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# The Consumption of Alcohol in Fourteen European Countries

A comparative Econometric Analysis

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## Foreword

In many European countries, excise taxes of alcoholic beverages have been an important instrument in the efforts of controlling per capita alcohol consumption and thereby the prevalence of alcohol-related harm. In even more countries, the alcohol taxes have been an important source of state revenue. But other views have also prevailed. A number of countries have traditionally adopted policies where alcoholic beverages, and wine in particular, have been regarded as a component of nutrition, and therefore applied low if any taxes on them. Within the European Union, harmonisation of alcohol taxation has proceeded slowly, and the main arguments in the debate around alcohol taxes have risen from concerns of the common agricultural policy rather than from the perspectives of prevention of alcohol-related harm. In any case, decisions on alcohol taxes are reflected in the prices of alcoholic beverages, and again in the demand for alcoholic beverages.

Another aspect of the demand for alcoholic beverages concerns the effects of changes in purchasing power, or total expenditure, on consumption of alcohol. Again, the countries may differ from each other in this respect, as in some countries increasing purchasing power may lead to increased consumption of alcoholic beverages that may be esteemed as attractive luxury products symbolising modernity and internationalisation. In other countries, much of alcohol consumption may come as ordinary everyday life consumption, without strong elements of luxury and high esteem. The effects of changes in purchasing power, or total expenditure, may then be widely different in different countries. The present volume provides a long-term perspective on the effects of economic factors on alcohol consumption in 14 European countries. The results tell how much of the variation of consumption could be explained by economic factors, and how much is left for other factors like culture, living conditions and preventive alcohol policies. The results also specify the differences between countries with respect to the effect of economic factors. All this information is important when considering the consequences of the continued harmonisation within the EU of taxation in general and taxation of alcoholic beverages in particular. At the same time, the information is relevant when considering the prospects for more unified preventive alcohol policies in the future in the EU. As comparative economic research on these issues has been scarce or difficult to access, the

present volume will improve the ground for political and scientific debate around economic factors, alcohol consumption and alcohol policies.

The report is part of the European Comparative Alcohol Study (ECAS), a study supported by the European commission, administrated by the Swedish National Public Health Institute and conducted by a Swedish-Finnish research team. Together with the other parts of the study (alcohol policies, alcohol consumption and drinking patterns, alcohol-related mortality) the present volume contributes to a more comprehensive view on alcohol-related issues in the EU countries and Norway since 1950.

Helsinki, March 30, 2001

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## Abstract

This paper analyses time series data on alcohol consumption in 14 European countries. The study is similar to that of Selvanathan (1991), but is the first to utilize quantity index data on the demand for alcoholic beverages. Flexible models of alcohol consumption using quantity index data and absolute alcohol in litres per adult have been specified to find similarities in consumer preferences. The SURE method and Wald tests were used to test for common parameters across the countries and to obtain the corresponding restricted estimates. Comparable price indices for alcoholic beverages and total expenditure variables were constructed to capture differences in price levels and the consumers' purchasing power between the countries.

The results show that the demand for alcoholic beverages has been declining for noneconomic factors since the mid-1980s. The hypothesis of common preferences was clearly rejected by the data. However, the tests revealed that total expenditure affects the demand for alcohol equally across the countries and that the price parameters are equal within the three groups, i.e. the monopoly countries, wine producers and the other countries with the exception of the Netherlands. The common estimate of the expenditure parameter suggests that alcoholic beverages are considered to be normal goods but not luxuries. The results indicate that the demand for alcoholic beverages is more easily controllable by excise taxes in the monopoly countries than elsewhere. In the wine-producing countries demand is relatively price-inelastic. The value of price elasticity indicates that taxes have not been set at their revenue-maximizing levels in the monopoly countries. In addition, the parameter for lagged absolute alcohol consumption, which is included to capture addictive features, is both positive and significant only in the monopoly countries.

In the case of absolute alcohol consumption, the similarities in the parameter values were not as clear as in analysing the demand for alcoholic beverages. The data did not support the hypothesis of equal price parameters within the three groups of countries. However, restricted estimates showed that the general pattern was also repeated here.

Analysis of absolute alcohol consumption revealed that the country-specific level parameters were the major factor in explaining the differences among the countries. Economic variables, the price of alcohol and total expenditure played a subsidiary but important role. It would appear that harmonization of consumption levels is more easily achieved by equal price levels rather than by equal levels in real expenditure per capita.



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## 1 Introduction

Econometric analyses of consumer demand are usually based on a system of demand equations. These equations can be used both to test for the existence of a rational representative consumer and to describe the structure of the preferences. In the Nordic and Anglo-Saxon countries, alcohol consumption has been a frequent subject of empirical demand analysis. Most of the studies consider demand for alcoholic beverages, using time series data for a single country. Holm and Suoniemi (1992) studied optimal taxation of alcoholic beverages and estimated a system of demand equations for four beverage groups (vodka, other spirits, wine and beer) for Finland. Lepänen (1999) produced recent estimates of Finnish price and expenditure elasticities for four beverage groups; spirits, fortified wine, table wine and beer. Strand (1993) estimated price and income elasticities for spirits and wine, and Berggren (1997) estimated the elasticities for liquor, wine and two separate categories of beer, using Norwegian and Swedish data, respectively. In the United Kingdom, Jones (1989) estimated the price and expenditure elasticities for beer, spirits, wine, cider and tobacco. A similar analysis was performed by Selvanathan (1988), presenting elasticities for three beverage groups (spirits, wine and beer) in the UK.

For the economist, the hypothesis of stable and common tastes provides a most useful starting point in a comparative study. The economist searches for differences in prices and incomes to explain any differences or changes in behaviour. Selvanathan (1991) made a comprehensive study by estimating a system of demand equations using time series data in nine countries, including Finland, Norway, Sweden and the United Kingdom. Selvanathan estimated demand equations for spirits, beer and wine in terms of alcohol consumption in litres per adult and examined whether the consumer preferences are identical in all countries. Empirically, he tested the hypothesis of a common econometric model for all countries. Selvanathan found that the hypothesis of common preferences was clearly rejected by the data.

In the present study, alcohol consumption in 14 European countries are analysed. The countries are Austria, Belgium, Denmark, Finland, France, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden and the UK. Except for Norway, they are Member States of the European Union. Unfortunately, Germany was excluded from the analysis, due to lack of sufficient data on alcohol consumption.

In contrast to the study by Selvanathan (1991), we do not use a system of demand equations for separate beverage groups, but instead estimate a single demand function for alcoholic beverages. This was done because we could not obtain quantity index data in the detail needed. Our dependent variable is the quantity index of alcoholic beverages which does not include

beverages sold in restaurants, cafes and hotels. On the other hand, we augment our analysis by estimating a similar equation for the consumption of alcohol in litres of absolute alcohol per adult. Here we include the drinks sold in the above outlets.

We focus particular attention on the construction of price indices for alcoholic beverages that capture differences in the price levels across the countries. The total real expenditure variables are treated similarly to capture differences in the consumers' purchasing power between the countries.

The hypothesis of stable and common preferences across the countries provides the benchmark by which alternative specifications are evaluated. However, previous studies and cursory examination of the data suggest that in the case of alcohol, we have to allow for some change in consumer habits over time. In our empirical model these slow movements were described by time trends, linear or quadratic functions in time. In analysing the demand for alcoholic beverages, the past absolute alcohol consumption is allowed to affect current utility and is used as a stock variable to describe the degree of current addiction.

First, the demand equation for alcoholic beverages is estimated in differenced form separately for each country by the Ordinary Least Squares method (OLS). The data which cover several countries with varying drinking patterns and prices of alcoholic beverages and total expenditures offer an interesting opportunity to estimate and compare price and expenditure elasticities between the countries. There are some common characteristics in the countries that may suggest some similarities in the consumption of alcohol. Some countries are wine producers, such as Austria, France, Greece, Italy, Portugal and Spain. In Finland, Norway and Sweden (the monopoly countries) sales of alcoholic beverages have been mainly controlled by state alcohol monopolies. A third, residual group, the other countries, was formed to include the rest of the data.

Secondly, we test for similarities in the parameter values within the above three groups and produce the restricted estimators, which are more efficient than the corresponding results for the individual countries. The statistical hypotheses are tested by Wald tests and the estimation is based on the Seemingly Unrelated Regressions (SURE) method introduced by Zellner (1962).

In addition, we provide for a similar analysis for absolute alcohol consumption. Here we again search for similarities in the coefficients of price and real expenditure variables. The economic variables that are used in the model are constructed to capture the differences in level of alcohol prices and real expenditure between the countries. We explain absolute alcohol consumption in each country by using relative price and total real expenditure variables and country-specific dummy and trend variables that capture

the variation in consumption levels left unaccounted for by the economic variables. Using these methods, it is possible to examine the relative importance of the economic factors, the price and total expenditure variables and other, residual factors in explaining the differences in absolute alcohol consumption between the countries.

The paper is organized as follows. Section 2 gives a short introduction to the economic theory of consumer behaviour and the functional form of the demand function of our study. Section 3 presents the data of the study. Particular attention is focused on construction of comparable price indices for alcoholic beverages and total expenditure variables that capture differences in their levels across the countries.

Section 4 gives the empirical results for the demand of alcoholic beverages. First, we present the estimates for the individual countries and compare the price and expenditure elasticities by graphical methods. Secondly, we test for similarities within the three groups of countries and give restricted estimates that impose common values for the price and expenditure elasticities.

Section 5 gives the results for absolute alcohol consumption. The results are organized similarly to those in Section 4. For example, we present statistical tests to determine whether the common parameters used are justified, and estimates of the price and expenditure elasticities are presented under different specifications of the model. In addition, Section 5 presents simple comparisons to examine the relative importance of the economic factors, the price and real expenditure variables and other, residual factors in explaining the differences in the absolute alcohol consumption between the countries. Section 6 concludes the report.

## 2 Economic models for consumer behaviour

### 2.1 Systemwide approach to consumer behaviour

There is a long tradition in economic research into consumer behaviour. It has been characterized by a strong interplay between the neoclassical theory of a rational consumer and the development of appropriate econometric techniques. Blundell (1988) and Deaton (1986) give authoritative, recent surveys of economic research into consumer behaviour.

Econometric analyses of consumer demand are usually based on a system of demand equations. These equations can be used to both test for the existence of a rational representative consumer and to describe the structure of his/her preferences. The system is frequently expressed in terms of expenditure shares,  $w_i = p_i q_i / M$ , where  $q_i$  and  $p_i$  denote the consumption and price of commodity  $i$ , respectively, and  $M$  is total expenditure on all commodities. Deaton and Muellbauer (1980) presented an Almost Ideal Demand System (AIDS), which is an extensively used example of this method of analysis. The equation for the expenditure share of commodity  $i$  takes the form:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(M/P), \quad (1)$$

where  $\alpha, \gamma, \beta$  are the parameters, and  $P$  is an index of the general price level involving nonlinearities in the model parameters. It is frequently substituted by Stone's geometric price index:

$$\log P = \sum_j w_j \log p_j \quad (2)$$

The above model gives a flexible basic presentation of consumer behaviour. According to neoclassical theory the parameters in Model (1) should satisfy the adding-up, homogeneity and symmetry restrictions:

$$\sum_i \alpha_i = 1, \quad \sum_i \beta_i = \sum_i \gamma_{ij} = 0, \quad \forall j \quad (3)$$

$$\sum_j \gamma_{ij} = 0, \quad \forall i \quad (4)$$

$$\gamma_{ij} = \gamma_{ji}, \quad \forall i, j \quad (5)$$

The adding-up restriction (3) is quite weak. It merely restates the accounting identity in that the expenditure shares must add up to one,  $\sum w_i = 1$ . It is satisfied by the data, and therefore the restrictions are trivially satisfied by all linear estimators of the model parameters. Homogeneity restriction (4) shows that if all prices and total expenditure are multiplied by the same positive number, the demand is left unchanged. This also means that the

choice of units in which quantities and prices are announced should not affect the decisions of the consumer. However, the symmetry restriction (5) is a demanding one. It implies the existence of a rational representative consumer. Here rationality means expenditure-minimizing behaviour in which the consumer minimizes money expenditure to obtain the present level of satisfaction (utility) by purchase of commodities.

