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Working Paper

The Sale of Alcohol in Denmark: Recent developments and dependencies on prices/taxes

Working paper, No. 18-2005

Provided in Cooperation with:

Department of Economics, Copenhagen Business School (CBS)

Suggested Citation: Cour, Lisbeth la; Milhøj, Anders (2005) : The Sale of Alcohol in Denmark: Recent developments and dependencies on prices/taxes, Working paper, No. 18-2005, Copenhagen Business School (CBS), Department of Economics, Frederiksberg, <https://hdl.handle.net/10398/7532>

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**Copenhagen
Business School**
HANDELSHØJSKOLEN

Department of Economics

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Working paper 18-2005

THE SALE OF ALCOHOL IN DENMARK- recent developments and dependencies on prices/taxes

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The Sale of Alcohol in Denmark – recent developments and dependencies on prices/taxes.

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1. Introduction

In the following we will analyse the sale of alcohol in Denmark. Various figures related to this question are published by Statistics Denmark at different frequencies. Our main concern will be with quarterly data for the sale of beer, wine and spirits from the period 1990 – 2004. Our two hypotheses are: First we want to convince the reader that the total sale of alcohol in Denmark since 1980 has been fairly stable. By total sale we mean the total sale of 100% alcohol so the three categories – beer, wine and spirits are measured in litres of 100% alcohol equivalents. In order to convince the reader that the total sale of alcohol has been fairly constant we will present graphs and various indicators and tests of the degree of temporal dependence in this series. The overall impression from this analysis is that our first hypothesis seems to be supported – at least not contradicted – by the data. Next, we want to model the sale of beer and wine as shares of the total sale of alcohol. Even though the total sale can be considered fairly stable there have been divergent paths of evolvement for the sub-groups: the sale of beer has decreased over the period and the sale of wine has increased. The sale of spirits has been fairly stable. Modelling the system of the beer-share and the wine-share we want to split the total development into a part that can be ascribed to changes in the relative prices and a part that can be explained by changes in taste and drinking habits specified as a trend. By specifying a system conditionally on the prices of beer, wine and spirits and a trend we manage to estimate price sensitivity and taste sensitivity. A small forecasting exercise shows that the final model is fairly good at predicting changes in the shares due to price changes. Finally, the effects on the market shares of hypothetical changes in the taxation of alcohol are discussed.

International studies of consumption and/or sale of alcohol very often base their empirical analysis on the so-called Almost Ideal Demand System (AIDS) – see e.g. Edgerton et al. (1996), Andrikopoulos & Loizides (2000) or Eakins & Gallagher (2003). Econometrically such studies end up estimating budget share equations with either prices or log prices as explanatory variables. An additional explanatory variable is some income measure. As our three groups of data are measured in the same units we will, however, focus on the quantities sold of these three kinds of alcohol rather than on budget shares. The focus of this paper is hence in some sense more on the business aspects of the alcohol market and not on the economic issues of the households. Of course one can even so argue that still an income measure would be appropriate in the equations, but as real income has grown during the sample period and due to the stability shown in the total amount of alcohol sold since 1980 such an income variable would probably turn out to be insignificant. Hence we decided not to use such a variable and in this way we avoid the discussion on how to best measure income for this type of analysis. Another argument against the introduction of an income measure is that alcohol in fact has become much cheaper, cf. section 2, without any sign of increasing sale in the period under study, again leading to the conclusion, that the alcohol consumption is not severely restricted by economic constraints. Our strategy concerning an income measure is supported – at least for the long run – by eg. Bentzen & Smith (2005).

For Denmark previous studies on the sale and/or the consumption of alcohol have been performed by e.g. Bentzen & Smith (2005), Bentzen & Smith (2004), Bentzen, Eriksson & Smith (2001) and Milhøj(1996). Their main conclusion is that consumption of wine seems to have grown relative to the other kinds of alcohol since the 60ies. In addition by use of unit root tests Bentzen et al (2001), (2004), (2005) conclude that there is not much evidence of mean reversion in the consumption of alcohol when the period from just around 1900 and up till today is considered. Also they compare the Danish consumption habits with both the Nordic and European ones. Similarities are not found to be impressive.

The rest of the paper is organized as follows: In section 2 we discuss our data and give a visual presentation of them. Next, in section 3 we perform analyses of our first hypotheses on the yearly data from 1980 till 2004. Our findings are confirmed by an analysis of the quarterly data set covering 3rd quarter of 1990 till 4th quarter of 2004. In section 4 we work with the quarterly data set and suggest a parsimonious dynamic (VECM) model of the share of beer and wine. In section 5 we demonstrate that this model has promising forecasting properties. Also section 5 contains

calculations of predicted effects of hypothetical changes in the alcohol taxation. Finally, a section with a summary and conclusions can be found.

2 The Data

The data for the total sale of alcohol on a yearly basis since 1955 (with some missing observations in the first part of the sample) comes from Statistics Denmark. Figures for the sale of beer, wine and spirits are made comparable by using the same unit: 100% alcohol. The data are collected as the taxes are paid thus indicating the quantity of alcohol sold to the retail sector and not necessarily that sold to the consumer. This implies e.g. that around new year the inventory building in shops may push some figures towards December. Given that such movements are of similar size each year it should not cause problems for the analysis. It is of course an important point, that the figures used are sales figures and not consumption figures. The border trade is highly important for Denmark as the prices in Germany are much lower leading to a both legal and illegal private import from Germany. But as the prices of alcoholic beverages in Sweden and Norway are much higher than in Denmark we also see a considerable private export from Denmark. So the sale of alcohol in Denmark is also affected by the price levels and border trade regulations in Norway and Sweden. One could say that the Danish alcohol market geographically also covers the southern parts of Sweden but not the southern part of Jutland with easy access to cheap German alcohol. But even if the market is not well defined as the Danish market it still covers most of the Danish population and hence is of interest. The illegal production of alcohol is of no importance. For English references to the Danish border trade see e.g. Bygvrå (1998) or Milhøj (1996). Figure 1A and 1B shows the movements over time in the total sale of alcohol:

Figure 1A: The total sale of alcohol in 100%

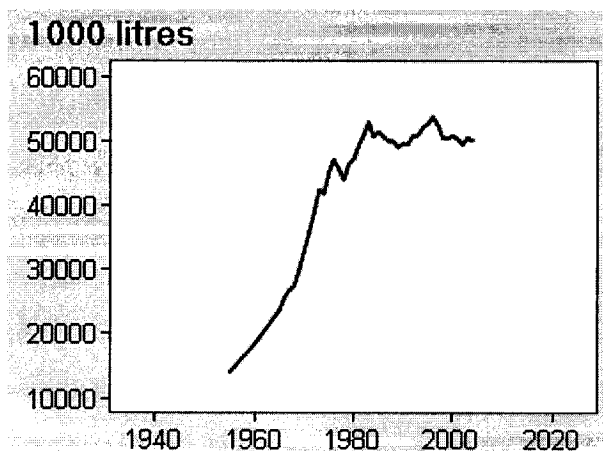
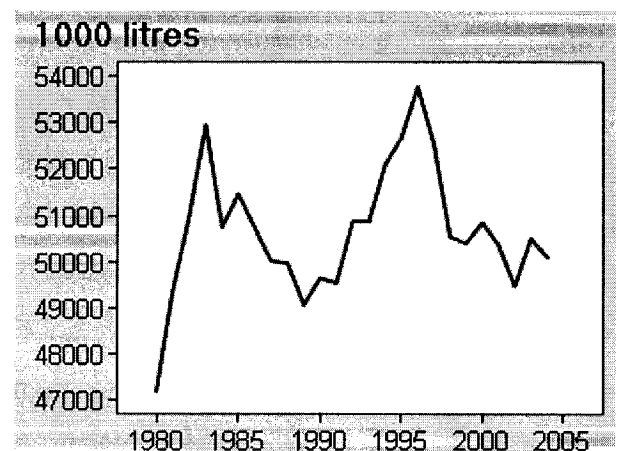


