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Relationship between consumption of cigarettes and alcohol in the Czech Republic

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Abstract

This thesis investigates the relationship between the consumption of cigarettes and pure alcohol in the Czech Republic during 1955-2016. It tests for a unit root in both series using ADF test and KPSS test. Next, Engle-Granger procedure and Johansen trace test are used to test for a cointegration relation between the two time-series. Both the ADF and the KPSS test found a presence of a unit root when controlled for a shift in a mean in 1989. However, Engle-Granger procedure did not find enough evidence for a cointegration relation, which was confirmed by Johansen trace test. The same results were obtained when only a subsample 1955-1989 was considered.

Keywords	Cigarettes, alcohol, cointegration

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Abstrakt

Tato práce zkoumá vztah mezi spotřebou čistého alkoholu a cigaret v období 1955-2016 v České republice přepočtené na jednoho obyvatele. Studie používá ADF test a KPSS test pro zjištění přítomnosti jednotkového kořene v obou proměnných. Následně je pro test kointegrace využita Engle-Granger procedura a Johansen trace test. ADF test a KPSS test objevili přítomnost jednotkového kořene v případě, kdy test počítá se skokem ve střední hodnotě v roce 1989. Následná Engle-Granger procedura nenašla dostatek důkazů pro kointegrační vztah a tento výsledek potvrdil i Johansen trace test. Daný postup došel ke stejným výsledkům i v případě, že bral v úvahu pouze období 1955-1989.

Klíčová slova	Cigarety, alkohol, kointegrace

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Declaration of Authorship

I hereby declare that I compiled this thesis independently, using only the listed resources and literature.

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Prague, May 9, 2018

Signature

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Bachelor Thesis Proposal

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Proposed topic	Relationship between consumption of cigarettes and alcohol in the Czech Republic

Preliminary scope of work: In 2017, smoking of cigarettes in public places in the Czech Republic was prohibited (Act no. 65/2017 Sb.). Previous year, following the EU directive (Directive 2014/40/EU) warnings with graphic images on cigarette packages were implemented. Regarding alcohol, the Ministry of Health of the Czech Republic ratified national action plan no. 4c for the prevention and control of noncommunicable diseases following WHO Global action plan (WHO 2012), which includes steps to reduce alcohol consumption. These government actions are examples of the long-term government policy, which try to decrease consumption of alcohol and tobacco and treats each of these categories differently. But we suppose consumption of alcohol and tobacco follow the same path. Therefore, in the thesis, we will investigate if consumption of alcohol and cigarettes are cointegrated. If it were true, it would be a reason for government to treat them as inseparable variables. We expect our results to contribute to the topic of health protection and support of healthy life in the Czech Republic. Specifically, our findings could help to structure our national action plan. The goal of these plans is to reduce consumption of alcohol and tobacco products, which is considered relatively stable (Sovinová, Csémy 2014).

Data

We will use time series data on a consumption of alcohol and cigarettes in the Czech Republic over the time period 1955-2012. The consumption of alcohol includes all beverages containing at least 0,5% of alcohol and is recorded in

the value of pure alcohol per person. The consumption of cigarettes is recorded in pieces per person and does not include cigars and other tobacco products.

Method

At first we will run Augmented Dickey-Fuller test for unit root to verify our assumption that both consumption of cigarettes and consumption of alcohol are I(1) processes.

Then we will test whether these two time series are cointegrated following the Engle-Granger procedure. The model takes the specified form:

$$y_t = \alpha + \beta x_t + u_t$$

where (n x 1) vector y_t represents consumption of alcohol and (n x 1) vector x_t represents consumption of cigarettes. Assuming both processes have unit roots, the variables are cointegrated (the process $u_t = y_t - \alpha - \beta x_t$ is I(0)) if there exist parameters $\beta, \beta \neq 0$, and α that this equation holds. To find them we will run the stated regression, save residuals and test them for the presence of a unit root.

Outline

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2. Literature Review
   (a) Alcohol consumption, effects and regulation
   (b) Tobacco consumption, effects and regulation
   (c) Relationship between alcohol and tobacco, relationship between consumption of alcoholic
3. Methodology
4. Results
5. Conclusion

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Acronyms

ADF Augmented Dickey-Fuller test

AR Autoregressive model

BIC Bayes information criterion

DF test Dickey-Fuller test

EG procedure Engle-Granger procedure

KPSS test Kwiatkowski-Phillips-Schmidt-Shin test

VAR Vector autoregressive model

Chapter 1

Introduction

Tobacco and alcohol consumption are the top causes of preventable death and, together with unhealthy diet and lack of physical activity, among the four shared risk factors of noncommunicable diseases (WHO *et al.* 2015b). While alcohol was responsible for an estimated 3.3 million deaths per year (5.9% of global mortality) (WHO 2014) and accounts for 5.1% of the global burden of disease measured in disability-adjusted life-years (WHO *et al.* 2015a), tobacco was the leading cause of avoidable death globally in 2014, caused around 5.4 million deaths per year (8% of global mortality). Moreover, in most OECD countries the productivity losses associated with harmful alcohol use are estimated to be around 1 % of GDP (OECD *et al.* 2016).

Therefore, following the EU directive (The European Parliament and the Council 2014b) warnings with graphic images on cigarette packages were implemented in 2016. The following year smoking of cigarettes in public places was prohibited in the Czech Republic (Parlament České republiky 2017). Regarding alcohol, the Czech Republic followed WHO Global action plan (WHO *et al.* 2012), which includes steps to reduce harmful effects of alcohol, and ratified the national action plan for the prevention and control of noncommunicable diseases in the time period 2015-2018 (Ministerstvo zdravotnictví 2015). These regulations are examples of long-term government effort to reduce negative effects on health of the consumption of tobacco and the consumption of alcohol. Hovewer, as Hawkins *et al.* (2018) mentioned, the consumption of tobacco is regulated much more than the consumption of alcohol.

To increase effectivity of these policies the relationship between alcohol and tobacco was examined in an extensive number of works in a rather indirect way, but we are aware only of two recent studies that try to asses the relationship

between alcohol and tobacco directly. Beard *et al.* (2017) studied whether there is a relationship between prevalence of smoking and a high-risk drinking. They employed Autoregressive Integrated Moving Average with Exogeneous Input (an extension of Autoregressive Integrated Moving Average model) modelling using monthly data collected between March 2014 and June 2016 in household face-to-face surveys in England. Koksal & Wohlgenant (2016) used data collected in the US between years 2002 and 2008 to study relationship between the consumption of alcohol and tobacco and employed a two-stage estimation model, pseudo-panel method. Moreover, they implemented a consumption of coffee in their model. Both studies found out that tobacco and alcohol are complements.

We believe that the consumptions of both commodities follow the same path. To the best of our knowledge, the consumption of alcohol and the consumption of cigarettes have not been tested on a cointegration relation yet. Therefore, the aim of this thesis is to test whether the consumption of alcohol and the consumption of tobacco are cointegrated using Johansen trace test and Engle-Granger procedure. As a necessary condition for a cointegration, we test for a presence of a unit root. The analysis is conducted using annual data on a consumption of ethylalcohol per person and a consumption of cigarettes per person in the Czech Republic in the time period 1955-2016. The consumption of cigarettes was chosen as a measure of the consumption of tobacco, because a consumption of other tobacco products is statistically insignificant according to Sovinová *et al.* (2014).

Our thesis would be the first pioneer using tests on cointegration between the consumptions of these two commodities. We expect our results to contribute to the topic of health protection in the Czech Republic and especially to the debate about the effectivity of antismoking laws. Understanding the relationship could provide valuable guidance when regulating both alcohol and tobacco consumptions. A policy that succesfully discourages smoking at the expense of increased consumption of alcohol would not be as desirable as a policy that does not have such effects. Therefore, it is important to study the relationship between alcohol and tobacco. If the variables are cointegrated, government should treat them as inseparable variables in order to maximise effectivity of the regulation.

Furthermore, most empirical studies of alcohol demand do not use the tobacco consumption as an explanatory variable and vice versa. So if there is a cointegration relation, results of those studies will be biased and require an adjustment of their models.

Chapter 2

Literature review

2.1 Alcohol and tobacco consumption

World average consumption of alcohol has been stable at 4.3 to 4.7 litres of pure alcohol per capita since 1990 (WHO *et al.* 2016). OECD average consumption was 6.2 liters in 2016 and since 2000 the consumption in OECD countries has been gradually decreasing and getting closer to the world average. Austria, Estonia, France and the Czech Republic are reported the highest consumption of alcohol with about 11.5 litres or more per adult per year (OECD *et al.* 2016).

In the Czech Republic there is a culture and long tradition of alcohol consumption. As many as 15% of the Czech adult population consumes alcohol every day or every other day. The aggregate consumption of alcoholic beverages has moderate increasing tendency in the adult population (Sovinová *et al.* 2014). The consumption in the Czech Republic follows an increasing trend of central-eastern and eastern countries, where average consumption has been increasing since 1999 (WHO *et al.* 2013).

Prevalence of smoking in OECD countries follows decreasing trend (OECD *et al.* 2016). On average, smoking rates in OECD countries have decreased by about one fourth since 2000, from 26% in 2000 to 19% in 2014. In the Czech Republic the prevalence of smoking is relatively stable. The smoking rate was between 28% and 30% (Sovinová *et al.* 2014). Czech tobacco consumers consume mainly cigarettes, consumption of other tobacco products is negligible (Csémy *et al.* 2017).

2.2 Effects of tobacco and alcohol consumption

It has been long known that excessive alcohol consumption has harmful effects on health. Already Adam Smith wrote in 1776 in The Wealth of Nations that "individuals may sometimes ruin their fortunes by an excessive consumption of fermented liquors" (Smith 1776).

