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Abstract
The main aim of this study was to estimate the demand for unregistered alcohol in Sweden 2001-2016 and to provide understanding on the determinants of demand for unregistered alcohol. The method used was a multiple linear OLS regression with fixed annual and regional effects. It was found that the relative share of the unregistered market
A. correlates positively to prices on spirits;
B. correlates negatively to Danish excise duties on wine;
C. correlates positively to a net income increase; and,
D. is dependent on the proximity to the Danish border.

Conclusively, the unregistered market gives rise to various external effects; why it is recommended to review the price setting system of Systembolaget, alternatively, to harmonize European alcohol policies.

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Table of contents

Abbreviations

UM = Unregistered market (of alcohol)

SM = Smuggle market (of alcohol)

UMMS = Unregistered market minus smuggle market (of alcohol)

AB = Alcoholic beverage

SB = Systembolaget

RNI = Regional net income (in Sweden)

DED = Danish excise duties (on alcohol)

PDB = Proximity to the Danish border

CAN = The Swedish Council for Information on Alcohol and Other Drugs (*Centralförbundet för narkotika- och alkoholupplysning*)

SCB = Statistics Sweden (*Statistiska centralbyrån*)

1. **Introduction**

Sweden is known to be one of the few countries in the world that has regulated the alcohol market by only allowing one retailer domestically. Before entering the European Union (EU) in 1995, market regulations made it easier for the government to adjust the market, and importing alcoholic beverages was relatively restricted. For a few years, after entering the EU, some dispensation quotas were allowed for Sweden and other countries with similar alcohol policies. According to Folkhälsomyndigheten (2015) and Arnberg & Lord (2009), these quotas ended in 2004, due to strong pressure from the EU.

As a politically sanctioned governmental constitution, the monopoly Systembolaget (SB), is used as means to lower the consumption of alcohol. If alcoholic beverages are easily purchased on the unregistered market (hereby "UM"), this could be seen as a failure of the monopoly. Kühlhorn (2000) showed that the UM, as a share of the total consumption of alcohol, generally has grown since entering the EU. Also, there is evidence that consumers, since entering the EU, have become more sensitive to price changes in SB, as described by Mihauscu & Hortlund (2015). According to the same authors (cf. Asplund et al., 2005; Grittner & Bloomfield, 2009; Gustafsson, 2010), the most important factor seems to be relatively lower prices in the neighboring countries. This implies that the pricing regime of SB has a substantial impact on the UM. No research has been done to cover more exactly how the prices on SB affect the demand on the UM.

Prices on SB are set through a price model which consists of four mark-ups:

A. a general percentage charge regardless of the type of alcoholic beverages, (administrative mark-up), and
B. a second fixed extra charge depending on the type of beverage.
C. An excise duty (alcohol duty) is added which also depends on the type and the volume of the alcoholic beverage, ranging from beers/ciders that have the lowest duty; to spirits, which carry the largest levy. This alcohol duty does not depend on the price, it is fixed and does not depend on the parameters above. E.g., in 2018, the excise duty on spirits was roughly 145 SEK per bottle .[1]
D. A VAT (Value Added Tax) of 25 percent is added on the final price (for more details, see Systembolaget, 2018).

SB could be regarded as a price setter, considering the fact of the monopolistic power. But given their pricing model, the price can be estimated by the supplier

[1] The excise duty on spirits was calculated from the following information on Skatteverket: https://www.skatteverket.se/foretagochorganisationer/skatter/punktskatter/alkoholskatt/skattesatser.4.4a47257e143e26725aecb5.html

and therefore be adjusted to the customers' willingness to pay, therefore making it possible to maximize profit within an interval of the demand function. For example, in 2014, when the excise taxation was increased on all alcoholic beverage types, the suppliers chose to lower the price, resulting in a zero net-change for many products. In some extremes, a price reduction was reported, as Holm (2016) stated in an Expressen article.

SB does not only use higher pricing to minimize consumption. Higher age limit (20) to purchase alcohol, few retail venues (compared to grocery stores), a conservative approach to opening hours and many closed days are a few examples of measures to meet their goal.

Asplund et al. (2007) have pointed out the relationship between distance to the Danish border and cross-border shopping. Having a less restricted market with limited monopolistic power, the prices in Denmark are lower. This leads to an easily accessible market abroad, which limits the impact of SB – particularly in regions close to the Danish border, which conclusively was shown by Norström (2005). The author discovered that the price elasticities of alcohol were higher in the south after entering the EU, meaning the consumers are more sensitive for price changes. The UM is, as described by Guttormsson et al. (2017), divided into four subcategories: the smuggle market (hereby abbreviated SM), non-commercial imports, illegally distilled alcohol, and, lastly, Internet purchases.

A growing SM is in and of itself a societal issue, resulting in higher criminality rates and is associated with larger costs for the government in form of judicial, police related and other similar costs. See, for instance, Dubourg & Prichard (2008), which concluded that organized crime involving excise goods (oils, tobacco and alcohol) costs 3.7 billion British pounds in Great Britain annually -- primarily through the loss of tax revenue. Considering all the factors of the price-setting model, we believe that additional parameters should be considered when setting the price of alcoholic beverages. Based on microeconomic theory, any regulation or tax with the purpose of increasing the price in relation to the optimal quantity demanded on the market might result in a market-entry for SM suppliers.

The main aim of this study is to estimate the demand for unregistered alcohol in Sweden and provide understanding on the determinants of demand for unregistered alcohol, with respect to prices of SB, Danish excise duties ("DED"), regional net income ("RNI") and proximity to the Danish border ("PDB"). A semi-log (explanatory variable) multiple OLS regression with fixed annual and regional effects will be utilized to attain the objective. More broadly, this study could be beneficial for policy makers as a rough estimate of how the UM dynamics work. For instance, to see how an increased excise duty with the intention of increasing the prices on alcohol affects the demand on the UM, could

possibly raise awareness of non-intended external effects from such an intervention. That is, increased criminality rates or loss of tax revenue, as shown by Dubourg & Pritchard (2008) and Ferris (2000). A main focus of this study is, therefore, whether the registered alcohol prices variables affect the aforementioned markets. This because alcohol prices could easily be affected by policies (especially in the case of Sweden), compared to other variables of analysis.

Also, the UM minus SM, hereby abbreviated "UMMS", will be researched. The purpose of doing so is to detect whether there are different dynamics determining the demand between them. For instance, Asplund et al. (2007) found that the demand for cross-border shopping varies strongly on the proximity to the Danish border, which justifies the approach of dividing the alcohol demand with respect to hypothesized market characteristics and regional factors.

We primarily aim to answer the following two questions:

- Does the pricing on SB affect the demanded quantity on the UM of alcohol?
- Does the pricing on SB affect the demanded quantity on the SM of alcohol?

And these are the research hypotheses:

A. Prices of alcohol abroad are positively related to the quantity demanded on the domestic market. The lower foreign price, the lower domestic demand. This supposition is supported by Asplund et al (2007), Grittner & Bloomfield (2009) and Norström (2005).
B. Unregistered alcohol is a normal good, which means that the demand for alcohol is positively related to an increase in income. This is supported by Grittner & Bloomfield (2009).
C. There is a substitution effect between alcoholic products on the registered market in regard to the UM. See, for instance, Norström (2005) who found higher alcohol price elasticities after entering the EU. And last,
D. similar dynamics will be found to Asplund et al. (2007) regarding fluctuations in demand on the UMMS and SM, depending on distance to the Danish border.

2. Theoretical background

2.1. The microeconomic assumptions

For an account of economic theory relevant to this study, see Perloff (2017). There are a few vital theoretical assumptions that need to be made to make economic theory feasible. A paramount concept is rationality – the assumption that economic actors behave rationally; that is, they maximize utility or profit under all given circumstances. From this assumption, further inferences follow.

