns. To further clarify this idea consider the following hypothesis. Lets assume for a moment that I were to fit a model for the pre-intervention period that cover exactly all of the underling features of the data. Such a model would have to be extremely complex with many parameters. Furthermore such a model once extrapolated into the post intervention period may not predict as well as a simple model with only a few parameters. In selecting a model the emphasis will be on a model that can best explain the behavior of the data once extrapolated into the future and not on a model that can best fit the historical pre-intervention period.

The first step in identifying Multiplicative Auto Regressive Moving Average Box Jenkins models will be to carefully analyze the stationrized autocorrelation and partial autocorrelation functions. These autocorrelation functions serve as a summary of the patterns that exist in the per capita consumption of the different alcoholic beverages.

The stationrized autocorrelation function will be used to identify the moving average order together with a partial autocorrelation function that dampens over time. This follows since a stationarized autocorrelation function measures the dependency in the series between two points separated by k time units. The autocorrelation coefficient measures the extent to which a value of the series above or below the mean at time t tends to be followed by a value of the series above or below the mean k time units later, since we are analyzing a stationrized series.

The stationrized partial autocorrelation function will be used to identify the autoregressive order together with a autocorrelation function that dampens over time. This follows, since the stationrized partial autocorrelation function measures the autocorrelations of the time series values k lags apart after we have eliminated or partialed out all the k-1 autocorrelations.

The formula for the partial autocorelation function is as follows:

$$r_{kk} = \frac{r_k - \sum_{j=1}^{j=k-1} r_{k-1,j}\, r_{k-j}}{1 - \sum_{j=1}^{j=k-1} r_{k-1,j}\, r_j}$$

This formula holds only for k values larger than one. When k equals to one, the partial autocorrelation function numerical value is identical to the first autocorrelation functions value.

Integrated process that have autoregressive and moving average components require a great deal of judgement in identifying the proper model.

6.1 Identification of the Pre-Intervention Beer Model

Since the firstorder autocorrelation and firstorder seasonal autocorrelation lags are very highly significant a simple moving average and seasonal moving average of order one was identified.

The following results were obtained:

$$y_t = e_t - 0.88 e_{t-1} - 0.69 e_{t-12}$$
$$(-23.57) \quad (-11.41)$$

The adjusted r square was found to be 0.61.

The Ljung Box test with 39 degrees of freedom was equal 36.58 .

The Ljung Box formula is as follows:

$$Q = T(T+2) \sum_{i=L}^{i=1} \frac{r_i^2}{(T-i)}$$

i is the number of the autocorrelation.

L is the maximum number of lags in the autocorrelation function.

T is the number of observations in the historical sample.

r is the autocorrelation function value.

The Ljung Box measures the overall error autocorrelations in the identified model[10]. The Ljung Box Statistics is an improved version of the Box Pierce Statistics which was introduced earlier. Over-whelming empirical evidence has determined that the Ljung Box Statistic is preferred over the Box Pierce measure as a test for overall error autocorrelation.

In percentage terms we can say that their is a 58% chance that the errors from the pre-intervention beer model are not correlated or we accept the null hypothesis of no error autocorrelation.

---

[10] In this case the Ljung Box measures the error autocorrelation of up to forty one lags. Since we had estimated a simple moving average and a seasonal moving average parameter we lost two degrees of freedom. The Ljung Box statistic should follow a chi square distribution with thirty nine degrees of freedom.

Let us examine the error autocorrelation function from this model.

A close examination clearly indicates that our error autocorrelation function has no significant correlations at any of the simple or seasonal key lags that would require us to revise our model.

Error autocorrelation from the pre-intervention beer model:

```
==========================================================================
      autocorrelations        partial autocorrelations        ac      pac
==========================================================================
|          . | .     |          . | .     | 1  0.010  0.010
|          .*| .     |          .*| .     | 2 -0.094 -0.094
|          . |*.     |          . |*.     | 3  0.057  0.060
|         ***| .     |         ***| .     | 4 -0.204 -0.217
|          . | .     |          . | .     | 5 -0.036 -0.016
|          . |**     |          . |*.     | 6  0.129  0.088
|          . |*.     |          . |*.     | 7  0.081  0.102
|          . |*.     |          . | .     | 8  0.047  0.027
|          . |*.     |          . |*.     | 9  0.060  0.055
|          . | .     |          . | .     |10 -0.010  0.029
|          . | .     |          . |*.     |11  0.017  0.070
|          . | .     |          . | .     |12 -0.033 -0.034
|          . | .     |          . | .     |13 -0.001  0.012
|          . |*.     |          . | .     |14  0.049  0.029
|          . |*.     |          . |*.     |15  0.049  0.056
|          . | .     |          . | .     |16  0.007 -0.015
|          . | .     |          . | .     |17  0.027  0.019
|          .*| .     |          .*| .     |18 -0.054 -0.056
|          . | .     |          . |*.     |19  0.013  0.047
|          . |*.     |          . |*.     |20  0.091  0.071
|          . |*.     |          . |*.     |21  0.051  0.062
|          . |*.     |          . |*.     |22  0.069  0.052
|          . | .     |          . | .     |23  0.011  0.014
|          . |*.     |          . |*.     |24  0.049  0.097
|          .*| .     |          . | .     |25 -0.050 -0.035
|          . |*.     |          . |*.     |26  0.065  0.092
|          . | .     |          . | .     |27  0.006 -0.032
|          . | .     |          . | .     |28 -0.021 -0.000
|          . |*.     |          . |*.     |29  0.088  0.042
|          . | .     |          .*| .     |30 -0.026 -0.040
|          .*| .     |          .*| .     |31 -0.057 -0.070
|          . |**     |          . |*.     |32  0.116  0.096
|          .*| .     |          .*| .     |33 -0.059 -0.072
|          . |*.     |          . |*.     |34  0.058  0.095
|          . |*.     |          . | .     |35  0.101  0.015
|          **| .     |          .*| .     |36 -0.141 -0.100
|          . |*.     |          . | .     |37  0.042  0.038
|          . | .     |          . | .     |38 -0.001 -0.021
|          . | .     |          . |*.     |39  0.012  0.061
|          . |*.     |          . | .     |40  0.081  0.019
|          . |*.     |          . |*.     |41  0.067  0.041
|          . | .     |          . | .     |42  0.015  0.034
|          . | .     |          .*| .     |43 -0.033 -0.050
|          .*| .     |          .*| .     |44 -0.073 -0.072
==========================================================================
 Q-statistic (44 lags)   35.437          S.E. of Correlations   0.075
```

6.2 Identification of the Pre-Intervention Wine Model

Based on the autocorerelation and partial autocrrelation function a simple secondorder autoregressive and a secondorder seasonally autoregressive model was identified.

The following results were obtained:

$$y_t = -0.78y_{t-1} - 0.55y_{t-2} - 0.40y_{t-12} - 0.23y_{t-24} + e_t$$
$$(-11.19) \quad (-7.84) \quad (-5.08) \quad (-3.04)$$

The adjusted r square was found to be 0.54.

The Ljung Box test with 36 degrees of freedom was equal 36.58 . In percentage terms we can say that there is a 23% chance that the errors from the pre-intervention beer model are not correlated or we accept the null hypothesis of no error autocorrelation.

Let us examine the error autocorrelation function from this model. A close examination clearly indicates that our error autocorrelation function has no significant correlations at any of the simple or seasonal key lags that would require us to revise our model.