The effects of the prices and total expenditure (or income) on demand are generally announced by using elasticities. In Model (1) the formulae for the expenditure (6), the own-price (7) and the cross-price elasticities (8) are:

$$\eta_i = \frac{\partial \log q_i}{\partial \log M} = 1 + \frac{\beta_i}{w_i}, \quad (6)$$

$$\eta_{ii} = \frac{\partial \log q_i}{\partial \log p_i} = -1 + \frac{\gamma_{ii}}{w_i} - \beta_i, \quad (7)$$

$$\eta_{ij} = \frac{\partial \log q_i}{\partial \log p_j} = \frac{\gamma_{ij}}{w_i} - \frac{\beta_i w_j}{w_i} \quad (8)$$

Above the price elasticities are the uncompensated elasticities. In their definition, the income and the substitution effects of price changes are both taken into account.<sup>1</sup>

The compensated price elasticities at the centre of economic analysis are:<sup>2</sup>

$$\tilde{\eta}_{ii} = -1 + \frac{\gamma_{ii}}{w_i}, \quad (9)$$

$$\tilde{\eta}_{ij} = \frac{\gamma_{ij}}{w_i} \quad (10)$$

and correspond to (7) and (8), respectively. The formulae show that elasticities are not constant but time-variant, depending on the expenditure share.

The system-wide approach to consumer behaviour would entail estimating an entire system of equations involving several groups of commodities. Here one would preferably utilize data for different categories of alcoholic beverages such as spirits, wine and beer (see Duffy 1987; Jones 1989; Holm and Suoniemi 1992; Selvanathan 1991). However, in the present case we

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<sup>1</sup>If the price of a commodity is increased the consumer's reaction can be divided into two parts: First, the consumers' purchasing power is diminished due to the price rise. This results in a general decrease in demand for all commodities. This part is the income effect of a price change. Secondly, the increase in price changes relative prices between commodities. This results in a shifting of consumption away from the commodity that has become more expensive. The latter effect is the substitution effect of a price change.

<sup>2</sup>Here the consumer is compensated for the income effect of the price change by leaving total expenditure unchanged in real terms.

could not obtain data in the detail needed, and we therefore resorted to using a single demand equation for alcoholic beverages.

## 2.2 Demand function of the study

We simplify the modelling exercise by using a single equation. The implicit second equation that lumps together the demand for all other commodities is functionally dependent on total expenditure and the equation for alcoholic beverages, therefore it can be ignored.<sup>3</sup> The equation has the quantity index of demand  $q_i$  as the dependent variable:

$$q_i = \alpha + \gamma \log(p_i/P) + \beta \log(M/P), \quad (11)$$

where  $p_i$  is the price index of alcoholic beverages,  $P$  is an index of the general price level and  $M/P$  is total consumption expenditure in fixed prices.

The above semilogarithmic functional form has some apparent similarities with the individual equations in the AIDS. It is a flexible presentation of consumer demand in prices and total expenditure. For example, the expenditure and compensated own-price elasticities are calculable by:

$$\eta_i = \frac{\beta_i}{q_i}, \quad (12)$$

$$\tilde{\eta}_{ii} = \frac{\gamma_i}{q_i} \quad (13)$$

But equation (11) has no connection with the approach that utilizes a complete system of demand functions which are derived as the decisions of a ‘rational consumer’. For example, it is not possible to impose parameter restrictions to guarantee the normal conditions of adding-up nor symmetry in equations having the form of (11). The model parameters in no way guarantee that the sum of expenditures that are forecast with the model is equal to the expenditure variable in the model. However, since we use only a single demand equation the price we pay in loosening the ties with the neoclassical theory may not be too heavy.<sup>4</sup>

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<sup>3</sup>Since the demand equations in (1) are dependent on each other by construction, one equation can be dropped in estimation. In the special case of two commodities, only restriction (4), homogeneity, has some additional force. If it is imposed on the data symmetry restriction (5) holds.

<sup>4</sup>Early estimation experiments revealed that equation (11) gave reasonable results after trials with different alternatives. It gives logical estimates for elasticities with signs that are in accord with neoclassical theory. However, a possible reason for this may be that the quantity of consumption is less stable than the value of consumption, and it may be expected that fitting the expenditure shares is only seemingly more demanding than fitting the corresponding quantities (see Footnote 13).

Nobel Prize winners, Stigler and Becker (1987) argued forcefully that tastes neither change capriciously nor differ significantly between people. The economist should search for differences in prices or incomes to explain any differences or changes in behaviour. But sometimes, hidden economic costs must be accounted for to end up with a reasonable explanation. In their opinion, the hypothesis of stable tastes yields the most useful predictions about observable behaviour.

Previous modelling experience in alcohol demand and cursory examination of the data suggest that we should relax our stand on their position.<sup>5</sup> However, after modification it offers a useful starting point for testing whether cross-border differences in alcohol consumption are explainable by differences in prices and total expenditure levels only.

In the case of alcohol, consumer habits may change over time. Taste changes can be incorporated into the analysis of consumer behaviour by time trends or via habit formation schemes (see Pollak (1970) on habit formation). In our empirical model these slow movements were described by time trends, linear or quadratic functions in time. Previous studies have also found out that new information on health hazards and health education can have a substantial impact on the consumption of alcohol and tobacco. For the above reasons, estimation of their demand equations is not usually successful without a trend variable implicitly describing their effects.<sup>6</sup>

Consumer behaviour may also be dependent on addiction to a commodity. It has been argued that addiction and habit formation are quite common in consumption. People become addicted not only to alcohol, drugs, or cigarettes but also to work, eating, music, television and many other activities (see Becker and Murphy 1988). In this paper we focus on physical dependence on alcohol. In our estimated equations, the past absolute alcohol consumption is allowed to affect current utility and is used as a stock variable to describe the degree of current addiction.<sup>7</sup>

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<sup>5</sup>We agree with their starting point which provides for a positive research strategy. Indeed, Becker and Murphy (1988) showed how seemingly irrational behaviour (addiction) can be reconciled with rational, forward-looking decision-making. In our modelling exercise, lack of detailed data prohibits testing their model. Instead, we have had to incorporate habits and addiction by proxies, using rather coarse methods of analysis.

<sup>6</sup>In addition, Deaton and Muellbauer (1980) found that the introduction of an essentially arbitrary time trend removes much of the conflict between the data and hypothesis of the representative consumer maximizing a conventional utility function. Blundell et al. (1993) showed that time trends can also partly correct for aggregation bias introduced into the study when time-series macrodata are used in place of the appropriate microdata.

<sup>7</sup>Note; Our choice of a stock variable means that the effects of past consumption are not cumulated. The effect on the addiction stock lasts for one period only.

### 3 Data

#### 3.1 Quantity and price of alcoholic beverages

The expenditure and price data on alcoholic beverages and all other commodities are based on the OECD statistics: National Accounts, Detailed Tables Volume II, for various years. Total expenditure consists of the final consumption of resident households in the domestic market at national currencies. The OECD data are compiled with specific reference to international comparability. Therefore, they are preferred for the purposes of the present study over national data sources. Table 1 presents a summary of the timespan of the available data by country and those years in where some interventions on the data have been deemed necessary. The time series are shown in three interesting groups of countries (log-scale) in Figure 1.

Table 1  
Some summary characteristics of the data

Country	Timespan available	Data interventions	
		Obs.	Level
Austria	1964-1996		>1994
Belgium	1960-1996	1989	
Denmark	1966-1995		
Finland	1960-1996		<1969
France	1963-1996		>1992
Greece	1960-1995	1969	
Ireland	1970-1996		
Italy	1964-1996		
Netherlands	1969-1996		
Norway	1963-1991		
Portugal	1960-1995		
Spain	1964-1994		<1977
Sweden	1963-1995		
UK	1960-1996		

Germany has been excluded from the analysis because we could not obtain adequate time series data on alcoholic beverages. The range in the time series varies substantially by country. The time interval that is common for all countries is 1970-1991. We used a few dummy variables to account for some exceptional values of the quantity index of alcoholic beverages or breaks in the series. Those dummy variables are indicated in the last two



columns of Table 1. For example, the observation in 1989 is removed from the Belgian data and a level correction is made to the Austrian data after 1994. In a differenced form of the series, the level correction corresponds to a deletion of one observation. The time series have rather short lengths, and even an individual outlier may have some undesirable influence on the estimation results.

The prices of alcoholic beverages and total consumption are the implicit price indices obtained by taking the ratio of the expenditure series in current and constant prices. In empirical analysis, the quantity index of demand per adult has been determined by dividing the constant price expenditure by the midyear population estimates of those 15 years of age and over. In empirical analysis, it has to be borne in mind that the expenditure on alcoholic beverages does not include beverages purchased in restaurants, cafes and hotels. Unfortunately, we did not have available expenditures on subcategories of alcoholic beverages, such as spirits, wine and beer, except in a few countries.

### **3.2 Consumption of absolute alcohol**

In addition to the conventional quantity indices of alcoholic beverages, we have available alternative data on alcohol consumption in litres of absolute alcohol per adult. This enables us to compare the levels of absolute alcohol consumption between the countries. The data on absolute alcohol consumption per adult, those 15 years of age and over, were obtained from the publication of the Brewers' Association of Canada (1997) in 1950-1995 (Figure 2). Greece is an exception, and the Greek data were obtained from World Drink Trends (1997) published by Productschap voor Gedistilleerde Dranken.<sup>8</sup> In contrast to the data on quantity indices of alcoholic beverages, the absolute alcohol consumption figures include drinks sold in restaurants, cafes and hotels. However, the data are probably of poorer quality than the quantity index data in those countries where excise taxes do not apply to alcohol consumption.

### **3.3 Comparable price and expenditure variables across countries**

In analysing alcohol consumption we use price and total consumption variables that account for their level differences across the countries. Eurostat

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<sup>8</sup>However, the consumption of spirits for Greece is not available for 1961-1975 and in addition, the consumption of beer and wine was expressed in litres. To obtain consumption in litres of absolute alcohol for Greece, the consumption of spirits is set to a constant 2.8 litres in absolute alcohol per capita for the above time period, and the alcohol contents of beer and wine are calculated as 4.5 and 12 per cents by volume.

