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Smoking - Impact on the State Budget and its Fair Taxation

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Smoking - Impact on the State Budget and its Fair Taxation

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Abstract:
The paper addresses the impact of smoking in the Czech Republic in 2009. The aim is to describe the current facts of tobacco taxation, assess the mortality attributable to smoking, compute the impact of smoking on the Czech state budget, assess consumer price elasticity for cigarettes, and compute a fair excise tax on cigarettes for the Czech Republic as well as the tax which would maximise the benefits of smoking for the state budget. The author defines "fairness" as a situation in which there is no net redistribution of state budget funds between two groups of citizens: non-smokers and smokers. Smokers create benefits (for example, savings on pensions due to their earlier deaths) and costs (for instance, increased healthcare costs) for the state budget. The author searches for a tax rate that would balance smoking-associated costs and benefits. The tax which would maximise net revenues from smoking to the government is also evaluated.
These findings were computed for the Czech Republic, 2009: There were 20,693 deaths attributable to smoking. 2.281 billion cigarettes were sold illegally. The costs to the state budget caused by smoking were estimated to 30,032 million CZK, whereas the benefits to 77,637 million CZK. The consumer price own elasticity,

controlled for income, was evaluated to be -0.506. Based on these findings and regarding the size of black market, the specific excise tax rate for a cigarette piece to attain the fair taxation should be -0.57 or 4.28 CZK. The specific excise tax rate for a cigarette piece to attain the maximum revenues for state budget is 2.01 CZK.

Keywords: tobacco taxation, economics of smoking, mortality and morbidity caused by smoking, smoking-attributable fractions, Czech Republic

JEL: H21

Abbreviations:

CDC Centers for Disease Control and Prevention
CSSA Czech Social Security Administration
CZK Czech crown code (currency unit)
CZSO Czech Statistical Office
FRS Fire Rescue Service of the Czech Republic
MLSA Ministry of Labour and Social Affairs
VAT Value Added Tax
VZP General Health Insurance Company of the Czech Republic

1 Introduction

Tobacco is a controversial commodity, mainly because its consumption has an adverse impact on health. In 2009, the Czech Republic had the twelfth highest per capita consumption out of 185 countries for which data were available (Tobacco Atlas)[1]. No source has provided unbiased and comprehensive analysis of the health impacts of tobacco consumption and its economic consequences in the Czech Republic so far. This paper should fill the gap. The author works with data from the Czech Republic for 2009. Just cigarettes are analysed, and not other tobacco products. There are two reasons for this. First, there is insufficient data available for other tobacco products. Second, Czech households spend 96.0% of their total tobacco spending[2] just on cigarettes[3].

Paper analyses the impact of smoking on mortality in the Czech Republic, the costs and benefits to the state budget caused by smoking, the price elasticity of smokers and finally, the rate of excise cigarette taxation that would equalise the costs and benefits of cigarette smoking to the Czech state budget is computed (as well as the excise tax rate maximising the revenue for a state budget from smoking).

The World Bank (1999, p.36) states that *"even if smokers reduce the net costs imposed on others by dying young, it would be misleading to suggest that society is better off because of these premature deaths. To do so would be to accept the logic that says society is better off without its older adults."* The author is not going to judge such a statement, because the aim is not to measure the impact of smoking on society, but on the state budget only.

1.1 Cigarettes Taxation

Smoking regulation may be divided into two main groups: non-price policies and price policies in a form of excise taxation. The author will model the impact of the changes of the latter. Detailed description of non-price policies is provided in Hait (2011).

Excise taxation is the most common method for regulating the demand for tobacco consumption. In the Czech Republic, it is in the form of the sum of a specific and ad valorem component. The specific component sets a fixed amount which must be paid for a cigarette piece, regardless of its retail price. The ad valorem tax is calculated as a percentage of the retail cigarette price. Then, there is also a minimal excise tax per cigarette piece which is the minimal amount that must be paid. In

[1] The average per head consumption derived by the Tobacco Atlas – 2,125 is a little bit higher than the figure obtained by CZSO (2010) - 2,071 for 2009. However, even if using the lower number and compare it with the Tobacco Atlas results, the Czech Republic would still be in twelfth place.

[2] Figure provided by Pavel Říha (CZSO). It is from 2010, data for 2009 is not available.

[3] According to the World Bank (1999, p.13), *"manufactured cigarettes and various types of hand-rolled cigarette now account for up to 85 percent of all tobacco consumed worldwide"*. Throughout the EU and the US, cigarettes accounted for over 90% of tobacco consumption (Cnossen, S., Smart, M. (2005)).

2009, the fixed component was 1.03 CZK, the variable one 28% and the minimal excise tax per piece 1.92 CZK (David 2010).

Denote retail price of a cigarette *p*, variable part of an excise tax *v*, fixed part of an excise tax (per piece) *f*, minimal excise tax revenue (per piece) *M*. Then, the amount of excise tax paid on one cigarette equals:

$$\max(f + vp; M)$$

After plugging in the figures for the Czech Republic for 2009:

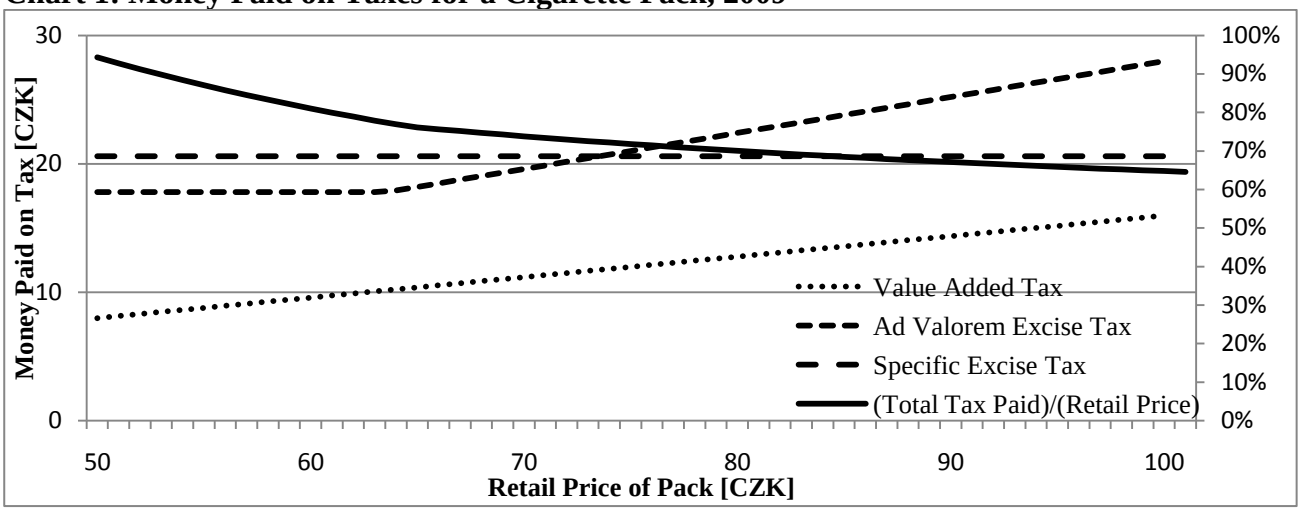
$$\max(1.03 + 0.28p; 1.92)$$

So, the cigarette producer pays the total excise tax 1.92 CZK for any cigarette with a retail price lower than 3.18 CZK. Cigarettes are also exposed to a value-added tax (VAT). It was set at the level of 19 %. The excise tax enters the tax base for the computation of the VAT. Therefore, the final tax pay-out of a cigarette's producer for a single cigarette is:

$$\max(1.03 + 0.28p; 1.92) + p\frac{0.19}{1.19}$$

The chart 1 depicts how much is paid on both excise and value-added tax based on the retail price of a pack (20 cigarettes).

Chart 1: Money Paid on Taxes for a Cigarette Pack, 2009



Source: Customs Administration of the Czech Republic (2011a), own computation

1.2 Size of Consumption

The official domestic consumption of cigarettes per capita in 2009 in the Czech Republic was 21,727 million pieces (CZSO, 2010). The estimation of the size of black market with cigarettes should be added to get the total consumption. Table 1 shows the list of estimations of the size of the illegal cigarette market in the Czech Republic.