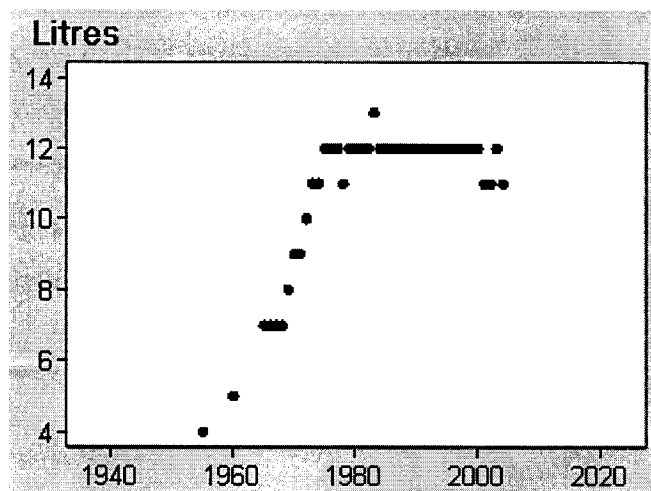
Figure 1B: And since 1980 ...



The figure illustrates that after the rapid growth from the mid-50's until around 1980 the sale has stabilized. From this graph it seems a reasonable hypothesis that the total sale of alcohol has been fairly constant for the last 25 years. What happened before 1980 is not the focus of this study, but tentative explanations are of the following kind: Consumption of alcohol by women seems to have increased in this period. The composition and size of the population have changed significantly when a period of fifty years is considered and this of course have implications for the total consumption of alcohol. Wealth has increased in this period and with an income elasticity greater than zero in this period the total consumption of alcohol has increased as well. Curiously one of the findings in our present study is that after this period the income elasticity of alcohol has decreased towards zero.

As it is quite difficult to correct for all these factors we decided to skip the period from 1955 – 1980 and focus on the sale of alcohol from 1980 to 2004. Seeing the total sale of alcohol in relation to the population size is quite normal in studies of sale of alcohol (see e.g. Bentzen & Smith (2005)) but as indicated by figure 2 showing the total Danish sale of alcohol per person over 14 years the picture from 1980 until today is not much different from the picture in figure 1.

Figure 2: The sale of 100% alcohol by population over age 14.



For a complete exposition of the structure of the Danish alcohol market in a period of 100 years and for further references, see Thorsen (1990).

Data from Statistics Denmark also covers the distribution of the total sale of alcohol into the categories beer, wine and spirits. As the sale is measured in 100% alcohol the sale of the three types

of alcohol is easily compared. The development in the market shares of these categories is shown in figures 3A and 3B below¹.

Figure 3A: Shares of beer, wine and spirits

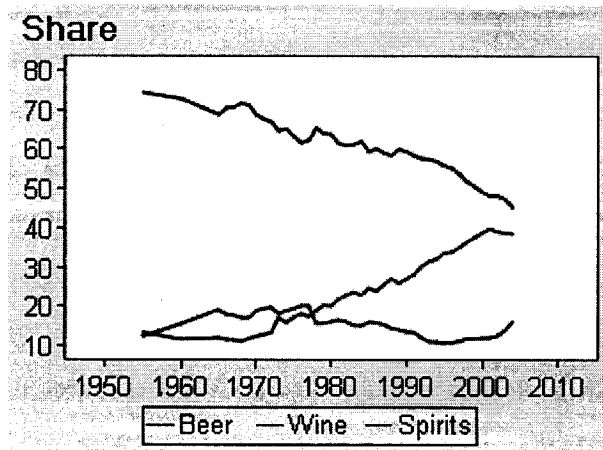


Figure 3B: And since 1980 ...

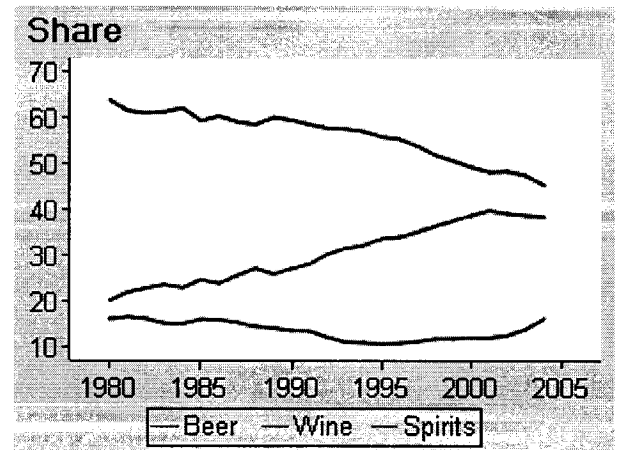


Figure 3A shows that while the share of sale of spirits has remained fairly constant over the period, beer has experienced a fall while wine shows an increasing upward trend. The same picture prevails if we limit our analysis to the period after 1980, cf. figure 3B.

In addition to the yearly data we have access to quarterly data of the same kind but only from 1990 3rd quarter to 4th quarter of 2004. The development over time in these series is shown in figures 4A and 4B below.

Figure 4A: Quarterly total 1990Q3-2004Q4

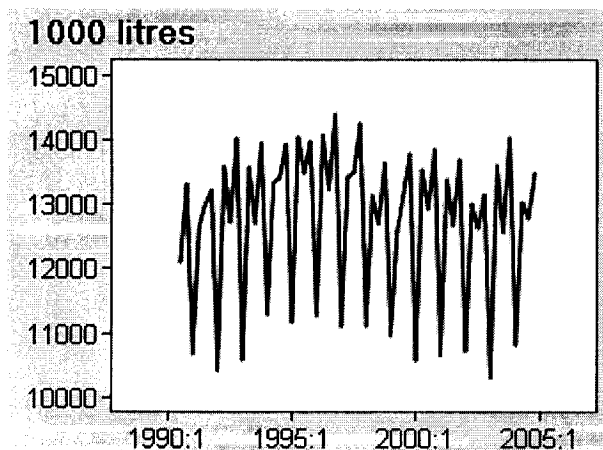
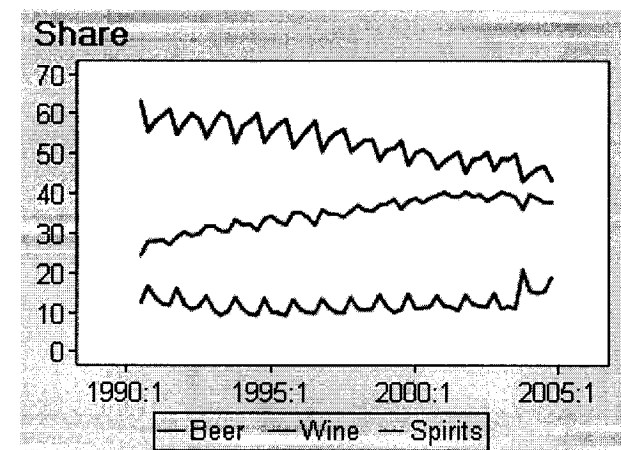