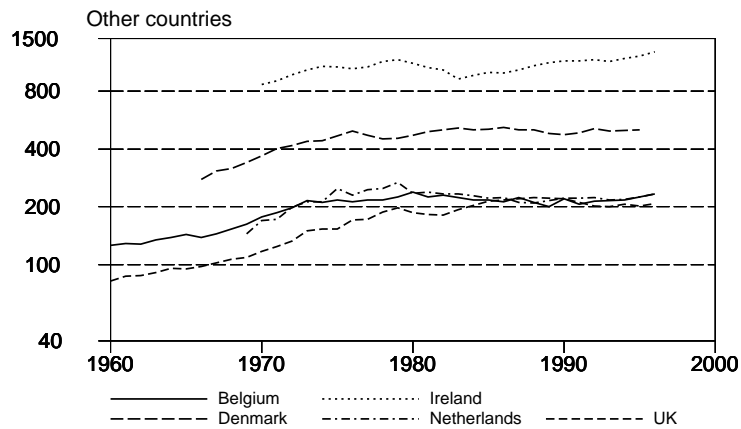
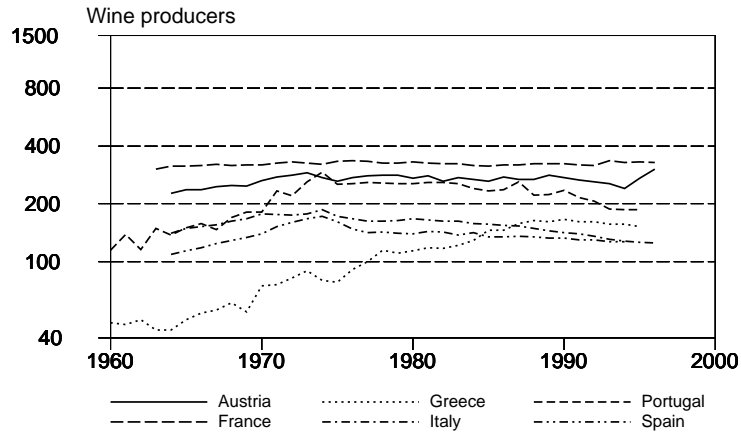
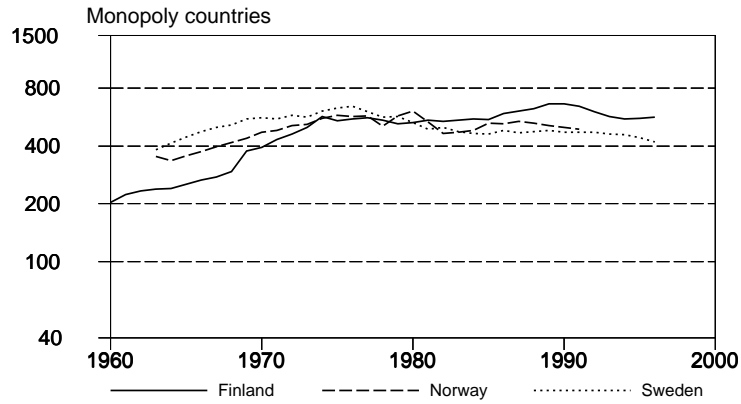


Figure 1: Alcohol consumption per adult (15 years of age and over) at constant prices in US dollars (log-scale)

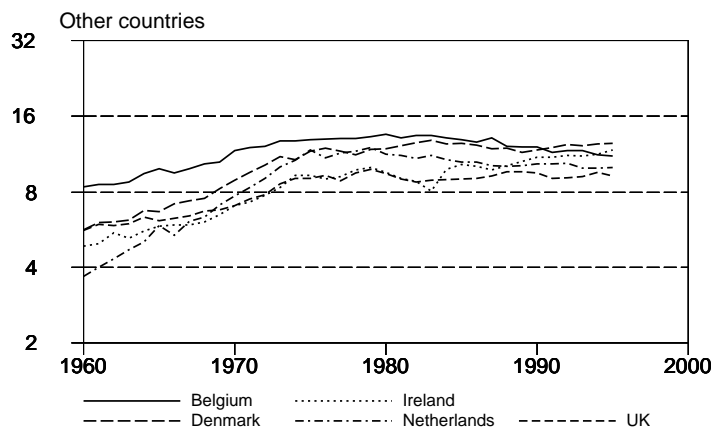
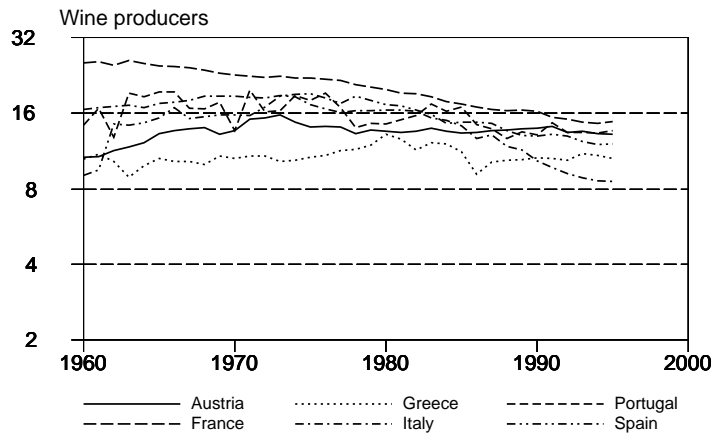
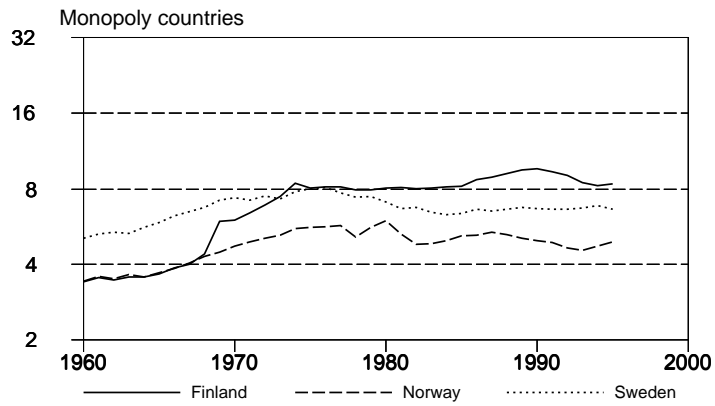


Figure 2: Alcohol consumption in litres per population 15 years of age and over (log-scale)

has regularly published price level indicators for alcoholic beverages. These show the relative price levels of OECD countries in index form. The price comparisons exclude beverages purchased in restaurants, cafes and hotels. Similar price level indicators are available for total consumption expenditure (private final consumption) in 1990-1995. Since the data for price level indicators are available for this short period only, we used their mean values in subsequent empirical analysis to make a level correction to the national price indices.<sup>9</sup>

The country-specific price indices for alcoholic beverages and total consumption were combined with the price level indicators to form comparable price variables that capture differences in price levels across the countries. For country  $i$ :

$$p_{it} = p_{it}^{91} * P_i^a, \quad (14)$$

$$P_{it} = P_{it}^{91} * P_i^c, \quad (15)$$

where  $P^a$  and  $P^c$  are the 1990-1995 means of the price level indicators for alcoholic beverages and total consumption, respectively. Variables  $p_{it}^{91}$  and  $P_{it}^{91}$  are the corresponding national current price indices of alcoholic beverages and total consumption for the base year 1991. The year 1991 was selected, since it is the latest year available for all countries (Table 1).

Similarly, we formed comparable real price indices for alcoholic beverages that reflect the differences in relative prices of alcohol across the countries. The real price that measures the price of alcoholic beverages in relation to the price level of all commodities is obtained by dividing (14) by (15):  $p_{it}/P_{it}$ .

To compare 'living standards' in terms of consumption levels across the countries we have formed a similar variable for total consumption per adult, those 15 years of age and over. First, total consumption expenditure is converted to common monetary units, in US dollars, for country  $i$ :

$$M_{it} = M_{it}^{91}/E_i, \quad (16)$$

where  $M_{it}^{91}$  is private final consumption expenditure at current prices per population 15 years of age and over and  $E_i$  is the mean exchange rate in 1990-1995 in national currency per US dollar.

The constant price-valued total expenditure variable in dollars is obtained by dividing the current price variable (16) with the corresponding price index (15). The variable should capture differences in the consumers' purchasing power across the countries.<sup>10</sup> Table 2 shows the real prices of alcoholic beverages and total expenditure in constant prices in 1991.

<sup>9</sup>This was done to minimize the effects of an exceptional exchange rate in a given year.

<sup>10</sup>We wish to make a reservation here. Public provision of private goods has a marked influence on the figures. In the Nordic Countries public welfare services account for a

Table 2

Real prices, total expenditure and  
absolute alcohol consumption in 1991

Country	Price index	Expenditure US \$	Alcohol litres per adult population
Austria	104.3	14 240	14.2
Belgium	100.2	15 650	11.5
Denmark	115.1	12 170	12.0
Finland	201.0	10 790	9.4
France	92.8	15 510	15.4
Greece	121.5	7 100	10.6
Ireland	194.2	11 380	11.0
Italy	92.8	14 370	9.7
Netherlands	103.8	14 030	10.4
Norway	199.3	11 830	4.9
Portugal	97.6	9 140	14.7
Spain	79.1	10 970	13.2
Sweden	166.4	11 800	6.6
UK	149.8	13 730	9.1

The relative prices for alcoholic beverages are highest in Finland, Ireland and Norway, over 2.5 times prices in Spain. In addition, we find large differences in real consumption expenditures. The values for Belgium and France are more than twice that of Greece. The last column presents consumption in absolute alcohol. We find that in those countries with alcohol monopolies (Finland, Norway and Sweden) and with high relative prices of alcohol, the figures for alcohol consumption are relatively low. On the other hand, Italy has a low level of alcohol consumption despite a low price and relatively high level of total expenditure. Therefore, we may expect that at least some part of the variation in absolute alcohol consumption is left unexplainable by economic factors, relative prices and total expenditure at our disposal.

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substantial part of the Government budget. On the other hand, social transfers are used more extensively in the Central European Countries. In the last case, the consumption of welfare services is accounted for in private consumption and in the first case in public consumption.

## 4 Demand equations for alcoholic beverages

### 4.1 Empirical model

The demand equations that are used in our empirical work are written with the quantities  $q_i$  as dependent variables. While the demand equations are estimated in aggregate time series data, the temporal evolution in size of the population merits some further consideration.<sup>11</sup> In the empirical model quantity is measured by the quantity index of alcoholic beverages per adult, those 15 years of age and over (Section 3.1), and the explanatory variables are modified accordingly.<sup>12</sup>

The quantity index for alcoholic beverages does not include drinks sold in restaurants, cafes and hotels (Section 3.1). The price indices are consistent with the quantity index data. The variable chosen to measure the quantity of demand also reflects quality changes in consumption. The temporal increase in living standards may lead to the consumption shifting to products with higher relative prices because they are deemed to be better, i.e. of higher quality than other products. Examples include bottled quality wine in lieu of bulk wine and established brands with a high market price v. cheap brands. The change in average quality is reflected in our quantity variable, but not in the price variable. This is exactly what we hope for. For an individual country the demand equation can be expressed in the form:

$$q_t^* = \alpha + \gamma \log(p_t/P_t) + \beta \log(m_t^*) + \delta A_{t-1}^* + \Psi(t) + \varepsilon_t, \quad (17)$$

where  $q^*$  =quantity index of alcoholic beverages per adult,  
 $p$  =price index for alcoholic beverages,  
 $P$  =price index for total consumption expenditure,  
 $m^*$  =total consumption expenditure at constant price per adult,  
 $A^*$  =total consumption of absolute alcohol in litres per adult,  
 $t$  =time index,  
 $\varepsilon$  =error term.

Above,  $\Psi(t)$  is a trend component, a quadratic function in time,  $\Psi(t) = \psi_1 t + \psi_2 t^2$ , and  $\alpha$  (the intercept),  $\gamma, \beta, \delta$  and the  $\psi$ 's are the estimable parameters.

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<sup>11</sup>If consumption data are expressed in expenditure shares, changes in the population present a less serious problem than if quantity indices are used.

<sup>12</sup>The quantity indices are calculated by expenditure on alcoholic beverages at constant prices. The dependent variable is divided by the value in 1980. Therefore, in each country the dependent variables have the value one in 1980 and the values are not comparable among the countries. The motivation for using quantity indices rather than comparable expenditure share data is that we have some reservations with respect to the comparability of expenditure data across the countries.

In systems of demand equations the dependent variables are the expenditure shares. They are naturally bounded in the interval  $[0, 1]$ . On the other hand, the use of the quantity index opens up the possibility of non-stationarity in the dependent variable, and the well-known problem of ‘Spurious regressions in econometrics’ may emerge (see the classical 1974 article by Granger and Newbold).<sup>13</sup>

For these reasons our selection of regressors is based more on considerations of economic theory rather than on statistical evidence alone. Neoclassical theory indicates that relative prices and total real expenditure should be included in the model. In addition, theory shows the likely sign of the coefficients and sometimes, but less often, a range within which a coefficient is likely to lie.