Table 1: Estimation of the Illegal Cigarette Market, Czech Republic

Author	Year of Estimation	Share of Smuggling to the Official Market
Joossens et al (2009)	2007	9.8%
Marek (2009)	2009	13.0%

Šárka Miškovská (Customs Administration of the Czech Republic)	2009	8.0%

Joossens et al result is not particularly relevant as it is not country specific, but only for a group of high-income countries. The author considers remaining estimates of the same importance, so the most reasonable way to reach a final figure is to weight both estimates equally. As a result, the percentage of smuggled cigarettes to the taxed ones sold in the Czech Republic was 10.5%. In conclusion, the total consumption of cigarettes in the Czech Republic in 2009 was 24,008 million pieces.

2 Smoking-Attributable Mortality

Diseases proved to be associated with smoking are divided into four main categories: neoplasms, cardiovascular diseases, respiratory diseases, and paediatric effects (Shultz, Novotny, & Rice, 1991, Thun et al, 1997, CDC, 2008). To quantify the estimated impact of first-hand smoking on mortality, the author used the "direct approach", calculating the fractions of individual mortality diagnoses that are attributable to smoking (SAF – Smoking Attributable Fractions). This is the most used method for calculating smoking-attributable mortality[4]. The relation for the computation of SAF for a given disease *a* is:

$$SAF_a = \frac{p_0 + p_1(RR_{1,a}) + p_2(RR_{2,a}) - 1}{p_0 + p_1(RR_{1,a}) + p_2(RR_{2,a})}$$

p_0 – Percentage of non-smokers in the population; a non-smoker is a person who has smoked less than 100 cigarettes in life

p_1 – Percentage of current smokers in the population; a current smoker is a person smoking more than 1 cigarette per day

p_2 – Percentage of former smokers in the population; a former smoker is a person who smoked more than 100 cigarettes in life but does not smokes any more

$RR_{1,a}$ – Value of the relative risk of death of current smokers vs. non-smokers for a given disease *a*

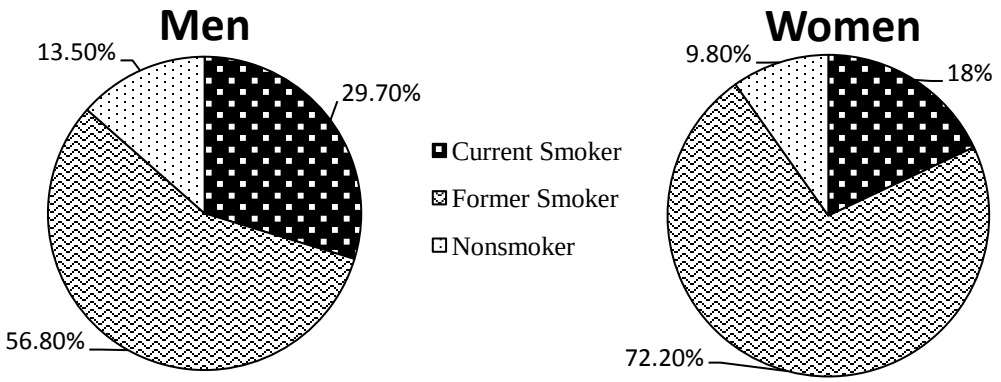
$RR_{2,a}$ – Value of the relative risk of death of former smokers vs. non-smokers for a given disease *a*

Smoking-attributable mortality can be evaluated by multiplying SAF with the actual population mortality data. To compute SAF, the current prevalence of smoking in the target adult (15+) population and the values of "relative risks" are required. The prevalence of smoking in the Czech Republic in 2009 was evaluated by Sovinova et al (2010). Separate values of the prevalence for men and women were not published in the study, but they were kindly provided to us by one of the authors, Petr Sadílek[5].

[4] It has been widely used by the U.S. Centers for Disease Control and Prevention (CDC) (2008). It has also been applied in European countries – for example Banegas et al (2005) for Spain, Walte et al (2000) for Germany.

[5] The outcomes of Sovinova et al (2010) study are not consistent with the cigarette consumption figures stated by the CZSO (2010) as described in Hait (2011). Therefore, there is a risk that the prevalence figures are not valid. But, there is no other big prevalence survey on the Czech data so the author must rely on Sovinova et al (2010) results.

Chart 2: Smoking Prevalence, Czech Republic, 2009



Source: Petr Sadílek

The values of the relative risk of illnesses and deaths associated with smoking are unavailable for the Czech population. According to Sovinová et al (2008, p.38), *"the application of relative risks values… (from other countries)… is a common procedure in those countries where these data are not available from domestic epidemiological studies"*. The author hence used the relative risks values published in Shultz, Novotny, & Rice (1991). They were later quoted for example by Thun et al (1997) and served as one of the inputs used by the CDC (2008) for various computations of the impact of smoking. They were also used in the study by Sovinová et al (2008). The research of relative risk has not progressed much since the beginning of 1990s so the relative risks by Shultz, Novotny, & Rice (1991) seems to be the most appropriate available[6].

For the information about the number of deaths caused by diseases for which the causality between smoking and that disease has been established (and hence RR values evaluated), the author used the data provided by the CZSO (2010a). Following the procedure described in Shultz, Novotny, & Rice (1991), only the deaths at the age of 35[7] and over for neoplasms, cardiovascular diseases and respiratory diseases[8] are considered. The author did the computation for the years 2000 and 2009. Chart 3 summarises the numbers of deaths from both reference years.

[6] Rehm et al (2006) used different relative risk values. The values are unpublished; however, they were kindly provided by one of the authors, Svetlana Popova. The study provides relative risks for fewer diseases than Shultz, Novotny, & Rice (1991). It also does not distinguish between sexes in most cases. Based on these facts, Shultz, Novotny, & Rice (1991) seem to be a better choice. Also, Shultz, Novotny, & Rice (1991) relative risks were personally recommended to the author of this paper by prof. Frank Chalupka, one of the most distinguished researchers at the field of tobacco mortality and taxation.

[7] The study does not directly describe why the threshold of 35 years is used.

[8] Following CDC (2008), the author also computed the deaths till the age of 1 in case of paediatric conditions (deaths of infants caused by smoking mothers during pregnancy). The obtained value for 2000 as well as 2009 was less than 5, therefore it is omitted from the analysis.

Chart 3: Mortality Caused by First-hand Smoking, Czech Republic

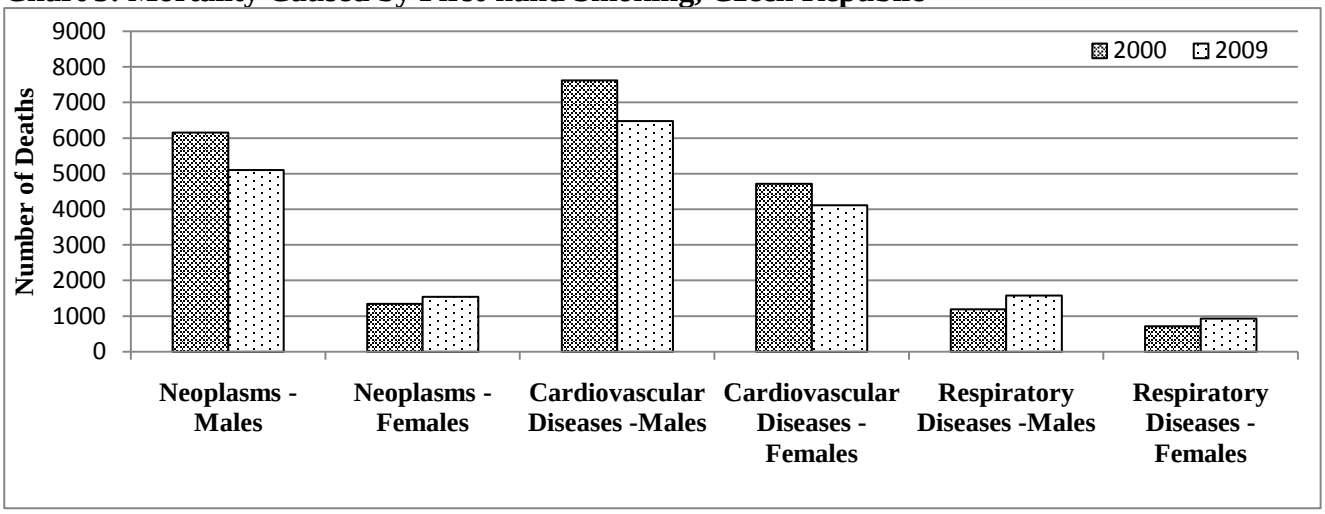


Table 2: First-hand Smoking-Attributable Mortality, Czech Republic

Year	Males	Females	Both sexes
2000	14,983	6,792	21,775
2009	13,173	6,597	19,770

Source to chart 3 and table 2: Shultz, Novotny, & Rice (1991), Sovinová et al (2010), CZSO (2010a), own computation

Comparing the results in table 2 with the sum of all deaths (provided in CZSO, 2010a), the first-hand deaths caused by smoking accounted for 20% of all deaths in 2000 and 18.4% in 2009 in the Czech Republic.