1. The transitive relation of good bundles is an assumption that follows from the idea of rationality: if good bundle A is better than B, and B is better than C, it must also imply that A > C. The consumer is, in other words, able to grade each good bundle with respect to the expected utility.
2. A consumer will always maximize her utility. Since utility is a personal experience by nature, the concept is inherently complex to account for. Usually, a proxy for utility is used instead: the willingness to pay. That is; the more utility (or benefit) a consumer reaps from a purchase, the more she is expected to pay for a certain good.

Another assumption is that of perfect information. All customers and businesses are assumed to possess knowledge of everything that may be of importance for an economic decision. Please note that not all assumptions of microeconomic theory are declared above. There are more concepts of importance, however, we deem the ones mentioned above the most relevant, given the purpose to analyze specifically consumer behavior -- that is, to derive a demand function.

2.2. Economic concepts

2.2.1. Supply and demand

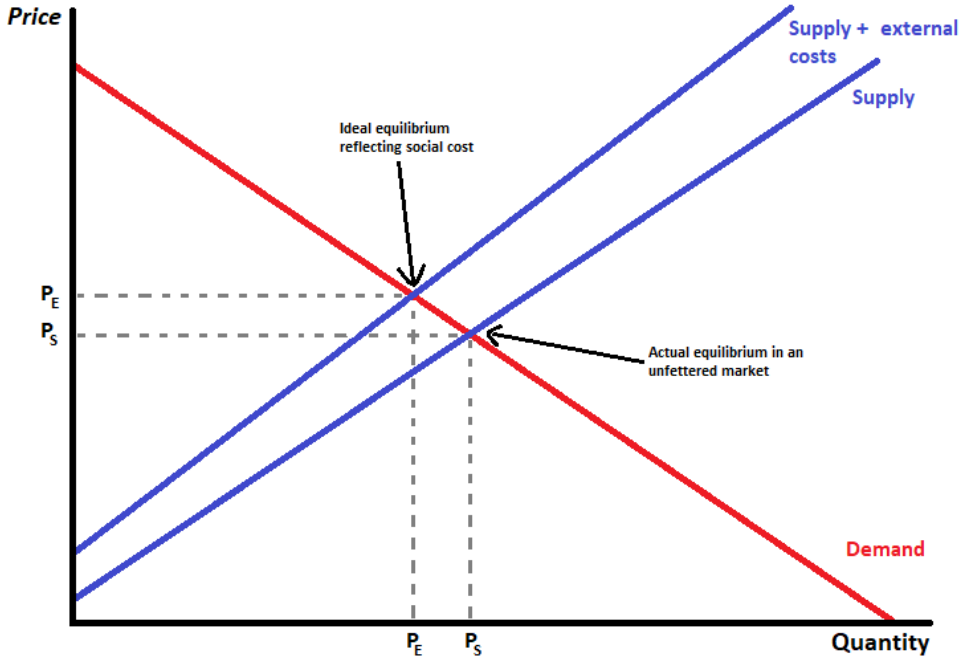
The model of linear supply and demand is one of the basic tools for economic analysis and the kind of model that will be used for this study. Supply is the aggregate of producers' marginal cost to produce an additional good. Demand is the aggregate of consumers and the respective amount they are willing to pay for the supplied good. It is assumed that the demand function is negatively related to the price level – that is, the higher the price, the lower the demand. The supply function is instead positively correlated to the price level. These functions are, hence, predicted to have an intersection, called the equilibrium. This equilibrium could be offset by a market-interfering policy. For instance, such as the sanctioned monopoly presented in this paper. Political interventions generally give rise to welfare-losses. If the intervention also causes unwanted side-effects,

this is called an external effect, which is displayed below. In this study, the aim is to estimate a demand function. This is a generic demand function:

$$Q_D = c - P_0 - (\dots) P_n \pm X_0 \pm (\dots) X_n \qquad \textit{(Equation 1)}$$

Denotations: Q = quantity demanded. c = Constant/intercept, P = Price, X = Facultative variable.

(Figure 1)



2.2.2. Elasticities

An elasticity is the derivative form of a demand coefficient which, for instance, measures how much the percental demanded quantity changes, if the own price (ε) – or income (η) – level increases with one percent. This concept is useful when analyzing sensitivity in demand. The demand can either be elastic ($\varepsilon > -1$, or $\eta > 1$), inelastic ($\varepsilon < -1$, or $\eta < 1$), or unit elastic ($\varepsilon = -1$, or $\eta = 1$). The elasticity measure answers the question how much a 1% own price (or income) increase/decrease affects the demanded quantity. In this study, the alcohol prices, Danish excise duties and regional net incomes will be logged to attain an interpretation similar to an elasticity. Mathematically:

$$\varepsilon = -\frac{\partial P(q)}{\partial P} \times \frac{q}{P} \qquad \textit{(Equation 2)}$$

$$\eta = \frac{\partial I(q)}{\partial I} \times \frac{q}{I} \qquad \textit{(Equation 3)}$$

Denotations: ε = own price elasticity. η = income elasticity. P = price. q = quantity.

2.3. Earlier research

Alcohol markets is a fairly well-researched economic field, and many studies have been made to measure the elasticities on the market, see e.g. Gallet's (2007) meta-study on the income effects and elasticities on alcoholic beverages. It is an attempt to gather a large sample of earlier, international, elasticity studies and find an average result. It was found that the income elasticity for alcohol, on average, in the studies are .690. Grittner & Bloomfield (2008), on the other hand, found a strong correlation between higher income and propensity to do cross-border shopping. High income was associated with a 16% increased propensity to do alcohol imports. The authors did not conclude on an income elasticity; however, it is reasonable to assume that the UM of alcohol relates differently to income level than alcohol consumption in general.

Norström (2005) conducted a study on the Swedish alcohol elasticities 1984-2004. The author only found a significant change in the own price elasticity of wine when entering the EU (from -.62 to -.81). Mihaescu & Hortlund (2015) covered the own price elasticities of alcoholic beverages between the years 2006-2013. They discovered a significant increase in all three beverage types (–1.36 for spirits, –1.64 for wine and –1.02 for beers). They, analogically with Asplund et al (2007), mean that this increase is mainly due to less restrictive trading and importing environments, which effectively lead to more price sensitive consumers.

Asplund et al. (2007) and Grittner & Bloomfield (2008) made attempts to find a correlation between the distance to the Danish border and Swedish domestic demand on cross-border alcohol imports. It was concluded that demand varies strongly with the distance, where distant regions (e.g. north Norrland) barely imported any alcohol. They argue that the differences in consumption arise from increasing transaction costs as the distance to the border grows. This will also be a paramount model of explanation in this study. Even though all beverage types are imported, independently of distance, Trolldal (2005) found that spirits are most commonly imported. Conclusively, this means one expects to find the largest coefficient for prices of spirits, compared to beers and wines, in this study.

When entering the EU, the Swedish consumers suddenly had easier access to a larger alcohol market in continental Europe, where prices were (are) substantially lower. This caused a larger UM. On the other hand, as Room et al (2013) concluded, the overall alcohol consumption did not increase more than marginally. Instead, as they and Gustafsson (2010) claimed, there were no evidence of increased alcohol consumption in southern Sweden (e.g. Skåne) when Denmark cut excise taxation on alcohol (2003) and Sweden abolished the strict import quotas (2004). It is argued that consumers who already were going abroad for lower priced alcohol were the ones most affected by the policy

changes, i.e., the price sensitive consumer segment. If a positive relation between the prices of SB and the UM is found, this could make the case for a strategical domestic price abatement, since these findings could imply that merely the ratio between UM and the total consumption is affected. Potentially, this could also increase tax revenue, since according to Mihaescu & Hortlund (2015), the taxation level on spirits are possibly reaching "Laffer territory", which means that additional taxation will reduce tax revenue. Or, as Lakhdar (2008) proposed regarding cross-border shopping of tobacco, a gradual harmonization of European excise goods policies could be a feasible solution to the UM complex of problems. Since the studies mentioned above discovered indices of an effect between the UM and prices of SB, this must be further investigated and depending on the results from the regression analysis, the feasibility of the above-mentioned measures will be further discussed in Chapter 5.1.