## 4.2 Results for individual countries

As an additional precaution against nonstationarity, the model (17) is estimated in differenced form separately for each country by OLS.<sup>14</sup> The estimated model parameters are presented in Appendix A with some summary statistics of the model: the estimated standard deviation of the equation error ( $\sigma$ ), the square of the multiple correlation coefficient ( $R^2$ ), with the P values for the associated F test, and the Durbin-Watson test statistics indicating first-order autocorrelation in the residuals.<sup>15</sup> The P values associated with the F test indicate that a significant part of the variation in the

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<sup>13</sup>Recall that fitting the expenditure shares is seemingly a more demanding exercise, because their variation in time is more moderate than that of the corresponding quantity indices. For example, under theoretical assumptions the price of the commodity and demand for it should move in opposite directions. Therefore, the value for consumption is more stable than the quantity of consumption. The expenditure shares inherit the above property, and have some additional stability with respect to similar changes in total expenditure.

<sup>14</sup>In empirical analysis of data consisting of repeated observations on economic units, it is often assumed that the coefficients (slopes) of the quantitative variables are the same while the intercepts (effects) may vary over units. In such a constant-slope, variable-intercept analysis one should account for a possible dependence that may exist between the quantitative variables and the effects. For example, the excise taxes of alcohol may be set permanently at a higher level in those countries experiencing higher than normal alcohol consumption. Differences in regulatory regimes of the alcohol market, monopoly, licence system and free retailing have similar effects. In analysing panel data, the resulting bias in estimates is frequently dealt with fixed effects estimation. In effect, one subtracts the country means from the observations of the dependent and independent variables or alternatively, uses dummy variables for each country in the estimations. An additional way to get rid of the effects is to estimate the model in differenced form separately for each country by OLS.

<sup>15</sup>The F test tests the hypothesis that all parameters of the model are zero except for the intercept. The test statistics are calculated by dividing the mean square for the model by the mean square for error.

(differenced) dependent variable is explainable by the model. However, the P value for Greece exceeds the one per cent significance level. Here the  $R^2$  is smallest and  $\sigma$  is about five per cent of the demand in 1980. In Portugal,  $\sigma$  is also relatively high. The Durbin-Watson statistics for Austria deviates most from the value two which corresponds to a first-order autocorrelation of zero, and gives the estimate -0.33 for the autocorrelation.

The dependent variable has values equal to one in 1980 in all countries. Therefore, the parameters for the price and total expenditure variables give directly the values of the elasticities in that year; see (13) and (12). The price coefficients, elasticities in 1980, are statistically insignificant on the five per cent level in six countries (Austria, Belgium, Greece, Italy, Portugal and Spain). Except for Belgium, which is near the border of significance, the countries are wine producers. France is the only wine-producing country that produced a significant price coefficient. Almost all coefficients of the expenditure variable are significant on the five per cent level, with the exceptions of Greece and the Netherlands.

A priori, we expected that the past absolute alcohol consumption would produce a positive coefficient. The past consumption is used here to capture the degree of addiction. However, the coefficient was negative for five countries (Austria, Belgium, the Netherlands, Portugal and the UK) but significant only for Belgium and Portugal. Estimates were significantly positive only for Finland, Italy and Sweden. Thus, the past absolute alcohol consumption did not appear to perform in its role quite as we expected, but captured some left-out dynamics instead.

Linear trends, i.e. intercepts in the differenced form of the model, were introduced into the equation to capture those slowly evolving changes in consumer preferences or population structure that are due neither to prices nor total expenditure. Trend variables obtained mostly negative coefficients. Only Greece and Ireland show up with slightly positive linear trends in estimation. However, these are not statistically significant. For Denmark, Sweden and the UK we introduced additional quadratic trend components after examining them for their statistical significance. All these produced negative values for the second-degree parameters. For Denmark the maximum value in the trend component is reached in 1976, for Sweden in 1970 and for the UK in 1986. The trends retard the growth in consumption after these years. In summary, in all countries with significant estimation results the demand for alcoholic beverages has been declining for noneconomic factors after the mid-1980s, and in most countries throughout the estimation period.

Table 3 shows the estimated price and expenditure elasticities. As noted above, the values of the elasticities are time-dependent. The figures in Table 3 are the average values for the years 1980 and after. The estimates show



Table 3  
Mean elasticities of alcohol demand

Country	Elasticities	
	Price	Expenditure
Austria	-0.026	0.930
Belgium	-0.438	1.083
Denmark	-0.573	0.414
Finland	-0.680	0.761
France	-0.308	0.520
Greece	-0.199	0.469
Ireland	-0.392	0.542
Italy	-0.087	0.890
Netherlands	-1.688	0.769
Norway	-1.308	0.879
Portugal	-0.166	0.917
Spain	-0.314	0.868
Sweden	-0.855	1.200
UK	-0.681	0.620
Mean	-0.551	0.776

The last row shows the unweighted mean of the elasticities over the countries.

the compensated price elasticities.<sup>16</sup>

The results indicate that demand for alcoholic beverages is price-elastic in the Netherlands and Norway, with the price elasticity less than minus one. Here the effect of price change on consumption is greater than the price change itself. The value for the Netherlands appears to be an outlier with respect to the rest of the data. The expenditure elasticities are greater than one in Belgium and Sweden. This would suggest that alcoholic beverages are luxuries in those countries. The expenditure share of a luxury good shows a tendency to rise when total expenditure is increased. Previous empirical work on alcoholic beverages suggests that alcoholic beverages are not luxury goods. Variation in the values of the expenditure elasticity is clearly smaller than the variation in values of the compensated price elasticities.

<sup>16</sup>This means that the income effects of price changes are compensated for the consumers in terms of their standard of living index, i.e. real consumption expenditure on all commodities. Since the observed expenditure shares of alcoholic beverages are low (less than 10 per cent of total expenditure) the differences between the compensated and uncompensated price elasticities are generally quite small.

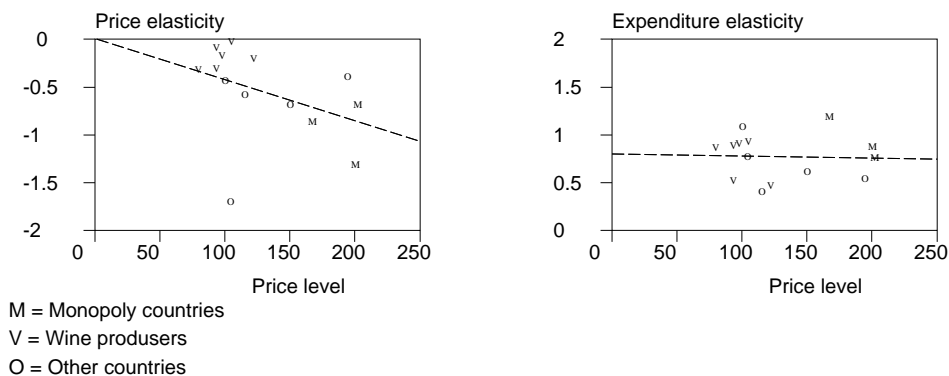


Figure 3: The trade-offs in price and expenditure elasticities and price levels of alcohol in 1980

Although a large number of demand studies are found in the literature, it is not easy to find results that are comparable to the present estimates. For example, Selvanathan (1991) in his comparative study reported conditional elasticities for absolute alcohol consumption in three beverage groups, under the condition that total outlay on alcohol is kept constant. Therefore, the elasticities show how the composition of alcohol consumption reacts to changes in the independent variables. In several cases elasticities are reported only for subgroups of beverages with no estimation results available for total demand for alcoholic beverages (Jones 1989). It should also be remembered that elasticities are time-dependent in the present study. Generally, great care should be taken when comparing results from different studies. Since estimation results that have been obtained by similar methods are available from only a few countries, no detailed comparisons are made here. Concerning future analysis, we point out that the elasticity estimates are obtained on a comparable basis in the present study.

### 4.3 Comparison of elasticities

In Figure 3 the estimated price and expenditure elasticities in Table 3 are plotted against the relative prices of alcoholic beverages in 1991 (Table 2). The price variables are calculated so as to capture differences in price levels between the countries (for details see Section 3.3). Figure 3 shows that the price elasticities have low absolute values in the wine producing-countries (Austria, France, Greece, Italy, Portugal and Spain), where the alcohol prices are also relatively low. In contrast, the price elasticities attain high absolute values in the monopoly countries that have relatively high prices. The regression line drawn in Figure 3 reveals a clear inverse dependence between the alcohol prices and the corresponding price elasticities. But

recall that in estimation no use has been made of the differences in prices between the countries. On the other hand, the inverse dependence is in accordance with the functional form used in our demand model. By (13) the absolute value of the price elasticity is increased as the demand falls in response to a rise in the price of alcoholic beverages. A similar relation holds for the expenditure elasticity (12). In contrast, Figure 3 shows no clear dependence between the values of the expenditure elasticity and the level of alcohol prices in our data.

Figure 4 shows the entire time paths of the price and expenditure elasticities. Here, the countries were grouped into three categories: the monopoly countries, wine producers and the other countries. During the 1960s the time paths show rather erratic behaviour, which has probably to do with the quality of our data. But later, it can be seen, that each individual group of countries appears to have a separate, common level to which the price elasticities converge. The tendency is most marked in the first two groups of countries. It is worth pointing out that the residual group, the other countries, appears to have a common convergence level with the possible exception of the Netherlands. However, it is not easy to find any common, natural characteristics in the residual group that would relate to their distribution system of alcoholic beverages or their production of beverages.

Visually, the expenditure elasticities may appear to converge at two distinct levels. The monopoly and the wine-producing countries converge at a value close to one and the other countries appear to converge at a somewhat lower value. France, Greece and Belgium show somewhat deviant development within their respective groups. While convergence of individual elasticities is considered, one may recall that the values of the elasticities are dependent on the quantity of demand in our functional specification. The quantities have been measured as indices, with a value of one in 1980. Therefore, the observed convergence of elasticities reveals no tendency for the demand levels to converge.<sup>17</sup>

So far, we have not considered statistical precision in our estimates. There is naturally substantial sample variation in the individual estimates. But graphical examination of the data suggests two statistical hypotheses. First, the price elasticities are equal within the three groups considered (the monopoly countries, wine producers and the other countries). Secondly, the scatter plot suggests that expenditure elasticities may have equal values in all countries. However, the time paths of elasticities (Figure 4) indicate that the expenditure elasticities may have two distinct values within the country groups. Next we examine the hypotheses by formal statistical analysis.

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<sup>17</sup>However, since trend components were introduced into the analysis they may reveal a simultaneous tendency for the autonomous trend components to converge.