Alcohol consumption causes undesirable behaviours, including drunk driving / road traffic accidents, domestic abuse and other forms of violence, alcoholism and children born with foetal alcohol spectrum disorders, suicide and homicide. On the other hand, there is still ongoing academic debate about the benefits connected with a low consumption of alcohol. According to WHO *et al.* (2006), no substantial beneficial effects of low alcohol consumption for consumers below the age of 40 has been seen. Only the consumption of at most one standard drink per day for men at age 70 and less than half of the drink per day for women of the same age are mentioned as beneficial in the Framework for Alcohol Policy in the WHO European Region (WHO *et al.* 2006).

Excessive alcohol consumption is especially harmful for adolescents, because their regular drinking is associated with poorer psychological, social and physical health outcomes. It also causes poorer educational outcomes, violence, injuries, smoking, drug use, and risky sexual behaviour (Franco 2015).

Tobacco and alcohol consumption are the top causes of preventable death and, together with unhealthy diet and lack of physical activity, among the four shared risk factors of noncommunicable diseases (WHO *et al.* 2015b). While alcohol was responsible for an estimated 3.3 million deaths per year (5.9% of global mortality) (WHO 2014) and accounts for 5.1% of the global burden of disease measured in disability-adjusted life-years (WHO *et al.* 2015a), tobacco was the leading cause of avoidable death globally in 2014, caused around 5.4 million deaths per year (8% of global mortality).

In the Czech Republic tobacco consumption was responsible for 19% of all deaths in 2002. Diagnosis responsible for the highest number of deaths attributable to smoking is lung (or bronchogenic) cancer. When the causes of deaths are divided into 4 groups of diseases, most deaths are due to cardiovascular diseases (more than one half of the total number of deaths caused by alcohol) (Sovinová *et al.* 2008). In constrast with alcohol, there is no safe level of tobacco consumption.

There are also economic costs related to the consumption of tobacco that affects not only the consumer but also non-smokers exposed to the smoke. Firstly,

there are direct costs related to the cure of ilnesses caused by the tobacco consumption such as costs of hospitalization, physician services, medications and home care. For example, health-related costs in China were estimated to be equal in 1989 to tobacco taxes, that accounted for 10% of the government revenue (Richmond 1997). Secondly, there are indirect costs related to productivity losses due to ilness or death of the consumer (International Development Research Centre & Research for International Tobacco Control and Université de Montréal 2003).

The consumption of alcohol has the same costs related to the medical care and the foregone production. The consumption has an impact on over 200 diseases (Franco 2015) that increase a burden on health services and consequently spread the money costs on the whole society including abstinents. In most OECD countries the productivity losses associated with harmful alcohol use are estimated to be around 1 % of GDP (OECD *et al.* 2016). Rehm *et al.* (2009) suggest that the costs associated with alcohol amount to more than 1% of the gross national product in high-income and middle-income countries. In the case of the alcohol consumption it has to be also accounted for additional economic costs resulting from the undesirable behaviours such as various injuries from traffic accidents.

2.3 Regulation

The alcohol and tobacco consumption, together with its costs, has two possible outcomes. First, alcohol and tobacco consumption and its costs will be higher than is socially desirable. Second, we will regulate the consumption and make the consumers of alcohol and tobacco to pay for the costs of their choices (Franco 2015).

Long time the regulation of tobacco and alcohol followed the common rule "your right to swing your arms ends just where the other man's nose begins" (Chafee 1919). Later the world development chose to follow the second path, the path of regulation. At first only taxes were imposed on alcohol and tobacco consumption to generate revenue. Over time other measures were implemented to reduce the consumption, because consumers of alcohol and tobacco often affect other than themselves consequently increasing the social costs. Alcohol and tobacco are currently reffered to be "sin goods".

In the following summary we state only changes that affected tobacco and alcohol consumption in the measured period 1955 - 2016. We are especially

interested in changes that could cause a structural break in either the consumption of cigarettes or the consumption of alcohol, because we would like to control for these changes.

2.3.1 Alcohol and tobacco regulation at international level

International effort to minimise negative effects of alcohol consumption was characterized by a lack of consensus and only partial successes, but WHO had been preparing a global strategy to reduce the harmful use of alcohol since 2008 and its efforts resulted in a consensus of all 193 Member States of World Health Organization. As a consequence they adopted resolution endorsing the global strategy in 2010. This strategy provides policy options and interventions that should be considered for implementation in each country (Organization *et al.* 2010).

Regarding alcohol consumption there are three policy options that are very cost-effective according to WHO *et al.* (2015b) i.e. generate an extra year of healthy life for a cost that falls below the average annual income or gross domestic product per person:

- Regulation of commercial and public availability of alcohol
- Restriction or ban of alcohol promotions advertising
- Pricing policies such as minimal price or excise tax increases on alcoholic beverages

Regulation of availability of alcohol is considered to be essential measure to prevent easy access to alcohol by high-risk and vulnerable groups. It also changes the social and cultural norms that support the harmful consumption of alcohol. Consequently it positively contributes to change of perceptions of people who help to take further actions in accordance with the policy. This policy area includes minimum age for purchase of alcohol, policies regarding drinking in public places and regulation of production, wholesaling and serving of alcohol beverages (Organization *et al.* 2010). Studies have shown that the longer opening hours of shops selling alcohol the more violent harm results (Anderson & Baumberg 2006).

Restriction or ban of alcohol advertising is suggested, because it is hard to influence alcohol consumers by advertisement without influencing cohorts of adolescents, which are especially prone to harmful effects of alcohol. Finally,

pricing policies is used, because high-risk groups, heavy drinkers and young people are sensitive to changes in the price of drinks (Organization *et al.* 2010). The price sensitivity of consumers is discussed in the next section.

In 2003, 50 years after negative effects of tobacco were scientifically proven, only few countries implemented measures decreasing their consumption (WHO *et al.* 2008). In the same year, international efforts took concrete shape in WHO Framework Convention on Tobacco Control, first legally binding document, which was signed by more than 150 Parties and more than 160 States including the Czech Republic and came into force in 2005. Term "tobacco products" are described as "products entirely or partly made of the leaf tobacco as raw material which are manufactured to be used for smoking, sucking, chewing or snuffing" (WHO *et al.* 2003). In the Czech Republic the Conventions was ratified in 2012. It provides the principles and context for policy development for tobacco control. It states what the minimal measures are and encourages countries to implement stricter policies (WHO *et al.* 2008). Later, a framework for alcohol policy in the WHO European Region was endorsed by the WHO Regional Committee for Europe (WHO *et al.* 2006).

To help countries to fulfill their commitment to reduce tobacco prevalence WHO *et al.* (2008) presented MPOWER: a policy package to reverse the tobacco epidemic. In the fight against tobacco consumption there are three policies that are considered very cost-effective (WHO *et al.* 2015b):

- Reduce an affordability of tobacco products by increasing tobacco excise taxes
- Creation of completely smoke-free environments in all indoor workplaces, public places and public transport
- Ban of all forms of tobacco advertising, promotion and sponsorship
- Warning of the dangers of tobacco and tobacco smoke through effective health warnings and mass media campaigns

Taxes are increased, because it is a revenue in the government budget, helps tobacco users to quit, reduces the number of new tobacco users and protects people from exposure to tobacco smoke, which is known for causing wide range of diseases. As in the case of smoking itself, there is no safe level of second-hand smoke. Therefore, creation of smoke-free environments is suggested as the only way to protect people from second-hand smoke. The smoke-free environments also help smokers to quit. Smokers working in smoke-free environment

are twice more likely to stop smoking than smokers working at places where smoking is permitted (Bauer *et al.* 2005). On the other, regulation of smoking in restaurants and other catering facilities is considered to be a restriction on their business.

Bans on advertising, promoting and sponsorship are recommended, because they spread awareness about the health risks of tobacco consumption and changes the public perceptions of smoking. In turn, they help to further enforce policies fighting the tobacco consumption (WHO *et al.* 2008). Warnings of the dangers of tobacco and tobacco smoke are suggested, because smokers do not fully realize the consequences of smoking including suffering, disfigurement and early death. Important part of this policy is an implementation of pictorial warnings on tobacco products.

The worldwide effort to reduce harmful use of tobacco and alcohol resulted in setting specific voluntary targets. World Health Assembly in 2013 adopted as a part of the NCD Global Monitoring Framework a target of reducing alcohol use by 10% by 2020 and 30% relative reduction in prevalence of current tobacco use in persons aged 15+ years. Different policy options were formulated by WHO *et al.* (2015b) and recommended in WHO Global Action Plan for the Prevention and Control of Noncommunicable Diseases, 2013-2020.

Regarding the European Union, it was stated already in 1992 in the Treaty establishing the European Community that "Community action, which shall complement national policies, shall be directed towards improving public health, preventing human illness and diseases, and obviating sources of danger to human health. Such action shall cover the fight against the major health scourges, by promoting research into their causes, their transmission and their prevention, as well as health information and education." (EU 1992) Directive 2001/37/EC of the European Parliament and of the Council on the approximation of the laws, regulations and administrative provisions of the Member States concerning the manufacture, presentation and sale of tobacco products was approved in 2001 and started a process of reducing differences in law regulating tobacco consumption (The European Parliament and the Council 2001). Another example of EU initiative in the field of tobacco consumption is Directive 2003/33/EC of 26 May 2003 on the approximation of the laws, regulations and administrative provisions of the Member States relating to the advertising and sponsorship of tobacco products (The European Parliament and the Council 2003). Later in 2007, the right to act towards improving public health was strenghtened incorporated in the Treaty on the Functioning of the European Union. According to

Article 6, one of the areas in which "the Union shall have competence to carry out actions to support, coordinate or supplement the actions of the Member States" is protection and improvement of human health. Moreover, the Union may also adopt measures "which have as their direct objective the protection of public health regarding tobacco and the abuse of alcohol, excluding any harmonisation of the laws and regulations of the Member States" (EU 2007). In 2014, based on incentives from the European Parliament and the Council Directive 2001/37/EC was repealed by Directive 2014/40/EU on the approximation of the laws, regulations and administrative provisions concerning the manufacture, presentation and sale of tobacco and related products, that created necessary conditions for implementing WHO Framework Convention on Tobacco Control in the Member States (The European Parliament and the Council 2014b).