So far, just first-hand smoking was analysed. The mortality caused by second-hand (passive) smoking should be included as it is widely accepted that second-hand smoke is a significant source of health problems and deaths[9]. Very comprehensive and recent study of the impact of second-hand smoke on non-smokers was conducted by Oberg et al (2011). The methodology of Oberg et al (2011) is sketched below:

$$AM_a = SAF_{shs,a} * M_a = \frac{p(RR_a - 1)}{(p(RR_a + 1) + 1)} * (M_a - (M_a * SAF_a))(1 - p_s)$$

AM_a – Attributable mortality of a disease *a* to non-smokers
SAF_{shs} – Smoking attributable fraction of a disease *a* from second-hand smoking
M_a – Mortality of a disease *a* among non-smokers
p – Prevalence of second-hand smoking among adults
RR_a – Relative risks of a disease *a* for non-smokers
M_a – Total mortality of a disease *a*
SAF_a – Smoking attributable fraction of a disease *a*
p_s – Prevalence of first-hand smoking

Sources how to obtain p_s , M_a and SAF_a were introduced already, values of RR_a and p are provided in WHO (2010). Oberg et al (2011) recommend evaluation of the impact of second-hand smoking on both adults (three diseases caused by second-hand smoking identified – asthma, lung cancer and ischemic heart disease) and children (two diseases – asthma and lower respiratory infection). The results for children are negligible, as there were no child deaths at all in 2009 in the Czech Republic

[9] For example: Barnoya et al (2005) or Woodward and Laugesen (2001).

caused by the two diseases (CZSO, 2010a). The author obtained the following results for the Czech Republic:

Table 3: Second-hand-Smoke Attributable Deaths Differentiated by Disease and Sex, Czech Republic, 2009

Disease	Number of Deaths – Men	Number of Deaths – Women	Total
Asthma	4	6	10
Lung cancer	14	40	54
Ischemic heart disease	345	514	859
Total	363	560	923

Source: Oberg et al (2011), Sovinová et al (2010), CZSO (2010a), own computation

In conclusion, the number of deaths caused by both first-hand and second-hand smoking in the Czech Republic for 2009 was 20,693, accounting for 19.26% of all deaths. Based on Wilkstöm et al (2010), Engel et al (2008), Cataldo et al (2010), and other studies, health benefits of smoking are rather ambiguous, therefore they are not considered in the analysis.

Deaths Caused by Smoking, Divided by Age at Death

For computing the benefits and costs of smoking for the state budget, the distribution of deaths attributable to smoking over the age at death must be examined. CZSO (2010a) provides the number of deaths according to disease, sex, and age at death. Then, the author multiplied the number of deaths by the appropriate SAF coefficient and also added the effect of the second-hand smoke that was already evaluated.

In 2009, most men deaths for the age groups 35-54 and 80+ are caused by ischemic heart disease. The biggest threat for active and passive male smokers between 55 and 79 were neoplasms of the trachea, lung, and bronchus. The diseases causing the most deaths among female smokers are: cerebrovascular diseases for ages 35-44 at death; neoplasms of the trachea, lung, and bronchus for ages 45-69 at death, and ischemic heart disease for deaths at ages 70+. Table 4 provides the distribution of deaths at different age intervals.

Table 4: Number of Deaths Caused by Smoking Divided by Sex and Age at Death, Czech Republic, 2009

Age	35 - 39	40 - 44	45– 49	50 – 54	55 – 59	60 – 64	65 – 69	70 – 74	75 - 79	80 - 84	85 - 89	90 - 94	95+
Males	58	102	253	655	1336	2021	1806	1653	1967	1862	1376	302	144
Females	16	35	63	152	344	547	501	583	1031	1509	1562	529	286

Chart 4: Percentage of Deaths Caused by Smoking by Age, Czech Republic, 2009

Source to Table 4 and Chart 4: Shultz, Novotny, & Rice (1991), Oberg et al (2011, Sovinová et al (2010), CZSO (2010a), own computation

Whereas 32.18% of male deaths at age 60-64 are attributable to smoking, the percentage for females for the same age is just 18.24%. The ratio of deaths attributable to smoking to the all deaths is the highest in this age interval for both sexes.

3 Costs and Benefits Attributable to Smoking

The author computes the benefits and costs of cigarette smoking to the state budget during a one-year period. Based on the literature review[10] and its evaluation, the structure of costs and benefits is shown in table 5.

Table 5: Costs and Benefits Considered

Costs:	**Benefits:**
Healthcare	Excise tax+ Excess corporate tax
Widow and widower pensions	Retirement pensions
Disability pensions	Healthcare savings
Sickness insurance benefits	Retirement homes
Orphans pensions	Housing +Material Need benefits
Fires	

On the costs side, there are costs to healthcare, sickness benefits and disability pensions for people being ill or disabled because of smoking. In case of death of smoker, her relative receives widow(er) pensions or/and orphans pensions. Furthermore, there are also costs of fires caused by smoking.

On the benefit side, there is excise tax from cigarettes sold, the excess corporate tax paid by the only Czech cigarette producer (Philip Morris), and the savings on pensions and healthcare caused

[10] Habrová & Hrubá (2007), Arthur D. Little (2000), Ross (2004), Sovinová et al (2007), Sadílek (2001) (all of them done on Czech data), examples of studies on foreign data covered: Viscusi (1994), Doran et al (1996), Scollo et al (2008). Description and comparison of these studies is provided in Hait (2011).

by early deaths of smokers. The early deaths of smokers also generate benefits in terms of the smaller government expenses on retirement homes and also, the government spends less on social and material need benefits. The revenue from VAT is not considered since it is assumed that if a producer does not spend money on cigarettes, she buys other goods/services, from which VAT is also paid. The same logic describes why only excess corporate tax revenue, and not total corporate tax revenue, is added to the analysis.

Comparing the production of cigarettes of Philip Morris – 28.6 billion units (Philip Morris, 2010) and the official consumption in the country – 21.7 billion units, the conclusion is that the Czech Republic was a net exporter of cigarettes in 2009. Liemt (2002) evaluated the size of employment in the tobacco industry in the Czech Republic as only 1000 spots. Due to productivity improvements, it is most probably lower now. Therefore, the impact of cigarette consumption on the Czech labour market (production as well as supply chain activities) might be considered as negligible. It can be argued that there are also people employed in fields directly or indirectly linked to the tobacco products (e.g. tobacconists). However, the potential impact of the total ban of smoking in the economy on the labour market seems to be neutral in the short-term and rather positive in the long term (following Warner et al (1996)).

3.1 Costs

Healthcare

Sovinová et al (2007) evaluated the costs to three subgroups of healthcare: hospital care, ambulatory care, and medicals.

Table 6: Healthcare Costs Attributable to Smoking, Czech Republic 2002

	Costs [CZK million]
Hospital Care	6,145
Ambulatory Care	2,181
Medicals	2,951
Total	11,277

Source: Sovinová et al (2007)

The total healthcare expenses that year (2002) were 154,066 million CZK, so smoking-attributable expenses were 7.32% of the total health care expenses

To do the same analysis for the year 2009, the data about the costs of treatment according to specific illnesses are needed. These data were provided by VZP for Sovinová et al (2007) study, but they were not provided for this study. Therefore, Sovinová's results were used to obtain an estimate of the total healthcare costs for the Czech public state budget in 2009. There are two potential approaches.

It can be assumed that the real costs of treatment attributable to smoking are the same every year. In this case, Sovinová's results will be adjusted by price indexes to get the value for 2009. Specific

yearly price indexes for hospital care, ambulatory care and medicals were obtained from Barbora Serbusova (CZSO). Between 2002 and 2009, the price index of hospital care grew by 136%, ambulatory care by 102% and medicals by 41%. After adjustment, the total healthcare costs incurred by smoking in 2009 would be 23,069 million CZK.