Error autocorrelation from pre-intervention wine model:

```
------------------------------------------------------------------------------
        autocorrelations          partial autocorrelations          ac     pac
------------------------------------------------------------------------------
|            . |*.          |             . |*.          | 1  0.050  0.050
|            .*| .          |             .*| .          | 2 -0.040 -0.040
|            .*| .          |             .*| .          | 3 -0.101 -0.096
|            **| .          |             **| .          | 4 -0.191 -0.187
|            .*| .          |             .*| .          | 5 -0.045 -0.042
|            .*| .          |             .*| .          | 6 -0.066 -0.097
|            **| .          |             **| .          | 7 -0.141 -0.189
|            .*| .          |             **| .          | 8 -0.069 -0.133
|            . |*.          |             . | .          | 9  0.065  0.004
|            . | .          |             .*| .          |10  0.017 -0.081
|            . |**          |             . |*.          |11  0.155  0.066
|            .*| .          |             **| .          |12 -0.062 -0.136
|            .*| .          |             .*| .          |13 -0.079 -0.104
|            . | .          |             . | .          |14  0.035 -0.009
|            . |*.          |             . |*.          |15  0.068  0.055
|            . |*.          |             . |*.          |16  0.103  0.066
|            .*| .          |             .*| .          |17 -0.052 -0.070
|            . | .          |             . | .          |18 -0.018  0.030
|            .*| .          |             . | .          |19 -0.045 -0.017
|            . |*.          |             . |*.          |20  0.068  0.071
|            . | .          |             . | .          |21  0.004  0.014
|            .*| .          |             .*| .          |22 -0.107 -0.088
|            . | .          |             . |*.          |23 -0.008  0.050
|            .*| .          |             . | .          |24 -0.055 -0.036
|            . | .          |             .*| .          |25  0.002 -0.044
|            . |*.          |             . |*.          |26  0.088  0.046
|            **| .          |             **| .          |27 -0.131 -0.181
|            . | .          |             . | .          |28 -0.014  0.009
|            . |*.          |             . | .          |29  0.065  0.002
|            . |*.          |             . |*.          |30  0.081  0.046
|            . |*.          |             . | .          |31  0.091  0.006
|            .*| .          |             .*| .          |32 -0.039 -0.073
|            **| .          |             .*| .          |33 -0.123 -0.053
|            . |*.          |             . |*.          |34  0.092  0.091
|            . | .          |             . | .          |35  0.023  0.009
|            .*| .          |             .*| .          |36 -0.085 -0.093
|            . |**          |             . |**          |37  0.122  0.147
|            . | .          |             . |**          |38  0.003  0.128
|            . | .          |             .*| .          |39 -0.028 -0.047
|            . | .          |             . | .          |40  0.007 -0.016
|            . | .          |             . |*.          |41  0.006  0.080
|            .*| .          |             . | .          |42 -0.068 -0.009
|            **| .          |             **| .          |43 -0.156 -0.140
|            . | .          |             . |*.          |44  0.020  0.053
------------------------------------------------------------------------------
Q-statistic (44 lags)   42.613             S.E. of Correlations  0.081
```

6.3 Identification of the Pre-Intervention Distilled Spirits Model

Based on the autocorerelation and partial autocrrelation function a firstorder simple moving average and a fourthorder seasonally autoregressive model was identified.

The following results were obtained:

$$y_t = -0.41y_{t-12} - 0.43y_{t-24} - 0.55y_{t-36} - 0.37y_{t-48} + e_t - 0.81e_{t-1}$$
$$(-4.50) \quad (-5.57) \quad (-6.99) \quad (-4.67) \qquad (-14.94)$$

The adjusted r square was found to be 0.66.

The Ljung Box test with 33 degrees of freedom was equal to 21.53. In percentage terms we can say that there is a 94% chance that the errors from the pre-intervention distilled spirits model are not correlated or we accept the null hypothesis of no error autocorrelation.
Let us examine the error autocorrelation function from this model.

A close examination clearly indicates that our error auto correlation function has no significant correlations at any simple or seasonal key lags that would require us to revise our model.

As a final verification to make sure that all pre-intervention models were correctly identified the first differences of the residuals were modeled as a moving average in the firstorder. The coefficient on the moving average parameter was approximately equal to 1 and the first error autocorrelation was approximately equal to -0.5[11].

[11] For a more formal proof see Walter Vandaele, Applied Time Series and Box Jenkins Models chapter five.

Error autocorrelation function from pre-intervention distilled spirits model:

```
==============================================================================
      autocorrelations          partial autocorrelations         ac      pac
==============================================================================
|          .*|  .         |          .*|  .         | 1 -0.085 -0.085
|           . |  .         |           . |  .         | 2  0.020  0.013
|           . |  .         |           . |  .         | 3  0.022  0.025
|          .*|  .         |          .*|  .         | 4 -0.047 -0.044
|          .*|  .         |          .*|  .         | 5 -0.070 -0.079
|           . |*.         |           . |*.         | 6  0.077  0.067
|           . |*.         |           . |*.         | 7  0.054  0.073
|          .*|  .         |          .*|  .         | 8 -0.056 -0.049
|           . |  .         |           . |  .         | 9  0.024  0.002
|          **|  .         |          **|  .         |10 -0.122 -0.121
|           . |*.         |           . |*.         |11  0.068  0.069
|          .*|  .         |          .*|  .         |12 -0.081 -0.069
|           . |*.         |           . |  .         |13  0.056  0.034
|           . |  .         |           . |  .         |14 -0.013 -0.015
|           . |  .         |           . |  .         |15 -0.013 -0.019
|           . |  .         |           . |  .         |16  0.023  0.037
|           . |  .         |           . |*.         |17  0.034  0.040
|           . |  .         |           . |  .         |18 -0.033 -0.033
|           . |  .         |           . |  .         |19  0.013  0.013
|          .*|  .         |          .*|  .         |20 -0.067 -0.097
|          .*|  .         |          .*|  .         |21 -0.088 -0.067
|          .*|  .         |          **|  .         |22 -0.112 -0.156
|           . |**         |           . |**         |23  0.124  0.129
|           . |  .         |           . |  .         |24  0.001  0.009
|           . |  .         |           . |  .         |25 -0.022 -0.027
|           . |  .         |           . |  .         |26  0.023 -0.004
|           . |  .         |           . |  .         |27 -0.034 -0.010
|          .*|  .         |          .*|  .         |28 -0.102 -0.080
|          .*|  .         |          **|  .         |29 -0.091 -0.117
|           . |  .         |          .*|  .         |30  0.022 -0.055
|           . |  .         |           . |*.         |31  0.032  0.065
|           . |**         |           . |*.         |32  0.133  0.109
|          **|  .         |          **|  .         |33 -0.158 -0.139
|           . |  .         |          .*|  .         |34 -0.022 -0.093
|          .*|  .         |          .*|  .         |35 -0.100 -0.075
|           . |  .         |           . |*.         |36  0.034  0.062
|           . |  .         |           . |  .         |37  0.033  0.034
|           . |  .         |           . |  .         |38  0.022 -0.030
|           . |*.         |           . |*.         |39  0.114  0.101
|          .*|  .         |          .*|  .         |40 -0.065 -0.050
|          .*|  .         |          .*|  .         |41 -0.042 -0.062
|           . |  .         |           . |  .         |42 -0.007 -0.036
|           . |**         |           . |*.         |43  0.127  0.099
|          .*|  .         |           . |  .         |44 -0.065  0.014
==============================================================================
Q-statistic (44 lags)   27.662          S.E. of Correlations  0.088
```

7. Analysis of the Results of the Pre-Intervention Models

In order to evaluate the effect of the federal tax intervention in distilled spirits which took effect starting October 1, 1985, the following procedure was applied.