2.3.2 Alcohol regulation in the Czech Republic

Alcohol was often viewed as a part of the tradition. As it was stated in the Framework for alcohol policy in the WHO European Region, alcohol drinking is valued for many reasons: "as a medium of sociability, as part of nutrition and as a symbolic break, bringing relaxation from everyday responsibilities". People are traditionally familiar with alcohol, which makes it difficult to stand back and realize the risks and harms connected with its consumption (WHO *et al.* 2006). As a result, it is hard to regulate the harmful consumption of alcohol, because it gets in the way of rational policy-making. Moreover, alcohol is assosiated with a number of jobs (Anderson & Baumberg 2006). Despite that, there is a steady progress in the Czech Republic.

The Czech Republic belongs to few states in the Europe, which have not introduced licences or state monopoly on alcohol sales. On the other hand, it belongs to a small number of states which have zero tolerance towards blood alcohol concentration levels for all drivers (WHO *et al.* 2013).

Minimum age limit was introduced already in Czechoslovakia in 1922. It was prohibited to provide any alcoholic beverages to people under the age of 18. It excluded beer and wine, that could have been sold to those over 16 years of age (Národní shromáždění republiky Československé 1922). In 1948, the limit was set on the age of 18 for all alcoholic beverages and since that time it has been at the age of 18 (Ústavodárné Národní shromáždění republiky Československé 1948).

Alcohol advertisements are not banned, but there are restrictions on the form of advertisements. Already in 1995, it was forbiden to focus alcohol advertisement on people who are under the age of 18. Advertisements also could not encourage people to consume harmful levels of alcohol or to ironically or negatively evaluate abstention. Moreover, advertisements could not be targeted or emphasize higher level of alcohol content as an advantage (Parlament České republiky 1995b).

In 1989, specific list of places, where alcohol could not be sold, was issued. It was prohibited to sell alcohol at sport events, in medical and social care facilities, in public transport and in canteens (Česká národní rada 1989).

Until 2002, there was no complex law regulating alcohol consumption in the Czech Republic. Therefore, reduction of the negative effects of harmful alcohol consumption together with reduction of negative effects of tobacco consumption in the Czech Republic was determined as the twelth goal of national strategy Health 21 issued by the Government of the Czech Republic. The overall aim of this programme was to increase health in the Czech Republic (Vláda České republiky 1999).

In 2005, conditions under which alcohol could be sold were specifically stated. Alcohol could have been sold in shops specialized on alcohol and in specialized departments of wholesalers. Moreover, it was allowed to sell alcohol in catering facilities with host licence, accommodation and cultural facilities with the exception of facilities for people under the age of 18. This ban does not apply on occasional sale of alcohol on celebrations, traditional events, annual markets and on similar occasions. In the same year, ban on entrance of persons obviously under the influence of alcohol into different places was introduced. Also, it gave people a possibility to double-check their breath tests. It is done by blood testing and is critised for its enabling to abscond, because there is a time delay between breath and blood testing due to transportation of the given person to medical facility (Parlament České republiky 2005).

There is no law which would command to use warnings on the alcohol products or mark places, where alcohol is sold, as it is in the case of tobacco. The only obligation is to hang out a sign stating that the seller does not sell alcohol to people under the age of 18 (Parlament České republiky 2005).

In comparison to other European states, we lagged behind. In 2006, the strictness of alcohol policy in the Czech Republic got less than 9 points on the scale from 0 to a maximum of 20, where 20 marked the most comprehensive policy. In comparison to other European states, the Czech Republic laged

behind the average of 10.8. For example, Norway had 17.7 points and, on the other side of the spectrum, Greece had 5.5 (Anderson & Baumberg 2006).

Death toll from methanol poisonings rose in 2012 in the Czech Republic. Therefore, on the 12th of September 2012, the Ministry of Health banned sale of beverages with alcohol content higher than 30 volume percent (Ministerstvo zdravotnictví 2012b). Two days later on the 14th of September, the limit on alcohol content was tightened on 20 volume percent (Ministerstvo zdravotnictví 2012a).

In 2017, list of places, where alcohol could be sold, was further specified and obligation to report in advance sale of alcohol to the respobsible excise administrator on special occassions like farmers markets was adopted (Parlament České republiky 2017).

Impact of policies that support education, training and public awareness is low (Anderson & Baumberg 2006). And as it does not have significant effects on alcohol consumption, I do not focus on these policies.

Also, taxes are an important factor in the fight against harmful consumption of alcohol. Pricing policies are between 10 recommended target areas of the WHO Global strategy to reduce the harmful use of alcohol (WHO *et al.* 2010). For illustration, if taxes were higher by 10% in older 15 EU countries, 9000 deaths in these countries due to alcohol consumption would be prevented in the following 12 months (Anderson & Baumberg 2006). From the 1st of January 1952 to the 31st of December 1992, all products were taxed by sales tax and the tax also applied to tobacco and alcohol (Národní shromáždění republiky Československé 1952). Since the 1st of January 1993, alcohol has been taxed through two channels: excise taxes and consumption taxes. Since 1993, there are separate rules for taxation of beer, ethyl alcohol and a group of wine and intermediary products. In the category of beer and a group of wine and intermediary products only beverages with alcohol content between 1,2% and 20% are counted. Beverages with higher alcohol content belong to the group taxed by the tax rate on ethyl alcohol (Parlament České republiky 2003b).

Then there were many amendments that changed the tax rates after their introduction in 1993. Already in 1994, the tax rate on ethyl alcohol was increased as it is shown in Table 2.1 and the tax rate on grape wine was decreased by 23% (Parlament České republiky 1993). In the next year, the tax rate on ethyl alcohol was increased again. Moreover, new amendment introduced a definition "small brewery" and stated different tax rates for small and big breweries (Parlament České republiky 1994).

In 1996, the tax rate on grape wine was decreased by 55% (Parlament České republiky 1995a). In 1998, there was an 20% increase in the tax rate on ethyl alcohol and change in the way how beer is taxed (Parlament České republiky 1997b).

After 1998, the consumption tax was stabilised for six years. New law, that was associated with the Czech Republic's integration in the EU and regulated excise taxes, came into force in 2004. It introduced higher tax on ethlyl alcohol (Parlament České republiky 2003b). Last change came in 2010, when the tax rate on ethyl alcohol was raised by 22 percentage points and all rates on beer were increased by 33 percentage points (Parlament České republiky 2009b).

Table 2.1: Development of excise tax on ethanol

Year	1993	1994	1995-1997	1998-2003	2004-2009	2010-present
Tax rate (CZK/l)	180	190	195	234	265	285

Consumption tax was introduced in 1993 and there is one rate for all alcoholic beverages and tobacco. Table Table 2.2 shows its development (Parlament České republiky 2004a; Česká národní rada 1992).

Table 2.2: Consumption tax

Date	1.1.1993 - 1.1.1994	1.1.1995 - 30.4.2004	1.5.2004 - 31.12.2009	1.1.2010 - 31.12.2012	1.1.2013 - present
Tax rate	23%	22%	19%	20%	21%

While it does not affect tobacco and alcohol consumption assymetrically and it does not consequently affect cointegration relation, we consider consumption tax only when explaining possible structural breaks.

2.3.3 Tobacco regulation in the Czech Republic

In the beginning, the situation of tobacco regulation was the same as the regulation of alcohol. The tobacco consumption was not highly regulated until the end of the Second World War, because Czechoslovakia and previously also the Austro-Hungarian Monarchy were interested only in financial gains and not in negative effects of tobacco consumption. To ensure the highest profit from tobacco consumption there was a state monopol on the production of tobacco in Czechoslovakia.

Before we describe the development of tobacco regulation, it is important to explain term "tobacco products" that is used in Czech laws. At first, tobacco products were specified as a cigarettes, cigarillos, cigars, polished cigars and pipe, cigarette, snuff and chewing tobacco in 1997 (Parlament České republiky 1997a). Since 2004, the definition has been explained as a tobacco products intended for chewing, sucking, smoking or snuffing if they are produced from tobacco including genetically modified tobacco (Parlament České republiky 2004b).

The first law regulating smoking was introduced in 1964. It banned smoking in passenger trains and waiting rooms designed for people waiting for train (Ministerstvo dopravy 1964). However, it was the first and also the last law regulating consumption of tobacco products, because their consumption was long perceived normal. The first law categorizing tobacco consumption as socially undesirable was passed in 1989. It introduced ban on smoking on work meetings in closed rooms, on work meetings when non-smokers are present, in schools and in medical, sport, catering and cultural facilities except places intended for smokers. Moreover, minimum age limit was set to 16 years (Česká národní rada 1989). Since 2000, tobacco products have been sold only to people over the age of 18 (Parlament České republiky 1999).

In 1991, broadcasters were obliged to ensure that advertisements on tobacco products end by warning that smoking is harmful and state a content of nicotine and tar (Česká národní rada 1991).

Ban on advertisement in TV was instroduced in 1995. Tobacco advertisements could not be broadcasted between 6 AM an 10 PM. The amendment has also prohibited broadcasters to focus tobacco advertisements on people under the age of 18 or to encourage smoking. Moreover, tobacco advertisements had to include a warning "Ministry of Health warns: smoking causes cancer" covering more than 10% of the surface (Parlament České republiky 1995b).