Figure 4B: Quarterly shares 1990Q3-2004Q4

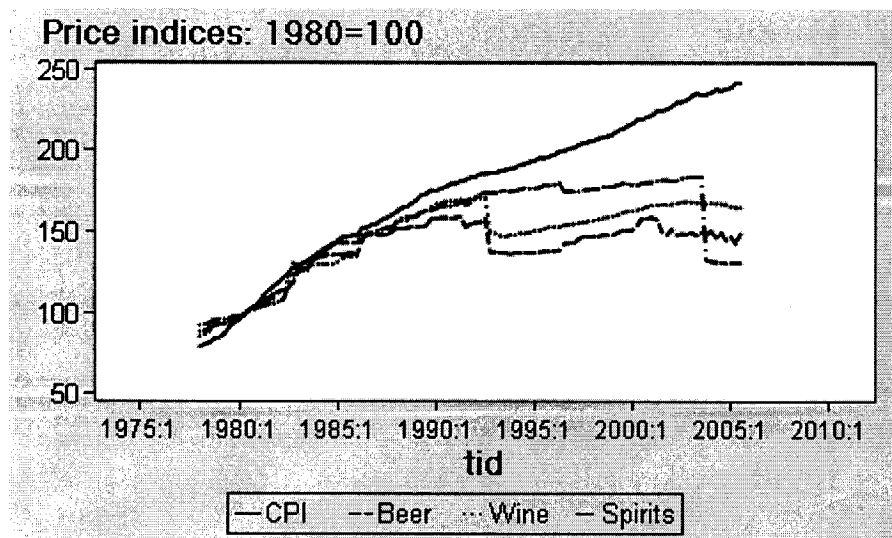


¹ Notice that the shares will be unaffected by whether we analyse sales of alcohol per person above the age of 14 or not.

When going from yearly to quarterly data the development in the series becomes noisier, clearly indicating that seasonality needs to be taken into account in the analysis. The seasonal components show that the sale of all types of alcohol are low in the first quarter and moreover the market shares of beer and spirits are higher in the fourth quarter as a part of the Danish Christmas traditions. Otherwise the conclusions from before still seem to hold: The total sale of alcoholic beverages seem to have been fairly stable in the recent past and while the share of beer has decreased the share of wine has increased. For most of the period the share of spirits has been fairly constant yet the reduced taxes on spirits in the autumn of 2003 has increased the level somewhat in the last part of the sample.

As for any other good it is quite obvious that prices somehow affects the sale of the various categories of alcoholic beverages. Below the development in quarterly index numbers for the prices of beer, wine and spirits are shown graphically. Moreover the index for the overall consumer prices is shown for comparison.

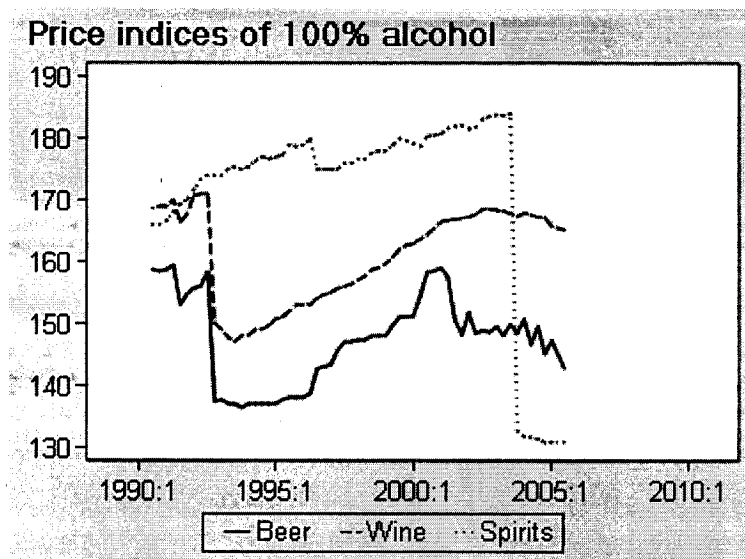
Figure 5A: Prices of alcohol.



The prices we use are the index numbers published by Statistics Denmark. The composition of the indices reflects the composition of the sale within each type of alcohol, so that for e.g. spirits the price index is a weighted average of the prices of Danish snaps and Danish bitter, which in total gives around 80% of the total sales of spirits leaving the last 20% for imported brands of cognac, whiskey etc.

As is evident from the figure the raise in the price indices caused by the overall inflation is the main reason for price movements in the period before 1990. Since 1990 the prices appears to be rather constant even if the overall price level is still increasing although at a more moderate speed. The various tax changes that took place during the sample period are clearly seen as jumps in the corresponding series. These are quite important reductions of the beer and wine taxations in the 90ies and a drastic reduction of the taxation of spirits in 2003.

Figure 5B: Prices of alcohol in sample period.



3. Analysis of the total sale of alcohol in Denmark.

To test the hypothesis that the total consumption of alcohol in Denmark has remained constant we study the temporal dependence in the series by means of the autocorrelation function and unit root and stationarity tests. Finding a unit root i.e. a stochastic trend in the series will violate our hypothesis. Even though most tests developed for investigating the hypothesis of a unit root are asymptotic in nature and therefore not really applicable for a time series as short as ours, we still perform the tests but we are careful not to draw too firm conclusions based on these tests. We will use them as guidelines rather than as actual tests. The tests will be performed using the yearly data since 1980 and for sensitivity we perform the same kinds of tests on the quarterly data from 1990 3rd quarter.

3.1 The autocorrelation function (ACF) for the total sale of alcohol in Denmark.

The autocorrelation function shows the correlation of a time series with past values of the series itself. With distance between the values for which a correlation is calculated on the x-axis and the correlations on the y-axis a picture showing slow, linear decay implies a unit root-like behaviour of the series and hence violates our hypothesis of a fairly constant total sale of alcohol during our period of interest. In figures 6A and 6B below autocorrelations are shown for the yearly and the quarterly data respectively. For the quarterly data the autocorrelations are calculated for the residuals from a regression of the original series on a set of seasonal dummies.