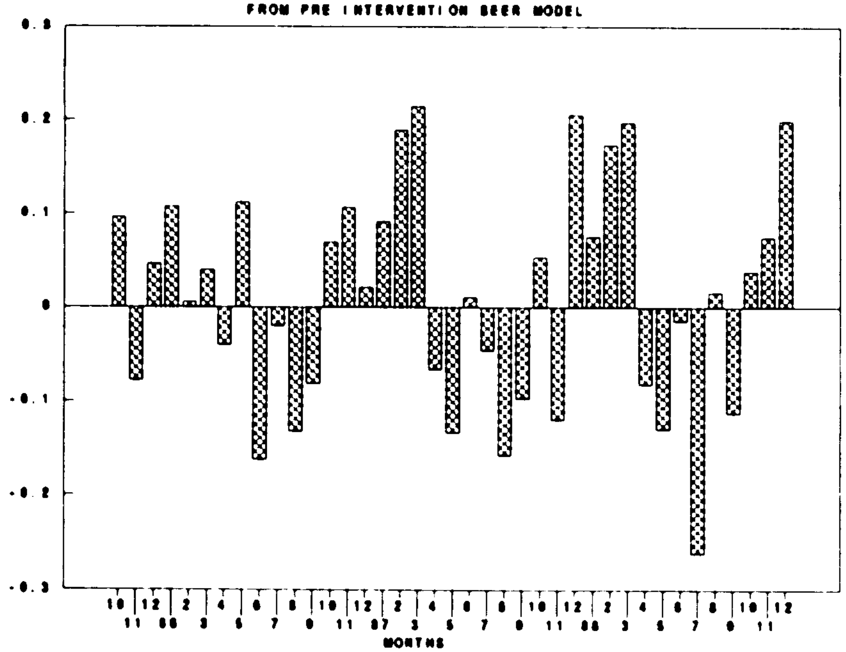
The pre intervention models which have be n estimated earlier were extrapolated into the future. The forecast of these models was then subtracted from the actual post-intervention data. These residuals are a simple and straight-forward way to show the effect of the tax intervention.

7.1 Analysis of the Residuals from the Pre-Intervention Beer Model.

Let us observe the plot of the residuals for the forecasted period:

ACTUAL MINUS FORECAST

FROM PRE INTERVENTION BEER MODEL



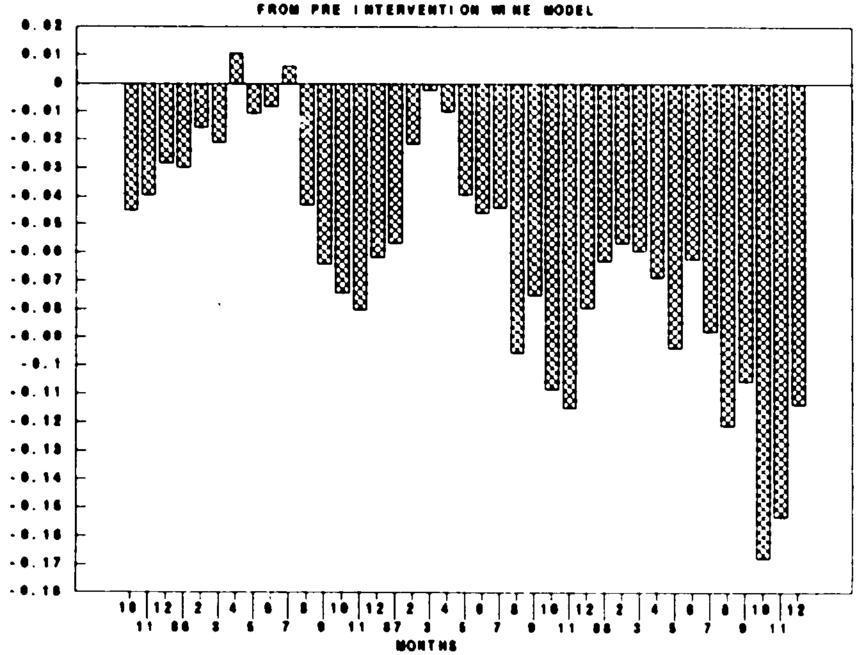
Just from simply analyzing these residuals we find that there is no pattern. The residuals are not always positive nor are they negative. The interpretation must be therefore that the federal tax intervention in distilled spirits did not cause the per capita consumption of beer to increase or decrease.

7.2 Analysis of the Residuals from the Pre-Intervention Wine Model.

Let us observe the plot of the residuals for the forecasted period:

ACTUAL MINUS FORECAST

FROM PRE INTERVENTION WINE MODEL



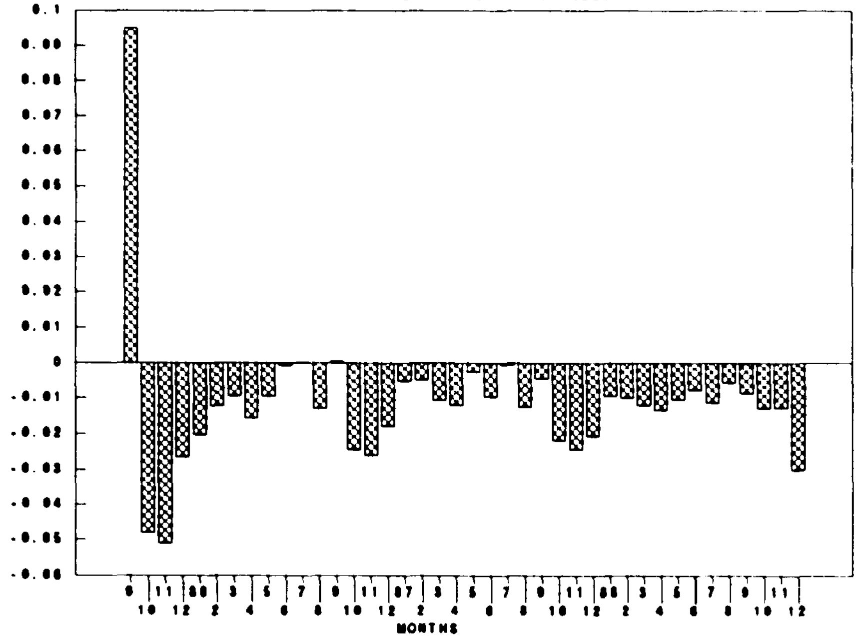
Just from simply analyzing these residuals we find that there is a pattern. The residuals are almost always negative. The interpretation must be therefore that the federal tax intervention in distilled spirits caused the per capita consumption of wine to decrease. This is because the actual figures which include the effects of the tax intervention in distilled spirits were consistently smaller than the forecasted values which do not include the effect of the tax intervention.

7.3 Analysis of the Residuals from the Pre-Intervention Distilled Spirits Model.

Let us observe the plot of the residuals for the forecasted period:

ACTUAL MINUS FORECAST

FROM PRE INTERVENTION SPIRITS MODEL



The analysis of the residuals fulfil what was expected. In analyzing these residuals we find that one month prior to the intervention there is a stockpiling effect, since it was very well anticipated that there was going to be an excise tax imposition in the following month. Once the actual tax intervention occurs we have a permanent decrease in the per capita consumption of distilled spirits.

8. Summary of the Findings Based on the Pre-Intervention Models.

The tax intervention in October 1985 caused an increase 0.1 of a gallon in the per capita consumption of distilled spirits in September 1985. Starting in October 1985 there is permanent decrease in the per capita consumption of distilled spirits. In October and November of 1985 there is a decrease of 0.05 of a gallon per month in the per capita consumption of distilled spirits. Starting in December 1985 there is a permanent decrease of approximately 0.02 gallons in the per capita consumption of distilled spirits.

With regards to wine there is a permanent decrease in the per capita consumption due to the federal tax intervention in distilled spirits. The decrease in the per capita consumption of wine is increasing throughout the entire forecasted period starting from approximately 0.01 gallons in October 1985 to 0.17 gallons in December 1988.