The exception of broadcasting betweem 10PM and 6AM was cancelled by an amendment in 2001. Further amendment passed in 2002 tightened up the regulation on advertising and contained the first significant regulation on print advertising. Print advertisers were obliged to include the warning "Ministry of Health warns: smoking causes cancer" covering more than 20% of the advertisement, not to advertise in magazines and newspapers intended for people under the age of 18 and to place posters farther than 300m from schools and playgrounds (Parlament České republiky 1995b).

In 1999, the first complex document summarizing all state initiatives was

passed by the Czech government. In this document called Health 21 targets were set and included ban on tobacco advertisement, antitobacco campaigns, foundation of central monitoring center responsible for implementing european action plan for a tobacco-free Europe and prevention programmes. Prevalence of smoking and tobacco consumption were chosen as a part of a group of indexes monitoring progress of implementation (Vláda České republiky 1999).

A full ban on advertising on tobacco products and sponzorship of these products was introduced in 2003 and came into force in September 2004. The advertising is defined by law as any form of business message whose purpose or direct or indirect effect is advertising on tobacco products. There are few exceptions that allow advertising and promotion. For example, the ban does not apply on magazines for professionals, specialised shops with tobacco, shop departments intended for tobacco products and motorsport sponzorship (Parlament České republiky 2003a).

In 2003, text warnings were also introduced in the Czech Republic (Parlament České republiky 2003c). Based on Commission Delegated Directive 2014/109/EU of 10 October 2014 amending Annex II to Directive 2014/40/EU (The European Parliament and the Council 2014a), the Czech Republic was obliged to implement picture warnings on the packages of tobacco products for smoking until the 20th of May 2016. Therefore, Parliament of the Czech Republic brought the law into force on the 20th May 2016. Since that time, producers, importers, retailers and distributors of tobacco products have been obliged to ensure that each package of tobacco product has to carry information message, general warning and combined warning. Combined warning is a health warning that consists of a text warning and a picture. The picture is specified by law and must cover 65% of the package surface (Parlament České republiky 2017).

Since 2005, it has been prohibited to sell tobacco products in places, where it is not possible to check the age of buyer. For example, it is forbiden to sell cigarettes in automats. This regulation applies to all forms of selling tobacco products if the check is not possible. The law also prohibited to sell tobacco products on cultural, social and sport events intended for people under the age of 18 and required sellers to hang a sign stating that the seller does not sell alcohol to those people as it was introduced in the same year in the case of alcohol. Moreover, list of places where smoking is banned was enlarged. For the first time, it was banned to smoke in indoor places established by the state or lower self-governing unit and was obligatory for hosts to mark places intended

for smokers and non-smokers (Parlament České republiky 2005). According to the Czech Labour Code, that was passed in 2006, employer is obliged to prohibit smoking at a workplace and in all common rooms if there is one or more non-smokers. In that case, the employer could design one or more rooms for smoking (Parlament České republiky 2006).

In 2009, the law specifying list of places where smoking is banned was amended in order to implement requirements of the WHO Framework Convention on Tobacco Control. In this law taxative list of public places where smoking is prohibited was stated including covered platforms intended for people waiting on public transport, public institutions and indoor spaces of financial institutions. This amendment also introduces and distinguishes between smoker facilities, non-smoker facilities and facilities with special room intended for smokers (Parlament České republiky 2009a).

Since 2017, smoking in catering services including all pubs, bars, wine bars, cafes, tearooms and all similar facilities in the Czech Republic has been prohibited. It has been also prohibited to smoke in zoological gardens with exception of a place intended for smokers (Parlament České republiky 2017).

As in the case of alcohol regulation, taxes represent an important tool for tobacco regulation. According to WHO Framework Convention on Tobacco Control (WHO *et al.* 2003), increasing of taxes on tobacco products is an important mean to decrease tobacco consumption. Until 31st of December 1992, there was a sales tax that affected both tobacco and alcohol consumption in the same way. Since 1st of January 1993 the price of tobacco products has been affected by consumption tax and excise tax in the Czech Republic and have been determined as a fixed price per one cigarette. Since 2004, the tax rates have been determined on the level of EU and consumption tax has been divided into percentual and fixed part. To get a final amount of tax given percentual share and the fixed part are added up. There is also a minimum tax rate, which is implemented if the sum of percentual and fixed part is lower than the minimal tax rate. Consequently, the price obtained by this procedure is further taxed by the consumption tax. The development of the excise tax rates is shown in Table 2.3.

2.4 Relationship between alcohol and tobacco

From the previous sections on regulation it is clear that tobacco and alcohol have been regulated highly asymmetrically in last 15 years. Also, Hawkins

Table 2.3: Development of tax rates on tobacco

Valid from	Tax rates (per one piece)		
	Percentual	Fixed	Minimal
1.1.1993	-	0,46 CZK * 0,27 CZK **	-
1.1.1995	-	0,41 CZK * 0,51 CZK **	-
1.1.2002	22%	0,36 CZK	0,67 CZK * 0,79 CZK **
1.1.2004	23%	0,48 CZK	0,94 CZK
1.7.2005	24%	0,60 CZK	1,13 CZK
1.4.2006	25%	0,73 CZK	1,36 CZK
1.3.2007	27%	0,88 CZK	1,64 CZK
1.1.2008	28%	1,03 CZK	1,92 CZK
1.5.2011	28%	1,12 CZK	2,10 CZK
1.12.2014	27%	1,29 CZK	2,37 CZK
1.1.2016	27%	1,39 CZK	2,52 CZK

Notes: * length $\leq$ 70mm, ** length $>$ 70mm

et al. (2018) mention an asymmetry in regulation of European Union and an asymmetry in regulation at the level of WHO. At the level of WHO, Framework Convention on Tobacco Control commits states to implement extensive tobacco control policies (WHO *et al.* 2003). In constrast, the WHO Global Strategy to Reduce the Harmful Use of Alcohol is significantly weaker. In 2006 the European Commission passed Alcohol Strategy, but this strategy lacked regulatory force. Furthermore, it expired in 2010 and has not been replaced. Hawkins *et al.* (2018) also compared EU regulation and found out that tobacco policy is more stringent. Markings and labelling of tobacco products, that are regulated extensively at the EU level via Tobacco Products Directive (The European Parliament and the Council 2014b), are another example of the asymmetry in regulation. Moreover, tobacco industry is often excluded from the policy making. According to Hawkins *et al.* (2018), alcohol should be regulated more because of the fact that it is the second most preventable factor of death.

There is an extensive number of works that study a demand for alcohol and tobacco separately. However, the number of studies focused on the relationship between these two commodities is much lower. For example, studies of Pierani & Tiezzi (2009), Tauchmann *et al.* (2013) and Yu & Abler (2010) suggest that alcohol and tobacco are complements, but there are two different approaches. Tauchmann et al. used the variation in the consumption of both commodities.

On the other hand, studies of Yu & Abler (2010) and Pierani & Tiezzi (2009) explain demand for both commodities using the variation in prices.

Yu & Abler (2010) used data from rural areas of 26 Chinese provinces. They analysed panel data collected in a time period of 10 years (1994-2003) using habit persistence model. In their model they considered biological and psychological characteristics of addiction, such as dependence, reinforcement and tolerance. Their results show insignificant effect of the price of cigarettes on either cigarette consumption or alcohol consumption. On the other hand, both the alcohol consumption and the tobacco consumption are highly sensitive to the price of alcohol.

Pierani & Tiezzi (2009) used aggregate time series of alcoholic beverage and tobacco product expenditures in Italy for the time period 1960 - 2002 and employed a rational coaddiction model that they developed for the purpose of their study. They studied, whether there is a gateway effect, i.e. whether past consumption of one commodity affects current comsumption of another commodity. If there was a gateway effect, it would mean that the conventional estimates of taxation on one of the commodities may be biased downwards. Moreover, the gateway effect would implicate that, for example, policy decreasing alcohol could mitigate the initiation of tobacco. They performed a number of diagnostic tests and one of them was ADF test in a version with a constant. Because of bias due to small sample they simulated p-value of the ADF test using bootstrapping and revealed unit roots in all following variables: tobacco consumption, alcohol consumption and alcohol prices. Additional Phillips-Perron test revealed unit root also in the case of tobacco prices. Therefore, they used first differences. Their results show that alcohol and tobacco are complements and that alcohol is a gate to tobacco. On the other hand, the effect of lagged consumption of tobacco on alcohol is not significant. Furthermore, according to results of Pierani & Tiezzi (2009), alcohol consumption is more rigid that tobacco consumption, but tobacco is more responsive to changes in alcohol consumption. It corresponds to findings of Yu & Abler (2010).

Tauchmann *et al.* (2013) used data from the "Population Survey on the Consumption of Psychoactive Substances in Germany" collected by mail at irregular intervals from 1980 to 2003. Their analysis is based on consumption of both commodities and studies how much alcohol consumption changes if tobacco consumption changes by one unit. For this purpose they employed a two-stage estimation with parental smoking and drinking habits as instruments.

So their model does not rely on prices as explanatory variables, which they do not use because of insufficient price-variation. In their model, they control for gender, age, age squared, and living in West-Germany and estimate reduced form equations by conventional Tobit procedures. Results of Tauchmann *et al.* (2013) suggest that a reduction in tobacco consumption results in a moderate reduction in alcohol consumption, although the result is statistically significant only for males.

There is a growing literature on the relationship between the alcohol and tobacco consumptions, but we are aware only of two recent studies of Koksal & Wohlgenant (2016) and Beard *et al.* (2017) that try to asses the relationship between alcohol and tobacco directly. The rest of studies focuses, for instance, on effects of a specific policy. Moreover, the study of Beard *et al.* (2017) is extraordinary because of the fact that it uses aggregate data. Although a vast majority of these works focused on an individual level including the study of Jiang *et al.* (2017) on effects of anti-tobacco policies on the alcohol consumption and the study of Krauss *et al.* (2014) on effects of tobacco excise taxes on the alcohol consumption, we are aware of just the study of Beard *et al.* (2017) that have done so on the level of population.