Alternatively, it can be assumed that the share of smoking-attributable expenses from the total healthcare expenses is the same. In 2009, the total healthcare expenses of health insurance companies were 217,658 million CZK (CZSO, 2012). Multiplying that by 7.32%, which is the percentage of the smoking-attributable expenses, provides the result of the second estimation approach: 15,932 million CZK. The author thinks that the costs to healthcare treatment attributable to smoking may change widely with the changes of the healthcare system itself[11], whereas the ratio of the total healthcare expenses attributable to smoking should stay almost constant even with changes of the healthcare system. Therefore, the second approach is selected.

There is not much literature on the impact of second-hand smoking on healthcare costs. Collins & Lapsley (1992) as well as Doran & Sanson-Fisher (1996) estimated that second-hand smoke causes 10% of direct smoking costs. The comprehensive study conducted by Behan et al (2005) predicted the yearly US healthcare costs attributable to second-hand smoke to be 4,982 million USD, while the CDC (2011) stated that the healthcare costs attributable to direct smoking were 96,000 million USD. Based on this information, the ratio of second-hand smoking healthcare expenditures to direct smoking healthcare expenditures was 1:19. Let's assume the same ratio holds in the Czech Republic. Therefore, the total healthcare cost of second-hand smoking in 2009 was 838 million CZK. Summing up the healthcare costs of direct and second-hand smoking, the result is 16,770 million CZK.

Widow(er) Pensions

The payment of these pensions is based on the death of the husband/wife. In 2009, the government spent 23,825 million CZK on these pensions (Jan Škorpík, MLSA). Multiplying that with the estimate of the fraction of smoking-attributable deaths - 19.26%, the size of resulting cost is 4,589 million CZK. It may be argued that it is not possible to model the impact on widow and widower pensions caused by smoking because of following reasoning: if a male smoker dies earlier, his partner gets a widow's pension if she is still alive (= this is a cost for the government). However, the early death of a smoker also means that he will not get the widower's pension that he might otherwise get (if his partner dies sooner) (=this means revenue for the government). The author will leave such complicated scenarios aside.

[11] For example, assume that the funds for healthcare are increased by 20%. Then it can be assumed that the funds for curing smoking-attributable diseases goes up by 20% as well.

Disability Pensions

CSSA provides a breakdown of newly paid disability pensions for a given year for given ICD health classifications (CSSA, 2010). It does not provide the breakdown for specific diseases. Knowing the figures for specific diseases would make it possible to precisely construct the amount of disability pensions paid due to smoking, as the morbidity rate caused by smoking for specific diseases was already computed.

Let's assume that the volume of newly paid disability pensions divided by health classification represents the overall distribution of disability pensions by health classification. Diseases proved to be associated with smoking (Shultz, Novotny, & Rice, 1991) belong to the classifications I. (certain infectious and parasitic diseases) II. (neoplasms), IX. (diseases of the circulatory system), X. (diseases of the respiratory system), XIV. (conditions originating in the prenatal period) and XVIII. (symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified).

Now the author computes the relative morbidity rate caused by smoking for each of these groups by dividing the number of deaths caused by smoking that was computed already and the total number of deaths (again assuming that mortality rate = morbidity rate) which is provided by the CZSO (2010a). It was realised that number of people suffering from illnesses from groups I., XIV., and XVIII. is negligible, hence these groups of illnesses are not presented in results below.

Table 7: Ratio of Deaths Attributable to Smoking for Selected Diagnoses, 2009

Diagnosis	Deaths – smoking	Deaths – total	Ratio
	Male		
II.Neoplasms	5,124	15,673	32.69%
IX. Cardiovascular diseases	6,827	24,051	28.39%
X. Respiratory diseases	1,585	3,505	45.22%
	Female		
II. Neoplasms	1,585	12,391	12.79%
IX. Cardiovascular diseases	4,631	30,049	15.41%
X. Respiratory diseases	942	2,888	32.62%

Source: Shultz, Novotny, & Rice (1991), Oberg et al (2011, Sovinová et al (2010), CZSO (2010a), own computation

The numbers of people newly awarded full disability pensions in 2009 according to their diagnosis are presented in the table 8.

Table 8: Number of Newly Disabled

Full disability			Partial disability		
Diagnosis	**Male**	**Female**	**Diagnosis**	**Male**	**Female**
II.	2,255	2,278	II.	805	1,459
IX.	1,733	387	IX.	1,865	653
X.	306	119	X.	251	247
All	12,461	8,531	All	13,425	12,766

Source: CSSA (2010a)

Multiplying the ratio of deaths attributable to smoking in a given diagnosis by the ratio of newly disabled people with a given diagnosis to the all newly disabled people, and then taking the sum by sex and by diagnoses II., IX., and X, the result is that 8.37% of new full disability is caused by

smoking, and 4.86% of partial disability is caused by smoking. The expense paid by the state for full disability in 2009 was 44,380 million CZK (CSSA, 2010a). Multiplying that by 8.37%, the result is 3,715 million CZK. The expense paid by the state for partial disability in 2009 was 16,609 million CZK (CSSA, 2010a). Multiplying that by 4.86%, figure 808 million CZK is obtained. The sum of both figures shows that the burden for the state budget of disability pensions payments caused by smoking-attributable diseases is 4,523 million CZK. Formally:

$$C = E_f\left(\sum_i \sum_s d_{i,s} * N_{f,i,s}/T_f\right) + E_p\left(\sum_i \sum_s d_{i,s} * N_{p,i,s}/T_p\right)$$

where:

i –Variable denoting diagnosis
s –Variable denoting sex
$d_{i,s}$ –Ratio of deaths attributable to smoking in a diagnosis *i* of a sex *s*
$N_{f,i,s}$ –Number of newly fully disabled people with diagnosis *i* of a sex *s*
$N_{p,i,s}$ –Number of newly partially disabled people with diagnosis *i* of a sex *s*
T_f – Number of all newly fully disabled people
T_p –Number of all newly partially disabled people
E_f –Total expenses paid by the state for a full disability pension
E_p –Total expenses paid by the state for a partial disability pension
C –Cost for the state budget from paying disability pensions attributable to disabilities caused by smoking

Sickness Insurance Benefits

The mortality rate can serve as a proxy for the morbidity rate (Neubauer et al, 2006). 18,215 million CZK were paid in sickness benefits in 2009 (Jan Škorpík, MLSA). Multiplying that figure with the evaluated morbidity rate 19.26 %, it is concluded that the sickness benefits paid that were caused by smoking-attributable morbidity amounted to 3,508 million CZK.

Orphans Pensions

These pensions are defined as the financial assistance for students under 26 years who lost one or both parents. They are not available for young people who work already. To model the impact of deaths caused by smoking on orphans pensions, a few inputs are needed. Let's consider that the end of education process and start of work happens approximately at 23 year of age. The average age of women giving childbirth in 60´s and 70´s was 25 years, whereas children's fathers were 3 years older (see for instance CZSO (2011b)). The Czech fertility rate in 60´s and 70´s was 2.1 (CZSO (2011b)). The average orphan pension for 2009 was 5,130 CZK (CSSA, 2010a). Costs for government in terms of orphans pensions payments caused by a single adult death can be computed as follows:

$$\max(F*(A-(D-G))*P;0)$$

where

F – Fertility rate
A – Age when youths start working

D – Age of death of parent
G – Gap between age of parent and age of youth
P – Average yearly pension

Based on assumptions, only women's deaths till the age 48 and men's deaths till the age 51 are relevant, because older people are assumed to have children being not at school any more, hence these children are not permitted to obtaining orphans benefits. Summing up the figure over deaths[12] caused by smoking in 2009, the result which shows the loss for the state budget on the orphans pensions payments caused by deaths caused by smoking is 376 million CZK[13].

Fires

The fires caused by smoking are done so mainly by carelessly discarded stubs. FRS provides various structured time-series data about fires at the national level for the last ten years in its statistical yearbooks 2001-2009. It evaluates the direct costs of fires. Other figures needed to evaluate the total cost of fires caused by smoking are not presented in the statistics, hence the author interviewed two representatives of the FRS: Captain Radek Kislinger, official spokesperson of the General Directorate, and Commander Jiří Hošek, directing investigator of the causes of fires in the Prague region. They were asked for their qualified estimations of the missing figures needed.

Approximately 4% of all fires were proved to be directly caused by smoking, with direct damage amounting to 40 million CZK per year. 7% of fires in the Czech Republic are not classified with any official reason for the fire, because it was not possible to determine the cause. These fires are responsible for 20% of the direct damage caused by fires in the Czech Republic. Based on interviewees' estimations, 80% of these unclassified fires were caused by smoking. The level of direct damages of fires caused by smoking has been fluctuating widely, peaking at 2 billion CZK in 2002, and plummeting in 2009 to 218 million CZK, the lowest value over the last decade. These figures only cover damages to property and land caused by fire. The indirect costs, particularly the cost of firefighters' work and the depreciation of their equipment when extinguishing the fire, must be added as well. These costs are determined by the number of firefighters needed, the equipment used, the size, type, and location of the fire, and so on. According to Captain Kislinger, the indirect costs associated with one event can be averaged to 10,000 CZK.