Figure 6A: ACF of the yearly data

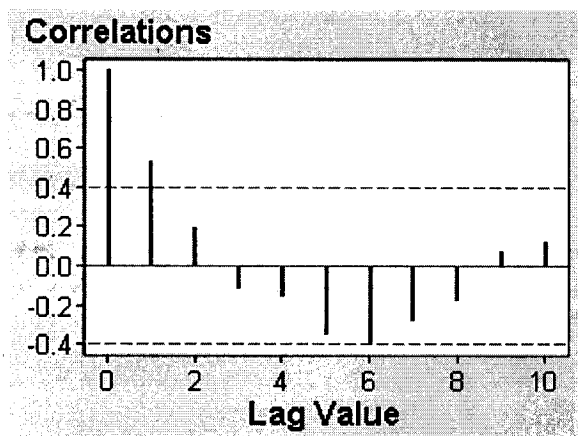
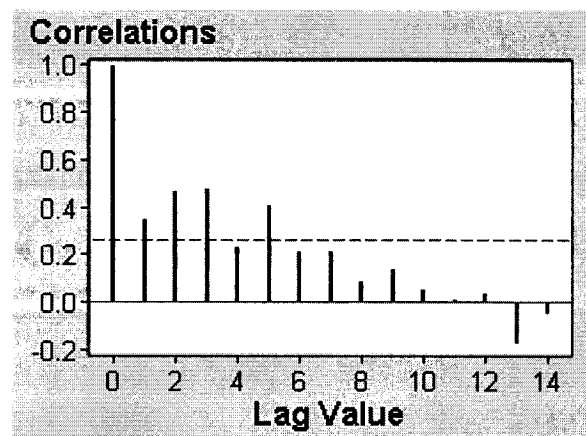


Figure 6B: ACF of the quarterly data



Both figures 6A and 6B support our hypothesis that there is no strong temporal dependence in the total sale of alcohol in Denmark. For the yearly data there is only one significant autocorrelation at lag 1. The value of this correlation is around 0.5 and thus quite far from the value “one” which would imply a unit root (in an AR(1) process). For the quarterly data the ACF shows signs of a fairly long memory with significant but medium size autocorrelations up till lag 5. Still, the picture is clearly different from that of a unit root process. Even though our series are quite short and the significance bounds presented in the graphs are based on asymptotic distributional results, our conclusion so far is that the data do not contradict our hypothesis. Next, we perform two types of numerical tests for nonstationarity/stationarity. The augmented Dickey-Fuller (ADF) test is by far the most popular univariate unit root test. For our purpose this test suffers from the fact that the null is that the series of interest has a unit root and following traditional procedures of doing inference one will thus favour the null until strong evidence against it is available. As our preferred null is that of stationarity using the ADF test is not optimal. Hence in addition we will run a test known as

the KPSS test (see Kwiatkowski et al (1992)) with stationarity as the null. For both the ADF test and the KPSS test we have to decide on the exact form of the model used: should the alternative be a stationary series with a mean that may be different from zero or should we allow for a deterministic trend in the alternative. Based on the initial graphs of the data there is no clear need for a trend hence we will concentrate on a model without a trend.

The ADF test is based on the regression equation:

$$(1) \quad \Delta x_t = \alpha_0 + \alpha_1 x_{t-1} + \sum_{i=1}^k \lambda_i \Delta x_{t-i} + \varepsilon_t$$

Where x is the series of interest, the alphas and lambdas are parameters and epsilon is a stochastic error term which is assumed to be iid normal. The hypothesis of a unit root is the hypothesis that α_1 equals zero. The t-test statistic (called tau) for testing this hypothesis follows a non-standard distribution which has been tabulated for various values of sample sizes. The results for the total sale of alcohol in Denmark are given below:

Table 1: Results of the ADF test

	Yearly data		Quarterly data	
	Tau-statistic	p-value	Tau-statistic	p-value
0 lagged changes	-3.26	0.0286	-5.35	0.0001
1 lagged change	-2.65	0.0970	-3.02	0.0390
2 lagged changes	-2.72	0.0868	-1.89	0.3337

For the yearly data we see that when testing at a 10% level we are able to reject the null of a unit root and conclude stationarity of the series. Given that the null is opposite to what we really want it to be it does not seem inappropriate to use a test level of 10%. Moreover, the short sample size indicates that a test level larger than 5% should be applied. The conclusion is not affected by the number of lagged differences included in the model (strictly speaking the residuals should be white

noise). For the quarterly data² the same conclusion is reached if none or 1 lagged change is included in the model. If we allow for 2 lagged changes then the null of non-stationarity cannot be rejected at any reasonable level. Hence the conclusion from the quarterly data is less robust.

To reinforce the picture the KPSS test is run. In this test the null is that of stationarity – our preferred null. The test allows for correction for autocorrelation by non-parametric means. The equation on which the test is based includes an intercept term but no trend. In addition, the test for the quarterly data is a bit non-standard in that we include a set of centred seasonal dummies in the regression on which it is based.

Table 2: Results of the KPSS test

	Yearly data, test statistic	Quarterly data, test statistic
No serial corr.	0.25	0.65**
Medium ^a corr	0.13	0.25
High ^a corr	0.21	0.17

a: In the test that allows for medium serial correlation the truncation parameter is set to 4 while it is set to 8 for the high correlation case.

One star, two stars and three stars indicate significance at the 10%, 5% and 1% level, respectively.

The results of the table indicate that for the yearly data we find no significant values of the test statistic – irrespectively of how much autocorrelation we allow for. Hence the yearly series is considered stationary when the KPSS test is used. For the quarterly data we find a significant value of the test statistic if we test at the 5% level but not at the 1% level when no autocorrelation is allowed for. For medium or high autocorrelation the quarterly series is considered stationary. As the ACF graph indicates some autocorrelation in the quarterly data we find the results of the tests that allow for autocorrelation the most appropriate ones.

To summarize the investigation of the time series properties of the total Danish consumption of alcohol we conclude that for the period from 1980 and till today (the yearly data) the data does not

² For the quarterly data a set of seasonal dummies is included in the equation.

contradict the hypothesis of stationarity whether studied graphically or by means of ADF or KPSS tests. We reach the same conclusion for the quarterly data for the period 1990 and till today.

4. The distribution of the total Danish consumption of alcohol among the categories: beer, wine and spirits.

As indicated earlier our hypothesis for the market shares is that both the prices and possibly also changes in taste and habits have affected their development over time. The focus is still on the years after 1990 with quarterly data available due to the low number of observations in the yearly data set. With only about 25 observations as we have with the yearly data more sophisticated time series techniques will be difficult to apply here. Notice that a model for market shares is something quite different from our investigation of the total sale of alcohol in Denmark in section 3 and hence is not affected by the conclusion we derived in that section.

4.1 Analysis of an unconditional system.

As the sales of beer, wine and spirits sum to the total sale of alcohol the development of the series of market shares are necessarily connected and we choose to focus on a system analysis. We choose to focus on the shares of beer and wine making the share of spirits redundant given the total sale leaving us with a 2 dimensional system. A necessary feature of a time series in order to enter a traditional regression analysis is stationarity as otherwise the results of the analysis may be "spurious" (see Granger and Newbold (1974)). Non-stationarity of a stochastic type may be handled by cointegration techniques while deterministic non-stationarity (trend stationarity of stationarity around a trend with deterministic shifts) needs other tools. We believe that the non-stationarity observed in the price series are mainly of a deterministic (politically induced tax changes) nature and as a result we prefer to condition on the 3 price series. Whether conditioning is also statistically valid can in fact be checked by starting out with an analysis of a 5 dimensional system in which the prices are viewed as stochastic³. Hence stationarity will be addressed in this preliminary study of a 5 dimensional system of the share of beer, the share of wine and the prices of beer, wine and spirits respectively. The analysis is done conditional on a restricted⁴ trend. The system is of the VAR-type

³ It is most probable that the price series in fact contain elements of both a stochastic and a deterministic nature.