Koksal & Wohlgenant (2016) employed a two-stage estimation model, pseudo-panel method. Prices of coffee were also implemented in the model in order to assess the relationship between these three commodities, because previous studies found out that the subjects of experiment who got coffee smoked more compared to other participants (Emurian *et al.* 1982; Marshall *et al.* 1980). Therefore, Koksal & Wohlgenant (2016) used twelve cohorts as intruments are defined by the interaction of three generations and four regions in the US. For their analysis they used Consumer Expenditure Survey (CEX) Diary data (2002 - 2008). Their results suggest that an increase in alcohol prices would decrease not only alcohol consumption, but also cigarette consumption, but increasing cigarette prices does not have the same effect on the alcohol consumption. On the other hand, their results of Morishima elasticities of substitution show that coffee, alcohol and cigarettes substitute each other when relative prices change. Koksal & Wohlgenant (2016) emphasize that the results are based on the U.S. data and we should be careful making generalizations on other countries.

Beard *et al.* (2017) analysed monthly data collected between March 2014 and June 2016 in household face-to-face surveys in England using Autoregressive Integrated Moving Average with Exogeneous Input (an extension of Autoregressive Integrated Moving Average model) modelling. The aim of their

study was to find out whether there is a relationship between prevalence of smoking and a high-risk drinking. Beard *et al.* (2017) found out that every 1% decrease from mean smoking prevalence of the series (18,6% over the studied period) causes decrease of 0.19% from the mean in prevalence of high-risk drinking (13.0%) 2 months later.

Chapter 3

Methodology

Consumptions of alcohol and cigarettes in the Czech Republic are typical examples of time series, because the values are time indexed. Study of past consumptions can help us to better predict their future development and responses to regulation, which can contribute to the improvement of both tobacco and alcohol policies.

In this bachelor thesis, we study the relationship between these two series. We believe that there is common underlying factor influencing both series. To verify our assumption we test if the series are cointegrated. The presence of cointegration allows one to estimate long-run coefficients in a manner that is free of simultaneous-equations bias and can help to correct, for example, models estimating cross elasticity of demand for alcohol and tobacco (Engle & Granger 1987). At first, we test for a unit root, which is a necessary condition for a cointegration. Then we test for the cointegration itself.

3.1 Unit root and stationarity tests

For many time series the stationarity is unrealistic. Namely, the mean of the series or the variance is time dependent. The stationarity assumption could be violated due to trends in the series and econometricians distinguish between two types of trends in the AR models:

1. Deterministic terms as a nonrandom functions of time
2. Stochastic trends due to unit roots

The difference of these trends is the fact, that stochastic shocks have a permanent effect in the case of unit root. It is important to control for a

stochastic trends, because they can cause problems: autoregressive coefficients biased toward zero, nonnormal distribution of t-statistics and spurious regression (Stock & Watson 2011). Moreover, an existence of a unit root in the series also implies that shocks to the output have a high persistence (Stock & Watson 2011). Also, it is a neccesary condition for a cointegration test. There are three possible ways how to verify stationarity: previous research, observation of the graph and formal tests. There has not been any research on the stationarity of alcohol and cigarettes consumption in the Czech Republic and we cannot say for sure by observing the data whether the series is an unit root process or not. Therefore, we use two formal unit root tests.

3.1.1 Dickey-Fuller test

Firstly, we use the test invented by Dickey & Fuller (1979), because it is the most reliable test and widely used in practice (Stock & Watson 2011). This test was also used by Engle and Granger in the paper introducing the topic of cointegration (Engle & Granger 1987). It tests for a unit root.

The test is based on the observation, that AR(1) process is not stationary if it follows a random walk. In other words, if the time series has $\beta_1 = 1$:

$$y_t = \beta_0 + \beta_1 y_{t-1} + u_t \tag{3.1}$$

Dickey & Fuller (1979) modified the AR(1) model by substracting y_{t-1} from both sides of Equation 3.1 and tested for nonstationarity by testing:

$$H_0 : \delta = 0$$
$$H_1 : \delta < 0$$
$$\text{in } \Delta y_t = \beta_0 + \delta y_{t-1} + u_t, \text{ where } \delta = \beta_1 - 1$$

To test for $\delta = 0$ is the same as testing for $\beta_1 = 1$ in the previous equation. The t-statistic follows non-standard Dickey-Fuller distribution, whose values were tabulated in Fuller (1976).

If we do not reject the H_0, it implies that the order of the series is higher or equal to 1. Therefore, we apply the DF test on the first differences of the series y_t to find out the number of orders. In this case, we test if the order of the original series is higher or equal to two. If we reject the H_0, it implies that the order of original series is equal exactly to one. In other words, it has

a unit root. If we do not reject H_0, we have to repeat the procedure on second and higher differences of the original series until we find the integration order of the series.

The result of DF test depends on the deterministic trends included in the test regression, because they change the t-statistic of the test. Inclusion of deterministic terms makes it harder to reject the H_0. Therefore, including deterministic terms it is easier to detect a unit root.

$$
\begin{aligned}
Case1 :&\Delta y_t = \phi y_{t-1} + \epsilon_t \\
Case2 :&\Delta y_t = c + \phi y_{t-1} + \epsilon_t \\
Case3 :&\Delta y_t = c + \delta t + \phi y_{t-1} + \epsilon_t
\end{aligned}
$$

Case 1 represents the basic setting of the regression, but a mean of series is rarely equal to 0. Therefore, the deterministic constant c is included in the Case 2. The Case 3 includes additionaly the trend to increase the probability of rejecting a presence of a unit root. In that regard, time series could be stationary, trend-stationary or non-stationary.

3.1.2 Augmented Dickey-Fuller test

In the case of a process with a lag order higher than one the DF test is inappropriate. The error term of AR(1) would be autocorrelated because of missing lags. Therefore, the DF test has to be adjusted to account for autocorrelation.

Consider an AR(p) process:

$$y_t = c + \alpha_1 y_{t-1} + ... + \alpha_p y_{t-p} + \epsilon_t \tag{3.2}$$

Dickey & Fuller (1979) adjusted the regression substracting y_{t-1} from both sides of Equation 3.2 and rearranged the terms to get:

$$\Delta y_t = \phi y_{t-1} + \alpha_1^\star \Delta y_{t-1} + ... + \alpha_{p-1}^\star \Delta y_{t-p+1} + \epsilon_t \text{ , where } \phi = (\alpha_1 + ... + \alpha_p) - 1$$
$$\text{and } \phi_i^\star = -(\alpha_{i+1} + ... + \alpha_p) \text{ for i=1,...,p-1}$$

The hypothesis pair is as follows:

$$H_0 : \phi = 0$$

$$H_1 : \phi < 0$$

ADF test statistic is based on t-statistic for ϕ from augmented regression (Stock & Watson 2011):

$$t^{ADF} = \frac{\hat{\phi}}{\sigma_{\hat{\phi}}}$$

The deterministic constant and time trend could be included in test regression as we explained in the case of DF test.

To specify the lag lenght we used the Bayes information criterion, also called the Schwarz information criterion. To estimate p we minimize the term:

$$\text{BIC(p)} = \ln\left[\frac{SSR(p)}{T} + (p+1)\frac{ln(T)}{T}\right]$$

where SSR(p) is the sum of squared residuals of the estimated AR(p). The BIC is looking for the lowest value among the possible choises of p, where p=0 corresponds to the model containing only intercept.

While testing for unit root in our case we tested against the alternative of stationarity around a linear deterministic time trend (Case 3), because both series exhibit a long-term growth in the studied time period.

3.1.3 KPSS test

DF test and ADF test are known to have relatively low power, which makes it difficult to distinguish between a unit root and values close to a unit root. Moreover, in the classical theory of hypothesis testing the null hypothesis and the alternative are not on the same footing. The null hypothesis is rejected only if there is a lot of evidence against it. Therefore, tests for stationarity are used to verify the results of tests for a unit root. We use the KPSS test introduced by Kwiatkowski *et al.* (1992), which is the most used test with stationarity as a null hypothesis.

To test the series for stationarity we have to express it as:

$$y_t = at + \epsilon_t + r_t \tag{3.3}$$

where at is a deterministic term, ϵ_t is a stationary error and r_t is a random walk:

$$r_t = r_{t-1} + u_t$$
where the u_t are iid $(0,\delta^2)$

We include deterministic term, because there is a clear increasing trend observable in both the consumption of alcohol and cigarettes in the Czech Republic. We use critical values, which were tabulated in Sephton (1995). The test is based on following statistics:

$$\mu = \frac{\sum(\sum_{i=1}^{T}(y_t - \bar{y}_t)^2}{T^2\bar{\sigma}^2}$$

We test these hypothesis:

$$H_0 : \sigma_u^2 = 0$$
$$H_1 : \sigma_u^2 \neq 0$$

Since the u_t is assumed to be stationary, under the null hypothesis y_t is trend-stationary. Otherwise the series has a unit root.

As in the case of the ADF test, an important issue of implementing the test is to choose an appropriate number of lags. To estimate the number of lags we use a rule of thumb suggested by Schwert (1989):

$$\text{number of lags} = 4 * \left(\frac{T}{100}\right)^{0.25}$$

where T is a sample size of a considered series.

3.2 Confirmatory analysis

As we wrote in the previos section, tests with stationarity as null are used to confirm the results of unit root tests:

Table 3.1: Confirmatory analysis

Test 1 (ADF test)	Test 2 (KPSS test)
H_0: y_t nonstationary (unit root)	H_0 : y_t stationary
H_1 : y_t stationary	H_1 : y_t nonstationary (unit root)

We have confirmation if test 1 rejects the null and test 2 not (or vice versa). If both tests reject the null or both tests do not reject the null, we have no confirmation.