3. Method

3.1. Data Collection

3.1.1. UM, SM and UMMS

Data material and tables on the UM was collected from The Swedish Council for Information on Alcohol and Other Drugs (*Centralförbundet för narkotika- och alkoholupplysning*, commonly abbreviated "CAN"). The UM is defined as all alcohol that has not been sold through SB or institutions that serve spirits (e.g. bars, night clubs or restaurants). The largest part of the unregistered consumption is cross-border shopping (that is, duty free or purchases abroad intended for personal, domestic consumption), and the second largest is smuggled alcohol. There are also other, less common, forms of unregistered alcohol: Internet purchases and illegally distilled alcohol. These forms generally constitute less than 3% of the total consumption, whereas cross-border shopping, in some regions, constitutes up to 49% of the total consumption. From 2001 and onwards, CAN conducts annual surveys, monitoring the Swedish alcohol consumption behavior. For this study, data from the report *Registrerad och oregistrerad alkohol i Sveriges län 2001-2016* by Guttormsson et al. is used (2017).

The data on the unregistered consumption covers the mean total consumption of alcohol per capita, divided into regions. Here, it is assumed that what is supplied is consumed; that is, there is an equilibrium between demand and supply, since the SM and UM are estimated through the consumption. The depending variables are rendered as ratios of the total consumption. In the regression equation, the ratios are rendered as percent of the total consumption. Furthermore, it should be noted that by using ratios – and not total consumption in absolute terms – it will be complicated to derive predictions regarding individual alcohol consumption.

Since the data is disaggregated, it was also possible to examine whether proximity to the Danish border would affect the consumption of unregistered alcohol, analogous to Asplund et al. (2007), while also achieving a denser set of data for the chosen years. The 21 Swedish counties are compiled into seven monitor regions as in Guttormsson et al. (2017):

1. Skåne;
2. Blekinge, Kronoberg and Halland;
3. Västra Götaland;
4. Östergötland, Jönköping, Kalmar and Gotland;
5. Stockholm;
6. Uppsala, Södermanland, Värmland, Örebro, Västmanland, and Dalarna, and finally;
7. Gävleborg, Västernorrland, Jämtland, Västerbotten and Norrbotten.

From these monitor regions, region 1, 2 and 3 was selected as being in proximity to the Danish border. The interpretation of these dependent variables is in percentage points: a 1% change in a dependent variable leads to a certain percentage change in the UM/SM/UMMS. Mathematical explanation:

$$UM_{r,t} = \frac{UMA_{r,t}}{TotC_{r,t}} \quad \text{(Equation 4)}$$

$$SM_{r,t} = \frac{SMA_{r,t}}{TotC_{r,t}} \quad \text{(Equation 5)}$$

$$UMMS_{r,t} = \frac{UMA_{r,t} - SMA_{r,t}}{TotC_{r,t}} \quad \text{(Equation 6)}$$

Denotations: UMA, SMA = The absolute size of the UM/SM, measured in liters of pure alcohol per consumer and year in a specific region. TotC = The total consumption, measured in liters of pure alcohol per consumer and year in a specific region. r = Region. t = Time (year).

3.1.2. Prices of Systembolaget

Data on the mean price of alcoholic beverages for the years 2001-2016 (16 years in total) was used, which was given to us by a co-author of *Registrerad och oregistrerad alkohol i Sveriges län 2001-2016*, Björn Trolldal. The prices are differentiated into three categories with respect to beverage type: beer (where commercially retailed beer with an alcohol content of 3.5% or lower is excluded), wines and spirits. The price index has a base year (2016), and is denoted 100 (%), where other years of consideration will be measured as a percentage of the base year. For instance, the year 2001 is 111.13 for spirits, which means the price level of sprits are 11.13 percentage points higher than 2016 for that year. Since the prices of alcohol are set centrally, regional or local price differences are not an issue in this study. The time span of the indexes is mainly chosen due to the limitations of the annual report from CAN regarding Swedish alcohol consumption on a regional basis – the first of this kind was published 2001.

The prices are adjusted with an inflation denominator. Otherwise there is a risk to find a positive gross price correlation. The used inflation data was the general CPI of Sweden for the years 2001-2016, where 2016 is the base year and denoted as 100 (%). For the sake of ease of interpretation, the index was logged. When logging a dataset, the interpretation will be in percent: a 1% change in prices (CPI) affects the UM/SM/UMMS by $\frac{\beta_0}{100}$ units, *ceteris paribus*. Mathematical explanation:

$$P_{j,t} = ln\left(\frac{Pn_{j,t}}{1+i_t}\right) \quad \text{(Equation 7)}$$

Denotations: P= real price on SB. Pp = nominal price on SB. j = index for spirits, beer or wine. i = inflation rate (CPI). t = time (year).

3.1.3. Net regional income

The net income is the income after taxes, plus transfer payments. It is measured as an average per capita and measured in SEK. This data was collected from Statistics Sweden (SCB) (2018). Since the regression model will be based on regional data, the net income was also mapped out in accordance with the seven monitor regions (as were mentioned above) and measured per capita. As with the prices of the alcohol, the income was adjusted with the CPI inflation index with the base year 2016. Also, the index was logged with the natural logarithm to attain a normal distribution – and for the sake of easier, percentage, interpretation. When logging a dataset, the interpretation will be in per cent: a 1% change in RNI affects the UM/SM/UMMS by $\frac{\beta_0}{100}$ units, *ceteris paribus*. Mathematical explanation:

$$NRI_{r,t} = ln\left(\frac{NRIn_{reg.,t}}{1+i_t}\right) \qquad \textit{(Equation 8)}$$

Denotations: NRIn = nominal regional net income. i = inflation rate (CPI). r. = Region. t = time (year).

3.1.4. Danish excise duties

The excise duties of Denmark (DED) were collected from Eurostat (the European statistics agency) (2018). The values of each duty are described in the domestic currency (DKK, Danish crowns), and then converted to SEK by using historical conversion rate data from OFX (2018). The used conversion rates were the average of a year. The logged duties were converted to SEK, this to attain a normal distribution and for the sake of easier interpretation. The interpretation of these variables is in percent: a 1% increase in excise taxation on an alcoholic beverage affects UM/SM/UMMS by $\frac{\beta_0}{100}$ units, *ceteris paribus*. Mathematical explanation:

$$DED_{j,t} = ln(DEDdkk_{j,t} \times ConvR_t) \qquad \textit{(Equation 9)}$$

Denotations: DEDdkk = Danish excise duties in DKK. j = spirits, beer or wine. ConvR = Conversion rate (DKK to SEK) (annual mean). t = time (year).

3.2. Statistical model

3.2.1. The assumptions of Ordinary Least Squares

The test that will be conducted is a semi-log, multivariable Ordinary Least Squares (OLS) analysis with fixed effects. The fixed effects will be achieved by using the dummy method (see below for further explanations).

To obtain an accurate result from an OLS regression, there are some conditions of the data set which need to be fulfilled:

1. *Linearity in parameters*. This means that the parameters (i.e., β_i) cannot follow a logarithmic or exponential pattern.
2. *Mean error distribution should be zero*. This means that the deviations of the specific observations from the fitted regression line should summarize to 0. This condition was reasonably well fulfilled, with standard errors of the regressions (S) close to 0 and high R2 (coefficient of determination) in all three regressions (see Chapter 4).
3. *No multicollinearity*. The predicting variables should not co-variate with other predictors of the regression. This condition was not fulfilled by the regressions, however, the causes of the high VIF (Variance Inflation Factor) numbers will be addressed in the analysis section.
4. *Homoscedasticity*. There can be no autocorrelation in the error terms. This usually occurs when using time panel data -- as in this case -- because the error term of one year is most likely dependent on the previous year. No way to compensate for eventual autocorrelations in this regression has been found. This will be discussed below.