With regards to the per capita consumption of beer there is no significant effect due to the federal tax intervention in distilled spirits.

In order to properly evaluate the accuracy of the forecasted results it is useful to calculate the Theil's U Statistic. The Theil's U Statistic is the ratio of the root mean square error of the forecast to the root mean square of the "naive" forecast of no change in the dependent variable.

The Theil's Statistic formula is given as follows:

$$U_t = \sqrt{\frac{\sum e_t^2}{\sum (y_t - y_{t-1})^2}}$$

u sub t is the U Statistics evaluated at time t.

In the numerator we have the forecasted error at time t.

In the denominator we have the naive forecast of no change in the dependent variable. For a perfect forecast the Theil's U Statistic should be equal to zero. If Theil's U Statistic is equal to one then our model has produced just as good as a naive forecast. However if the Theil'S U Statistics is larger than 1 this indicates that we have forecasted worse than a naive forecast. The Theil's U Statistic is a pure number therefore we can compare the results of all three pre intervention models simultaneously.

Let us examine the Theil's U Statistic for the first three years following the intervention.

Theil's U Statistics

	beer	wine	spirits
1	0.460629	0.713849	0.496091
2	0.336873	0.540879	0.356528
3	0.257134	0.520735	0.374537
4	0.215518	0.592744	0.267103
5	0.198812	0.662836	0.259150
6	0.186332	0.658187	0.296057
7	0.193169	0.610469	0.266113
8	0.202044	0.500567	0.250664
9	0.239188	0.405897	0.248861
10	0.321596	0.457673	0.245495
11	0.471337	0.750053	0.313842
12	0.937781	1.264454	0.728561
13	0.554977	1.017838	0.339255
14	0.400603	0.855893	0.319231
15	0.304518	0.852113	0.366794
16	0.255309	0.908150	0.253602
17	0.237618	0.980065	0.264265
18	0.222045	0.974595	0.311396
19	0.216527	0.985094	0.274936
20	0.226240	0.871585	0.256483
21	0.255914	0.717225	0.273431
22	0.370680	0.806045	0.262777
23	0.551044	1.177606	0.351641
24	0.951926	1.621155	0.626629
25	0.564889	1.422956	0.393344
26	0.418574	1.224303	0.396893
27	0.351260	1.158435	0.529234
28	0.264990	1.149708	0.303236
29	0.248617	1.245764	0.306154
30	0.238191	1.512598	0.376953
31	0.224363	1.971824	0.324553
32	0.261901	1.690073	0.298160
33	0.306659	1.161292	0.296060
34	0.458917	1.315347	0.264059
35	0.373052	1.574962	0.290418
36	1.092858	1.751655	0.413885

It is clear from analyzing the Theil's U statistic that the forecasts from the pre intervention models for beer and spirits are fairly reliable. The forecast produced by the pre intervention wine model is much less reliable. The wine forecast is often worse than the naive forecast. It is important to realize that the beer and spirits models do perform better than a naive forecast but that is not necessarily the best forecast one can achieve.

Since the pre intervention model analysis must be taken with some degree of caution, let us proceed with an alternative analysis, with which we will model the entire period. The pre-intervention as well as the post- intervention, period. After modeling the entire period we will include an intervention component into the Multiplicative Autoregressive Box Jenkins models.

There are three major benefits to the alternative analysis over the initial procedure described thus far. First, the alternative analysis measures the intervention effect directly. There is no need to compare the pre and post intervention periods. Secondly if there is a structural change in the model from the pre to the post intervention period then our initial analysis results will be biased. Third the alternative analysis can be modeled in such a way that it takes into account the specific shape of the intervention.

The alternative analysis does, however, have two minor disadvantages over the original analysis. First, the degree of complexity of the model is increased due to the fact we have one more parameter, namely the intervention parameter, to estimate. The additional intervention parameter causes us to lose one more degree of freedom, which in itself is not a great loss, considering the fact that we have more than two hundred degrees of freedom. Nevertheless, since our objective is to estimate the best model with the minimum number of parameters, our alternative analysis could obviously produce inferior results. Secondly, when dealing with Box Jenkins models, an intervention component has a specific meaning. The intervention component implies that we have a determansitic trend in the data. Since the autoregressive and moving average components are parts of a stocastic process, we are forced to model the intervention determanstic trend separately. If there is no determanstic trend change in the data as a direct result of the federal tax intervention in October 1985, then there is no theoretical justification for the inclusion of an intervention component in our analysis[12].

[12] S.N. Durlauf and P. C. B. Phillips, 1988, trends versus random walks in time series analysis, econometrica 56, 6, pages 1333-1354.

9. The Intervention Models

9.1 Results of the Beer Model for the Entire Period.

The beer model identified was a simple moving average in the firstorder and a seasonal moving average in the firstorder. Thus there was no change in the structure found in the pre-intervention model. The intervention component in the beer model was not significant. The empirical results were as follows:

$$y_t = e_t - 0.89 e_{t-1} - 0.69 e_{t-12}$$
$$(-27.23) \quad (-12.78)$$

The adjusted r square was 0.61.

The Ljung Box statistic with forty two degrees of freedom was 52.92. In percentage terms we would say that there is a 12% chance that the errors in this model are uncorrelated. In any event, 12% is sufficient to accept the null hypothesis of no serial correlation.

9.2 Results of Wine Model for the Entire Period.

The wine series was modeled as a simple autoregressive in the secondorder and a seasonal autoregressive in the secondorder.
This is the same structure that was found in the pre–intervention model. An intervention component that represents a once and for all permanent change in the levels of the series was incorporated into the Auto Regressive Moving Average Multiplicative Box Jenkins model.

The intervention component was specified in such a way that it takes on the value of zero prior to October 1985, which is the actual date of intervention, and the value of one thereafter. Unfortunately, this intervention component was significant only at the ninety percent level and not at the ninety five percent level.

The wine model results are as follows:

$$y_t = -0.68y_{t-1} - 0.46y_{t-2} - 0.37y_{t-12} - 0.28y_{t-24} + e_t - 0.004i$$
$$(-10.30) \quad (-7.06) \quad (-5.26) \quad (-3.90) \qquad (-1.74)$$

i represents the intervention component.
The adjusted r square was 0.47.

The Ljung Box test with thirty nine degrees of freedom was 89.9, which revealed that the errors of this model were in fact correlated. We had to reject the null hypothesis of non error autocorroleation.

Since analysis of the first differences of the residuals of this model clearly indicate that the model has correctly been specified (that is, the first difference of the residuals can be modeled as a simple moving average in the firstorder where the moving average parameter is equal to 1 and the first autocorrelation is equal to -0.5) we are able to accept this model as an adequate model even though the model suffers from overall autocorrelation in the errors.

9.3 Results of Distilled Spirits Model for the Entire Period.

The basic Auto Regressive Moving Average Multiplicative Box Jenkins model had the same structure found in the pre-intervention period. The basic model follows a simple moving average in the firstorder and a seasonal auto regressive in the fourthorder. In this model it was necessary to design two dichotomous variables to represent the intervention effect. The first intervention component takes on the value of one for the month of September 1985 and zero elsewhere. This intervention component measures the stockpiling effect and takes the following form:

$$y_t = W_1(I_{1_t})$$

I sub one sub t takes on the value of one in September 1985 and zero else where.

W sub one is the coefficient on the stockpiling intervention component.

It was very well-anticipated in September 1985 that in the following month the price of distilled spirits would rise due to a imposition of a new federal tax.