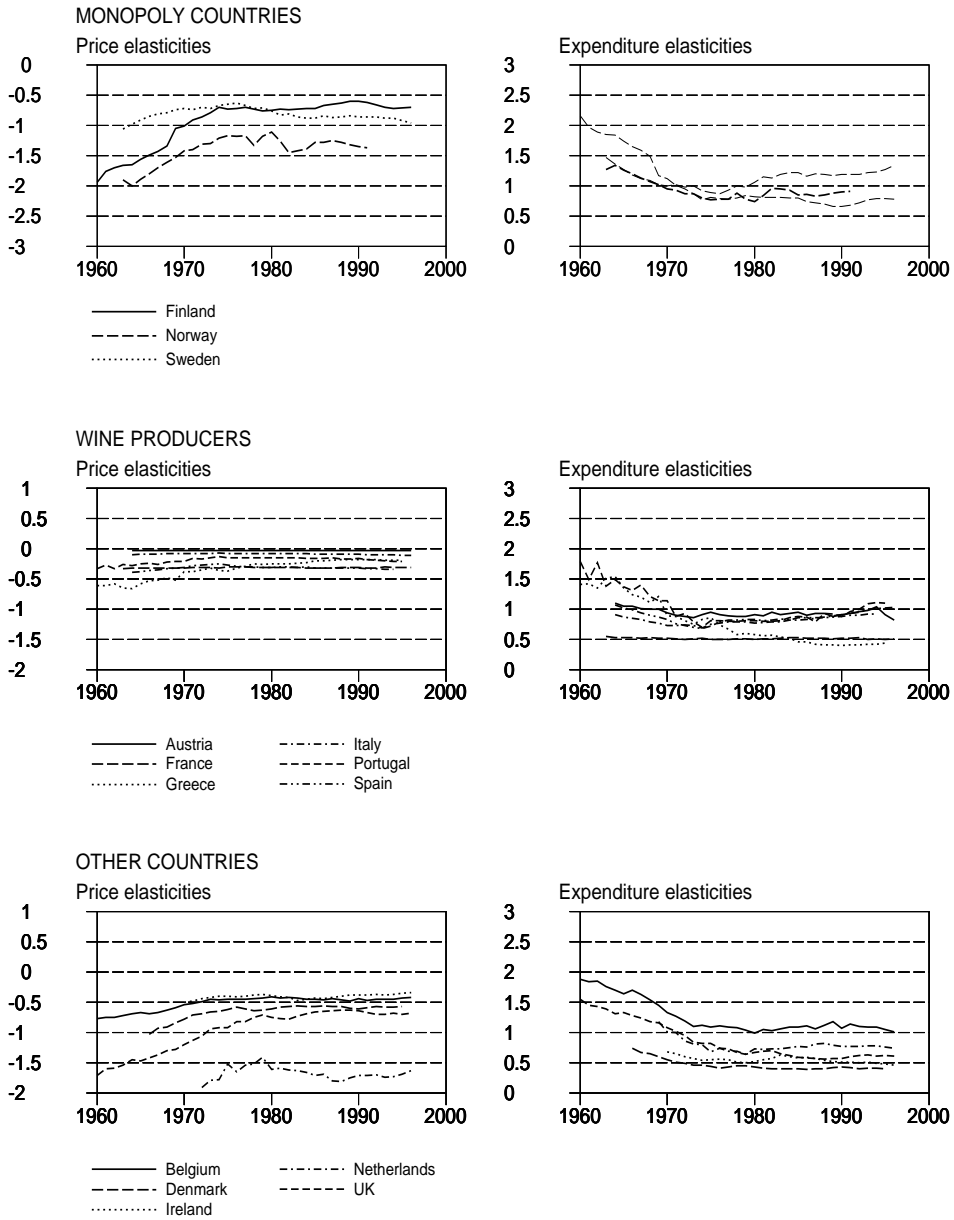


Figure 4: Time series for price and expenditure elasticities of alcohol

#### 4.4 SURE estimation and tests

Here we examine similarities in demand responses to the economic variables, i.e. the relative price of alcoholic beverages and the real expenditure variable. To be more specific, we formulate statistical hypotheses for common parameter restrictions across the countries and test whether these restrictions hold. The hypotheses have been suggested by graphical examination of the results for the individual countries. Furthermore, we re-estimate the model under the restrictions. Here we use a simple extension of the SURE method by Zellner (1962) in which the number of observations differs between the equations. The method utilizes the correlation in equation errors across the countries, and the estimators are more efficient and unbiased under the cross-equation restrictions. A Wald test statistic was used to test for the hypothesis on model parameters. It has a  $\chi^2$  distribution (for details, see Appendix B).

Tests for the parameters of the model correspond to the values of corresponding elasticities in 1980 by the construction of our dependent variable. The following sequence of nested hypotheses are examined:

- HM** The expenditure parameters are equal for all countries.
- HMPG** First, the expenditure parameters are equal for all countries. Second, the price parameters are equal within country groups, with the Netherlands treated as a special case.
- HMPA** First, the expenditure parameters are equal for all countries. Second, the price parameters are equal within country groups, with the Netherlands treated as a special case. Third, the parameters for absolute alcohol consumption are equal within country groups.
- HMP** Both price and expenditure parameters are equal for all countries. In addition, the parameters for absolute alcohol consumption are equal within country groups.

To guard against possible overrejection of the hypotheses, the test statistics were calculated under two alternative assumptions, first by assuming no autocorrelation in the equation errors and second with an autoregressive process of order one, AR(1), in the errors. In the last case the standard deviations of the model parameter are generally estimated to be too low by OLS. To be on the safe side, Table 4 gives the tests statistics that were calculated under the assumption of an AR(1) process for errors.<sup>18</sup> The hypotheses form a nested sequence, **HMP**  $\subset$  **HMPA**  $\subset$  **HMPG**  $\subset$  **HM**. All hypotheses in the nested sequence, **HMPA**  $\subset$  **HMPG**  $\subset$  **HM** are

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<sup>18</sup>If the price and expenditure parameters are considered, the tests produced quite similar results.

Table 4

Demand for alcoholic beverages, Wald tests

Hypothesis	Wald statistics	DF	P value
<b>HM</b>	10.77	13	0.630
<b>HMPG</b>	20.07	23	0.638
<b>HMPA</b>	44.39	34	0.109
<b>HMP</b>	103.90	37	0.000

accepted by the data (Table 4). The results reveal that the hypothesis **HMP** of common price and expenditure parameters and equal parameters within country groups for absolute alcohol is clearly rejected. Therefore, any additional restrictions other than those in the last nested sequence are rejected by the data.

We conclude that there is a single common parameter equal to the elasticity in 1980 for total expenditure, and the price parameters are equal within the three country groups, with the exception of the Netherlands. The Netherlands obtained an exceptional estimate. However, further analysis revealed that the value is not robust if we allow autocorrelation in the equation error. In addition, the parameters for absolute alcohol consumption are equal within country groups. In fact, further analysis revealed that the common value is both positive and significant only in the monopoly countries group.

Table 5 shows the new restricted SURE estimates of the elasticities in 1980, obtained under the accepted hypothesis **HMPA**.<sup>19</sup> The restricted estimators are more efficient, and their estimated standard deviations are much lower than the results for individual countries indicated (Appendix A). The tests revealed the similarities in parameter values that could be observed in our graphical examination of the estimation results. In addition, the tests show noticeable differences in the price elasticities between the three country groups. The Netherlands present a doubtful outlier, but the current results for the Netherlands are not very robust, and further analysis is obviously needed before anything definite can be said of price elasticities in the Netherlands.

The demand for alcoholic beverages appears to be more easily controllable by excise taxes in the monopoly countries than elsewhere. In the monopoly countries the prices of alcoholic beverages are set at a relatively

<sup>19</sup>Detailed estimation results are available on request.

Table 5  
 Restricted estimates for the groups of countries

	Elasticities	
	Price	Expenditure
Monopolies	-0.782 (10.6)	0.752 (14.4)
Wine producers	-0.216 ( 4.6)	0.752 (14.4)
Others	-0.495 ( 5.5)	0.752 (14.4)
Netherlands	-1.466 ( 5.8)	0.752 (14.4)

t values are given in the parentheses

high level by taxes which are the cornerstone of alcohol policy there. We observe simultaneously high excise taxes of alcoholic beverages giving considerable tax revenue and the relatively high response of alcohol demand to taxes in the monopoly countries. On the other hand, recall that the differences in the alcohol price levels between the countries were not utilized in the estimation and do not affect the results. In addition, the estimated value of the price elasticity that lies significantly above -1 indicates that the taxes have not been set at their tax revenue maximizing level in the monopoly countries.<sup>20</sup>

However, in the monopoly countries spirits may constitute a higher share of alcohol consumption. If their price elasticity is higher than those of beer and wine, their high share could show up in higher price elasticities for all alcoholic beverages.<sup>21</sup> Whether this holds true is an open question. In several previous studies the question has been left unanswered because it has been frequently assumed that the demand for alcoholic beverages is weakly separable from all other consumption. In the separable case, relative expenditure shares of the beverage groups do not affect the overall price elasticity of alcoholic beverages.

<sup>20</sup>There is a complicating feature in the monopoly countries. In these countries taxes and prices of alcohol may be set in response to recent developments in consumption of alcohol. If the policy rule is entirely backward-looking there are no complications nor bias in the estimation. But the model would perform rather badly in forecasting because there is feedback from the demand to the prices. However, if the policy rule is forward-looking there would be a simultaneous bias present in the estimates.

<sup>21</sup>We thank Björn Lindgren for bringing this to our attention.

Demand appears to be least sensitive to prices in the wine-producing countries. The results support our choice for the functional form of the demand function where elasticities are inversely dependent on the level of demand (13).



## 5 Consumption of absolute alcohol

### 5.1 Empirical model

Below we analyse absolute alcohol consumption and examine whether there are interesting similarities within the three groups of countries. In contrast to the quantity index data on alcoholic beverages, absolute alcohol consumption includes beverages sold in restaurants, cafes and hotels. First, we explain absolute alcohol consumption in each country with a pooled model by using relative price and total real expenditure variables and country-specific level-shift variables, capturing cultural differences in consumption levels. As above, the country-specific trend components, linear or quadratic functions in time, were used to describe slow movements in consumption habits. We examine whether there are any similarities in the model parameters, using similar groupings of countries as above. In the analysis we use such price and total expenditure variables that are comparable between the countries and capture differences in their values (Section 3.3).

Our model is similar to the one used in modelling the quantity index of alcoholic beverages. Here we try two alternative functional forms, a log-linear and a semilogarithmic form:

$$\log A_i = \gamma_i \log(p_i/P_i) + \beta_i \log(M_i/P_i) + \sum_i \phi_i D_i + \Psi_i(t) + \varepsilon_i, \quad (18)$$

$$A_i = \gamma_i^* \log(p_i/P_i) + \beta_i^* \log(M_i/P_i) + \sum_i \phi_i^* D_i + \Psi_i^*(t) + \varepsilon_i^* \quad (19)$$

Above,  $A$  is the yearly alcohol consumption in litres of absolute alcohol per adult,  $p/P$  and  $M/P$  are the pooled relative real price and expenditure variables that capture cross-border differences (Section 3.3). The dummy variables  $D_i$  capture the mean levels in individual countries taking a value of one, if the country is  $i$ , and zero if otherwise.<sup>22</sup> The country-specific trend components  $\Psi_i(t)$  are quadratic functions in time,  $t$ ,  $\Psi(t) = \psi_1 t + \psi_2 t^2$ , with the variable  $t$  having the value zero in 1980. In this way the effects due to the trends do not become confused with the level effects. In the present case

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<sup>22</sup>We have given Finland special treatment by using an additional dummy variable describing the effects of the 1968 Alcohol Act in Finland. The 1968 Alcohol Act in Finland permitted the establishment of outlets for alcoholic beverages and licensed restaurants in rural areas. The formerly beer - only restaurants obtained more extensive licences and the number of fairly cheap fully licensed restaurants increased greatly. The act also reduced the legal age limit for alcohol purchases: from 21 years to 18 years for light beverages and to 20 years for strong alcoholic drinks. Minor changes in alcohol control have also occurred. The Medium Beer Act, one part of the 1968 legislation, authorized the monopoly to grant grocery shops the right to sell medium beer off-the-premises and cafes the right to serve it (Österberg 1981).

the coefficients of the level-shift variables  $D_i$  directly show the differences in absolute alcohol consumption in 1980 not accounted for by the variation in price and expenditure variables.

In (18) the parameters  $\gamma_i$  and  $\beta_i$  give the constant compensated price and expenditure elasticities, respectively. In contrast, in (19) the corresponding elasticities are time- and country-variant. The exact values are obtainable from the the formulae (13) and (12) as above. So far we have used country-specific indices in the price and expenditure parameters. It will be interesting to examine how successful restricted specifications of the model with common parameters, say  $\gamma_i = \gamma$ , are in explaining the data.