3.2.2. Limitations of the OLS

As stated above -- a major drawback when utilizing an OLS regression for time-dependent panel data is the condition of homoscedasticity. The homoscedasticity assumption is the assumption of independent observations across time. Since, for instance, the size of the UM most likely is dependent on the size of the previous year, these two observations are closely interlinked. By not fulfilling this criterion, the regression violates the BLUE (Best Linear Unbiased Estimator) condition, as established by Gauss-Markov. However, autocorrelation does not necessarily affect the coefficients of a regression. Rather, it is the standard errors which are likely to be underestimated; hence, also the p-values.

Analogically to the autocorrelation issue at hand, there is also another drawback when utilizing OLS to predict time-series panel data. Since consumption, prices

and income all are associated with the level of the previous year, it cannot be predicted how fast a population adjusts to the new levels of, e.g., income. This becomes an issue, as the level of the dependent variable might not be associated with the predicting variable of the same year. An OLS cannot account for such time lags. This could be remedied by using robust standard errors. On the other hand, Norström (2005) pointed out that consumers adapt relatively quickly to new price levels, still making the approach of this study adequately feasible. Also, the analysis only covers a small interval of possible prices on the goods. It is dubious whether extrapolations of the results will make for adequate predictions since elasticities are prone to change as a dependent variable change, possibly resulting in a non-linear relationship. Considering the drawbacks of the chosen method, it is advised to interpret the results as mere signs of correlational direction, rather than the coefficients being accurate pinpoints.

Another issue with OLS is causality. Even though significant results are found, it cannot surely be concluded that the variables measured have a causal relationship. For instance, a lurking – or mediating – variable could instead be a factor which affects both the independent and dependent variables.

3.2.3. Dependent variables

To cover as many aspects of the demand of unregistered alcohol as possible, a regression model with three responding variables was constructed: the total share of the unregistered alcohol market (UM), the smuggled alcohol as a share of the total market (SM), and finally, the unregistered market excluding the smuggled part as a share of the total market (UMMS). These are the dependent variables:

$$UM_{r,t}$$
$$SM_{r,t}$$
$$UMMS_{r,t}$$

3.2.4. Explanatory variables

The predicting variables are divided into continuous predictors and indicator variables. The continuous predictors are those which can take on intervals of values (e.g., income can vary indefinitely) and are generally denoted $\beta_i x_i$ in the generic regression model. Indicator variables are categorical elements, which cannot possibly take on a numerical value (e.g., a region cannot be ascribed more than an arbitrary numerical value). These variables are instead ascribed either a 0 or 1, analogous to “off” and “on”. These are the continuous predictors:

$$lnP_{j,t}$$

$$lnNRI_{r,t}$$
$$lnDED_{j,t}$$

Please note: the log is included in these variables for the sake of easier interpretation of the regression models – the variables are not double-logged.

3.2.5. Indicator variables

The indicator variables are dummies for the seven monitor regions, dummies for the studied years (2001-2016), a dummy for the event of ending the import quotas for alcohol, and lastly, a dummy for regions in close proximity to the Danish border. Including these dummies in the regression model creates fixed effects (FE). That is; most continuous predictors and response variables of the model are not to be arbitrarily correlated. Some predicting variables have an effect on other predictors (e.g. the year has an effect on net income and prices). Since this is assumed, a fixed effect model is necessary. Leaving this out causes omitted variable bias, where variables are arbitrarily coupled, where no consideration is taken for geographical or temporal conditions. These are the indicator variables of the regression:

$$\alpha_1 Reg_{1\ldots7}$$
$$\alpha_2 Y_t$$
$$\alpha_3 PDB_r$$

Denotations: α = coefficient. Y = FE for years. PDB = Proximity to Danish border. Reg = Monitor regions 1-7.

3.2.6. Test models

Since there are many similar predictors among the fixed effect dummies, these generic models will aggregate the year and region predictors. This to make the models more appealing and comprehensible:

$$UM_{r,t} = \alpha_0 + \beta_0 lnP_{j,t} + \beta_1 lnNRI_{r,t} + \beta_2 lnDED_{j,t} + \alpha_1 Reg_{1\ldots7} + \alpha_2 Y_t + \alpha_3 PDB_r + \varepsilon_{j,r,t} \quad \textit{(Model 1)}$$

$$SM_{r,t} = \alpha_0 + \beta_0 lnP_{j,t} + \beta_1 lnNRI_{r,t} + \beta_2 lnDED_{j,t} + \alpha_1 Reg_{1\ldots7} + \alpha_2 Y_t + \alpha_3 PDB_r + \varepsilon_{j,r,t} \quad \textit{(Model 2)}$$

$$UMMS_{r,t} = \alpha_0 + \beta_0 lnP_{j,t} + \beta_1 lnNRI_{r,t} + \beta_2 lnDED_{j,t} + \alpha_1 Reg_{1\ldots7} + \alpha_2 Y_t + \alpha_3 PDB_r + \varepsilon_{j,r,t} \quad \textit{(Model 3)}$$

4. Results

The results will be presented in the following order: UM, SM and UMMS. For a complete account of the results and for summary statistics, please see Appendix 1. Below is a summary table of the regressions:

Table 1 (Summary statistics on regressions)

	UM R2 = 93.7% S (ε) = .0355265	SM R2 = 74.84% S (ε) = .0209315	UMMS R2 = 92.67% S (ε) = .0316366
Constant (α)	.2687*** (.0886)	.0906* (.0520)	.1781** (.0787)
Price of Spirits (log)	3.82** (1.67)	.860 (.987)	2.96** (1.49)
Price of Beers (log)	.66 (2.14)	0.24 (1.26)	.42 (1.91)
Price of Wines (log)	-1.80 (2.54)	-.2 (1.50)	-1.60 (2.26)
DED on Spirits (log)	-.0166 (.0430)	-.0241 (.0253)	.0075 (.0383)
DED on Beers (log)	.0251 (.179)	.108 (.105)	.144 (.159)
DED on Wines (log)	-.2167** (.0867)	-.0469 (.0511)	-.1698** (.0772)
RNI (log)	.914*** (.301)	.113 (.177)	.801*** (.268)
PDB	.0918*** (.0263)	.0432*** (.0155)	.0486** (.0767)

*= Statistically significant on the 10% level. **= Statistically significant on the 5% level. ***= Statistically significant on the 1% level. Numbers without brackets are coefficients. Numbers with brackets are standard errors (SE).

4.1. Unregistered market

Table 2 (Regression on UM)

	Coefficient	**SE Coef**	**P-value**	**VIF**
Constant (α_0)	.2687	.0883	.003	-
Price of spirits (log)	3.82	1.64	.025	406.25
Price of beer (log)	.66	2.14	.759	685.75
Price of wine (log)	-1.80	2.54	.480	550.10
RNI (log)	.914	.301	.003	333.63
DED on spirits (log)	-0.0166	.0430	.700	58.28
DED on beers (log)	.251	.179	.163	2487.54
DED on wine (log)	-.2167	.0867	.014	96.40
PDB	.0918	.0263	.001	15.03

An OLS regression was run to predict UM from prices of SB, RNI, DED and PDB. R2 = .937. Interpretation of the constant (α_0): the mean minimum share of the UM is .2687 of the total consumption (p = .003). With an α (significance level) = .05, the true intercept is within the interval .095632 to .441768 (.2687±.0883×1.96). Only results below, or of, a 10% alpha will be interpreted. Parenthesis marks the correlation coefficient.

4.1.1. Prices of Systembolaget

The price of spirits statistically significantly predicted UM on the 5% level, p = .025 (3.82). Prices of beers and wines were not significant, p = .759 and p = .480, respectively. Interpretation: a 1% increase in spirits prices on SB is predicted to increase the UM, as a share of the total consumption, with $\frac{3.82}{100}$ units, which is the equivalent of 3.82%, *ceteris paribus*. With an α = .05, the true coefficient is within the interval .6056 to 7.0344 (3.82±1.64×1.96). This result strengthens the hypothesis that a higher price on spirits cause consumers to seek cheaper substitutes on the UM.