The second intervention component which measures the impact of the intervention from October 1985 and thereafter was represented by I sub two sub t. The second intervention component takes on the value of zero prior to October 1985 and the value of one from October 1985 and thereafter. In modeling the federal tax intervention in such a way, we are showing a once and for all permanent reduction throughout the post intervention period.

The second permanent intervention component takes the following simple form:

$$y_t = W_2(I_{2_t})$$

The empirical results of the distilled spirits model where the post intervention is modeled as having a long-lasting effect yields the following results:

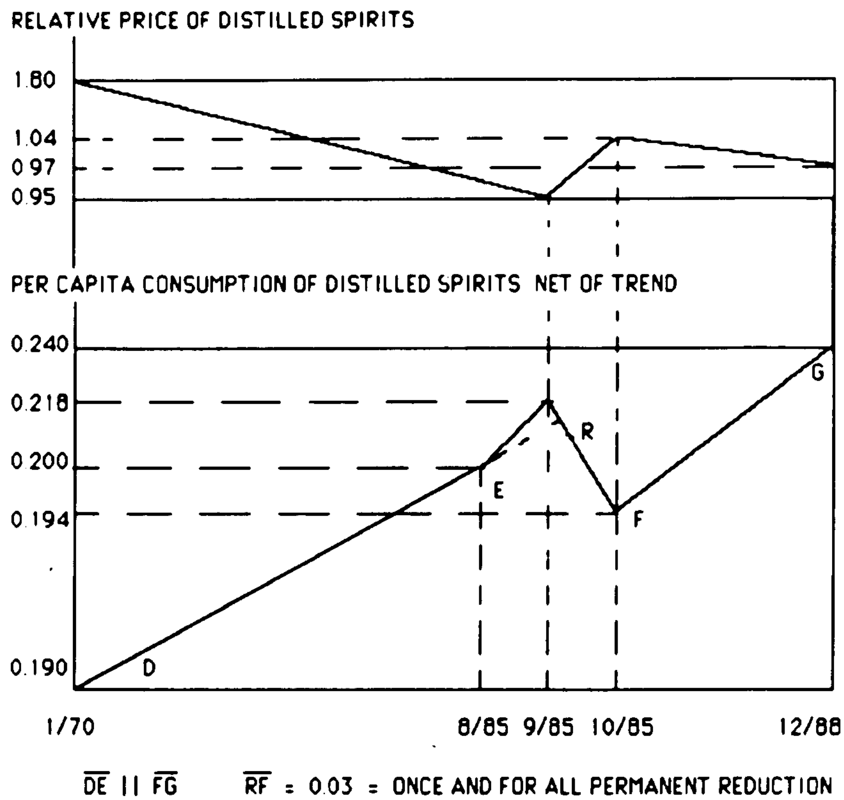
$$y_t = -0.47y_{t-12} - 0.44y_{t-24} - 0.58y_{t-36} - 0.39y_{t-48}$$
$$(-6.42) \quad (-6.61) \quad (-8.75) \quad (-5.59)$$

$$-0.7e_{t-1} + e_t + 0.09i_{1_t} - 0.03i_{2_t}$$
$$(-12.13) \quad (12.11) \quad (-5.5)$$

The adjusted r square was 0.85 .

The Ljung Box statistics was 30.34 or in percentage terms, we would say there is a 73% chance that the errors in this model are non correlated. Needless to say, we can easily accept the null hypothesis of no error autocorrelation.

These findings are illustrated in the following diagram where the direct federal tax intervention in distilled spirits is modeled as having an abrupt start and a permanent duration.


RELATIVE PRICE OF DISTILLED SPIRITS
1.80
1.04
0.97
0.95
PER CAPITA CONSUMPTION OF DISTILLED SPIRITS NET OF TREND
0.240
0.218
0.200
0.194
0.190
D
E
R
F
G
1/70
8/85
9/85
10/85
12/88
DE || FG
RF = 0.03 = ONCE AND FOR ALL PERMANENT REDUCTION

As an alternative analysis in modeling the intervention component the following model was tested. The first intervention component, namely the stockpiling effect, was modeled in the same way as outlined previously.

However, the second intervention component was modeled as having a gradual temporary effect for the post intervention period. The second intervention component takes on the value of one on October 1985 and the value of zero elsewhere. This intervention component was modeled as having a gradual and temporary effect which decreases over time.

This model is represented in the following fashion:

$$y_t = W_1(I_{1_t}) + \delta y_{t-1} + W_2(I_{2_t})$$

I sub 1 sub t is the stockpiling effect in September 1985.
I sub 2 sub t is equal to the gradual temporary effect that takes place from October 1985.
δ is the coefficient on this gradual temporary intervention component.

The decision to model the intervention in such a way was based on the fact that the relative price of distilled spirits, that is, the consumer price index of distilled spirits, divided by the consumer price index of all items, increased abruptly in October 1985 due to the federal tax intervention and decreased gradually thereafter.

The coefficient of i sub two sub t takes on the form of $(w / 1 - \delta)$.

W represents the decrease in the level of per capita consumption in October 1985. W was found to be equal -0.04 with a t Statistic of -7.51 .

δ is the rate of recovery from the increase in the federal tax intervention in distilled spirits in the post-intervention period. δ must be positive and less than one in order for our model to be stable.

The gradual temporary intervention effect after n periods is:

$$y_n = \delta^n (W_2)$$

Since δ must be positive and less than one it follows that δ to the power of a large n is zero. This implies that the intervention effect disappears over time.

δ was found to be 0.74 With a t Statistic of 12.47.

This model predicts a reduction of 0.04 per capita gallons in October of 1985, which is the first month of the intervention. In November of 1985, the second month following the intervention, the model predicts a smaller reduction of only 0.04 times 0.74 which is equal to 0.03 per capita gallons. In the third month following the intervention the model predicts an even smaller reduction of 0.04 times 0.74 squared which is equal to 0.02 per capita gallons. After only one year following the intervention, the model predicts an effect that is approximately zero.

The cumulative effect of the gradual temporary intervention is equal to the simple sum of a geometric series, that is, -0.04 divided by (1 - 0.74) which amounts to -0.15 per capita gallons.

The distilled spirits model results are as follows:

$$y_t = -0.4y_{t-12} - 0.43y_{t-24} - 0.56y_{t-36} - 0.34y_{t-48}$$
$$(-5.19) \quad (-6.46) \quad (-8.44) \quad (-4.95)$$

$$-0.83e_{t-1} + e_t + 0.09i_1 - 0.04 * (0.74^n)\, i_2$$
$$(-18.09) \quad (14.50) \quad (-7.51) \quad (12.47)$$