## 5.2 Pooling the countries

The above analysis of the quantity index data indicated that the price elasticities are equal within the three groups of countries (monopoly countries, wine-producing countries and other countries). In addition, the tests revealed that the expenditure elasticity has a common value for all countries (Section 4). Below we examine to which extent common parameters for the prices and expenditure variables are justified in a pooled model for absolute alcohol consumption.

In the estimation we simply stack the observations from individual countries together, construct pooled price and expenditure variables and use OLS. We start with an unrestricted specification, **H** with country-specific parameters  $\gamma_i$  and  $\beta_i$ . First, we test whether the expenditure parameters  $\beta_i$  can be set equal across the countries and subsequently whether the price parameters can be treated similarly. In the tests we use both functional specifications of the model, the log-linear and the semilogarithmic forms.

<b>H</b>	The hypothesis, with free price and expenditure parameters.
<b>HM</b>	In the hypothesis, the expenditure parameters are set equal.
<b>HMP</b>	In the hypothesis, both the price and expenditure parameters are set equal.

The hypotheses form a nested sequence, **HMP**  $\subset$  **HM**  $\subset$  **H**. The hypothesis **HMP** is the least general one. First, we test whether the residual sum of squares (SSR) of the specification **H** is significantly smaller than that of the specification **HM**, using both the log-linear and semilogarithmic speci-

fications.<sup>23</sup> Under standard assumptions the expression:

$$\frac{(SSR_{HM} - SSR_H)/n}{SSR_H/(T - k_H)} \quad (20)$$

assumes an F distribution with  $n$  and  $T - k_H$  degrees of freedom. Above  $SSR_{HM}$  and  $SSR_H$  refer to the SSRs of the restricted **HM** and unrestricted **H** specifications, respectively.  $T$  is the number of observations,  $k_H$  is the number of parameters in hypothesis **H** and  $n$  stands for the number of restrictions involved in the test. Table 6 shows the results.

Table 6

Testing **HM** v. **H**

Specification	F value	DF <sub>1</sub>	DF <sub>2</sub>	P value
log-linear	1.79	13	385	0.042
semilogarithmic	1.36	13	388	0.178

The test for the log-linear specification shows a significant improvement on the five per cent significance level if the common expenditure parameter (or variable in the OLS estimation) is replaced by their country-specific counterparts. The test for the semilogarithmic specification reveals no such improvement, and here the hypothesis of the common coefficient for expenditure is accepted.

Next we impose the common parameter for the expenditure variable and test whether the price parameters can be set equal for each country. The test is performed similarly as above (Table 7). The tests indicate

Table 7

Testing **HMP** v. **HM**

Specification	F value	DF <sub>1</sub>	DF <sub>2</sub>	P value
log-linear	3.95	13	398	0.000
semilogarithmic	2.91	13	401	0.001

that significant improvement can be achieved in both the log-linear and the semilogarithmic specifications if the common price parameter is replaced by

<sup>23</sup>In the pooled estimation we calculate the SSR for the hypotheses **H** and **HM** using a simple procedure: the pooled price  $p/P$  and expenditure variables ( $M/P$ ) are replaced by their country-specific counterparts. First,  $p_r = D_i(p/P)$  for **HM**. Second,  $p_r = D_i(p/P)$  and  $M_i = D_i(M/P)$  for **H**.

its country-specific counterparts. Consequently we reject the hypothesis of a common coefficient for the price variable.

We prefer the semilogarithmic specification to the log-linear specification because of its attractive property of having the elasticities inversely proportional to the level of absolute alcohol consumption. In addition, the tests revealed that this property is at least partially supported by our data. The tests accept the hypothesis of equal coefficients for expenditure in the semilogarithmic form (Table 6), and the preferred specification for the absolute alcohol consumption is (19) where the price parameters vary across the countries.

Above, the dependent variable was expressed in level form. The consumption levels were explicitly accounted for because later the results are used to discuss the roles of economic and other, e.g. cultural, factors in explaining the differences in absolute alcohol consumption between the countries.<sup>24</sup> Country-specific dummy and trend variables were included in all specifications of the model. The effect of using country-specific level dummies is fairly similar to that of differencing (see footnote 14). Therefore, only within countries deviations from the means have been utilized in estimating the price and expenditure parameters of the model.

Table 8 presents the estimated price and expenditure elasticities from the restricted semilogarithmic specification **HMP** and its two variants. The variants are the preferred specification **HM** and the free specification **H**. The figures are averages of elasticities from 1980 and after. The Durbin-Watson statistics indicates considerable autocorrelation in the pooled residuals.<sup>25</sup> The multiple correlation coefficients of the equations are very high. The standard deviation of the equation error is less than 70 centilitres.

By examining the values within the three groups (monopoly countries, wine producers and other countries) the similarities in values of the elasticities are not as clear as in the case of the quantity index data (Table 8, columns **H**). However, the general pattern is repeated here. The price elasticities of the absolute alcohol consumption have smaller absolute values in the wine-producing countries than those in the monopoly countries. The expenditure elasticities are quite similar in most of the countries. Similarly, if the restricted specification **HMP** is considered, the absolute values of both price and expenditure elasticities are higher for the monopoly countries than

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<sup>24</sup>Nonstationarity of the dependent variable may be a problem in the estimation. However, the case of a unit root in the per capita consumption of alcohol may in principle be ruled out by physiological considerations. But the time series have considerable autocorrelation which shows up as some inefficiency in estimation.

<sup>25</sup>The Durbin-Watson statistics were calculated from pooled residuals where observations from different countries were stacked together. Therefore, the test value should be taken only as a proxy.

Table 8  
 Absolute alcohol, price and expenditure elasticities

Country	Price elasticities			Expenditure elasticities		
	Re- stricted <b>HMP</b>	Pre- ferred <b>HM</b>	Free <b>H</b>	Re- stricted <b>HMP</b>	Pre- ferred <b>HM</b>	Free <b>H</b>
Austria	-0.336	0.360	0.359	0.529	0.511	0.518
Belgium	-0.369	-0.256	-0.265	0.581	0.562	0.637
Denmark	-0.375	-0.769	-0.772	0.591	0.571	0.493
Finland	-0.532	-0.638	-0.537	0.838	0.809	0.730
France	-0.274	-0.031	-0.386	0.431	0.417	1.214
Greece	-0.416	-0.481	-0.478	0.655	0.633	0.623
Ireland	-0.452	-0.675	-0.736	0.711	0.687	0.343
Italy	-0.391	0.066	0.478	0.615	0.594	-0.169
Netherlands	-0.437	-0.793	-0.575	0.688	0.664	0.968
Norway	-0.889	-1.279	-1.727	1.400	1.353	0.853
Portugal	-0.318	-0.381	-0.418	0.501	0.484	0.557
Spain	-0.322	-0.002	-0.427	0.507	0.490	1.153
Sweden	-0.688	-1.742	-1.736	1.083	1.047	1.542
UK	-0.497	-0.527	-0.498	0.783	0.756	0.493
$\sigma$	0.67	0.65	0.65			
$R^2$	0.98	0.98	0.98			
P value	0.000	0.000	0.000			
Durbin-Watson	1.36	1.50	1.55			

for the other countries. But in this specification the observation is merely due to the functional relationship between the elasticities and consumption level ((13) and (12)). The unrestricted specification **H** gave illogical values in the estimates of price elasticities for Austria and Italy. But the estimates are quite imprecise if no common restrictions are imposed on them.

One reason for the missing pattern in price elasticities may be that absolute alcohol consumption is not determined by the same variables as the demand measured by the quantity indices. For example, absolute alcohol consumption is explained by a price index of consumption that does not include beverages sold in restaurants, hotels and cafes<sup>26</sup>

In addition, one may ask what is the proper price variable. Tastes for one characteristic of alcoholic beverages only, albeit an important one (absolute

<sup>26</sup>There may be considerable variation in the consumption from the above sources between the countries. Whether they originate from economic or cultural factors is an open question.

alcohol content) may not be adequately captured by a model that uses a conventional price variable. Minimum price to obtain a unit of absolute alcohol could have been more appropriate but was not available for the present study.

### 5.3 Absolute alcohol consumption, SURE estimation

Above we presented estimates of the price and expenditure elasticities for absolute alcohol consumption. The estimates were obtained from the pooled model and were restricted to having common parameters for the price and expenditure variables. Next we give alternative estimates with and without these restrictions. Above, our estimators did not utilize possible correlation of equation errors between countries. In the analysis we use the semilogarithmic functional form (19). Additional country-specific trend and level variables are also employed here. The only difference lies in the chosen estimation method. In the present case, we utilize the SURE method, (Zellner 1962; cf. Section 4.4). Table 9 gives the estimation results.

By construction, the pooled specification  $\mathbf{H}$  and the SURE method produce exactly the same parameter estimates because no common parameter restrictions are imposed across the countries. However, the standard deviations of the estimators differ. The time-varying values of the elasticities are calculated in 1980. The statistical precision of the estimators varies across the countries, and some unnatural values show the fragility of estimates if no common restrictions are imposed on the data. We use a Wald test to examine the following hypotheses on the parameters of the model (Appendix B):

**HMG** The parameters of the expenditure variable are equal within the three groups of countries (the monopoly countries, wine producers and the others).

**HMPG** The price and expenditure parameters are equal within the three groups of countries.

Table 10 gives the results of the Wald tests. In all cases the test statistics are highly significant, and we reject the hypothesis of common parameters for both price and expenditure parameters within country groups. But above, we could accept the hypothesis **HMG** in pooled estimation. In fact we could even impose a stricter version of it, **HM**.<sup>27</sup>

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<sup>27</sup>We naturally tested also for the hypothesis **HPG** with common price parameters within country groups. However, this hypothesis proved to be a stricter restriction than **HMG** and was rejected quite conclusively. In addition to the tests for price and expenditure parameters we also tested for equality in the values of the corresponding elasticities in 1980. Since the elasticities are time-varying we can restrict the equality in one year

Table 9

Absolute alcohol, prices and expenditure elasticities in 1980, **H**

Country	Elasticities			
	Price		Expenditure	
Austria	0.361	( 2.9)	0.520	( 4.8)
Belgium	-0.242	(-2.6)	0.582	( 4.9)
Denmark	-0.793	(-6.8)	0.507	( 4.3)
Finland	-0.573	(-4.6)	0.779	(17.0)
France	-0.324	(-2.6)	1.018	( 5.8)
Greece	-0.399	(-2.8)	0.518	( 1.9)
Ireland	-0.778	(-4.7)	0.362	( 2.6)
Italy	0.339	( 1.5)	-0.120	(-0.3)
Netherlands	-0.533	(-2.4)	0.896	( 3.8)
Norway	-1.489	(-6.6)	0.736	( 4.3)
Portugal	-0.415	(-2.7)	0.552	( 2.9)
Spain	-0.351	(-2.0)	0.947	( 4.5)
Sweden	-1.627	(-8.3)	1.445	( 7.0)
UK	-0.485	(-4.3)	0.480	( 2.7)
Mean	-0.522		0.659	

t values in parentheses. The values on the last row refer to an unweighted mean of the elasticities.

Table 10

SURE estimation test results

Hypothesis	Wald	DF	P value
<b>HMG</b>	36.06	11	0.000
<b>HPG</b>	59.23	11	0.000
<b>HMPG</b>	97.97	22	0.000

The difference in test results arises from the cross-border correlation in the equation errors which is utilized in the SURE method. The SURE method gives more efficient restricted estimators. Table 11 reports the estimated restricted elasticities in 1980, after imposing restrictions on values

only. These tests produced similar results to those in Table 10 with rejections for the hypotheses **HMG** and **HMPG**. In the case of **HMG** the P value was just under one per cent.