⁴ A restricted linear trend in an equation is a trend that is restricted to appear in the long-run relations only - which implies that the model does not allow for quadratic trends in the levels of the series. A linear trend is still allowed through the constant term of the equation.

that allows for non-stationary and possibly cointegrated series. Estimation and hypothesis testing follow Johansen (1995). The model on VECM form can be written as:

$$(2) \quad \Delta X_t = \Pi X_{t-1} + \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} + \mu + \Phi D_t + \varepsilon_t$$

where X is the 5-dimensional vector of the series of interest, μ is an intercept term, D contains the restricted trend and a set of centred seasonal dummies. The matrices in front of the lagged X , the lagged changes in X and the dummies in D are matrices of parameters. The error vector, ε , is assumed to be iid normal with mean 0 and a covariance matrix Ω .

In this preliminary study of the 5-dimensional system the sample period is limited to cover 3rd quarter of 1990 till 3rd quarter of 2003 due to a major decrease in the Danish tax on spirits from October 1st 2003 and onwards. Inclusion of the last quarter of 2003 and all quarters of 2004 will just make the non-normality of the errors of the system worse something that will disappear when we transform the system into a conditional one later on. So this limitation is not considered crucial for the results later on. The model chosen for the present data set is a VAR model of order 1⁵. First we check to what extent the assumptions concerning the error term are fulfilled. This is done by a battery of multivariate and univariate misspecification tests:

⁵ As the misspecification tests are quite similar for a VAR(1) and a VAR(2) we base our choice of lag length on information criteria. By both the SC and HQ criteria the VAR(1) model is preferred with values being SC=-15.2 and -14.1 and HQ=-16.4 and -15.8 for the VAR(1) and VAR(2), respectively.

Table 3: Results of the multivariate misspecification tests.

Test	Chi square DF's	Test statistic	p-value
Test for autocorrelation			
LM(1)	25	29.98	0.23
LM(4)	25	17.67	0.86
Test for normality			
Hansen-Doomnik	10	78.89	0.00*
Test for ARCH			
LM(1)	225	248.59	0.13
LM(4)	900	788.19	1.00

Table 4: Results of the univariate misspecification tests.

Equation:	ARCH(1)	Normality ^a	R squared
Change in share of beer	0.19	1.17	0.97
Change in share of wine	0.53	3.21	0.84
Change in price of beer	0.72	21.66*	0.29
Change in price of wine	0.11	53.19*	0.27
Change in price of spirits	0.02	67.93*	0.22

a: the Hansen-Doomnik test

A star at a test statistic indicates significance at the 5% level.

As can be seen in the two tables the model is well-specified except for normality of the price series. This is just what we would expect given that the nature of these series are more deterministic than stochastic, as the shifts according to changes in taxation are dominant. Fortunately, the Johansen trace test is not heavily affected by non-normality of the errors. For this test it is more important that we find no remaining autocorrelation in the errors.

Next, we perform the Johansen trace test in order to test for the cointegration rank. When using the Johansen trace test we have to keep in mind that the distributional results of this test statistic is of an asymptotic nature while our sample period is limited to 53 observations. Also it is well known from various simulations studies that the small sample properties of the test may divert quite a lot from the large sample ones. We will try to get around this problem by use of various indicators: In the

table that presents the results of the trace test we will in addition show the Bartlett corrected values of the test which is a way to make a small sample correction of the test statistic, see Johansen (2002). Furthermore we will present the modulus of the roots of the characteristic polynomium and finally we will show graphs of the candidates for cointegrating relations.

Table 5: Results of the Johansen trace test.

P - r	r	Eigenvalue	Trace	p-value	Trace*	p-value*
5	0	0.65	113.59	0.000	110.33	0.000
4	1	0.44	58.47	0.130	57.51	0.152
3	2	0.22	27.86	0.634	27.74	0.641
2	3	0.17	14.46	0.625	-	-
1	4	0.08	4.55	0.665	-	-

The trace column is the original test statistic of the trace test and the trace* is the Bartlett corrected version. The Bartlett corrected version is not available for $r = 3$ and $r = 4$ but it is not a problem for the present decision. Based on both the original trace test and the Bartlett corrected version we can at a 20% level conclude that two relations are stationary. A test level of 20% may seem high yet we face the same problem as with the univariate ADF test: the null of the test is that of non-stationarity and only if this hypothesis is rejected we proceed to test for one stationary relation and four non-stationary relations etc. Hence again we may argue that using a test level above the traditional one may be quite appropriate in this case.

The results of our additional indicators are:

Table 6: Modulus of the roots of the companion matrix before and after a rank of $r = 2$ is imposed:

	Root 1	Root 2	Root 3	Root 4	Root 5
No rank restriction	0.891	0.780	0.780	0.141	0.133
r = 2	1.000	1.000	1.000	0.147	0.138

The table shows that initially three of the roots are close to 1. After imposition of these three unit roots the remaining roots a very small supporting our conclusion of the presence of two long-run stationary relations (the cointegrating relations).

Below, graphs of the two cointegration relations are shown. Again the picture is that of fairly stationary series that tend to cross the mean value quite often. This holds true whether (lower panel) or not (upper panel) we correct for the short-run dynamics.

Figure 7A: The first cointegration relation. Upper panel shows the relation itself while the lower panel shows the relation after correction for short-run dynamics (incl. seasonal effects).

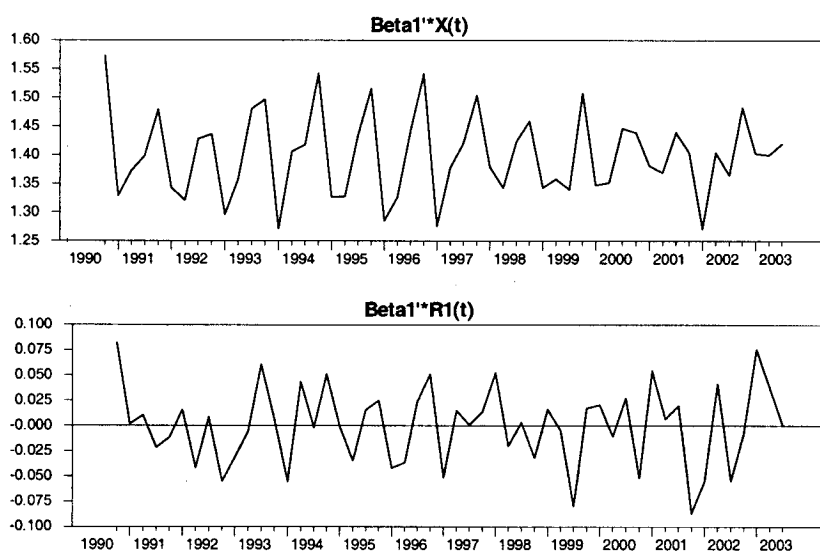
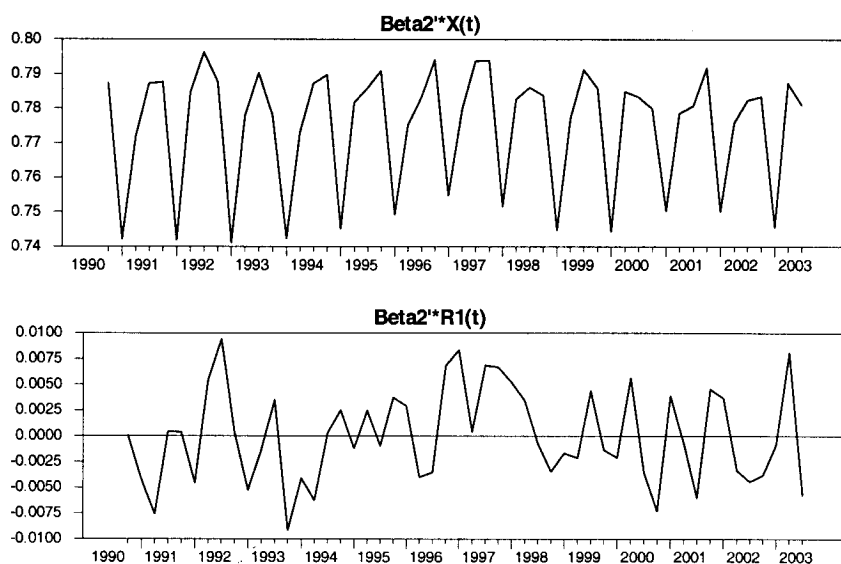