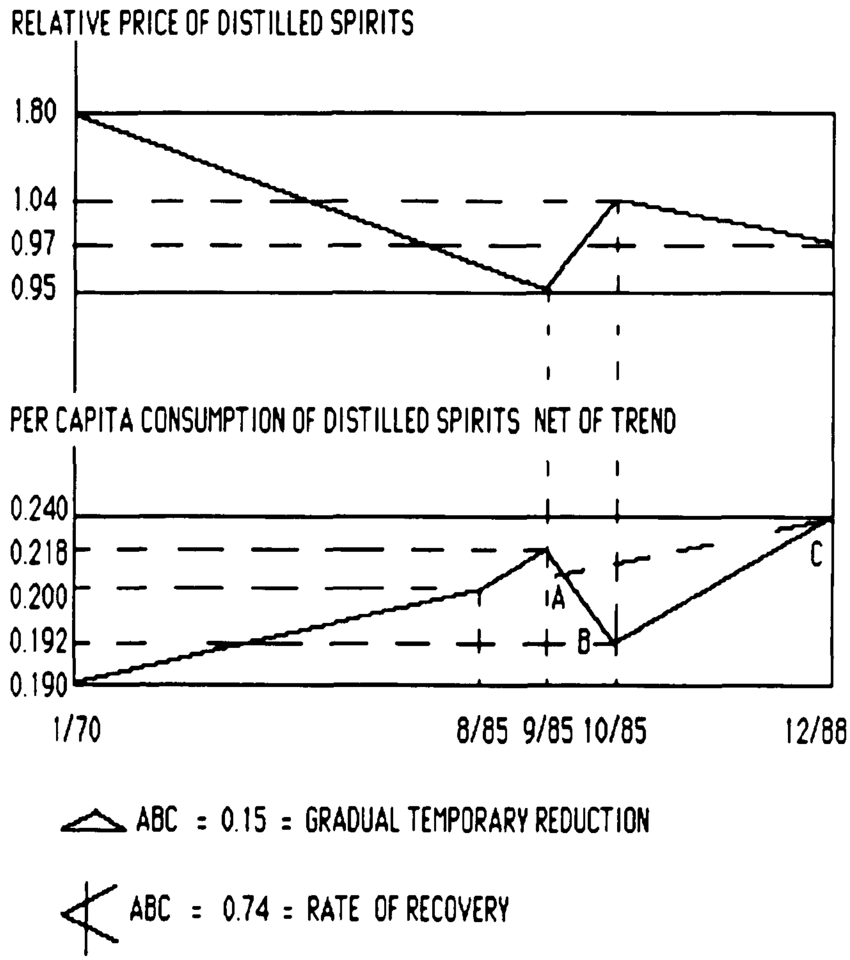
n is equal to zero prior to October 1985.

n is equal to one in October 1985 and it increases by one each month thereafter.

The adjusted r square was 0.87 .

The Ljung Box with thirty six degrees of freedom was 29.53 or, in percentage terms we would say that there is a 77% chance that the errors are uncorrelated.

These findings are illustrated in the following diagram, where the direct federal tax intervention in distilled spirits is modeled as having an abrupt start and a temporary duration.


RELATIVE PRICE OF DISTILLED SPIRITS
1.80
1.04
0.97
0.95
PER CAPITA CONSUMPTION OF DISTILLED SPIRITS NET OF TREND
0.240
0.218
0.200
0.192
0.190
A
B
C
1/70
8/85 9/85 10/85
12/88
ABC = 0.15 = GRADUAL TEMPORARY REDUCTION
ABC = 0.74 = RATE OF RECOVERY

10. Summary of the Findings when we Incorporate an Intervention Component in the analysis.

The federal tax intervention in distilled spirits had no effect on the per capita consumption of beer. The federal tax intervention had a slight if any effect on wine, since the intervention coefficient was barely significant. In order to find the percentage change in the per capita consumption of wine, we must exponentiate the intervention coefficient and subtract it from one. The numerical value obtained here is -0.44% which is a very mild effect.

In the per capita consumption of distilled spirits we find that both intervention components are large and significant. The stockpiling effect which took place lasted only through the month of September 1985 and caused a temporary increase of 0.09 gallons. This result was obtained in both per capita distilled spirits intervention models.

Regarding the effects on the per capita consumption of distilled spirits throughout the post intervention period, that is, from October 1985 and thereafter we must examine the specific form of the intervention.

If we model the post intervention period as having a once and for all permanent change in the level of the per capita consumption of distilled spirits then we find a permanent decrease of 0.03 gallons throughout the entire post-intervention period.

If we model the post intervention period as having a gradual and temporary decrease then we realize the following facts: an initial drop in the level of per capita consumption of distilled spirits of -0.04 gallons in October 1985 and a rate of recovery from the federal tax imposition of 0.74 gallons per month. This rate of recovery is fairly high and it lies within the bounds of invertabilty, which makes the effects of the federal tax intervention disappear rapidly. The cumulative effect of the federal tax intervention in this temporary gradual distilled spirits intervention model are found to have a decrease of 0.15 gallons from October 1985 till December 1988.

On the one hand, the permanent intervention model in distilled spirits has an effect on the per capita consumption of distilled spirits that does not disappear or even diminish in the long run, this makes this model reliable only as a short run model which must be reexamined once some more data is available. On the other hand, the gradual temporary model in distilled spirits has an effect on the per capita consumption of distilled spirits that disappears within less than a year following the intervention which is much too rapid.

In search for a model that would demonstrate a temporary effect on the per capita consumption that would last for a reasonable period of time and that would diminish gradually, the following model was evaluated.

Thus far, our analysis was basically a univariate analysis. Up until this point we have focused on the behavior of one variable, namely, the per capita consumption of a particular alcoholic beverage in order to explain the federal tax intervention that had been imposed starting in October 1985. Let us now proceed with a multivariable conventional demand function approach.

11. The Conventional Demand Functions Analysis.

The Dependent Variable.

In using conventional demand function analysis the dependant variable will always be the per capita consumption of the specific beverage we are evaluating.

The Explanatory Variables.

The own relative price, that is the nominal own price divided by the consumer price index of all items in the economy, will always be present as the first explanatory variable.

The real per capita income, that is personal desposable income divided by the consumer price index of all items in the economy, will always be present as the second explanatory variable.

An intercept will be included in all models.

Later on, I include some "well known explanatory variables". These are variables that are believed to have a substantial effect on the consumption of the specific beverage. The more explanatory variables we include, the greater the chance we may have a problem of multicollinearity among the explanatory variables; therefore, only the most well known explanatory variables will be included in following models.

These additional explanatory variables are as follows :

1. A trend variable. Per capita consumption of beer trended upward in the seventies and downward in the eighties and the per capita consumption of wine trended upward until the eighties while the per capita consumption of distilled spirits trended downward throughout the entire period. Two different trend variables were included in alternative models. The first trend variable was a linear trend variable, a simple time variable. The second trend variable was time squared which is a non linear trend variable.

2. The relative cross prices. In addition to the own price of the specific beverages the relative price of the other two beverages will be included. The examination of the cross relative prices may be able to indicate the type of relationship that exist among the different beverages.

3. The legal drinking age.

4. The fraction of the population sixteen years and over.

5. The legal drinking age times the fraction of the population sixteen years or over.

6. The unemployment rate. The unemployment rate is a good approxy variable for all the missing variables that we may have omitted.

In the first attempt all variables I will use will be seasonally adjusted variables. As an alternative approach all variables used will be nonseasonally adjusted variables[13] and in addition I will include eleven seasonal dichotomous variables for each month except January. All demand functions were corrected for serial correlation using the maximum likelihood grid procedure.

[13] With the exception of the personal disposable income variable which is not available in nonseasonal form.

11.1 The Conventional Demand Function for the Per Capita Consumption of Beer :

$$taba = 5.95 - 2.00rb - 0.008rinc + e$$
$$(14.35)\ (-11.38)\ (-3.31)$$

taba is the per capita consumption of beer.

rb is the relative price of beer.

rinc is the real personal disposable per capita income.

The numbers in parentheses are the t ratios.

The adjusted r square is 0.61.

The Durbin Watson was found to be 1.98, which clearly indicates that we can accept the null hypothesis of no firstorder error autocorrelation.

The f ratio was 175 which clearly indicates that all the coefficients are jointly significant.

The same demand function in logarithmic form renders the following result:

$$ltaba = 2.18 - 0.73lbeer - 0.22linca + e$$
$$(5.03)\ (-9.86)\quad (-2.42)$$

The adjusted r square is 0.60, the Durbin Watson is 1.99 and the f ratio is 168.

The coefficients in this demand functions are the price and income elasticites.