The number of fires without any direct costs is also covered in the Czech Fire Rescue Service statistics. This mainly means fires that burn only grass and fires in landfills. These non-damaging fires still have indirect costs in the form of the work of firefighters who have to go to the fire site

[12] As having said, only deaths of women to the age 48 and men to 51 are considered.
[13] For example, a woman dying at 37 leaves 2.1 orphans who are 12 years old, and they finish school at 23, so they will obtain orphans benefits for 9 years. Whereas a man dying at 37 leaves 2.1 orphans who are 9 years old, so they will obtain orphans benefits for 12 years.

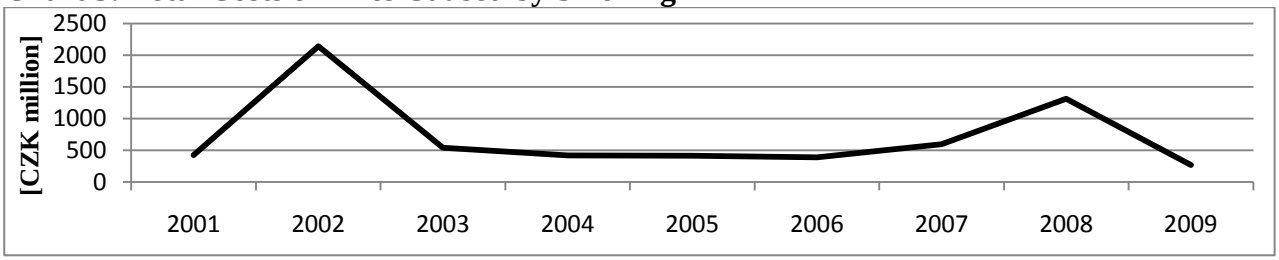
and check it. Based on the interviewees, the indirect cost of such non-damaging fire may be evaluated as 5,000 CZK.

Captain Kislinger estimated that 55% of these non-damaging fires were caused by smoking; Commander Hošek estimated the figure at 65%. These figures were obtained independently, so the final estimate was established as an arithmetic average.

Under all estimations mentioned above, the total costs of fires caused by smoking can be computed in a following way: $TC = S + T * 0{,}8 + (s + 0{,}8 * t) * 10 + N * 0{,}6 * 5$

TC – Total costs caused by smoking [CZK thousand]
S – Direct costs of fires caused by smoking [CZK thousand]
T – Direct costs of fires without classified cause [CZK thousand]
s – Number of fires caused by smoking
t – Number of fires without classified cause
N – Number of non-damaging fires
S, T, s, t and N are available in the annual FRS statistics

Chart 5: Total Costs of Fires Caused by Smoking



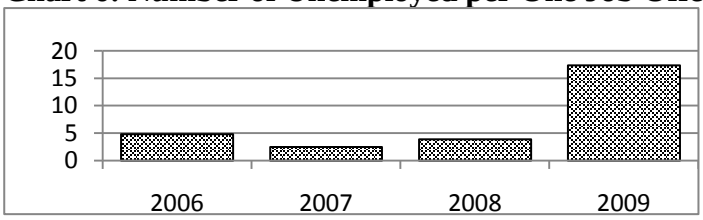
Source: FRS, Interviews with Captain Kislinger and Commander Hošek, own computation

In 2009, the total costs were 266 million CZK. There are additional costs not included in the analysis. The author omitted the treatment costs for any people injured during these fires, deaths caused by smoking-associated fires, legal and administrative costs and the costs due to lost productivity of the injured. There is no data on prediction of these variables. Hence the costs are in reality most probably higher than the estimation.

Income Tax, Social Insurance, Health Insurance Losses

Habrová & Hrubá (2007) assumed that if a person dies at a productive age, that person's employment will virtually disappear. Hence, the state would not get funds from the income tax of the person. However, the author finds it more reasonable to assume that if a person dies, that person is immediately replaced by another who was previous unemployed. This may be true especially for 2009. There were seventeen unemployed people per one job offering, so it can be assumed that any newly available positions were very quickly filled at that year.

Chart 6: Number of Unemployed per One Job Offering, Czech Republic



Source: CZSO public database (2011a)

Assuming that both persons get the same salary for the work, there is no loss in income tax for the state when somebody dies at productive age because of smoking. The author is aware of the limitations of the assumptions. Both his approach and that of Habrová & Hrubá (2007) are extreme. However, he considers his assumption to be closer to reality in 2009. The same logic applies for the obligatory payments of social and health insurance from the salary.

Lower Productivity

Ross (2004, p.185) states that *"The internal costs borne by private employers result from lower productivity among smoking employees, since they spend a certain percentage of their working hours pursuing their habit. In addition, smokers have more sick days, which represent additional losses to a company."* However, following standard free-market assumptions, the author considers that the remuneration is entirely determined by productivity of the worker, hence there are no losses for a company if a worker is spends less hours at work, this simply reduces her salary.

There are other costs not covered by this analysis as there is a lack of data. These are for example costs of cleaning up cigarette litter, transport accidents caused by smoking, anti-smoking campaigns or emotional losses caused by death.

3.2 Benefits

Net Tax Revenues

In 2009, the government revenues from excise tax on tobacco were 37,704 million CZK (Customs Administration of the Czech Republic, 2010). There is no information on the breakdown of the total tax revenue by the different kinds of tobacco products (cigarettes, cigars, and other tobacco). However, as mentioned already, the percentage of the total expenses on tobacco that customers spend on cigarettes was 96.0%. Data about the average price of cigars and packaged tobacco that creates the residual 4.0% are not available. But, the excise taxation and hence the state revenues for these products is very low in comparison with cigarettes (Custom Administration of the Czech Republic, 2010a). Therefore, the author assumes that the revenues from excise taxes on all tobacco products equal the revenues from excise taxes on cigarettes[14].

[14] However, under such an assumption, the state revenues from the cigarette excise tax is overvalued.

Concerning the corporate tax, it must be considered if the tobacco industry generates higher profits than the average. Philip Morris paid 676 million CZK in corporate taxes, when its total assets were worth 13,706 million CZK and its net profit was 2,506 million CZK (Philip Morris, 2010). Therefore, its Return on Asset (ROA) defined as the net profit divided by the value of total assets was 18.28%. The average ROA in Czech industry in manufacturing in 2009 was 2.87% (CZSO, 2011c). Let´s assume a manufacturing firm with the same value of total assets as Philip Morris, having standard ROA and paying standard 20% corporate tax. Such a firm would have paid 79 million CZK in corporate tax, so as a result, the government has corporate tax revenues of 601 million CZK more than if no cigarettes were produced[15] in the Czech Republic.

However, collecting taxes is costly. Customs Administration estimated the ratio of the administrative costs of collecting excise taxes to the tax revenue to be 1.5% (Customs Administration of the Czech Republic, 2010). For the estimation of the ratio of collecting corporate taxes, OECD (2011) can be used, which specifies the figure 1.46 % for the Czech Republic. If the tax revenues are taken and the estimated costs of collecting the taxes are deducted, a net taxation revenue reaching 37,138 million CZK from excise tax and 592 million CZK from excess corporate tax is obtained.