Figure 7B: The second relation. Interpretation of the panels as above.



So based on various indicators a choice of $r = 2$ seems appropriate and we continue the analysis based on this choice.

Next step is to perform the formal likelihood ratio (LR) test for weak exogeneity of the price series. As normality is not fulfilled the distributional assumptions for this test may not be exactly met yet we run the test anyway to see what it indicates. The hypothesis of the test is that the three last rows of the alpha-matrix contain zeros – i.e. the price series do not adjust to the disequilibrium errors of the system (or: deviations from the cointegrating relations do not enter the price equations significantly). The results of the LR test for weak exogeneity of prices are:

Test statistic: 5.65; p-value = 0.463

Hence it appears that the hypothesis cannot be rejected by the data and this conclusion will reinforce our arguments for turning towards an analysis of a 2-dimensional system for the series of market shares conditioned on the prices. Compared to the model in (2) the system we now focus on is:

$$(3) \quad \Delta X_t = \Pi X^*_{t-1} + \Gamma_1 \Delta X^*_{t-1} + \dots + \Gamma_{k-1} \Delta X^*_{t-k+1} + \mu + \Phi D_t + \varepsilon_t$$

where a “star” after X on the right hand side of the equal sign indicates that the vector of the shares (X) has been extended by the three price series. When conditioning on the prices we feel safe to analyse the whole sample period from 1990Q3 till 2004Q4.

4.2 Analysis of the conditional system.

When performing the residual analysis of the conditional system we find that both a VAR(1) and a VAR(2) fulfil the assumptions – this time also the assumption of normality! Hence we choose the VAR(1) because the information criteria are smaller in this case⁶.

⁶ As the misspecification tests are quite similar for a VAR(1) and a VAR(2) we base our choice of lag length on information criteria. By both the SC and HQ criteria the VAR(1) model is preferred with values being SC=-0.85 and -0.37 and HQ=-1.43 and -1.17 respectively for the VAR(1) and VAR(2).

Table 7: Results of the multivariate misspecification tests.

Test for autocorrelation	Chi square DF's	Test statistic	p-value
LM(1)	4	1.05	0.90
LM(4)	4	5.21	0.27
Test for normality			
Hansen-Doornik	4	1.14	0.89
Test for ARCH			
LM(1)	9	21.19	0.01
LM(4)	36	41.01	0.26

Table 8: results of the univariate misspecification tests.

Equation:	ARCH(1)	Normality ^a	R squared for equation
Change in share of beer	0.15	0.20	0.96
Change in share of wine	2.01	0.63	0.82

a: The Hansen-Doornik test

We will not repeat the tests for the cointegration rank in the conditional system as the asymptotic distribution of the trace test will be affected by the presence of the conditioning variables. It is, however, not a problem as we can still rely on the conclusion we reached in the 5-dimensional system with respect to the rank such that we have two cointegrating relations in the system. Identifying the two cointegrating relations as a relation for the share of beer and a relation for the share of wine, respectively leads to the following long-run relations:

The long-run relation for the share of beer (intercept present but not shown):

$$(4) \quad \text{Beer share} = -0.13456 \text{ PB} + 0.06455 \text{ PW} + 0.02073 \text{ PS} - 0.25400 \text{ Trend}$$

$$(0.03183) \quad (0.03215) \quad (0.00796) \quad (0.00681)$$

The long-run relation for the share of wine (intercept present but not shown):

$$(5) \quad \text{Wine share} = 0.12189 \text{ PB} - 0.149920 \text{ PW} + 0.05722 \text{ PS} + 0.25016 \text{ Trend}$$

$$(0.02809) \quad (0.02837) \quad (0.00703) \quad (0.00601)$$

The values in parentheses below the estimates are the standard errors. It can be concluded that all parameters are significant at the 5% level. Furthermore, the sign of the coefficients are as expected from economic theory: when the own price increases the share of the corresponding category falls while the cross price effects are positive (which is expected for goods that are to some extent substitutes). The sensitivity to changes in the price index for spirits are of the smallest magnitude. The trend parameters indicate that the market share of beer declines by 0.25 percent point every quarter even if the price relations are kept constant. The market share of wine correspondingly increases by 0.25 percent points every quarter while the market share of spirits as the redundant series is almost constant. These trends are interpreted as measuring changes in taste, habits etc. in the Danish alcohol consumption.

As the loadings of the wine share relation is insignificant in the beer equation and vice versa⁷ each category only adjusts towards equilibrium in relation to its own demand equation.

Finally, a system of short-run relations is estimated for the change in the share of beer and the change in the share of wine. The reporting of the system will be equation-wise even though full maximum likelihood estimation has been performed. In Table 12 the results for the beer share equation is given and in Table 13 the results for the wine equation can be found. The system seems well-specified when judged by the results of the misspecification tests given in Tables 9-11. Even after our transformation of the model into a parsimonious one it seems quite well-specified as the following misspecification tests show:

Table 9 Results for the misspecification tests of the parsimonious model (equation for beer).

	Distribution	Test statistic	p-value
AR 1-4 test	F(4, 44)	0.966	0.44
Normality test	$\chi^2(2)$	0.284	0.87
ARCH 1-4 test	F(4, 43)	0.746	0.57
Hetero test	F(10, 40)	1.078	0.40
Hetero-X test	F(20, 30)	0.966	0.52

⁷ The speed-of-adjustment coefficient of wine in the beer equation is 0.081 with a standard error of 0.187 while the speed-of-adjustment coefficient of beer in the wine equation is 0.053 with a standard error of 0.181.

Table 10 Results for the misspecification tests of the parsimonious model (equation for wine).

	Distribution	Test statistic	p-value
AR 1-4 test	F(4, 44)	0.944	0.45
Normality test	$\chi^2(2)$	1.165	0.56
ARCH 1-4 test	F(4, 43)	2.420	0.06
Hetero test	F(10, 40)	0.590	0.81
Hetero-X test	F(20, 30)	1.029	0.46

Table 11 Results for the misspecification tests of the parsimonious model (multivariate tests).