11.2 The Conventional Demand Function for the Per Capita Consumption of Wine :

$$tawa = 0.43 - 0.24rw + 0.0007rinc - 0.0003dt + e$$
$$(5.66) \quad (-7.92) \quad (1.40) \qquad (-2.14)$$

tawa is the per capita consumption of wine.

rw is the relative price of wine.

rinc is the real personal disposable per capita income.

dt is a trend variable. This trend variable was specified in such a way that it has a value of zero prior to January 1981 and has a linear trend thereafter.

The adjusted r square is 0.82.

The Durbin Watson was found to be 2.11 .

The f ratio was 339.

The same demand function in logarithmic form renders the following result:

$$ltawa = -3.95 - 1.29lwine + 0.56linca - 0.002dt + e$$
$$(-3.78) \quad (-8.31) \qquad (2.51) \qquad (-3.76)$$

The adjusted r square is 0.82.

The Durbin Watson is 2.14 which clearly indicates that we can accept the null hypothesis of no firstorder serial correlation among the error terms.

The f ratio was 339.

11.3 The Conventional Demand Function for the Per Capita Consumption of Distilled Spirits :

$$tasa = 0.36 - 0.11rwh + 0.0008rinc - 0.0008tl + e$$
$$(18.96)\ (-14.46)\ (3.51)\ \ (-16.70)$$

tasa is the per capita consumption of distilled spirits.

rwh is the relative price of whisky[14].

rinc is the real personal disposable per capita income.

tl is a linear trend variable.

The numbers in parentheses are the t ratios.

The adjusted r square is 0.76.

The Durbin Watson was found to be 2.02 .

The f ratio was 235 .

The same demand function in logarithmic form renders the following result:

$$ltasa = -3.83 - 0.93lwh + 0.65linca - 0.005tl + e$$
$$(-7.97)\ (-16.62)\ (5.92)\ \ (-19.13)$$

The adjusted r square is 0.79.

The Durbin Watson is 2.02 .

The f ratio was 297 .

[14] The consumer price index for distilled spirits was not available up until 1978; therefore, the consumer price of whisky which is a sub industry within the distilled spirit industry was taken.

It was not possible to include the cross relative prices in the conventional demand functions due to the high degree of multicolinearity among the relative beverage prices (for example in the demand function for beer it was not possible to include the relative price of wine and the relative price of distilled spirits).

The attempt to include the cross relative prices in the demand functions was unsuccessful even with regards to just one other cross relative price (for example, in the demand function for beer it was not possible to include only the relative of wine or only the relative price of distilled spirits).

The three symmetry conditions imposed were as follows:

A. The coefficient of the relative price of wine in the demand function for beer should equal the coefficient of the relative price of beer in the demand function for wine.

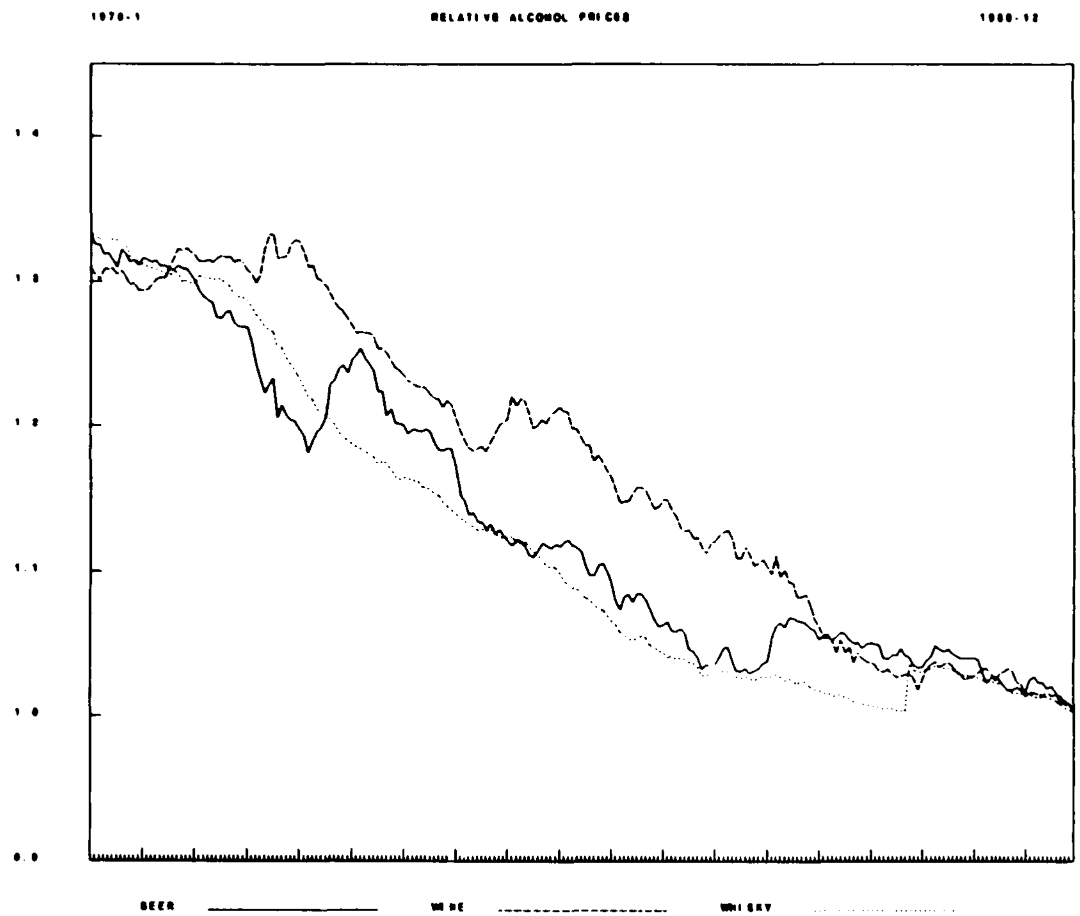
B. The coefficient of the relative price of whisky in the demand function for beer should equal the coefficient of the relative price of beer in the demand function for distilled spirits.

C. The coefficient of the relative price of whisky in the demand function for wine should equal the coefficient of the relative price of wine in the demand function for distilled spirits.

The imposition of the symmetry condition was not successful in two ways. First, the coefficients on the cross relative prices were insignificant due to the high rate of multicollinearity among the relative prices. Secondly, the restrictions on the coefficients of the relative prices were not justified. A chi square test that compares the restricted and the unrestricted models reveals that the restricted models are significantly different than the unrestricted ones and therefore one is not justified to impose the restrictions on the relative prices. Unfortunately these two limitations hold true even if we were to impose only one symmetry restriction.

The conventional demand functions that try to incorporate all three cross relative prices can be found in the appendix.

The high rate of mullticolinearity among the relative prices of beer, wine and whisky is illustrated on the next page.



1970-1
RELATIVE ALCOHOL PRICES
BEER
WINE
WHISKY

Attempts to include the other explanatory variables, namely, the unemployment rate, the legal drinking age and the portion of the population between sixteen and twenty years of age did not improve the analysis.

With regard to using nonseasonlized data and the inclusion of eleven seasonal dichotomous variables - one for each month except January - the results came out to be inferior to the seasonal analysis described above.

12. Interpretation of the Findings using Conventional Demand Functions.

On October 1985 the federal tax rate on the purchase of distilled spirits increased by two dollars per proof gallon. In order to properly evaluate the effect of this excise tax hike on the per capita consumption of distilled spirits the following model was designed.

$$s_t = \alpha_0 + \alpha_1 (r_t)$$

s sub t is the per capita consumption of distilled spirits.

r sub t is the relative price of distilled spirits which equals to the following:

$$r_t = \frac{m_t}{c_t}$$

m sub t is the nominal money price of distilled spirits and

c sub t is consumer price index of all items.

m sub t is defined as:

$$m_t = \Pi_t + f_t$$

π sub t is equal to the nominal price of distilled spirits exclusive of the tax.