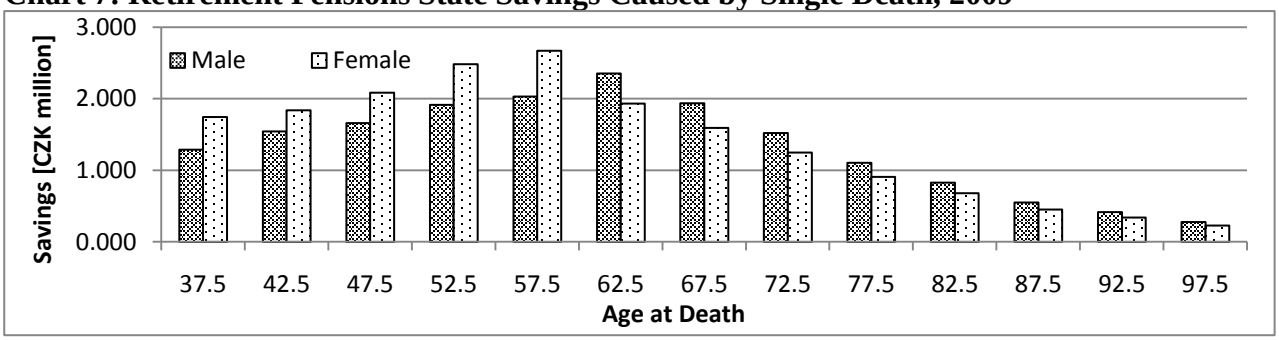
Retirement Pensions

The average monthly retirement pension was 11,189 CZK for men and 9,149 CZK for women in 2009 (MLSA, 2010). The average age for entering the pension in 2009 in the Czech Republic was 60 years for women and 62 years for men (Eurostat). Based on the new Czech Pension reform that passed in 2011, it will move up gradually. In the computation, the author assumes that the smokers who die early would otherwise reach pension at the age set up by the new reform, receive the average pension, and die at the age according to the life expectancy tables (CZSO, 2010b) [16]. Chart 7 shows savings for the state budget caused by the early death of one person.

[15] Here the author assumes that once there is no cigarette consumption in the Czech Republic, there would be also no cigarette production.

[16] For example, a female smoker dying at the age of 37.5 loses a retirement pension of 1.7 million CZK. The female life expectancy for age 37.5 is 44 years, hence she would have lived to 81.5 years. Subtracting the pension age for females born in 1972 – 66 years and 2 months, she would receive the retirement pension for 15 years 4 months. Multiplying that by the annual average retirement pension, the result is 1,744,688 CZK.

Chart 7: Retirement Pensions State Savings Caused by Single Death, 2009



Source: CZSO (2010b), MLSA, Eurostat, own computation

Referring to chart 7, the reason the state saves on average more on a person dying at the age of 42 than on a person dying at the age of 37 is the different life expectancies (see CZSO, 2010b). By multiplying the savings of a single death with the number of deaths caused by smoking divided by sex and age at death (already computed), female deaths caused by smoking saved 7,029 million CZK and male deaths 20,043 million CZK, making together 27,072 million CZK saved on retirement pensions[17].

Healthcare Savings

In the Czech Republic, much health treatment is provided free of charge by one of the health insurance companies to which the citizen is assigned. There is a legal constraint that a citizen must be assigned to one and only one health insurance company. If a person dies earlier from smoking, there is an excess benefit in forms of savings from the healthcare that must otherwise be provided. The average healthcare costs per an insured based on age and sex in 2009 is provided by Czech Health Statistics Yearbook 2010 (2011). This information is given in the table below:

Table 9: Average Annual Costs for Healthcare for 1 person in 2009 [CZK]

Age	**0-4**	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**
Male	17,242	10,016	9,687	8,950	7,676	8,425	9,683	10,584	13,584
Female	15,328	8,455	9,569	10,996	10,952	14,661	16,024	15,341	15,952
Age	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Male	15,763	22,004	30,305	39,201	48,327	56,804	64,373	64,138	63,875
Female	19,127	23,495	26,695	31,967	39,622	45,758	53,068	55,503	57,742

Source: Czech Health Statistics Yearbook 2010 (2011)

Using the number of deaths due to smoking divided by age of death that was already calculated, savings on healthcare due to those deaths can be found[18]. The author ran the computation for every sex and age interval.

[17] Disregarding the new Pension reform, thus assuming that the current average age of entering pension will be unchanged, would lead to the result 28,884 million CZK.

[18] The computation is done as follows (example): The number of deaths of females aged 35-39 is 16. The author assumed that the age at death for all of them is 37.5. The life expectancy at the age of 37 is another 44 years of life. One of these deaths thus results in the following savings for the healthcare system (using table 9 as an input): 2.5*15,341+5*15,952+5*19,127+5*23,495+5*26,695+….+1.5*55,503

Table 10: Healthcare Savings Due to Early Deaths Attributable to Smoking [CZK million]

Age at death	Males	Females
37.5	71	22
42.5	122	46
47.5	283	78
52.5	713	179
57.5	1,366	364
62.5	1,846	529
67.5	1,486	422
72.5	1,137	400
77.5	1,010	512
82.5	715	514
87.5	263	279
92.5	19	24
97.5	6	7
Sum	9,037	3,376

Source: Shultz, Novotny, & Rice (1991), Oberg et al (2011, Sovinová et al (2010), CZSO (2010a), VZP (2010), own computation

The total savings due to the early deaths of first-hand and second-hand smoking for 2009 were 12,413 million CZK. It is assumed here that the real value of the average annual healthcare costs in the future would be the same.

Retirement homes

By the end of the year 2009, there were 35,192 seniors accommodated in retirement homes (MLSA, 2010). The total governmental expenses for that year on retirement homes were 2,686 million CZK (Daniel Dárek, MLSA). There were 1,513,525 retirement pensioners (CSSA, 2010a)[19]. Hence the annual governmental cost per one retirement homes client per year was 76,324 CZK and the ratio of seniors accommodated in retirement homes was 2.32%.

For next piece of analysis, one assumption and 2 additional inputs are needed (valid for Czech Republic, 2009):

1. most common lowest age for becoming a client of a retirement home was 65
2. Distribution of deaths caused by smoking divided by age at death (evaluated above)
3. Life expectancy table (CZSO, 2010b)

Using these inputs, it can be derived that there were 200,001 potential years of life lost (PYLL[20]) by smoking that might be otherwise spent in the retirement home[21]. Multiplying that figure by the ratio of seniors accommodated in retirement homes and by the governmental cost per one client per year, we get 355 million CZK, which are the governmental savings on retirement homes caused by early deaths of smokers. Formally:

[19] Number obtained as an average of quarterly figures.

[20] For every person dying because of smoking, it is assumed that if she does not die because of cigarettes, she would live the expected number of years for his/her age-group – this information is available in life tables (CZSO (2010b)). The computation of PYLL is described in Hait (2011).

[21] For example, for man at age 37, the life expectancy is 75 years. Hence when a man dies due to smoking at 37, there is a loss of 10 years that he could otherwise spent in the retirement home.

$$S = \frac{C}{D} * \frac{E}{C} \sum_{i=1}^{n} max(A_i - B; 0) = \frac{E}{D} \sum_{i=1}^{n} max(A_i - B; 0)$$

S – State savings
i – Variable denoting people who died because of smoking
A_i – Potential age at death of a person who died earlier because of smoking
B – Most common lowest age for becoming a client of retirement home
C – Number of retirement pensioners accommodated in retirement homes
D – Number of retirement pensioners
E – Governmental expenses for retirement homes

State Social Support, Social Services, Material Need Benefits

State Social Support Benefits has an aim to help individuals/families with low income. They are divided into child, social, housing, parental, foster care, birth and funeral allowances.

Child, parental and foster care allowances are provided for low income people caring about a child. It might be assumed that the death of adult smoker, who is the recipient, does not change the payments of these allowances, they will be just redistributed to somebody else (another parent or foster who will care about the child).

Social allowances as well as social services benefits are payments for people when they care about a disabled person. In the analysis, this is the same case as above – the death of a person receiving these payments will just cause the redistribution of payments to another person[22] who will care about the disabled one.

Housing allowance helps people to cover their housing costs. It was received by 96 thousand households, the average monthly housing allowance was 1996 CZK in 2009 (CZSO (2010d)). The savings for a state occurs only if dies a person who obtains this allowance and lives alone[23]. There were 4,116 thousand households in 2009 (CZSO public database, 2011), hence the housing allowance was received by 2.3% of households. There were 1,180 thousand single households (CSZO (2010c)) and 8,659,802 adult population (CZSO (2010d)), so 13.6% of adults lived in single household. The deaths by smoking in 2009 caused in total 239,705 PYLL. Multiplying that figure with the ratio of adult population living in a single household, the ratio of households receiving the allowance, and the yearly housing allowance, the resulting figure describing the state savings is 18 million CZK. Formally:

$$S = \frac{N}{A} * PYLL * \frac{H}{B} * M$$

S – Yearly state savings
N – Number of single households
A – Number of adults in the population
PYLL – Number of potential years of life lost
H – Number of households receiving the allowance

[22] State savings on these payments caused by deaths of disabled people caused by smoking are not considered here.
[23] Otherwise the payments are just reallocated to the partner living with the person.