4.1.2. Excise duties of Denmark

The wine variable statistically significantly predicted the UM on the 5% level, p = .013 (-.2177). Interpretation: A 1% increase in Danish excise taxation on wine is predicted to decrease the demand on the UM with $\frac{-.2167}{100}$ units, which is the equivalent of -.2167%, *ceteris paribus*. With an α = .05, the true coefficient is within the interval -.046768 to -.386632 (-.2167±.0867×1.96). This result strengthens the hypothesis that alcohol prices abroad have a negative relation to unregistered demand on the domestic market.

4.1.3. Regional net income

The RNI of Sweden statistically significantly predicted UM on the 1% level, p = .003 (.914). Interpretation: if the RNI rises with 1%, the UM is predicted to increase with $\frac{.914}{100}$ units, which is the equivalent of .914%, *ceteris paribus*. With an α = .05, the true coefficient is within the interval .32404 to 1.50396 (.914±.301×1.96). This result strengthens the hypothesis that alcohol on the UM is a normal good.

4.1.4. Proximity to Danish border

PDB statistically significantly predicted UM on the 1% level, p = .001 (.0918). Interpretation: It is predicted that the monitor regions in proximity to the Danish border are associated with an increased amount of unregistered alcohol consumption by 9.18 percentage points, *ceteris paribus*. With an α = .05, the true coefficient is within the interval .040252 to .143348 (.0918±.0263×1.96). This strengthens the hypothesis that consumers in regions close to the Danish border are more prone to go to the UM.

4.2. Smuggle market

Table 3 (Regression on SM)

	Coefficient	**SE (Coefficient)**	**P-value**	**VIF**
Constant (α_0)	.0906	.0520	.085	-
Price on spirits (log)	0.860	0.987	.386	406.25
Price on beer (log)	.24	1.26	.851	685.75
Price on wine (log)	-.20	1.50	.895	550.10
RNI (log)	.113	.177	.525	333.63
DED on spirits (log)	-.0241	.0253	.344	58.28
DED on beer (log)	.108	.105	.309	2487.54
DED on wine (log)	-.0469	.0511	.361	96.4
PDB	.0432	.0155	.006	15.03

A multiple regression was run to predict SM from prices of SB, RNI, DED and PDB. R2 = .7484. Interpretation of the constant (α_0): The mean minimum share of the SM is .0906 (9.06%) of the total consumption (p = .085). With an α = .05, the true intercept is within the interval -.01132 to .19252 (.0906±.0520×1.96). Only results below, or of, a 10% alpha will be interpreted below. Brackets mark the correlation coefficient.

4.2.1. Prices of Systembolaget

Prices of spirits, beers and wines were not significant, p = .378, p = .857, and .900, respectively. The variables failed to statistically significantly predict the SM.

4.2.2. Excise duties of Denmark

Danish excise duties on spirits, beers and wines were not significant, p = .343, p = .313 and p = .361, respectively. The variables failed to statistically significantly predict the SM.

4.2.3. Regional net income

The regionally distributed net income of Sweden was not significant, p = .525. The variable failed to statistically significantly predict the SM.

4.2.4. Proximity to Danish border

PDB significantly predicted SM on the 1% level, p = .006 (.0432). Interpretation: It is predicted that monitor regions in proximity to the Danish border are associated with an increased amount of unregistered alcohol consumption by 4.32 percentage points, *ceteris paribus*. With an α = .05, the true coefficient is within the interval .01202 to .07358 (.0432±.0155×1.96). The standard error partly covers the same interval as the UMMS (see results below), therefore it cannot be assumed that the SM is less dependent on geographical situation.

4.3. Unregistered market minus smuggle market

Table 4 (Regression on UMMS)

	Coefficient	**SE Coefficient**	**P-value**	**VIF**
Constant (α_0)	.1781	.0787	.026	-
Price of spirits (log)	2.96	1.49	.05	406.25
Price of beer (log)	.42	1.91	.826	685.75
Price of wine (log)	-1.60	2.26	.480	550.10
RNI (log)	.801	.268	.004	333.63
DED on spirits (log)	.0075	.0383	.846	58.28
DED on beer (log)	.144	.159	.369	2487.54
DED on wine (log)	-.1698	.0772	.031	92.40
PDB	.0486	.0234	.041	15.03

A multiple regression was run to predict UMMS from prices of SB, RNI, DED and PDB. R2 = .9267. Interpretation of the constant (α_0): The mean minimum share of the UMMS is .1781 (17.81%) of the total consumption (p = .025). With an α = .05, the true intercept is within the interval .023848 to .332352 (.1781±.0787×1.96). Only results below, or on, a 10% alpha will be interpreted. Parentheses mark the correlation coefficient.

4.3.1. Prices of Systembolaget

The price of spirits statistically significantly predicted UMMS on the 5% level, p = .05 (2.96). Prices of beers and wines were not significant, p = .759 and p = .480, respectively. Interpretation: a 1% increase in spirits prices on SB is predicted to increase the UMMS, as a share of the total consumption, with $\frac{2.96}{100}$ units, which is the equivalent of 2.96%, *ceteris paribus*. With an α = .05, the true coefficient is within the interval .0396 to 5.8804 (2.96±1.49×1.96). This result strengthens the hypothesis that a higher price on spirits cause consumers to seek cheaper substitutes on the UMMS.

4.3.2. Excise duties of Denmark

The wine variable statistically significantly predicted the UMMS on the 5% level, p = .031 (-.1698). Interpretation: A 1% increase in Danish excise taxation on wine

is predicted to decrease the demand on the UMMS with $\frac{-.1698}{100}$ units, which is the equivalent of -.1698%, *ceteris paribus*. With an α = .05, the true coefficient is within the interval -.028288 to -.31492 (-.1698±.0722×1.96). This result strengthens the hypothesis that alcohol prices abroad have a negative relation to unregistered demand on the domestic market.

4.3.3. Regional net income

The RNI of Sweden statistically significantly predicted UMMS on the 1% level, p = .004 (.801). Interpretation: if the RNI rises with 1%, the UMMS is predicted to increase with $\frac{.801}{100}$ units, which is the equivalent of .801%, *ceteris paribus*. With an α = .05, the true coefficient is within the interval .27572 to 1.32628 (.801±.268×1.96). This result strengthens the hypothesis that alcohol on the UMMS is a normal good.

4.3.4. Proximity to Danish border

PDB statistically significantly predicted UMMS on the 5% level, p = .041 (.0486). Interpretation: It is predicted that the monitor regions in proximity to the Danish border are associated with an increased amount of unregistered alcohol consumption by .0486 percentage points, *ceteris paribus*. With an α = .05, the true coefficient is within the interval .002736 to .094464 (.0486±.0234×1.96). This strengthens the hypothesis that consumers in regions close to the Danish border are more prone to go to the UMMS.

5. Discussion

5.1. Analysis

While the objective of the study was to find a demand function for smuggled and unregistered alcohol, the main goal was to find to what extent the prices of SB affect the demand on these markets. We had the following hypotheses:

A. Prices of alcohol abroad are positively related to the quantity demanded on the domestic market.
B. Unregistered alcohol is a normal good, which means that the demand for alcohol is positively related to an increase in income.
C. There is a substitution effect between alcoholic products on the registered market with respect to the UM.
D. UMMS and SM depend similarly on proximity to the Danish border.

The results of the regressions seem to confirm that especially spirits prices are sensitive to consumers on the UM and UMMS. However, the prices of wines and beers proved statistically insignificant. Either this confirms that the share of the UM is not sensitive to changes in these prices, or it could also be explained by lower volatility in the studied time period. It could also be, as discussed in Chapter 3.2.2., due to poorly matched variables. We adhere to the former explanation, as Asplund et al (2007) and Mihaescu & Hortlund (2015) have found indices on increased own price elasticities for both wine and beer. Even though a poor proxy for the prices in Denmark was used in this study, significant results for the DED on wine was still found, which also, indeed, confirms their findings. The findings also seem to confirm both hypothesis C (for wine) and A (for spirits) on the UM and UMMS. The results of the SM with respect to the alcohol prices of SB were not significant. It is still reasonable to assume a correlation between these variables. In addition to low variability in pricing, we believe this can be explained by few observations for each county and year. Safer results could be achieved by using fewer regions to get more accurate predictions, at the expense of lower resolution results.