3.3 Tests for cointegration

Sometimes two or more time series seem to move together. Therefore, different procedures to test whether they follow the same trend were introduced. Engle & Granger (1987) came up with an idea that the series could be generated by the same stochastic trend and they named the sitauation as cointegration. They suggested that two variables with order of integration higher than 0 are generated by the same stochastic process if their difference is stationary (Engle & Granger 1987).

3.3.1 Engle-Granger procedure

We will test whether these two time series are cointegrated following the Engle-Granger procedure (Engle & Granger 1987). The model takes the specified form:

$$y_t = \alpha + \beta x_t + z_t \tag{3.4}$$

where (nx1) vector y_t represents consumption of alcohol and (nx1) vector x_t represents consumption of cigarettes. Assuming both processes have unit roots, the variables are cointegrated (the process $u_t = y_t - \alpha - \beta x_t$ is I(0)) if there exist parameters $\beta, \beta \neq 0$, and α that Equation 3.4 holds.

The coefficient β in unknown. Therefore, we follow the two-step procedure suggested by Engle & Granger (1987). In the first step we estimate the cointegration coefficient β. We use the OLS estimator. In the second step, ADF test is used to test for a unit root in the residuals $\hat{z}_t$ from the regression (1):

$$\Delta z_t = \phi z_{t-1} + \alpha_1^\star \Delta z_{t-1} + ... + \alpha_{p-1}^\star \Delta z_{t-p+1} + \epsilon_t \tag{3.5}$$

The intercept is not included, because the error terms are assumed to have a zero mean. In this residual based test, known as the Engle-Granger Augmented Dickey-Fuller test for cointegration, special critical values suggested in Stock & Watson (2011) are used. If we reject the unit root hypothesis for $\hat{z}_t$, there is evidence for cointegration between the consumption of cigarettes and the consumption of alcohol in the Czech Republic.

3.3.2 Johansen trace test

The Engle-Granger procedure is easily implemented, but it has also several defects as was summarised in the book Applied Econometric Time Series (Enders 2010). Firstly, in small samples the result of EG procedure depends on the chosen dependent variable in Equation 3.4. Results of a regression with one variable as the dependent one could show cointegration, but when substituting the dependent and independent variable results could indicate no cointegration. Secondly, the EG procedure is dependent on the two-step estimator. This implies that any error in the first step is carried over into the second step. Johansen test is free of these defects (Johansen 1991).

The starting point of the Johansen test is the vector autoregressive model:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + u_t \tag{3.6}$$

It has a vector error correction representation, which we get after adjustment:

$$y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + ... + \Gamma_{p-1} \Delta y_{t-p+1} + u_t$$

where $\Pi = -(I_K - A_1 - ... - A_p)$ and $\Gamma_i = -(A_{i+1} + ... + A_p)$ for $i = 1, ..., p-1$

Π and Γ_i are coefficient matrices and u_t is a vector of error terms. The number of lags is chosen by Schwarz information criteria. The matrix Π could be written as $\Pi = \alpha\beta'$. α and β' are (a x b) matrices, where a is a number of variables and b is a rank of the matrix. The variables are cointegrated if Π has a reduced rank b and $0 < b < a$.

We determine the rank of Π by a sequence of the Likelihood Ratio tests invented by Johansen (1991) . The null hypothesis is that the rank is equal to n. The alternative hypothesis is that the rank is at least n+1:

$$H_0 : rk(\Pi) = n$$
$$H_1 : n < rk(\Pi) \leq a$$

We start with n=0. If we reject the hypothesis in favor of H_1, we repeat the test for n+1 and continue doing so until we accept the null hypothesis. Then the rank is chosen accordingly.

The test is based on testing if eigenvalues of Π are statistically different from zero. The Likelihood ratio test statistic is used for it:

$$\text{LR(b,n)}=-T\sum_{i=b+1}^{n} ln(1-\lambda_i)$$

where λ_i are the eigenvalues obtained from Johansen reduced rank regression and T is number of observations.

If b=0, the matrix Π is equal to 0. It means, that both variables follow random walk and are not cointegrated. If rk(Π) = a, det(Π) = det($-\Pi$) = det($I_K - A_1$) $\neq$ 0. In this case, there is no unit root in VAR polynomial and the two variables in y_t are stationary. Therefore, there are cointegration relations only if $0 < rk(\Pi) < a$. The number of cointegration relations is equal to the rank of Π.

3.4 Structural breaks

We have to adjust the ADF test because of its poor performance in the case of a small sample. As Perron (1989) showed, the usual ADF test does not reject its null of a unit root if there is a structural break. The test mistakenly perceives structural break as a persistent innovation to a stochastic (non-stationary) trend, innovation that is typical for a unit root process. In other words, the unit root test that does not take into account structural break has a low power.

Cointegration relation could be also influenced by structural changes. While variables are cointegrated when their first and second moment are still the same, the first moment (mean) could be changed due to a structural change causing cointegration tests not to find enough evidence for a cointegration relation. We believe that after 1989 there is an assymetric regulation in the case of the alcohol and tobacco consumption as it was also indicated by Hawkins *et al.* (2018). On the other hand, there could be structural breaks that affect both tobacco and alcohol consumptions at the same time and cause a spurious relationship. Because of that the consumptions of cigarettes and alcohol could be wrongly considered interrelated because their means changed at the same time.

According to Lütkepohl & Krätzig (2004), the K x 1 vector processes y_t, in our case alcohol and cigarette consumptions, are generated by a constant, a linear trend and level shift terms:

$$y_t = \nu_0 + \nu_1 t + d_{t\tau} + x_t \tag{3.7}$$

where dummy variable $d_{t\tau}$ is defined by $d_{t\tau}$=0 if t< τ and $d_{t\tau}$=1 if t $\geq \tau$. In our case, we do not have to consider trend and constant, because further

analysis is designed to cope with that. Therefore, to correct given series we use adjusted data from auxiliary regression:

$$\hat{x}_t = y_t - \hat{d_{t\tau}} \tag{3.8}$$

In our case, there are many events that could possibly change the mean of both alcohol or cigarette consumption and consequently decrease the power of the ADF test and distort cointegration tests. In order to account for this breaks we will adjust the test by including dummy variables for years in which the break took place.

We add their dummies representing the possible structural breaks one by one in the auxiliary regression. In the case, that the added dummy is insignificant, we do not include this dummy in the next step. On the other hand, if it is significant, we leave it in our model. We repeat this step until we test for significance of all considerable shocks to a given variable, which we will add to the auxuliar regression. In further analysis we use residuals from Equation 3.8 and create new variables.

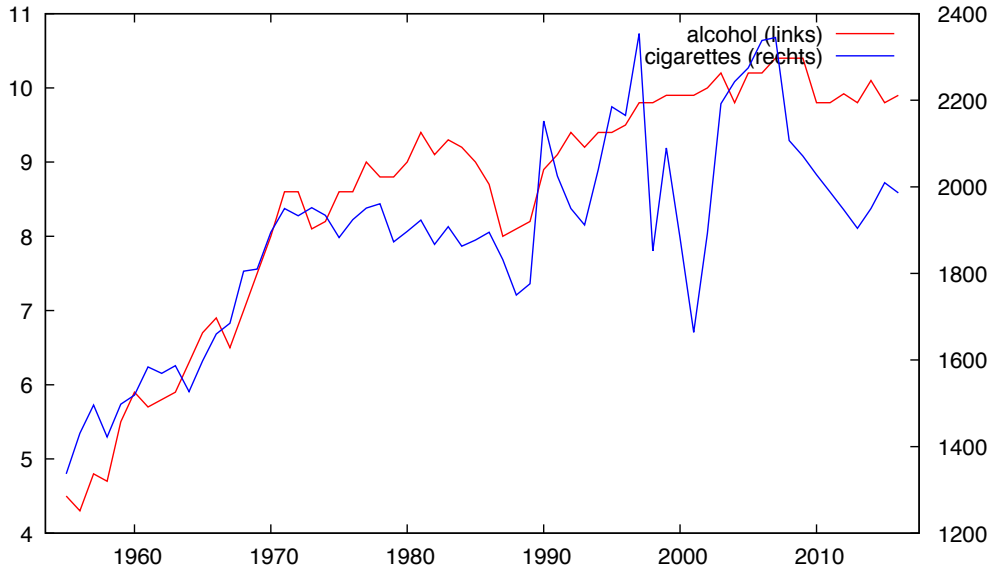
Chapter 4

Data

We use time series data about the consumptions of alcohol and cigarettes in the Czech Republic over the time period 1955-2016. The consumption of alcohol includes all beverages containing at least 0,5% of alcohol and is recorded in the value of pure alcohol per person. The consumption of cigarettes is recorded in pieces per person and does not include cigars and other tobacco products.

Aggregate data is gained by balance method based on results of animal production, final data on harvest of agriculture crops, production of specific Czech industry products, state of the initial and final inventory of agriculture organizations and food producers, export and import of food products and on information about self-supply of food products (ČSÚ 1956-2017).

Figure 4.1: Graph of both consumptions (1955-2016)



The data shows an increasing trend in the consumption of alcohol between

1955 and 1986 (see Figure 4.1). The consumption increased from 4.5 litres of alcohol per person in 1955 to 8.7 litres per person in 1986. In 1987 the consumption of alcohol experienced a slump to 8.0 litres per person and it stayed at this level until 1989. In 1990 the consumption returned on the level in 1986 and continued growing before reaching its peak at 10.4 litres of alcohol per person in 2009. Since then, the consumption has been moving around 9.9 litres per person. The series has its global minimum of 4.3 litres in 1956 and its global maximum of 10.4 in three consecutive years 2007, 2008 and 2009.