B – Number of households
M – Yearly average housing allowance

Material Needs benefits are provided as a general help for people with low incomes. There were 1,109 thousand of these benefits payments provided amounting to 3,089 million CZK (CZSO, 2010d), so the average amount was 2,785 CZK in 2009. Dividing the number of benefits payments to the total adult population, multiplying the product by PYLL and by the average amount of a single Material Need benefit payment, the resulting figure that may be defined as savings for the government on Material Needs benefits payment was 85 million CZK. Formally:

$$S = \frac{N}{A} * PYLL * \frac{T}{N} = \frac{T}{A} * PYLL$$

S – Yearly state savings
N – Number of benefit payments
A – Number of adults in the population
PYLL – Number of potential years of life lost
T – Total yearly government expenses on that benefit

The table 11 summarises the evaluated costs and benefits for the Czech state budget in 2009 caused by smoking:

Table 11: Resume of Costs and Benefits for the State Budget Caused by Smoking in 2009, [CZK million]

Costs		**Benefits**	
Healthcare	16,770	Net excise tax+excess corporate tax	37,730
Widow(er) pensions	4,589	Retirement pensions	27,072
Disability pensions	4,523	Healthcare	12,413
Sickness benefits	3,508	Retirement homes	355
Orphans pensions	376	Housing + Material need benefits	103
Fires	266		
Total	**30,032**		**77,673**

In total, smoking generated a net benefit of 47,637 million CZK for the state budget in 2009. The most relevant factors are benefits in form of excise tax income and retirement pensions savings.

4 Price Elasticity of Cigarette Consumer Demand

Following the literature review (see for example Gallet & List (2003)), the following regression is run on the macroeconomics data to obtain the aggregate own price elasticity of cigarette consumer demand:

$$\ln(Consumption_t) = \beta_0 + \beta_1 \ln(\mathrm{Pr}ice_t) + \beta_2 \ln(Income_t) + \varepsilon_t$$

where *consumption* is the per head consumption of cigarettes, *price* is the average retail price of cigarette pack, and *income* is the average income during selected period. The source of data for per capita consumption of cigarettes and the average annual nominal gross salary is the CZSO (2008, 2010, 2011a). As a measure of the average price of cigarette pack, the author uses the arithmetic

average of the cigarette packs in the consumer's consumption basket as defined by the CZSO[24]. The monthly prices of cigarettes in the consumer basket since 1991 were obtained from Pavel Říha, CZSO. The information on annual cigarette consumption per head has been provided since 1955, the average annual nominal gross income has been available since 1993. This restricts the dataset so that it begins in 1993. The monthly data of consumption and income are not available, so time series regression might be conducted for years only.

After running OLS estimation, all the OLS conditions are fulfilled except for the condition of no autocorrelation. The value of Durbin-Watson statistics is 1.15. The author was unsure about the specific form of the autocorrelation; hence the regression with Newey-West standard errors is used.

Table 12 – Regression Results

Variable	Estimated Coefficient	Standard Error	P value
Constant	5.1779	1.0617	0.000
Price	-0.5058	0.2458	0.059
Income	0.4525	0.2008	0.041

The whole model is significant at the 10% rejection rate. The observed estimation of the price elasticity is -0.506 (and the elasticity of the salary is 0.453, both significant at a 10% rejection rate[25]). That is similar to results in the other countries[26].

5 Optimal Tax Computation

In this chapter, computation of a fair excise tax rate and tax rate maximising the government revenue from cigarettes is provided. All main findings derived in the paper so far are used in the computation. It is assumed that the change of tax burden would be fully transmitted into the retail price. The changes of the specific tax rate are modelled, keeping the ad valorem rate constant[27]. The variables used are summarised in the table 13.

Table 13: Variables, Their Notation and Values Used in Computations

Notation	Variable	Value (year 2009)
C_0	Total costs to the budget caused by smoking before the tax change	30,032 million CZK
C_1	Total costs to budget caused by smoking after the tax change	*Unknown*
B_0	Total benefits to the budget caused by smoking before the tax change	77,673 million CZK
B_1	Total benefits to the budget caused by smoking after the tax change	*Unknown*
C	Relative own price elasticity of cigarettes	-0.506
T_0	Total excise tax revenue from cigarettes before the tax change	37,138 million CZK

[24] The information about the volumes of different brands of cigarettes sold is not publicly available.

[25] The author did the same regression, allowing the maximum lag (a parameter of the Newey West estimator) to be 2, 3 and 4, and in all cases, the coefficient of the price elasticity was significant at 10% rejection rate. There might be the spurious regression present, however, more observations are needed to analyse that.

[26] See for example Gallet & List (2003).

[27] The analysis for changes of the ad valorem rate is possible as well, only derivation the formula for computation would slightly differ.

r_0	Ad valorem tax rate (in % of retail price)	28%
t_0	Specific tax rate of one cigarette before the tax change	1.07 CZK
t_1	Specific tax rate of one cigarette after the tax change	*Unknown*
v	VAT for cigarettes (in %)	20%
P_0	Average retail price of one cigarette before the tax change	3.28
P_1	Average retail price of one cigarette after the tax change	*Unknown*
N_0	Number of cigarettes legally sold on the Czech Market before the tax change	21,727 million
N_1	Number of cigarettes legally sold on the Czech Market after the tax change	*Unknown*
I	Number of cigarettes sold on the Czech illegal Market	2,281 million

The analysis is divided into two parts. In the first one, the illegal market with cigarettes is not considered. In the second one, it is added into the model.

Omitting the Illegal Market

A fair excise tax rate is such a rate that:

$$C_1 = B_1 \tag{1}$$

The own-price elasticity is defined as follows:

$$c = \frac{\frac{\Delta N}{N}}{\frac{\Delta P}{P}} = \frac{\frac{N_1 - N_0}{N_0}}{\frac{t_1 - t_0}{\left(\frac{1}{1+v} - r_0\right)P_0}} \tag{2}$$

In the equation (2), there are two unknowns – N_1 and t_1. The relationship

$$\Delta P = P_1 - P_0 = \frac{t_1 - t_0}{\frac{1}{1+v} - r_0} \tag{3}$$

used in (2) is derived from the fact that total tax burden plus tax-free price equals the retail price including taxes. Denoting the tax-free price as *k*, the equation could be written in a following way:

$t_0 + r_0 P_0 - \frac{P_0}{1+v} + k = 0$ for the situation before the tax change

$t_1 + r_0 P_1 - \frac{P_1}{1+v} + k = 0$ for the situation after the tax change

From these two equations, (3) can be simply derived.

Let's assume that costs depend linearly on the number of smoked cigarettes[28]. Therefore, the costs after the tax change would be:

$$C_1 = \frac{C_0}{N_0} N_1 \tag{4}$$

Let's assume the same for benefits, except for excise taxes, because the exact benefit of excise taxes under the new tax regime can be computed. So then:

$$B_1 = \frac{B_0 - T_0}{N_0} N_1 + t_1 N_1 + r_0 P_1 N_1 \tag{5}$$

Substituting (3), (4) and (5) into (1):

$$\frac{C_0}{N_0} N_1 = \frac{B_0 - T_0}{N_0} N_1 + t_1 N_1 + r_0 \left(P_0 + \frac{t_1 - t_0}{\frac{1}{1+v} - r_0} \right) N_1 \tag{6}$$

[28] Analysing the elasticises of concrete benefit and cost factors to the number of cigarettes smoked may be a possible extension of this paper.

(6) can be divided by N_1 (under the assumption that the number of consumed cigarettes after taxation would not be zero), then

$$t_1 = \frac{\frac{C_0 - B_0 + T_0}{N_0} + r_0\left(\frac{t_0}{\frac{1}{1+v} - r_0} - P_0\right)}{1 + \frac{r_0}{\frac{1}{1+v} - r_0}} \tag{7}$$

The second solution is a case when N_1 equals zero. Then, using solely (2):

$$t_1 = \frac{N_0 c t_0 - N_0 P_0\left(\frac{1}{1+v} - r_0\right)}{c N_0} = \frac{c t_0 - P_0\left(\frac{1}{1+v} - r_0\right)}{c} \tag{8}$$

It is also possible to compute a tax rate that would maximise the revenue for the state budget. The setting of the optimisation problem is as follows:

$$\max\ (B_1 - C_1) \tag{9}$$

Inserting (4), (5) and (2) into (9) gives:

$$max_{t_1}\left\{\left[\frac{N_0 c(t_1 - t_0)}{P_0\left(\frac{1}{1+v} - r_0\right)} + N_0\right]\left[\frac{B_0 - T_0 - C_0}{N_0} + t_1 + r_0\left(P_0 + \frac{t_1 - t_0}{\frac{1}{1+v} - r_0}\right)\right]\right\} \tag{10}$$

Taking the first differentiation with respect to t_1 and putting it equal to zero:

$$t_1 = \frac{\frac{T_0 + C_0 - B_0}{N_0} - r_0 P_0 + \frac{r_0 t_0}{\frac{1}{1+v} - r_0} + \frac{t_0}{1 - r_0 - r_0 v} - \frac{P_0}{(1+v)c}}{1 + \frac{r_0}{\frac{1}{1+v} - r_0} + \frac{1}{1 - r_0 - r_0 v}} \tag{11}$$

For given figures, the second differentiation of (10) is negative, so (11) determines local maximum. Going to results, the specific tax rate equalising costs and benefits for the state budget is -0.58 CZK or 4.62 CZK. The second case implies the zero consumption of cigarettes. The rate maximising state revenue is 2.02 CZK.