RNI was clearly significant for both the UM and UMMS regression equations, and both correlations were positive. It is likely there are causal correlations between income and demand on the UM and UMMS as found by Grittner & Bloomfield (2008), and the results seem to confirm hypothesis B – that income is a likely parameter in unregistered alcohol consumption.

We expected the SM to be dependent on geographical situation. This seems to be true and could possibly be explained by lower transaction costs for smugglers, or, perhaps, easier consumer access, analogous to the reasoning of Asplund et al

(2007) about the UMMS. This result seems to confirm hypothesis D. If the transaction costs are lower, it is reasonable to assume lower market prices, which presumably causes a higher demand on the goods in question.

The results of the UMMS regression were somewhat unexpected. As explained above, this regression equation was used to see the difference in p-values and coefficients between the UM and itself, minus the smuggle share. It was expected that the p-values were higher for UMMS, compared to UM, especially for the income variable. This because of the generally high p-values of SM. This did not seem to be true; the correlations for alcohol, PDB, DED and RNI were all still similar to UM, though, all of the mentioned variables showed higher p-values and weaker correlations in the UMMS regression. Lower correlation coefficients could be due to the lower share of the UMMS, which – per definition (see Chapter 3.1.1.) – must be smaller, or equal to, the UM. A possible explanation, and aggravating issue, when studying these markets separately is that the point estimates of alcohol consumption could be relatively inaccurate due to smaller sample sizes (as in the case of the SM). This likely resulted in more significant results on the aggregated UM. All in all, it seems the UMMS and SM are somewhat disparate phenomena. For further studies, we would recommend keeping these markets separated to find more adequate results.

Lastly, the results consistently showed significantly high VIF numbers which indicate multicollinearity (A VIF over 10 indicates there is multicollinearity) – among the price variables, the DED and RNI. While it usually should be seen as a major drawback for the accuracy of a regression, we argue it could be explained by just looking at the variables included in the regressions. The prices of beers, spirits and wines are all depending on the same VAT and excise duties. Although, as explained earlier, different beverage types have different levels of excise taxation. Generally, excise duties for different beverages are imposed at the same time, which causes a temporal price correlation between the goods. This is also evident in the data tables – the prices generally follow a similar trend. By the same reasons as presented above, the VIF numbers of the Danish excise duties could also be explained. However, as the goal of the study merely was to find out the polarity of different variables, we would still recommend further investigation by using statistical methods which account better for multicollinearity.

5.2. Limitations

Please note: Limitations of the chosen statistical method is discussed in Chapter 3.2.2.

5.2.1. Endogenous weaknesses

There are some significant differences between the UM and the registered market. For instance, there are no perfect instruments to measure the size and impact of the former. The data collected for this study is based on the report *Registrerad och oregistrerad alkohol i Sveriges län 2001-2016* by Guttormsson et al. (2017). This report is the most complete record of the alcohol consumption of Sweden's population, however, it has inherent issues. The authors note that it is hard to estimate the SM of the unregistered consumption, due to, among other factors, consumers' proneness to under-report such behavior. Sometimes, it is also due to too few self-reports for counties with a small population. This leads to a wide, or hard-to-estimate, confidence interval which could effectively cause an inaccurate point estimation of the average consumption in a region. These estimations are fundamental to this study, which might cause lower degrees of statistical power (higher chances of type I and II errors) in the predictions of the demand models. A weakness of measuring the size of the UM as a ratio of total consumption is that the UM could seem to be changing, even though it is of a constant size, because of fluctuations in registered consumption.

Another weakness of the data material is the excise duty tables that are used as predictors for the approximative alcohol pricing in Denmark. Excise duties do have an impact on the prices of alcoholic beverages, though, there are more factors determining the retailing price. These duties merely mirror the absolute value of the duty itself; not in combination with VAT, which causes distortions to the pricing proxy. That is, if the VAT on, e.g., beer, increases, the effective excise duty also increases. This is because the VAT is added on the retailing price of the beer, as explained earlier, where the excise duty is already included. Apart from that, the prices can also change from a retailer or producer perspective because of changes in prices of input products (e.g. wheat, barley or potatoes) or exogenous demand fluctuations. All in all, the excise duty proxy has some inherent issues, so it should primarily be regarded as a rather blunt approximate of foreign alcohol pricing. Preferably, proper price data would have been used for this study, but due to limited access to the DST's (*Danmarks Statistik*, Denmark's Statistics) statistical archives, this could not be achieved.

The prices of SB are based on the mean percentage change of each alcoholic category of each year, which in turn is based on an inflation adjusted CPI (Consumer Price Index). This could become fallacious, or rather, a cause of an underestimation of the price sensitivity of the potential customers of the UM and

SM. There is, as mentioned in Chapter 2.3, evidence that Swedish customers turning to the UM are more price sensitive. Therefore, the closest substitute to the unregistered alcohol is cheap, registered such. This would not have been problematic if the taxation of alcohol worked analogically to other foodstuffs; lower priced alcohol is to a larger percentage part constituted by an excise duty. A change in this excise duty will, consequently, cause a bigger percental change in the price of cheap alcoholic beverages.

5.2.2. Exogenous weaknesses

A factor that may affect the results is changes in preferences, which are not the cause of a general decline or incline in consumption, such as people becoming increasingly risk-averse, causing consumers to avoid the SM for different reasons. Analogically to risk-aversion, risk seeking behavior – or implementations of judicial measures that aim to alter smugglers' illegal behavior – is also a factor that is intricate to exclude or account for when measuring fluctuations of the UM share. Theoretically, every new legislation or policiary command must be attributed with a dummy variable. However, such variables are not included in the analysis. Originally, a dummy marking the end of the import quota (2004) was included, which had to be discarded due to too few observations.

There are most likely many omitted variables which will not be accounted for in the demand function, which causes an omitted variable bias. This could be regarded as a limitation in the scope of this study. For instance, there are probably more prices than the Danish that affect the demand on the UM. Germany is a popular destination for alcohol imports, and the excise duties of the country was first included in the regression. Due to monolithic pricing during the studied time period, the variable had to be discarded. Also, when considering the SM, there are probably more factors which determine demand. Demographical variables, such as age composition, could be a feasible determinant to explain the SM. Bearing that in mind, as the results will show, all models showed rather high R2 numbers: 93.7% for UM, 74.84% for SM, and 92.67% for UMMS. This implies the most important factors determining demand are still included.

In the regression model, a dummy variable indicating proximity to the Danish border (PDB) is included. This is to find out whether consumers in counties bordering to Denmark more easily substitute the registered market with the UM or SM. However, Sweden is technically bordering several more countries (Norway, Finland, Germany, Poland, Estonia, Lithuania, Latvia and Russia), which are not accounted for in this study. In Asplund et al. (2007), the authors noted occurrences of consumers in, for instance, Haparanda (a community located in the far north of Sweden), going to the Finnish market for alcohol. The

authors did, on the other hand, conclude that the cross-border shopping in the region is too small to be accounted for. Similarly, this study does not have enough data to cover such specific instances of cross-border shopping. Nevertheless, there are still other borders than the Danish that arguably have an effect on unregistered alcohol demand. Geographically, only the borders of Finland and Norway can be attributed a direct proximity to Sweden. With other countries there is an immense issue of attributing specific monitor regions to specific borders, more than through ferry routes. Suitably, most ferry routes to continental Europe are in southern Sweden, which means they will be accounted for in this study, with exception of Nynäshamn (which is located in the Stockholm region and is connected to continental Europe).