	Distribution	Test statistic	p-value
Vector EGE-AR 1-4 test	F(16, 84)	0.865	0.61
Vector Normality test	$\chi^2(4)$	1.496	0.83
Vector hetero test	F(30, 112)	0.531	0.98
Vector hetero-X test	F(60, 84)	0.628	0.97

Table 12: Estimation of the short run equation for the change in the share of beer.

Variable	Full model			Parsimoneous model		
	Estimat	Std.err.	p-value	Estimat	Std.err.	p-value
Intercept	59.508*	17.920	0.002	63.063*	6.655	0.000
Change in price of beer	-0.050	0.055	0.364	-	-	-
Change in price of wine	0.027	0.063	0.670	-	-	-
Change in price of spirits	0.012	0.015	0.410	-	-	-
Ci1-term	-0.933*	0.211	0.000	-0.958*	0.101	0.000
Ci2-term	0.081	0.204	0.694	-	-	-

Table 13: Estimation of the short run equation for the change in the share of wine.

Variable	Full model			Parsimoneous model		
	Estimat	Std.err.	p-value	Estimat	Std.err.	p-value
Intercept	20.449	16.740	0.228	23.777*	2.149	0.000
Change in price of beer	0.024	0.051	0.635	-	-	-
Change in price of wine	-0.068	0.059	0.255	-0.061*	0.019	0.003
Change in price of spirits	0.107*	0.014	0.000	0.116*	0.008	0.000
Ci1-term	0.053	0.197	0.788	-	-	-
Ci2-term	-0.999*	0.191	0.000	-0.992*	0.091	0.000

Technical comments to the tables: Ci1 is the deviation from the long-run beer share relation (1st cointegration relation) while Ci2 is the deviation from the long-run wine relation (2nd cointegration relation). A star indicates that the parameter is significant at the 5% level. (we are not removing any seasonal dummies they are just not shown in the tables).

The economic interpretation of the parsimonious system seems convincing: If the beer share is too high compared to the long-run relation (a positive Ci1 term) the beer share will adjust downwards (a negative coefficient in front of Ci1). Qualitatively the same mechanism works for the wine share.

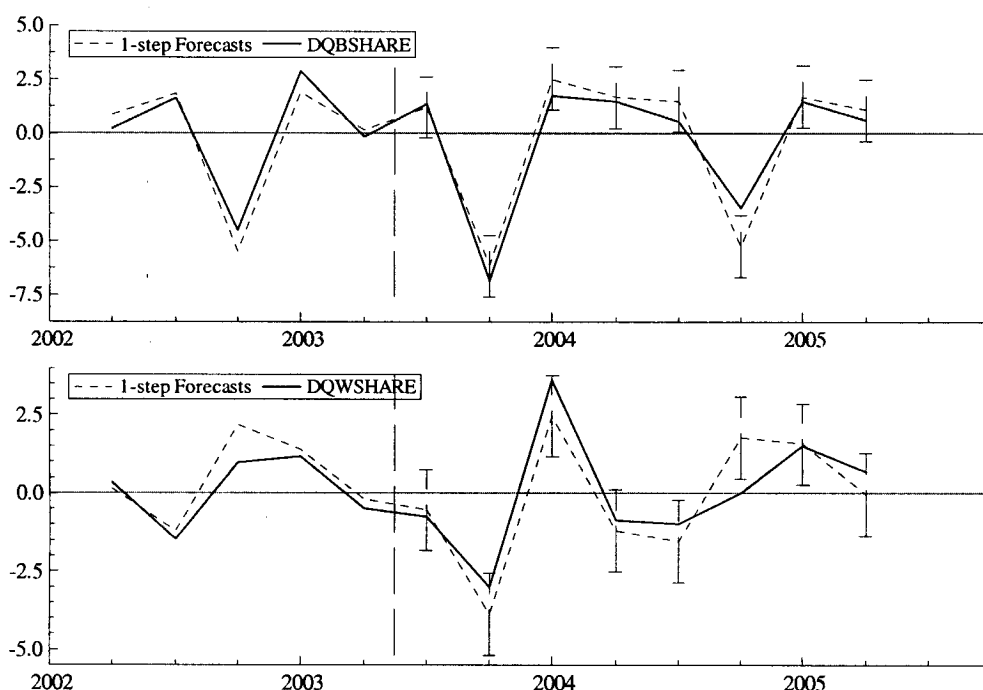
5 A forecasting exercise.

5.1 One step ahead forecasts.

In this section we will make a small forecasting exercise in order to assess how good the model is at predicting the effects of a major price change. From October 1st 2003 the price of spirits in Denmark experienced a large drop due to reductions of the taxes. Hence by re-estimating the model for a sample period that ends in 2003 2nd quarter and afterwards predicting the development of the shares for the period 3rd quarter 2003 and till 4th quarter of 2004 conditional on the actual development in the three prices (based on 1-step ahead predictions) we want to assess the forecasting ability of the 2-dimensional model. When doing 1-step ahead forecasts we take as given the parameter estimates for the sample period 1990 3rd quarter to 2003 2nd quarter and in addition we assume that for each prediction we make that we know the immediate past. Also the prices of the prediction period are assumed known. Using 1-step forecasts is a good way of investigating whether a model can capture the very short run effects of a change – here in one of the conditioning

variables. The results of this forecasting exercise are shown in Figure 8 below. The top panel (DQBSHARE) shows the actual and predicted values for the change in the market share of beer while the bottom panel shows the actual and predicted values for the change in the market share for wine (DQWSHARE). The units on the y-axis are changes in percentage points.

Figure 8: Results of the 1-step forecasts for the period 3rd quarter 2003 till 2nd quarter 2005.



The graph illustrates that the model is good at capturing the effects on the shares of the major change in the price of spirits in the autumn of 2003: for both the wine and the beer share the actual values are within the significance bounds of the forecasts. The only observation for which this is not the case is the one of the 4th quarter of 2004. A tentative explanation for this may be that this change in the shares was not primarily due to changes in the relative prices but rather to some other factor that apparently is not fully captured by the presence of the trend in the model. The actual observations are, however, not very far from the border of the bounds and we still believe that the present model – simple as it is – is a good one!

5.2 Market shares in scenarios with changes in the taxes on alcoholic beverages.

In this section we try to derive the consequences of a set of changes in the taxes on alcoholic beverages. The way we do this is to calculate the indices of the prices given what we believe are

interesting possibilities for changes in the Danish taxation. This calculation of price indices after a changes in taxation is of course only approximate, but the results all the same give an indication of the consequences for the market shares. We present a dynamic forecast of the markets shares given these price changes compared to a no-change scenario to obtain the differences for the market shares of beer, wine and spirits.

We assume that the change in taxation took place in 1st quarter of 2005 and that the price indices keep the new level after the tax change. For the “no change” scenario we let the price indices of 4th quarter 2004 extend to the period of the forecasts (i.e. no price changes from 2004 4th quarter and onwards). Due to the fast error correction of our model we need only present the change in market shares for a few periods.

In the first scenario we try to remove all taxes on alcoholic beverages. In scenario 2 we consider the more realistic situation of the tax on spirits reduced to the level of that of beer and wine. This scenario is a political possibility, as it is often argued that the Danish taxation on alcohol is in fact a restraint on trade. Note that the taxations of alcohol for the categories of beer and wine at present are almost equal. In the third scenario we assume that the Danish taxes on alcohol are reduced to match the German ones.