The figure for the consumption of cigarettes gradually increased from 1337 pieces per person in 1955 to 1950 pieces in 1971 (see Figure 4.1). After that, the trend reversed. From 1972 onwards, the figure for consumption of cigarettes slowly falled, reaching 1750 pieces per person in 1988. Similar level of the consumption also stayed in year 1989. After that, the consumption jumped to 2152 pieces of cigarettes in 1990 and a period of strong period of fluctuations followed with a minimum of 1664 pieces in 2001 and a maximum of 2345 pieces in 2007. In last three years of considered sample, the consumption of cigarettes stabilised at about 1980 pieces of cigarettes per person. The series has its global minimum of 1337 pieces in 1955 and its global maximum of 2345 pieces in 2007.

To capture possible structural breaks we created new dummy and trend variables. As it was described in the Section 3.4, dummy variable $d_{t\tau}$ is defined by $d_{t\tau}$=0 if t$< \tau$ and $d_{t\tau}$=1 if t $\geq \tau$. For example, dummy variable for 1989 is 0 for the time period 1955-1988 and 1 for the time period 1989-2016. We also created trend variables $t_{t\tau}$ that are defined by $t_{t\tau}$=0 if t$< \tau$ and $t_{t\tau} = t - \tau + 1$ if t $\geq \tau$.

Chapter 5

Results

At first, we tested for a unit root considering the whole time period 1955-2016. Based on the Schwarz criterium, we used one lag. Results of ADF test give a strong evidence for the presence of unit root in the consumption of alcohol. The p-value of the ADF test is 0.5153 for the original series and 5.96e-09 for the first differences (see Table 5.1).

Table 5.1: ADF test for the consumption of alcohol

Lags	1	2	3	4	5	6
BIC	0.489561*	0.550398	0.615142	0.618013	0.679094	0.744629

	p-value
ADF test on original series	0.5153
ADF test on first differences	5.96e-09

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

In the case of KPSS test, Schwert criterium suggests to use three lags. The p-value of KPSS test is lower than 0.01 for the original series and greater than 0.1 for the first differences, so the KPSS confirmed the results of the ADF test (see Table 5.2).

In the case of cigarette consumption, we used also one lag for the ADF test based on results of Schwarz criterium. Results of the ADF test suggest stationarity of the series at 5 % significance level, because the p-value is 0.04915 (see Table 5.3). The KPSS test for the consumption of cigarettes does not confirm the previous results and suggests a presence of a unit root (p-value of the original series is 0.38 and p-value of the test on the first differences is higher than 0.1, see Table 5.4). Therefore, we cannot say whether the series is stationary or not.

Table 5.2: KPSS test for the consumption of alcohol

	10%	5%	1%
Critical values	0.121	0.148	0.214
	Test statistic	p-value	# of lags
Test statistic of original series	0.294516	<.01	3
Test statistic of first differences	0.058595	>.10	3

Table 5.3: ADF test for the consumption of cigarettes

Lags	1	2	3	4	5	6
BIC	12.54419*	12.60267	12.67447	12.74619	12.81471	12.87046
			p-value			
ADF test on original series			0.04915			

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

Table 5.4: KPSS test for the consumption of cigarettes

	10%	5%	1%
Critical values	0.121	0.148	0.214
	Test statistic	p-value	# of lags
Test statistic of original series	0.167797	0.038	3
Test statistic of first differences	0.0307419	>.10	3

While previous analysis did not discover a unit root in the case of the consumption of cigarettes, we cannot test for cointegration. We assume that there is not enough evidence for a unit root, because the unit root tests lost some power due to probable structural breaks. Therefore, in the next step, we would like to control for these breaks.

We test dummies representing a shift in a mean in years 1989, 1993 and 2004 using the procedure explained in Section 3.4. Year 1989 was chosen, because a transition of power from a communist regime to a parliamentary democracy occured from 17th November to 29th December 1989. We chose year 1993, because new taxation system of alcohol and tobacco was implemented as was explained before. In 2004, there was a significant change in tax rates and the Czech Republic was integrated in the European Union and in 2001 there was a change in both the consumption tax and the tax on alcohol and tobacco. In addition, we test on significance of change in a trend of both the consumption

of cigarettes and the consumption of alcohol in 1989, because we believe that a new open economy could have changed not only the mean but also the trend.

In the case of the alcohol consumption, at first, only the trend variable for 1989 was added and was significant at 1% significance level (see model 1 in Table 5.5). After adding the dummy variable representing the shift in 1989 the trend variable lost its significance (see model 2 in Table 5.5). So the trend variable for the year 1989 was significant only if we tested for it without considering the dummy variable representing the shift in the mean in the same year. We assume that the significance of the trend variable was caused by a change of mean in the same year. So we left only the dummy variable representing structural change in 1989 and tested on the significance of other dummy variables. No additional variable was found significant. Therefore, we conclude that there was only one structural change in 1989 caused by change in a mean.

To correct for the structural break in 1989 we run auxiliary regression with the consumption of alcohol as a dependent variable and with a dummy variable for year 1989 as an independent variable (model 3 in Table 5.5) and save its residuals. These residuals are, in fact, original series without the structural break, the shift in the mean, in 1989.

Table 5.5: Tests on the significance of dummy variables and trend variable with the consumption of alcohol as a dependent variable

	t_{89}	d_{89}	d_{93}	d_{04}
model 1	1.31e-09 ***	-	-	-
model 2	0.7552	0.0001 ***	-	-
model 3	-	6.43e-13 ***	-	-
model 4	-	0.0029 ***	0.7486	-
model 5	-	2.40e-08 ***	-	-
model 6	-	4.41e-07 ***	-	0.8069

Notes: * significant at 10% significance level, ** significant at 5% significance level, *** significant at 1% significance level
dependent variable = the consumption of alcohol

In the case of cigarettes, we test also on a structural break representing a shift in a mean in 2001 when the advertisement on tobacco products was banned. We add it as the last tested variable.

The results are the same as in the case of the consumption of alcohol. Only the dummy variable representing the shift in the mean in 1989 is significant.

To correct for this structural break we run auxiliary regression with the consumption of cigarettes as a dependent variable and with a dummy variable for year 1989 as an independent variable and repeat the same procedure as in the case of alcohol.

Table 5.6: Tests on the significance of dummy variables with the consumption of cigarettes as a dependent variable

	t_{89}	d_{89}	d_{93}	d_{01}	d_{04}
model 1	2.48e-08 ***	-	-	-	-
model 2	0.9785	0.0002 ***	-	-	-
model 3	-	2.00e-11 ***	-	-	-
model 4	-	0.0043 ***	0.9080	-	-
model 5	-	2.26e-07 ***	-	-	0.8701
model 6	-	1.85e-06 ***	-	0.9580	-

Notes: * significant at 10% significance level, ** significant at 5% significance level, *** significant at 1% significance level
dependent variable = the consumption of cigarettes

If we control for the shifts in the means in 1989, there is an evidence for a unit root in both series. These results of the ADF test are confirmed by KPSS test with an exception of the ADF test on stationarity of the consumption of alcohol (see Table 5.7, Table 5.8, Table 5.9 and Table 5.10). The p-value of the ADF test on the consumption of alcohol without the structural break in 1989 is 0.5361. It is significant only at 10% level. However, given the results of the KPSS test and the fact that the p-value is almost significant at 5% level, we assume that the series has a unit root.

Table 5.7: ADF test on the consumption of alcohol without the structural break in 1989

Lags	1	2	3	4	5	6
BIC	3.517392*	3.586283	3.653202	3.724416	3.792525	3.863353

	p-value
ADF test on original series	0.5361
ADF test on first differences	1.699e-09

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

While both modified series have a unit root, we could test them on a cointegration relation. At first, we follow Engle-Granger procedure with the consumption of alcohol without the structural break in 1989 as a dependent variable and the consumption of cigarettes without the structural break in 1989 as

Table 5.8: KPSS test for the consumption of alcohol without the structural break in 1989

	10%	5%	1%
Critical values	0.121	0.148	0.214
	Test statistic	p-value	# of lags
Test statistic of original series	0.2109	0.012	3
Test statistic of first differences	0.0985583	>.10	3

Table 5.9: ADF test on the consumption of tobacco without the structural break in 1989

Lags	1	2	3	4	5	6
BIC	14.35562*	14.40645	14.47462	14.54371	14.61531	14.68552

	p-value
ADF test on original series	0.3939
ADF test on first differences	1.762e-10

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

Table 5.10: KPSS test for the consumption of tobacco without the structural break in 1989

	10%	5%	1%
Critical values	0.121	0.148	0.214
	Test statistic	p-value	# of lags
Test statistic of original series	0.199421	0.019	3
Test statistic of first differences	0.0872748	>.10	3

an independent variable. To test for another possibility of the Engle-Granger procedure, we run regression with interchanged variables and use one lag based on Schwarz criterium (see Table 5.11 and Table 5.12). Both ADF tests on a unit root in residuals of the series show that the residuals are not stationary. It means that there is not a cointegration relation.

Furthermore, we used Johansen trace test with one lag as it is suggested by Schwarz criterium. Results suggest that the rank of π matrix 0, which means that there is no cointegration relation (see Table 5.13). This result is in accordance with the results of the Engle-Granger procedure. So the series are not cointegrated.