6. Concluding discussion

A quite strong association between SB's pricing regime for spirits and the spirit demand on the UM was found. This could be regarded as a negative external effect arising from the governmentally sanctioned monopoly. Theoretically, this means that SB has to harmonize its prices to the European level to solve the issue of the UM. Practically, this does not necessarily need to be a required measure, since there are more factors at work determining demand on the UM (proximity to the Danish border, and income has been covered in this study). As stated above in the discussion, more accurate research needs to be done to find more exact correlations. For instance, a PLS (Partial Least Squares) analysis which accounts for multicollinearity; and autocorrelation among temporally dependent variables, by, e.g., utilizing a VAR (Vector Autoregression).

The explicit goal of SB is to reduce alcohol consumption. It is reasonable to assume that a revenue-maximizing government has the goal to maximize duty revenue from alcohol sales, and at the same time reduce the consumption of alcohol (to decrease costs for, e.g., hospitalizations related to alcohol induced diseases). These goals could be contradictory at this point of spirits taxation (see Hortlund & Mihaescu, 2015), meaning, the government must make trade-offs when deciding upon a new alcohol policy. From this study it is complicated to derive an obvious conclusion whether the prices are too high or too low compared with the stated goals. However, the correlation seems to exist for spirits on the UM, while there was also weaker evidence confirming the same hypothesis when using the Danish excise duties for wine as a price proxy. From the collected results we recommend that extra caution should be taken governmentally when deciding upon new excise duty regimes for spirits. As the consumption seems to be rather stable (see Room et al., 2013), increased taxes risk to push more consumers to the UM, effectively causing lower tax revenues and more unregistered alcohol to flow into Sweden. Also, in the long term, as Lakhtar (2008) suggested about tobacco policies, it could be feasible to address the UM issue by harmonizing European alcohol policies, however, this is an unlikely way to go, judging from the Swedish alcohol policy history.

APPENDIX 1

Legend:
Unreg_tot = UM
Smug_tot = SM
Unreg_minus = UMMS
Spirits = Price on sprits
Beer = Price on beers
Wine = Price on wines
Income = RNI
dutysprit_dn = DED on spirits
dutywine_dn = DED on wine
dutybeer_dn = DED on beer
dummy_[region] = monitor region 1-7
dummy_[year] = year 2001-2016

Regression on unregistered market (as retrieved from Minitab)

(Summary statistics on UM)

ANOVA on UM	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	22	1,67147	0,075976	60,20	0,000
Price on spirits (log)	1	0,00656	0,006561	5,20	0,025
Price on beer (log)	1	0,00012	0,000119	0,09	0,759
Price on wine (log)	1	0,00063	0,000634	0,50	0,480
RNI (log)	1	0,01162	0,011620	9,21	0,003
DED on spirits (log)	1	0,00019	0,000188	0,15	0,700
DED on beer (log)	1	0,00250	0,002500	1,98	0,163
DED on wine (log)	1	0,00788	0,007876	6,24	0,014
PDB	1	0,01537	0,015374	12,18	0,001
Error	89	0,11233	0,001262		
Total	111	1,78380			

Regression Analysis: Unreg_tot versus Spirits; Beer; Wine; Income; dutysprit_dn; ...

```
The following terms cannot be estimated and were removed:
   dummy_vasterg; dummy_gavleborg; dummy_2010; dummy_2011; dummy_2012;
dummy_2013;
   dummy_2014; dummy_2015; dummy_2016


Method

Categorical predictor coding  (1; 0)

Continuous predictor standardization
Subtract the mean

Predictor        Mean
Spirits        4,6339
Beer           4,5676
Wine           4,5794
Income         5,2347
dutysprit_dn  12,1274
dutybeer_dn    5,5251
dutywine_dn    8,5254



Model Summary

        S    R-sq  R-sq(adj)  R-sq(pred)
0,0355265  93,70%     92,15%      90,08%


Coded Coefficients

Term               Coef  SE Coef  T-Value  P-Value      VIF
Constant         0,2687   0,0883     3,04    0,003
Spirits            3,82     1,67     2,28    0,025   406,25
Beer               0,66     2,14     0,31    0,759   685,75
Wine              -1,80     2,54    -0,71    0,480   550,10
Income             0,914    0,301    3,03    0,003   333,63
dutysprit_dn     -0,0166   0,0430   -0,39    0,700    58,28
dutybeer_dn        0,251    0,179    1,41    0,163  2487,54
dutywine_dn      -0,2167   0,0867   -2,50    0,014    96,40
danish_border
  1               0,0918   0,0263    3,49    0,001    15,03
dummy_skane
  1               0,1533   0,0132   11,58    0,000     1,90
dummy_blekinge
  1               0,1232   0,0137    9,02    0,000     2,03
dummy_osterg
  1               0,1519   0,0135   11,26    0,000     1,98
dummy_stockholm
  1              -0,2281   0,0834   -2,74    0,007    75,49
dummy_uppsala
  1               0,0388   0,0158    2,45    0,016     2,73
dummy_2001
  1               -0,396    0,347   -1,14    0,257   625,20
dummy_2002
  1               -0,468    0,378   -1,24    0,218   741,19
dummy_2003
  1               -0,420    0,372   -1,13    0,262   720,07
dummy_2004
  1               -0,348    0,342   -1,02    0,313   608,57
dummy_2005
```

1	0,180	0,188	0,96	0,339	183,19
dummy_2006					
1	0,138	0,201	0,69	0,494	209,63
dummy_2007					
1	0,111	0,191	0,58	0,563	189,81
dummy_2008					
1	0,1742	0,0638	2,73	0,008	21,17
dummy_2009					
1	0,1162	0,0760	1,53	0,130	30,04

Regression on smuggle market (as retrieved from Minitab)

(Summary statistics on SM)

ANOVA on SM	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	22	0,115993	0,005272	12,03	0,000
Price on spirits	1	0,000333	0,000333	0,76	0,386
Price on beer	1	0,000016	0,000016	0,04	0,851
Price on wine	1	0,000008	0,000008	0,02	0,895
RNI	1	0,000178	0,000178	0,41	0,525
DED on spirits	1	0,000396	0,000396	0,90	0,344
DED on beer	1	0,000459	0,000459	1,05	0,309
DED on wine	1	0,000369	0,000369	0,84	0,361
PDB	1	0,003405	0,003405	7,77	0,006
Error	89	0,038993	0,000438		
Total	111	0,154986			

Regression Analysis: Smug_tot versus Spirits; Beer; Wine; Income; dutysprit_dn; ...

```
The following terms cannot be estimated and were removed:
   dummy_vasterg; dummy_gavleborg; dummy_2010; dummy_2011; dummy_2012;
dummy_2013;
   dummy_2014; dummy_2015; dummy_2016


Method

Categorical predictor coding  (1; 0)

Continuous predictor standardization
Subtract the mean

Predictor        Mean
Spirits        4,6339
Beer           4,5676
Wine           4,5794
Income         5,2347
dutysprit_dn  12,1274
dutybeer_dn    5,5251
dutywine_dn    8,5254


Analysis of Variance

Source              DF    Adj SS    Adj MS  F-Value  P-Value
Regression          22  0,115993  0,005272    12,03    0,000
  Spirits            1  0,000333  0,000333     0,76    0,386
  Beer               1  0,000016  0,000016     0,04    0,851
  Wine               1  0,000008  0,000008     0,02    0,895
  Income             1  0,000178  0,000178     0,41    0,525
  dutysprit_dn       1  0,000396  0,000396     0,90    0,344
  dutybeer_dn        1  0,000459  0,000459     1,05    0,309
  dutywine_dn        1  0,000369  0,000369     0,84    0,361
  danish_border      1  0,003405  0,003405     7,77    0,006
  dummy_skane        1  0,000439  0,000439     1,00    0,320
  dummy_blekinge     1  0,000013  0,000013     0,03    0,863
  dummy_osterg       1  0,028188  0,028188    64,34    0,000
  dummy_stockholm    1  0,000174  0,000174     0,40    0,530
  dummy_uppsala      1  0,005146  0,005146    11,75    0,001
  dummy_2001         1  0,000756  0,000756     1,73    0,192
  dummy_2002         1  0,000590  0,000590     1,35    0,249
  dummy_2003         1  0,000502  0,000502     1,15    0,287
  dummy_2004         1  0,000527  0,000527     1,20    0,276
  dummy_2005         1  0,000080  0,000080     0,18    0,669
  dummy_2006         1  0,000075  0,000075     0,17    0,681
  dummy_2007         1  0,000056  0,000056     0,13    0,721
  dummy_2008         1  0,000633  0,000633     1,45    0,232
  dummy_2009         1  0,000292  0,000292     0,67    0,417
Error               89  0,038993  0,000438
Total              111  0,154986


Model Summary

        S    R-sq  R-sq(adj)  R-sq(pred)
0,0209315  74,84%     68,62%      60,17%


Coded Coefficients

Term                 Coef  SE Coef  T-Value  P-Value      VIF
Constant           0,0906   0,0520     1,74    0,085
```