All three scenarios describe the consequences of reducing the Danish taxation, which is the politically most probable situation, as e.g. the retail sector argues for a reduction of the Danish border trade with Germany. The present econometric model gives us the possibility of deriving the consequences for the market shares for beer, wine and spirits but not for the actual sales figures. Of course reductions of the taxation on alcohol in Denmark would lead to increasing sales in Denmark, as it must be expected that Danes are less urged to travel to Germany and moreover Swedes and Norwegians will be even more willing to buy alcohol in Denmark. The model in this paper, however, gives no quantification of this increased sale. Yet the forecasts of the shifting market shares are also of economic interest as the breweries play a fairly large role in the Danish labour market and more than half of the Danish sale of spirits is produced in Denmark. The Danish wine production is very small – almost non-existing.

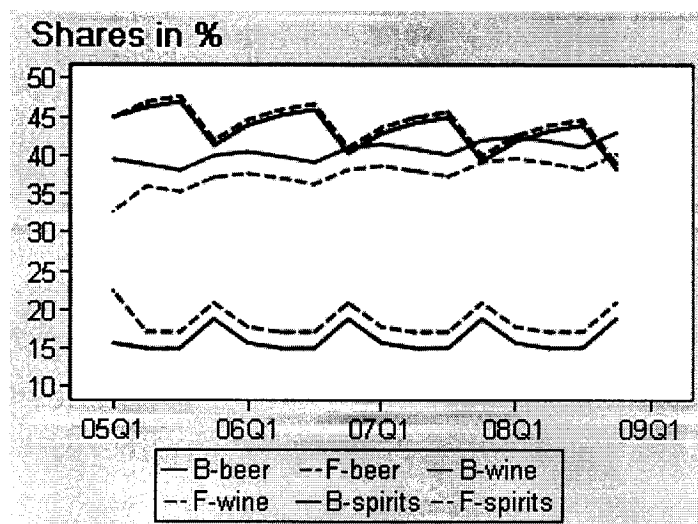
Table 14 Results of simulation studies. Changes in market shares of beer, wine and spirits compared to a “no change” scenario.

Quarter	Scenario (no taxes)			Scenario2 (spirits down to beer and wine)			Scenario3 (German taxes)		
	Beer	Wine	Spirits	Beer	Wine	Spirits	Beer	Wine	Spirits
1 st 2005	0	-6.78	6.79	0	-5.61	5.61	0	-0.80	0.80
2 nd 2005	0.71	-2.86	2.15	-1.16	-2.53	3.69	0.94	0.61	-1.55
3 rd 2005	0.74	-2.82	2.08	-1.21	-2.50	3.71	0.98	0.62	-1.60
4 th 2005	0.74	-2.82	2.08	-1.21	-2.50	3.71	0.98	0.62	-1.60

The results of the first scenario reflect the price relations among the tax free beverages. In fact spirits has the lowest production costs while wine (as seen on the Danish market) is most expensive. The present taxation changes these price relations so that spirits is in fact far the most expensive type of alcohol in Denmark. A total relaxation of the taxes then makes spirits relatively much cheaper than today leading to an increasing market share. Moreover the taxations on beer and wine are almost equal today, but as the production cost of beer is the lowest a total removal of the taxes, changes the price relation between beer and wine in the direction of beer being cheaper.

Figure 9: Comparisons of market share changes for scenario 1 – no taxes.

(B- refers to base scenario and F- refers to scenario with changed tax)



In the second scenario where the level of taxation of spirits is reduced to match the level of taxation on beer and wine the market share of spirits increases by almost 4 percentage points. The negative effect on wine is about twice as big as the one for beer.

Figure 10: Comparisons of market shares changes for scenario 2 – spirits tax down.

(B- refers to base scenario and F- refers to scenario with changed tax).

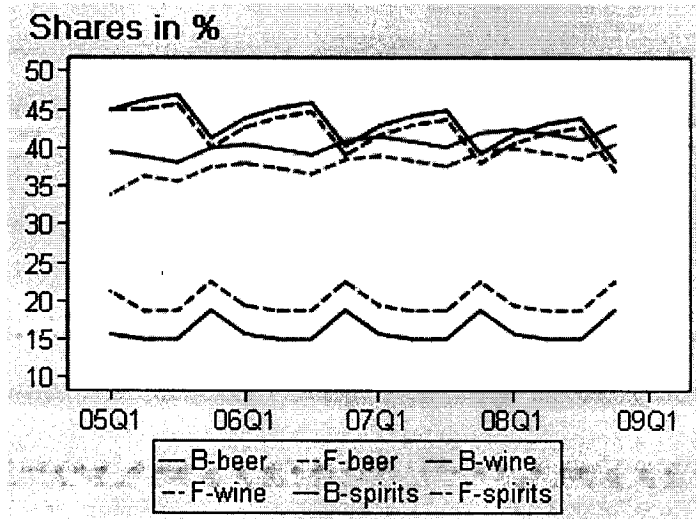
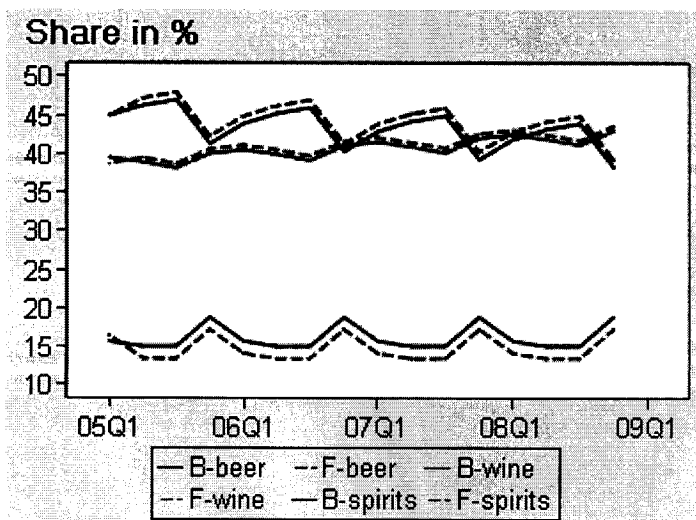


Figure 11: Comparisons of market shares changes for scenario 3 – German taxes.

(B- refers to base scenario and F- refers to scenario with changed tax).



In the third scenario the results reflect the German taxation with mainly taxation on spirits, but at a lower level than in Denmark, while beer and wine are taxed much milder. A change of the Danish taxation to copy of the German taxation then increases the relative price of spirits and reduces the relative prices of beer and wine.

6. Concluding remarks.

In the present paper we have been analysing data for the Danish sale of alcohol. In the first part of the study we managed to demonstrate that the total sale measured in litres of 100% alcohol equivalents has been fairly stable since 1980. Hence we do not find indications of a steady increase. In the second part of the study we focus on the distribution of the total sale into beer, wine and spirit. Using modern time series techniques we end up suggesting a parsimonious VECM model for the shares of beer and wine – a model in which the parameters have the expected signs in relation to economic theory both for the long- and the short run. Eventually, it is demonstrated that a model of this kind seems well suited to forecast the effects of even a major change in one of the category-prices. A model of the kind suggested in the present study also seems to be a valuable tool for predicting the effects on the market shares of changes in the relative prices of beer, wine and spirits for Denmark.

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