Including the Illegal Market:

Cigarettes sold on the black market incur the same costs as cigarettes sold legally. They produce the same benefits, except for the tax revenue. Following Merriman et al (2000), the author assumes that the size of illegal market is constant, regardless of the retail price of cigarettes. So, denoting the size of illegal market as *I*, the cost after the tax change would be:

$$C_1 = \frac{C_0}{N_0 + I}(N_1 + I) \tag{12}$$

whereas the benefits after tax change would be:

$$B_1 = \left(\frac{B_0 - T_0}{N_0 + I}\right)(N_1 + I) + t_1 N_1 + r_0 P_1 N_1 \tag{13}$$

Incorporating (3), (12), and (13) into one equation results in:

$$\left(\frac{C_0 - B_0 + T_0}{N_0 + I}\right)(N_1 + I) = \left[t_1 + r_0\left(P_0 + \frac{t_1 - t_0}{\frac{1}{1+v} - r_0}\right)\right] N_1 \tag{14}$$

The own-price elasticity is now defined as follows:

$$c = \frac{\frac{\Delta N}{N}}{\frac{\Delta P}{P}} = \frac{\frac{N_1 - N_0}{N_0 + I}}{\frac{t_1 - t_0}{\left(\frac{1}{1+v} - r_0\right)P_0}} \tag{15}$$

It is different from the price elasticity defined in case a) in only one respect: the basis for the total consumption is now extended by adding the size of illegal market. From (15), it is clear that:

$$N_1 = \frac{(N_0 + I)c(t_1 - t_0)}{P_0\left(\frac{1}{1+v} - r_0\right)} + N_0 \tag{16}$$

Inserting (16) into (14):

$$\left(\frac{C_0 - B_0 + T_0}{N_0 + I}\right)\left[\frac{(N_0 + I)c(t_1 - t_0)}{P_0\left(\frac{1}{1+v} - r_0\right)} + N_0 + I\right] = \left[t_1 + r_0\left(P_0 + \frac{t_1 - t_0}{\frac{1}{1+v} - r_0}\right)\right]\left[\frac{(N_0 + I)c(t_1 - t_0)}{P_0\left(\frac{1}{1+v} - r_0\right)} + N_0\right]$$

After a simple transformation:

$$(C_0 - B_0 + T_0)\left[\frac{c(t_1 - t_0)}{P_0\left(\frac{1}{1+v} - r_0\right)} + 1\right] = \left[t_1 + r_0\left(P_0 + \frac{t_1 - t_0}{\frac{1}{1+v} - r_0}\right)\right]\left[\frac{(N_0 + I)c(t_1 - t_0)}{P_0\left(\frac{1}{1+v} - r_0\right)} + N_0\right] \tag{17}$$

The only unknown variable in equation (17) is t_1. This is a quadratic equation. So again, there are two results for a fair excise fixed tax rate per cigarette piece: the first is -0.57 CZK and the second "trivial" one 4.28 CZK.

In case of revenue maximisation, the following task is run, using (3), (12), (13), and (16):

$$max_{t_1}\left\{\left[t_1 + r_0\left(P_0 + \frac{t_1 - t_0}{\frac{1}{1+v} - r_0}\right)\right]\left[\frac{(N_0 + I)c(t_1 - t_0)}{P_0\left(\frac{1}{1+v} - r_0\right)} + N_0\right] - (C_0 - B_0 + T_0)\left[\frac{c(t_1 - t_0)}{P_0\left(\frac{1}{1+v} - r_0\right)} + 1\right]\right\} \tag{18}$$

The same as in the previous case, it can be shown that it has a unique local maximum. This reveals that the specific rate maximising the net revenue for the government would be 2.01 CZK. Chart 8 depicts the net revenue for a government based on a specific excise tax rate. The assumption that the consumption cannot be negative is incorporated there.

Chart 8: Net Revenue from Cigarette Taxation

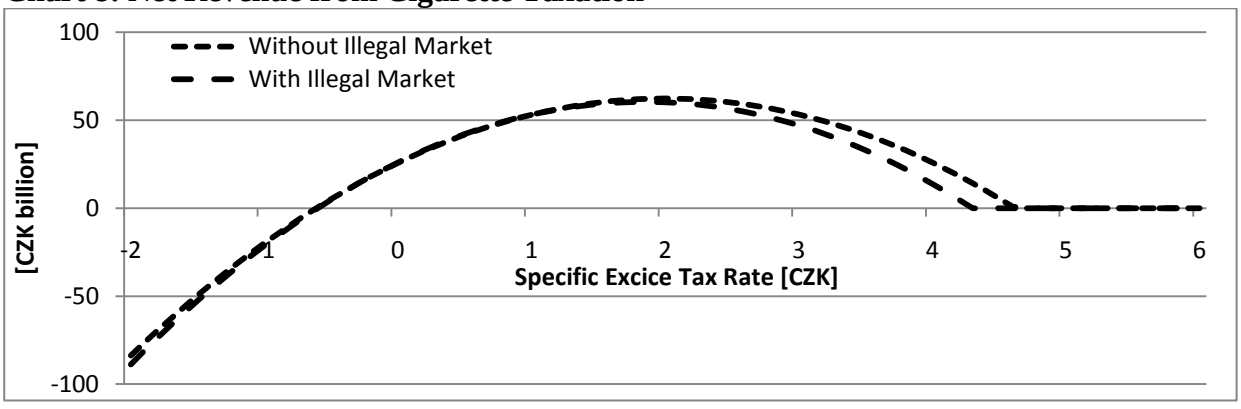


Table 14: Tax Rates Suggestions

	Specific tax rate [CZK]	Taxed cigarette consumption [CZK million] (N_1)	Retail price per cigarette [CZK] (P_1)
Omitting the illegal market			
Fair taxation (1)	-0.58	31,479,489,248	0.37
Fair taxation (2)	4.62	0	9.77

State budget revenue maximisation	2.02	15,730,127,729	5.07
Including the illegal market			
Fair taxation (1)	-0.57	32,436,565,833	0.39
Fair taxation (2)	4.28	0	9.15
State budget revenue maximisation	2.01	15,167,390,927	5.05

In the model, it was assumed that the change in retail price as well as the change in demand initiated by the change in taxation would take place immediately. In reality, these transitions take time. There are possible extensions of the model. For example, some studies conclude that the size of the illegal cigarette market is negatively dependent on the retail price of cigarettes (World Bank, 1999).

6 Conclusion

In the Czech Republic in 2009, there were 20,693 deaths caused by smoking, which accounted for 19.26% of all deaths. The current cigarette excise taxation is such that smokers are beneficial for the state budget. Smoking caused costs for the government budget amounting 30,032 million CZK and benefits 77,673 million CZK. The price elasticity of smoking, controlling for income, was -0.506. A fair specific excise tax rate that would neutralise the impact of smokers on the state budget should be either -0.57 CZK or 4.28 CZK. The latter case is trivial, because the excise specific tax rate of 4.28 CZK or higher would cause taxed cigarette consumption to be zero. The rate maximising the revenue for state budget would be 2.01 CZK, bringing a net contribution amounting to 51,938 million CZK. The illegal cigarette market was evaluated as 10.5% of the legal market and considered in the computations. Some economists and doctors (for example Ross, 2004, Habrova & Hruba, 2007, Kralikova, 2011) claim that the consumption of cigarettes cause burden to the Czech state budget. This study says the opposite. It is the highest hope of the author that this paper will stir both academic and public rational debate about cigarette consumption and the impact on the state budget, replacing the ideological pleas that are currently widely present.

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