Since 1989, changes in regulation of tobacco has been so frequent that it is

Table 5.11: ADF test on residuals of regression with the modified consumption of alcohol as a dependent variable

Lags	1	2	3	4	5	6
BIC	1.666984*	1.738481	1.810350	1.882160	1.952716	2.021905

	p-value
ADF test on the residuals	0.03508

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

Table 5.12: ADF test on saved residuals from regression with the modified consumption of cigarettes as a dependent variable

Lags	1	2	3	4	5	6
BIC	12.51949*	12.59137	12.66325	12.73497	12.80354	12.86834

	p-value
ADF test on the residuals	0.03658

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

Table 5.13: Johansen trace test with new variables

Lags	1	2	3	4
BIC	16.059041*	16.250493	16.498079	16.734261

Rang	Eigenvalue	Trace-Test	p-value
0	0.14461	10.628	0.2395
1	0.017872	1.1001	0.2943

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

even hard to say whether the consumption would increase or decrease without the external stimuls. So the unit root test could find an evidence for a unit root even if the evidence is created by multiple shocks and vice versa. Therefore, in further supplementary analysis, we consider only subsample 1955-1989, because there were no significant changes in the regulation of the considered commodities. We test the sumpsample 1955-1989 on the cointegration relation and repeat the same procedure as before.

Results of both the KPSS test and the ADF test showed that there is a strong evidence of a presence of a unit root in the case of both the consumption of cigarettes and the consumption of alcohol (see Table 5.14, Table 5.15, Table 5.16 and Table 5.17).

Table 5.14: ADF test on the consumption of alcohol (1955-1989)

Lags	1	2	3	4	5	6
BIC	0.756789*	0.858057	0.959121	1.029451	1.129127	1.211565

	p-value
ADF test on original series	0.9703
ADF test on first differences	7.114e-05

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

Table 5.15: ADF test on the consumption of cigarettes (1955-1989)

Lags	1	2	3	4	5	6
BIC	10.76377*	10.87926	10.98330	11.07401	11.18990	11.28938

	p-value
ADF test on original series	0.9443
ADF test on first differences	1.277e-05

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

Table 5.16: KPSS test for the consumption of alcohol (1955-1989)

	10%	5%	1%
Critical values	0.122	0.149	0.211
	Test statistic	p-value	# of lags
Test statistic of original series	0.223444	<.01	3
Test statistic of first differences	0.0773371	>.10	3

Table 5.17: KPSS test for the consumption of cigarettes (1955-1989)

	10%	5%	1%
Critical values	0.122	0.149	0.211
	Test statistic	p-value	# of lags
Test statistic of original series	0.234736	<.01	3
Test statistic of first differences	0.0681106	>.10	3

Engle-Granger procedure did not find enough evidence in both possibilities to reject the hypothesis of a unit root (a dependent variable in the regression is either the consumption of alcohol or the consumption of cigarettes, see Table 5.18 and Table 5.19). It means that the series are not cointegrated. We also run Johansen trace test for the sumsample 1955-1989. Results of the test show

that the rank of π matrix is 0. In other words, Johansen trace test suggests that there is no cointegration relation (see Table 5.20). From the results of the Johansen test and the Engle-Granger procedure we conclude that there is no cointegration relation between the consumption of alcohol and the consumption of cigarettes in the period 1955-1989.

Table 5.18: ADF test on saved residuals from regression with the consumption of alcohol as a dependent variable (1955-1989)

Lags	1	2	3	4	5	6
BIC	1.168098*	1.283794	1.399676	1.435484	1.534230	1.571730

	p-value
ADF test on the original series	0.08994

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

Table 5.19: ADF test on saved residuals from regression with the consumption of cigarettes as a dependent variable (1955-1989)

Lags	1	2	3	4	5	6
BIC	10.75759*	10.87346	10.98927	11.05466	11.16419	11.17996

	p-value
ADF test on the residuals	0.05066

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

Table 5.20: Johansen trace test (1955-1989)

Lags	1	2	3	4
BIC	11.408370*	11.710660	11.729347	11.969175

Rang	Eigenvalue	Trace-Test	p-value
0	0.26679	10.745	0.2316
1	0.0056837	0.19380	0.659

Notes: * our minimum when tested up to 12 lags using the Schwarz criterium

Chapter 6

Discussion

We tested for a unit root in the consumption of alcohol and the consumption of cigarettes in the Czech Republic, because it is a necessary condition for testing a cointegration relation between these two series. We found out that both series have a unit root when controlled for a structural break, shift in a mean, in 1989. There is also evidence for a unit root in both series when only the period 1955-1989 is considered.

Then we tested for the cointegration itself. Engle-Granger procedure did not find enough evidence for a cointegration relation in both cases, in the whole sample without the structural break in 1989 and in the subsample considering only the era of communism in the Czech Republic. Johansen trace test suggests that there is no cointegration relation either. So it confirmed the results of the Engle-Granger procedure.

The findings of a presence of a unit root has an important implication on studies using the consumption of alcohol and the consumption tobacco in regressions. If these studies do not take into account that there is a unit root in both series, it could lead to a spurious regression. As Enders (2010) mentioned, a spurious regression has a high R^2 and also t-statistics that appear to be significant. Hovewer, the results of a spurious regression are with no economic meaning. Many studies used the original series without diagnostic tests such as the ADF test. Therefore, our results show the coefficients of these studies could be biased.

The analysis is a pioneer in this area in the Czech Republic and we acknowledge that it suffers from drawbacks. We would divide these problems into two groups. First group of problems is connected with an imprecision of unit root tests in a small sample with a low frequency of observations. As we analyze

annual data, we are not able to properly control for the structural breaks that did not always occur on the 1st of January. There are many changes in the regulation of alcohol and tobacco that affect both the consumption of cigarettes and the consumption of alcohol in the Czech Republic and occured in the middle of the year. For example, there is a change of the consumption tax rate on the 1st of May 2004. Possible decrease in a mean of the consumption is not detecable, because there is no significant shift. As it affects only the second half of 2004, the change in the mean is observed as a slow decline in the respective consumption.

As 90% of the changes occured before the year 1989, we analyzed subsample 1955-1989 in order to avoid problems with structural breaks. However, there is a problem connected with the small number of observations. The supplementary analysis with the subsample 1955-1989 is just on the cirical border of number of observations for the tests. The number of observations is just high enough to create a whole distribution for the tests. It means that one outlier could significantly change the results. So even the supplementary analysis did not solve the problem with the imprecision of the ADF and the KPSS test. Therefore, we suggest further analysis of both series in the future, because we will have more observations for the unit root and stationarity test. We believe that it would give us better results than in a current size of the sample.

Second group of problems is connected with the fact that we used aggregate data. It could hide rather complicated picture because of various alcohol content. The consumption of alcohol could be further divided into three subsamples: wine, beer and spirits consumptions. As spirits have much higher alcohol content compared to wine and beer, a lower number of new consumers of spirits is equivalent to a higher number of new consumers of beer or wine. Therefore, trends in the consumption of spirits have much bigger impact on an aggregate trend in the consumption of the whole population than the consumption of beer and wine. Consequently, it is hard to recommend actions towards healthy population in the case of the Czech Republic where tax rates are different for all three commodities.

In the case of cigarette consumption, the aggregate data is a good measure of negative effects, because there is no safe level of consumption as it was metioned in Section 2.2.

On the contrary, there is a generely assumed safe level of alcohol. Thus the reults also depend on a distribution of moderate, medium and heavy drinkers in the population, because there is a safe level of the alcohol consumption for

a specific group of people as mentioned in Section 2.2. The consumption of alcohol at lower levels in one sitting could have for the consumer more benefits than risks (Harvard School of Public Health). However, these consumers are not subject to the alcohol regulation. Therefore, based on the aggregate data we are not able to make recommendations for changes in the laws whose aim is to minimise the negative effects of alcohol. If we had an individual data, we would be able to substract the beneficial consumption of alcohol.

Chapter 7

Conclusion

This thesis analyzed a relationship between the consumption of tobacco and the consumption of alcohol since the consumptions of both of these commodities exert negative health and economic effects on the society.

Data on the consumption of alcohol the consumption of cigarettes in the Czech Republic over the time period 1955-2016 was used. The consumption of cigarettes was used as a measure of tobacco consumption, because the consumption of other tobacco products is negligible as mentioned by Csémy *et al.* (2017). The consumption of cigarettes is recorded in pieces per person and does not include cigars and other tobacco products. The consumption of alcohol includes all beverages containing at least 0,5% of alcohol and is recorded in the value of pure alcohol per person.

In order to test the cointegration relation using Engle-Granger procedure and Johansen trace test, we first tested both series on the presence of unit root using the KPSS test in a version with a deterministic trend and the ADF test with a linear deterministic time trend and a constant. We implemented Schwarz criterion to choose an appropriate number of lags used in the ADF test and Schwert criterion in the case of the KPSS test.

In the case of the cigarette consumption, results of both tests found enough evidence for a unit root. Regarding the consumption of alcohol, the ADF test found enough evidence for a presence of a unit root, but the KPSS test did not confirm it. Thus we could not test for cointegration.

Since we assume that structural breaks cause stacionarity of the tobacco consumption, we then control both for structural breaks and trends in both series. We found that both series have a unit root when controlled for the shift in a mean in 1989. However, the tests suffers from low frequency of

observations. As a majority of possible reasons for changes in a mean or a trend in both consumptions occured in the middle of the year, we are not able to detect all structural breaks. Moreover, most of the regulations occured after the year 1989. For that reason, we conducted the ADF test and the KPSS test considering only the period 1955-1989. Results of the test showed that there is a unit root in both series.

So the assumption of cointegration was satisfied. To test for the cointegration relation itself we followed the two-step procedure suggested by Engle and Granger and the trace test suggested by Johansen. Engle-Granger procedure did not find enough evidence for a cointegration relation in either the whole sample without the shift in 1989 or the subsample considering only the consumptions before 1989. Moreover, Johansen trace test showed that the rank of the matrix Π is equal to zero. In other words, there is no cointegration, which confirms the result of the Engle-Granger procedure.

We acknowledge that the analysis as a pioneer in this area in the Czech Republic suffers from several drawbacks. However, we believe that our results could be used to design future studies of the consumptions and consequently to make recommendations to laws regulating the consumption of both commodities.

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