Table 11

Absolute alcohol, prices and expenditure elasticities in 1980, **HMPG**

Country	Elasticities	
	Price	Expenditure
Austria	-0.169 (-2.7)	0.592 (7.8)
Belgium	-0.434 (-10.3)	0.356 (7.3)
Denmark	-0.497 (-10.3)	0.407 (7.3)
Finland	-0.855 (-10.6)	0.824 (26.6)
France	-0.115 (-2.7)	0.403 (7.8)
Greece	-0.174 (-2.7)	0.608 (7.8)
Ireland	-0.615 (-10.3)	0.503 (7.3)
Italy	-0.139 (-2.7)	0.486 (7.8)
Netherlands	-0.522 (-10.3)	0.427 (7.3)
Norway	-1.154 (-10.6)	1.112 (26.6)
Portugal	-0.158 (-2.7)	0.554 (7.8)
Spain	-0.133 (-2.7)	0.464 (7.8)
Sweden	-0.971 (-10.6)	0.935 (26.6)
UK	-0.625 (-10.3)	0.512 (7.3)

t values in parentheses.

of elasticities as in **HMPG** (Section 4.4).

However, in finite samples the Wald tests are more powerful than the corresponding likelihood tests or the F tests that have been employed above. This may account for part of the difference. On the other hand, the current test is made conditional on the observed cross-country covariance structure which may produce some noise in finite samples. Therefore, the current test utilizes more information in the data than the test in the pooled model but may over-reject in finite samples. The conflicting evidence indicates that the restrictions on the parameters of the expenditure variable may not be in accordance with the data. However, they appear to present a less severe restriction than the corresponding restriction with respect to the price coefficients. In summary, the analysis of absolute alcohol consumption revealed less clear similarities in the values of the elasticities between the countries than the corresponding analysis of the quantity index data.

#### 5.4 Role of economic factors

The role of economic factors in explaining absolute alcohol can be examined by a simple Variance Decomposition Table (Table 12). We present



the results of the pooled model **H** in 5.2. The dummy variables which ac-

Table 12  
Variance Decomposition Table

Model	Share explained	Increase	Number of parameters	Increase
Country dummies	0.826	0.826	13	
Adding economics	0.935	0.109	51	28
Adding trends	0.981	0.045	73	22
Price and expenditure	0.559		2	

count for the country means explain over 80 per cent of the variation in the data and are the most important factors in the model. Introducing the country-specific price and expenditure variables adds about 11 per cent to the explanation. The remaining 4.5 per cent is accounted for by the trend components.<sup>28</sup>

For comparison, we present the results using only pooled price and expenditure variables in the lower part of Table 12. Introducing price and expenditure variables with common coefficients explains slightly over half the total variation. It is in itself no mean achievement using only two parameters, but falling short of that obtained by using dummy variables for the countries.

Next we discuss the relative role of economic factors, prices and total expenditure in explaining absolute alcohol consumption by two simple comparisons. Here we use the specification **HMP** in which the price and expenditure parameters are common to all countries.<sup>29</sup> First, we examine the level parameters for individual countries in more detail. Recall that our trend variables have values of zero by construction in 1980. Therefore, the values of the level parameters account for those differences in consumption levels that are left over after eliminating the estimated effects due to prices and total expenditure.

Table 13 shows the actual consumption of absolute alcohol in 1980 and the fitted values that were decomposed with respect to whether they originate from the economic variables or from the parameters accounting for the country levels. We chose Denmark as a reference point because both

<sup>28</sup>The total variation that has been decomposed consists of the variation in absolute alcohol consumption left unaccounted for by the general mean in the data and the Alcohol Act dummy variable in Finland.

<sup>29</sup>In this way we deliberately play down the role of economic factors and insulate the estimates of the country-specific level parameters from them.

Table 13

Consumption of absolute alcohol in 1980, differences from Denmark

Country	Actual Values	Economic Variables	Level Effects	Residual Term
Austria	1.7	1.2	1.3	-0.9
Belgium	1.7	2.6	-1.1	0.1
Denmark	0.0	0.0	0.0	0.0
Finland	-3.8	-2.9	-0.9	0.0
France	8.0	2.9	4.9	0.2
Greece	1.3	-3.5	3.0	1.8
Ireland	-2.3	-1.2	-0.8	-0.3
Italy	4.6	2.0	2.5	0.1
Netherlands	-0.6	2.5	-2.8	-0.2
Norway	-5.9	-1.1	-4.9	0.2
Portugal	2.6	-1.3	5.5	-1.6
Spain	5.4	1.3	3.6	0.5
Sweden	-4.8	-1.5	-3.3	0.0
UK	-2.5	-0.4	-2.4	0.3
MS	17.5	4.7	11.1	0.6

Actual = differences in actual consumption  
Economic= part accounted for by prices and total expenditure  
Level = part accounted for by level effects  
Residual = unexplained part  
MS = mean square

the price and expenditure variables acquire values near the median in the sample (Table 2). The bottom rows show how large a part of the total variation is accounted for by the different factors. Country-specific level effects account for most variation across the countries. Residual variation, left unexplained in 1980, is relatively unimportant. In France, Portugal and Norway the level effects are particularly pronounced.

Secondly, we calculate simulated levels of absolute alcohol consumption, assuming counterfactual values for the economic variables using the specification **HMP**. Here we simulate consumption levels in 1991, which is our base year for comparable price and expenditure variables. First, we simulate consumption when the relative price of alcohol is set at the second highest value in our sample in 1991. Similarly, we examine the corresponding simulations when the relative price of alcohol is the second lowest in the

Table 14

Simulated consumption in litres of absolute alcohol in 1991

Country	Consumption in 1991		Consumption if			
	Actual	Model	Price level		Expend. level	
			High	Low	High	Low
Austria	14.2	13.8	10.8	14.3	14.4	10.6
Belgium	11.5	11.9	8.7	12.2	11.8	8.0
Denmark	12.0	12.1	9.5	13.0	13.8	10.0
Finland	9.4	9.0	9.1	12.6	11.6	7.8
France	15.4	15.6	12.1	15.6*	15.6*	11.8
Greece	10.6	10.6	8.3	11.8	16.2	12.4
Ireland	11.0	11.0	10.9	14.4	13.2	9.4
Italy	9.7	10.5	7.0	10.5	11.0	7.2
Netherlands	10.4	10.3	7.3	10.8	11.1	7.2
Norway	4.9	4.7	4.7*	8.2	6.6	2.8
Portugal	14.7	13.7	10.4	13.9	17.5	13.7*
Spain	13.2	13.0	8.8	12.3	15.5	11.7
Sweden	6.6	6.7	5.9	9.4	8.7	4.9
UK	9.1	9.3	8.0	11.5	10.2	6.4
MS	8.8	8.3	4.1	4.1	9.5	9.6

MS = the mean square. The reference countries are marked by asterisks.

sample. Furthermore, we treat real expenditure variables similarly (for the values, see Table 2).

Table 14 gives the simulated consumption levels. Our reference countries are marked by an asterisk. For example, if the relative prices are raised to the second highest level, that of Norway, the simulated value for Norway remains unchanged. Values for all other countries decrease, except in Finland which has the highest prices. Alcohol consumption remains highest in France whether we either lower or raise the relative price of alcoholic beverages. The variation in consumption levels appears to decrease when prices are set to the same values, but to increase slightly when real expenditures are equalized. It would appear that the harmonization of absolute alcohol consumption is more easily achieved by equal prices rather than equal real expenditure levels.

In summary, we found that country-specific level parameters appeared to account for the major part of the variation in alcohol consumption. The economic variables, the relative prices of alcohol and real expenditure, played

a subsidiary but important role in explaining the differences between the countries. However, it may not be an easy task in finding the objective characteristics and measurable variables that lie behind these level factors and interpreting their effects in terms of, say cultural factors.

## 6 Conclusion

Alcohol consumption in 14 European countries was analysed in the present paper. Here we would have preferably utilized the quantity index data for different categories of alcoholic beverages, such as spirits, wine and beer. However, in the present case we could not find data in the detail needed, and we resorted to using a single demand equation for alcoholic beverages.

The economic theory of consumer behaviour provides our starting point in the analysis. We examined to what extent cross-border differences in preferences are explainable by differences in prices and expenditure alone. In these respects, our study is similar to that of Selvanathan (1991), but is the first to utilize the quantity index data on alcohol demand for several European countries.

We focused particular attention on the construction of comparable price indices for alcoholic beverages that capture differences in price levels across the countries. The total real expenditure variable that is used in the model was treated similarly to capture the differences in the consumers' purchasing power between the countries.

First, we estimated a demand function for all alcoholic beverages. The dependent variable is the quantity index of alcoholic beverages which is divided by the adult population. The main explanatory variables are the price index of alcoholic beverages and total expenditure.

However, in our modelling exercise we had to allow for some change in consuming habits over time. Here these slow movements were described by time trends, linear or quadratic functions in time. In analysing the demand for alcoholic beverages the past consumption of absolute alcohol was allowed to affect current utility and was used as a stock variable to capture the degree of current addiction.

The demand equation for alcoholic beverages was estimated in a differenced form separately for each country using the OLS method. The estimated country-specific trend components indicated that in all countries with significant estimation results the demand for alcoholic beverages has been declining for noneconomic reasons since the mid-1980s and in most countries throughout the estimation period. In addition, the results appeared to support our choice of the semilogarithmic functional form of the demand function with the elasticities inversely dependent on the level of demand.

We used graphical methods and formal statistical tests to compare price and expenditure elasticities between the countries. The hypothesis of stable and common preferences across the countries provides for the benchmark by which alternative specifications are evaluated. The countries have some common characteristics that may suggest similarities in the consumption

of alcohol. Some countries are wine producers (Austria, France, Greece, Italy, Portugal and Spain). In Finland, Norway and Sweden (monopoly countries), sales of alcoholic beverages have been mainly controlled by state alcohol monopolies. An additional group, the other countries, was formed to include the rest of the data.

Secondly, we tested for similarities in the parameter values within the above three groups and produced the corresponding restricted estimators which are more efficient than the results for individual countries using the SURE method introduced by Zellner (1962). Following Selvanathan (1991) we found out that the hypothesis of common preferences was clearly rejected by the data. However, the tests revealed some similarities in parameter values within the three country groups and noticeable differences in the price elasticities between the groups. More specifically, the tests indicated that there is a single common parameter, equal to the elasticity in 1980 for total expenditure, and the price parameters are equal within the three country groups with the exception of the Netherlands. The clear pattern in the elasticities is in accordance with the functional specification that has been utilized in our model. However, more detailed analysis revealed that the current results for the Netherlands are not very robust, and further study is needed before anything definite can be said of price elasticities in the Netherlands. In addition, the coefficients of the lagged absolute alcohol consumption, which was included in the model to capture addictive features, revealed that the common parameter is both positive and significant only in the monopoly countries group.

The common value of expenditure elasticity in 1980 suggests that alcoholic beverages are normal goods, but not luxuries. This means that the quantity in fixed prices has a tendency to increase while total expenditure is increased. Since they are not luxury goods their expenditure share, which is measured in current prices, shows a tendency to fall while total expenditure is increased, and moves in the opposite direction while total expenditure falls.

The results indicated that demand for alcoholic beverages appears to be more easily controllable by excise taxes in the monopoly countries than elsewhere. In the monopoly countries the prices of alcoholic beverages are set at relatively high levels by taxes. We observe simultaneously high excise taxes on alcoholic beverages giving considerable tax revenue and relatively high response of alcohol demand to taxes in the monopoly countries. However, the differences in alcohol price levels between the countries were not utilized in the estimation and did not affect our results. Furthermore, the estimated value of the price elasticity indicates that the taxes were set at a lower level than the tax revenue maximizing level in the monopoly countries. Demand appears to be least sensitive to prices in the wine-producing coun-

tries. Therefore, it may be that the structure of the demand for alcoholic beverages affects the value of their composite price elasticity. However, in the present study this question had to be left open due to the lack of data.