Rewriting our tax equation renders the following:

$$s_t = \alpha_o + \alpha_1 \left(\frac{\Pi_t}{c_t}\right) + \alpha_1 \left(\frac{f_t}{c_t}\right)$$

Now, for the period prior to the tax intervention we have the following equation:

$$A.\quad s_t(f_t - 10.50) = \alpha_0 + \alpha_1\left(\frac{\Pi_t}{c_t}\right) + \alpha_1\left(\frac{10.50}{c_t}\right)$$

Once the intervention occurs we have the following equation:

$$B.\quad s_t(f_t - 12.50) = \alpha_0 + \alpha_1\left(\frac{\Pi_t}{c_t}\right) + \alpha_1\left(\frac{12.50}{c_t}\right)$$

Subtracting equation B from equation A gives the following:

$$C.\quad 2\frac{\alpha_1}{c_t}$$

Equation C gives us the difference between actual per capita consumption and consumption in the absence of a tax hike of two dollars per proof gallon.

Earlier I had estimated the effect of the relative price of whisky on the per capita consumption of distilled spirits and the coefficient obtained was equal to -0.11 . Rewriting that equation gives the following form:

$$s = \alpha_0 + \alpha_1 \frac{n(p_t)}{c_t}$$

n is the real price of distilled spirits. By linear interpolation, n was found to be equal to 6.88 .

In our earlier estimation we have actually found the following:

$$-0.11 = 6.88\alpha_1$$

and α sub one is -0.016 .

The federal tax caused a $0.32 change on the purchase of a 750 milliliter bottle. Now we can properly evaluate the effect of the tax hike in distilled spirits on the per capita consumption of distilled spirits. It amounts to the following formula:

$$\frac{-0.05}{c_t}$$

Where -0.05 = (-0.16)(0.32)

This model predicts a decline of 0.032 gallons in October 1985 which is the date the intervention actually takes place. This effect decreases rather slowly as time passes due to a mild increase in the consumer price index over time. In December 1988 this model predicts a decline of 0.029 gallons. The cumulative effect of this model for the entire post-intervention period is approximately 39*(0.03) or 1.17 gallons per capita.

13. Comparison of the Results Obtained in the Multiplicative Auto Regressive Moving Average Box Jenkins Models to those Obtained with Conventional Demand Function Specifications.

In the Multiplicative Auto Regressive Moving Average Box Jenkins models we found that the government intervention in distilled spirits caused a reduction in the per capita consumption of distilled spirits. Based on the pre-intervention distilled spirits model we found a 0.02 permanent reduction.

Based on the entire period models with the inclusion of an intervention component the amount of the reduction in the per capita consumption of distilled spirits depends on how we model the intervention component.

If we model the intervention as a once and for all permanent effect then we find a 0.03 gallons permanent reduction in the per capita consumption of distilled spirits. If we model the intervention as a temporary effect then we find a temporary reduction of 0.04 gallons with a rate of recovery of 0.74 gallons and a total effect of 0.15 gallons throughout the post intervention period. The effects on the per capita consumption of wine and beer were not significant in the multiplicative auto regressive models.

In the conventional demand function analysis we found that the excise tax of two dollars on the purchase price of distilled spirits causes a reduction of 0.03 gallons per month and a cumulative effect of 1.17 gallons on the per capita consumption of distilled spirits. The effects on the per capita consumption of wine and beer remained unknown in the convention demand function analysis due to the high rate of multicolieanrity among the relative prices.

In comparing the results of the Multiplicative Auto Reggressive Moving Average Box Jenkins models and the conventional demand functions models, one must exercise a large degree of care. In the Multiplicative Auto Reggressive Moving Average Box Jenkins models the effects of the reduction in the per capita consumption of distilled spirits are based primarily on the behavior of the series itself; that is, basically a pure univariate analysis. In the conventional demand function analysis the reduction in the per capita consumption of distilled spirits is based on the change in the relative price of distilled spirits after we have removed the effects of the other two variables, namely, the real income and the trend effects, which is basically a multivariate analysis.

Appendix

Empirical Results of the Conventional Demand Functions when the Cross Relative Prices are Incorporated.

A. Unrestricted Models:

1. Dependent Variable TABA

Adjusted R Square .652170788

Durbin-Watson 1.92413984

Explanatory Variable	Coefficient	T-Statistic
Constant	3.933678	8.166540
RB	-.6476293	-1.554171
RW	.8901116	5.086647
RWH	-.7784415	-5.195272
RINC	-.2568612E-02	-1.241961

2. Dependent Variable TAWA

Adjusted R Square .76181760

Durbin-Watson 1.00720189

Explanatory Variable	Coefficient	T-Statistic
Constant	.5442245	7.689017
RB	-.1520293	-2.495630
RW	-.1308960	-2.446517
RWH	.9835056E-03	0.3472285E-01
RINC	-.9624653E-04	-.2376441
DT	-.1588747E-04	-.1091353

3. Dependent Variable TASA

Adjusted R Square .75647336

Durbin-Watson 2.16009517

Explanatory Variable	Coefficient	T-Statistic
Constant	.3455100	5.907150
RB	-.1745505E-01	-.4409688
RW	.3076402E-01	.9576144
RWH	-.1096441	-8.199893
RINC	.6767790E-03	2.564872
T1	-.7190919E-03	-7.036489

B. Restricted Models:

1. Dependent Variable TABA

Adjusted R Square .652170788

Durbin-Watson 1.92413984

Explanatory Variable	Coefficient	T-Statistic
Constant	5.949369	17.98442
RB	-1.763425	-10.14129
RW	-.1073825	-2.134854
RWH	-.5050377E-01	-1.469391
RINC	-.8486797E-02	-4.573725

2. Dependent Variable TAWA

Adjusted R Square .76032496

Durbin-Watson 1.00187710

Explanatory Variable	Coefficient	T-Statistic
Constant	.5265554	8.538467
RB	-.1073825	-2.134854
RW	-.1647375	-3.985444
RWH	.1174792E-03	.6350471E-02
RINC	-.1154167E-04	-.2943568E-01
DT	-.5587573E-04	-.4606714

3. Dependent Variable TASA

Adjusted R Square .75395971

Durbin-Watson 2.15084744

Explanatory Variable	Coefficient	T-Statistic
Constant	.4056021	9.496078
RB	-.5050377E-01	-1.469391
RW	.1174792E-03	.6350471E-02
RWH	-.9779160E-01	-7.876254
RINC	.6976090E-03	2.862475
T1	-.7826985E-03	-10.83591

Chi-Square(3) = 42.40631 Significance Level = 0.0000000

Data Source

Consumption of Beer

Brewers Almanac Association, Annual Report, table 54 for the years 1970 - 1971, table 53 for the years 1972 - 1977 and table 45 for the years 1978 - 1986. The 1987 - 1988 figures were given to me directly from the Brewers Almanac Association.

Consumption of Wine

Wine Institute, Economic Research Report.

Consumption of Distilled Spirits

Distilled Spirits Council of the United States, Annual Statistical Review, table 34.

Population Data

Bureau of Labor Statistics, Federal Reserve Board, table for sixteen years of age and over and table for twenty years and over.

Unemployment Rate

Bureau of Labor Statistics. Table for unemployment rate of the civilian labor force.

Consumer Price Index

Bureau of Labor Statistics. Indexes for: beer at home, wine at home, whisky at home and all items.

Personal Disposable Income Per Capita

Department of Commerce, The National and Income Accounts table 2.6.

Legal Drinking Age

The Insurance Institute for Highway Safety, State Minimum Alcohol Purchase Age Laws, July 1988.

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