Spirits	0,860	0,987	0,87	0,386	406,25
Beer	0,24	1,26	0,19	0,851	685,75
Wine	-0,20	1,50	-0,13	0,895	550,10
Income	0,113	0,177	0,64	0,525	333,63
dutysprit_dn	-0,0241	0,0253	-0,95	0,344	58,28
dutybeer_dn	0,108	0,105	1,02	0,309	2487,54
dutywine_dn	-0,0469	0,0511	-0,92	0,361	96,40
danish_border					
1	0,0432	0,0155	2,79	0,006	15,03
dummy_skane					
1	-0,00780	0,00780	-1,00	0,320	1,90
dummy_blekinge					
1	0,00139	0,00805	0,17	0,863	2,03
dummy_osterg					
1	0,06377	0,00795	8,02	0,000	1,98
dummy_stockholm					
1	-0,0310	0,0491	-0,63	0,530	75,49
dummy_uppsala					
1	0,03200	0,00934	3,43	0,001	2,73
dummy_2001					
1	-0,268	0,204	-1,31	0,192	625,20
dummy_2002					
1	-0,258	0,222	-1,16	0,249	741,19
dummy_2003					
1	-0,235	0,219	-1,07	0,287	720,07
dummy_2004					
1	-0,221	0,202	-1,10	0,276	608,57
dummy_2005					
1	0,047	0,111	0,43	0,669	183,19
dummy_2006					
1	0,049	0,118	0,41	0,681	209,63
dummy_2007					
1	0,040	0,113	0,36	0,721	189,81
dummy_2008					
1	0,0452	0,0376	1,20	0,232	21,17
dummy_2009					
1	0,0365	0,0448	0,82	0,417	30,04

Regression on unregistered market minus smuggle market (as retrieved from Minitab)

(Summary statistics on UMMS)

ANOVA on UMMS	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	22	1,12609	0,051186	51,14	0,000
Price on spirits (log)	1	0,00394	0,003939	3,94	0,050
Price on beer (log)	1	0,00005	0,000048	0,05	0,826
Price on wine (log)	1	0,00050	0,000503	0,50	0,480
RNI (log)	1	0,00892	0,008920	8,91	0,004
DED on spirits (log)	1	0,00004	0,000038	0,04	0,846
DED on beer (log)	1	0,00082	0,000817	0,82	0,369
DED on wine (log)	1	0,00484	0,004837	4,83	0,031
PDB	1	0,00431	0,004308	4,30	0,041
Error	89	0,08908	0,001001		
Total	111	1,21517			

Regression Analysis: unreg_minus_ versus Spirits; Beer; Wine; Income; dutysprit_dn; ...

```
The following terms cannot be estimated and were removed:
   dummy_vasterg; dummy_gavleborg; dummy_2010; dummy_2011; dummy_2012;
dummy_2013;
   dummy_2014; dummy_2015; dummy_2016


Method

Categorical predictor coding  (1; 0)

Continuous predictor standardization
Subtract the mean

Predictor        Mean
Spirits        4,6339
Beer           4,5676
Wine           4,5794
Income         5,2347
dutysprit_dn  12,1274
dutybeer_dn    5,5251
dutywine_dn    8,5254


Analysis of Variance

Source              DF   Adj SS    Adj MS  F-Value  P-Value
Regression          22  1,12609  0,051186    51,14    0,000
  Spirits            1  0,00394  0,003939     3,94    0,050
  Beer               1  0,00005  0,000048     0,05    0,826
  Wine               1  0,00050  0,000503     0,50    0,480
  Income             1  0,00892  0,008920     8,91    0,004
  dutysprit_dn       1  0,00004  0,000038     0,04    0,846
  dutybeer_dn        1  0,00082  0,000817     0,82    0,369
  dutywine_dn        1  0,00484  0,004837     4,83    0,031
  danish_border      1  0,00431  0,004308     4,30    0,041
  dummy_skane        1  0,18695  0,186947   186,78    0,000
  dummy_blekinge     1  0,10030  0,100299   100,21    0,000
  dummy_osterg       1  0,05384  0,053844    53,80    0,000
  dummy_stockholm    1  0,00706  0,007063     7,06    0,009
  dummy_uppsala      1  0,00023  0,000234     0,23    0,630
  dummy_2001         1  0,00017  0,000170     0,17    0,681
  dummy_2002         1  0,00039  0,000389     0,39    0,534
  dummy_2003         1  0,00031  0,000314     0,31    0,577
  dummy_2004         1  0,00017  0,000172     0,17    0,679
  dummy_2005         1  0,00063  0,000633     0,63    0,429
  dummy_2006         1  0,00025  0,000249     0,25    0,619
  dummy_2007         1  0,00017  0,000172     0,17    0,679
  dummy_2008         1  0,00515  0,005153     5,15    0,026
  dummy_2009         1  0,00139  0,001386     1,38    0,242
Error               89  0,08908  0,001001
Total              111  1,21517


Model Summary

        S    R-sq  R-sq(adj)  R-sq(pred)
0,0316366  92,67%     90,86%      88,38%


Coded Coefficients
```

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0,1781	0,0787	2,26	0,026	
Spirits	2,96	1,49	1,98	0,050	406,25
Beer	0,42	1,91	0,22	0,826	685,75
Wine	-1,60	2,26	-0,71	0,480	550,10
Income	0,801	0,268	2,99	0,004	333,63
dutysprit_dn	0,0075	0,0383	0,19	0,846	58,28
dutybeer_dn	0,144	0,159	0,90	0,369	2487,54
dutywine_dn	-0,1698	0,0772	-2,20	0,031	96,40
danish_border					
1	0,0486	0,0234	2,07	0,041	15,03
dummy_skane					
1	0,1611	0,0118	13,67	0,000	1,90
dummy_blekinge					
1	0,1218	0,0122	10,01	0,000	2,03
dummy_osterg					
1	0,0881	0,0120	7,33	0,000	1,98
dummy_stockholm					
1	-0,1972	0,0742	-2,66	0,009	75,49
dummy_uppsala					
1	0,0068	0,0141	0,48	0,630	2,73
dummy_2001					
1	-0,127	0,309	-0,41	0,681	625,20
dummy_2002					
1	-0,210	0,336	-0,62	0,534	741,19
dummy_2003					
1	-0,186	0,331	-0,56	0,577	720,07
dummy_2004					
1	-0,126	0,305	-0,41	0,679	608,57
dummy_2005					
1	0,133	0,167	0,80	0,429	183,19
dummy_2006					
1	0,089	0,179	0,50	0,619	209,63
dummy_2007					
1	0,071	0,170	0,41	0,679	189,81
dummy_2008					
1	0,1289	0,0568	2,27	0,026	21,17
dummy_2009					
1	0,0797	0,0677	1,18	0,242	30,04

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