We provided for a similar analysis for the consumption of absolute alcohol and examined it for interesting similarities within the above three groups of countries. Here we explained absolute alcohol consumption with a pooled model by using relative price and total real expenditure variables and country-specific level-shift variables capturing residual, possibly cultural, differences in consumption levels. Additional country-specific trend variables were also employed. We experimented with two functional specifications of the model, the log-linear and the semilogarithmic forms. The semilogarithmic specification was found to be preferred to the log-linear specification because of its attractive property of having the elasticities inversely proportional to the level of absolute alcohol consumption. In addition, the tests revealed that this property is at least partially supported by our data.

By examining the values within the three groups (monopoly countries, wine producers and other countries), it became evident that similarities in values of the elasticities were not as clear as in analysing the quantity index data. The tests accepted the hypothesis of equal coefficients for expenditure in the semilogarithmic form, but the price parameters could not be restricted to having common values within the three groups of countries.<sup>30</sup> However, the general pattern was also repeated here. The price elasticities of absolute alcohol consumption have smaller absolute values in the wine-producing countries than in the monopoly countries. The expenditure elasticities are quite close to each other in most of the countries. The specifications give illogical but quite imprecise values for price elasticities in Austria and Italy if no common restrictions are imposed on them.

A reason for the missing pattern in price elasticities may be that the consumption of absolute alcohol is not determined by the same variables as the demand measured by quantity indices. For example, absolute alcohol consumption was explained by a price index that does not include beverages sold in restaurants, hotels and cafes. In contrast to the quantity index data, the consumption of absolute alcohol includes beverages sold in restaurants, cafes and hotels.

In addition, one may ask what is the proper price variable. Tastes for one characteristic of alcoholic beverages only, albeit an important one (absolute alcohol content) may not be adequately captured by a model that uses a conventional price variable. A minimum price to obtain a unit of absolute

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<sup>30</sup>The pooled estimation and the SURE method produced somewhat conflicting evidence. The pooled estimation and F test accepted the hypothesis of equal coefficients for expenditure, but the Wald test in the SURE method rejected it.

alcohol could have been more appropriate, but was unavailable to us.

Finally, we presented some simple comparisons to examine the relative importance of the economic factors, the price and real expenditure variables and other (residual) factors in explaining the differences in absolute alcohol consumption between the countries. First, an Analysis of Variance Table showed that the dummy variables that account for the country means explain over 80 per cent of the variation in the data. Introducing country-specific price and expenditure variables adds about 11 per cent to the explanation. The remaining, four per cent is accounted for by the trend components. Therefore, the country dummies are quite important in explaining the data. In contrast, introducing only the price and expenditure variables with common coefficients explains slightly over half the total variation. It is in itself no mean achievement using only two parameters to model the data, but falling short of that obtained by using dummy variables for the countries.

Secondly, we calculated simulated levels of absolute alcohol consumption assuming counterfactual values for the economic variables. The variation in consumption levels decreased when prices were set to an equal level, but appeared to increase slightly when real expenditures were equalized. It would appear that the harmonization of absolute alcohol consumption could be more easily achieved by equal prices rather than by equal real expenditure levels across the countries.

We discovered that the country-specific level parameters appeared to account for the major part of the variation in alcohol consumption levels. The economic variables, the relative prices of alcohol and real expenditure, played a subsidiary but important role in explaining the differences between the countries. However, it may not be an easy task in finding objective characteristics and measurable variables that lie behind these level factors and interpreting their effects in terms of, say cultural factors.



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## Appendix A. Testing for common parameter restrictions across countries

Consider a time-series, cross-sectional analysis of the model

$$y_{ki} = x_{ki}^T \beta_k + \varepsilon_{ki}, \quad (21)$$

where the values of the explanatory variables are given by the row vector  $x_{ki}^T$ ,  $y$  refers to the dependent variable and  $\varepsilon$  to the error term of the model. The observation indices,  $k = 1, \dots, m$ , and  $i = t_k, \dots, T_k$ , refer to the cross-section and time period, respectively.

Note that we allow for different numbers of time observations in the cross-section, i.e. the countries under consideration. Furthermore, we assume that the error terms relating to the same time period are correlated in the cross-section, but uncorrelated in different time periods. Below, we will relax the last assumption. More specifically,

$$\text{Cov}(e_{ki}, e_{lj}) = \sigma_{kl} \delta_{ij}, \quad (22)$$

where  $\delta$  stands for the Kronecker delta,  $\delta_{ij} = 1$ , if  $i = j$ , and zero otherwise.

We test for the hypothesis:  $H_0$ , defined by the linear parameter restrictions in matrix notation

$$\sum_k R_{hk} \beta_k = 0, \quad (23)$$

holding simultaneously for  $h = 1, \dots, n$ .

Under the null hypothesis, the equation-by-equation OLS estimators

$$b_k = (X_k^T X_k)^{-1} X_k^T y_k \quad (24)$$

consistently estimate the parameters  $\beta_k$  under the restrictions above.

Under the assumption (22) the unbiased estimators  $b_k$  have a common covariance matrix

$$\text{Cov}(b_k, b_l) = (X_k^T X_k)^{-1} (X_k^T E(\varepsilon_k \varepsilon_l^T)) X_l^T (X_l^T X_l)^{-1}, \quad (25)$$

where  $E$  stands for the expectation operator, and the notation  $X_k, X_l$ , and  $\varepsilon_k, \varepsilon_l$  is used to define those matrices, and vectors, respectively, that contain only those observations that belong to the common, overlapping time interval of the observations in equations  $k$  and  $l$ .

The term in the middle can be written as,

$$X_k^T E(\varepsilon_k \varepsilon_l^T) X_l^T = \sigma_{kl} \sum_i x_{ki} x_{li}^T, \quad (26)$$

where the summation contains only the common, overlapping time interval.

The cross-sectional, covariance terms  $\sigma_{kl}$  can be consistently estimated by the mean of the product of the estimated residuals

$$(1/T_{kl}) \sum_i e_{ki} e_{li}, \quad (27)$$

where  $e_{ki} = y_{ki} - x_{ki}^T b_k$ , and the summation runs through the common, overlapping time interval, and the number of common observations is given by  $T_{kl}$ .

The equations (25) are used to define a common covariance matrix

$$\Omega = (Cov(b_k, b_l)) \quad (28)$$

Similarly, the parameter vectors  $\beta_k$ ,  $k, 1, \dots, m$ , and the matrices  $R_{hk}$  are stacked to define a parameter vector

$$\beta = (\beta_k), \quad (29)$$

and a large restriction matrix

$$R = (R_{hk}) \quad (30)$$

The estimators that obey the above parameter restrictions are given by

$$\tilde{\beta} = b - \Omega R^T (R \Omega R^T)^{-1} R b \quad (31)$$

Under the null hypothesis it has the asymptotic covariance matrix

$$\Omega - \Omega R^T (R \Omega R^T)^{-1} R \Omega \quad (32)$$

The Wald test statistics for the parameter restrictions is given by

$$(R b)^T (\Omega R^T (R \Omega R^T)^{-1} R \Omega)^{-1} (R b) \quad (33)$$

Under the null hypothesis, defined by (23), the test statistic is asymptotically distributed as a chi-square random variable,  $\chi^2(r)$ , where  $r$  is the row rank of the matrix  $R$ , i.e. the number of linearly independent restrictions.

Next we relax the assumption of no autocorrelation in the errors by modifying the above procedure, allowing for an autoregressive AR(1) process in the equation errors. In the present case, cf. (21),

$$\varepsilon_{ki} = \lambda_k \varepsilon_{ki-1} + \nu_{ki}, \quad (34)$$

where  $\lambda$  refers to the autoregression parameter and  $\nu$  is the innovation error of the model uncorrelated with the history of the process.

Define the matrix  $P(\lambda)$

$$P(\lambda) = \begin{bmatrix} \sqrt{1-\lambda^2} & 0 & 0 & 0 \cdots 0 & 0 & 0 \\ -\lambda & 1 & 0 & 0 \cdots 0 & 0 & 0 \\ 0 & -\lambda & 1 & 0 \cdots 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & 0 \\ 0 & 0 & 0 & 0 \cdots 0 & -\lambda & 1 \end{bmatrix} \quad (35)$$

The covariance matrix of equation errors in a single equation  $(\varepsilon_{kt_k}, \dots, \varepsilon_{kT_k})$  is under (34)

$$\Sigma_k = \sigma_{\nu_k}^2 (P(\lambda_k)^T P(\lambda_k))^{-1} \quad (36)$$

By the transformation  $\nu = P(\lambda)\varepsilon$  we may substitute

$$E(\varepsilon_k \varepsilon_l^T) \quad (37)$$

in equation (26) by

$$P^{-1}(\lambda_k) E(\nu_k \nu_l^T) P^{-1}(\lambda_l)^T \quad (38)$$

Assuming cross-sectional correlation in the innovation terms  $\nu$  and estimating the covariance terms  $\sigma_{kl}$

$$E(\nu_k \nu_l^T) = \sigma_{kl} \quad (39)$$

by  $(1/T_{kl}) \sum_i u_{ki} u_{li}$ , where the innovation residuals are obtained from  $u_k = P(\lambda_k)e_k$ , one may proceed as above.

In calculating the test the unknown parameters  $\lambda$  are substituted for their consistent estimators which are obtained by (34) in a conventional manner using the OLS estimates and residuals of the model.

## Appendix B. Demand for alcoholic beverages, estimation results

Country	Intercept	Price	Expenditure	Lagged alcohol	Trend	$\sigma$	$R^2$	P value	Durbin-Watson
Austria	-0.020 (-2.327)	-0.025 (-0.117)	0.918 (3.490)	-0.004 (-0.387)		0.028	0.59	0.0002	2.65
Belgium	-0.013 (-1.506)	-0.401 (-1.915)	0.991 (3.571)	-0.027 (-1.963)		0.026	0.45	0.0008	2.25
Denmark	-0.006 (-0.793)	-0.603 (-3.415)	0.436 (2.372)	0.013 (0.948)	-0.0007 (-2.096)	0.023	0.57	0.0003	2.38
Finland	-0.006 (-1.225)	-0.741 (-7.061)	0.830 (5.071)	0.036 (2.958)		0.022	0.78	0.0001	2.11
France	-0.010 (-2.236)	-0.302 (-3.609)	0.510 (3.441)	0.006 (1.168)		0.010	0.63	0.0001	2.37
Greece	0.007 (0.502)	-0.250 (-0.996)	0.589 (1.874)	0.003 (0.205)		0.048	0.32	0.0195	1.85
Ireland	0.008 (1.104)	-0.382 (-2.247)	0.528 (2.894)	0.007 (0.622)		0.026	0.53	0.0007	2.49
Italy	-0.018 (-2.507)	-0.075 (-0.579)	0.771 (4.010)	0.015 (2.035)		0.021	0.51	0.0002	2.37
Netherlands	-0.018 (-1.860)	-1.602 (-5.254)	0.730 (1.624)	-0.030 (-1.737)		0.036	0.62	0.0001	2.31
Norway	-0.002 (-0.291)	-1.101 (-5.154)	0.740 (2.822)	0.013 (0.489)		0.032	0.65	0.0001	2.53
Portugal	-0.020 (-1.606)	-0.147 (-1.335)	0.816 (3.509)	-0.013 (-2.397)		0.054	0.51	0.0001	2.17
Spain	-0.007 (-1.034)	-0.302 (-1.865)	0.835 (3.888)	0.004 (0.533)		0.022	0.69	0.0001	1.80
Sweden	-0.014 (-3.100)	-0.759 (-4.939)	1.064 (4.665)	0.041 (2.288)	-0.0007 (-2.941)	0.021	0.78	0.0001	1.95
UK	0.005 (0.799)	-0.746 (-3.451)	0.678 (3.046)	-0.016 (-0.998)	-0.0004 (-2.015)	0.024	0.55	0.0001	1.92

t values in parentheses.