Institute of Economic Studies, Faculty of Social Sciences
Charles University in Prague

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Vojtech Korbelius
Michal Paulus
Tomas Troch

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Institute of Economic Studies,
Faculty of Social Sciences,
Charles University in Prague

[UK FSV – IES]

Opletalova 26
CZ-110 00, Prague
E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Institut ekonomických studií
Fakulta sociálních věd
Univerzita Karlova v Praze

Opletalova 26
110 00 Praha 1

E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

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Life Expectancy and its Determinants in the Czech Republic

Vojtech Korbelius
Michal Paulus[a]
Tomas Troch[a]

[a]Institute of Economic Studies, Faculty of Social Sciences, Charles University in Prague, Smetanovo nábřeží 6, 111 01 Prague 1, Czech Republic

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Abstract:
We model the life expectancy function for the Czech Republic using three types of explanatory variables: socio-economic, healthcare and environmental pollution factors. The paper presents the first life expectancy model of the Czech Republic and contributes to the existing literature also by the analysis of district level data and inclusion of environmental pollution variables. We found two qualitatively different life expectancy functions where one is applicable for men at the age of 45 and 65 and women at the age of 45 and the other is suitable for women at the age of 65. Key findings can be summarized as follows: only one healthcare factor was significant in all models simultaneously and environmental pollution factors were revealed as significant and should be included in other models of life expectancy function.

1 Introduction

Life expectancy, which is one of the key factors for measuring and comparing health, mortality, morbidity and development of countries in general, has become a topic of increasing importance in recent years. During the 20th century life expectancy has increased by 40 to 50 percent (Eggleston & Fuchs, 2013), which means that we live on average 30 years longer than at the start of the 20th century.

In the Czech Republic the situation during the 20th century has been similar to the developed parts of the world. The life expectancy of men (women) at birth in the Czech Republic in 2012 was 75 (81). E.g. the situation for Germany in 2012 was 79 (83).[1]

It is possible to single out two most important factors that helped life expectancy to increase in such a significant way. These were the introduction of basic hygiene conditions of life and democratization (Lin et al., 2012; Mackenbach, Hu & Looman, 2013; Miller Jr. & Frech, 2000; Shaw et al., 2005).

The key intuition behind the impact of democracy is stemming from the voting rights of citizens, whose needs include high-quality and efficient healthcare (see e.g. Lin et al., 2012). Europe experienced two waves of democratization during the past 100 years (Mackenbach et al., 2013), which have helped to create life expectancy gap between Middle-Eastern Europe and Western Europe.

The second reason for the major increase in life expectancy was the improvement in sanitation of cities and villages through the introduction of sewerage and clean water supply (Miller Jr. & Frech, 2000; Shaw et al., 2005).

The goal of this paper is to determine the factors influencing life expectancy in the Czech Republic. These factors were traditionally divided into socio-economic factors (e.g. Auster, Leveson & Sarachek (1969) who first showed the impact of income on life expectancy) and healthcare factors, where a special focus has been paid to pharmaceuticals consumption, which is increasing in recent years and is linked to life expectancy (for a list of studies see Shaw et al., 2005).

In addition to these traditionally factors, we study in our paper the effects of environmental variables. Even though there have been studies focusing on the way how pollution affects life expectancy (Pope, Ezzati & Dockery (2009) who found that regions with lower air pollution in the US experienced higher increases in life expectancy than regions with high air pollution), our study is

[1]Eurostat

the first to include such factors in a complex model.
We use Czech district level data and build an econometric model upon the work of Shaw et al. (2005), who used socio-economic, healthcare and lifestyle factors. The model is also inspired by Miller Jr. & Frech (2000) whose work was focused on consumption of pharmaceutical and by Chan & Kamala Devi (2015) who modeled life expectancy on district level.
Our results suggest that environmental variables are significant in all specifications of the life-expectancy model. In addition, we found that contrary to previous research the consumption of pharmaceuticals in Czech Republic has little effect on life expectancy. Further we discovered that the factors influencing life expectancy in the Czech Republic are the same for men at the age of 45 and 65 and women at the age of 45 with a small exception for women at the age of 65, for whom economic factors play lesser role while environmental pollution is more important.
The results provide policy-makers with relevant conclusion. Just two health care factors were significant in the model and none of them was significant across all models while the amount of poisonous oxides into the environment has been significant in all our models. Therefore besides focusing on improving healthcare, the policy-makers should also not neglect the environment and its protection.
The contribution of the paper is primarily empirical. It is the first study of the life expectancy determination in the Czech Republic that uses a comprehensive econometric model on district data and it is also the first study including environmental pollution variables into the complex life expectancy function.

2 Model & Methodology

2.1 Baseline model

Our baseline model is an extension of Shaw et al. (2005) and can be schematically described as follows:

$$\begin{aligned} LE_i = \beta_0 + \boldsymbol{\beta_1}\mathrm{SocioEconomicFactors_i} + \boldsymbol{\beta_2}\mathrm{HealthCareFactors_i} \\ + \boldsymbol{\beta_3}\mathrm{EnvironmentalPollutionFactors_i} + \epsilon_i \end{aligned} \quad (1)$$

where LE is life expectancy, ϵ is the disturbance and betas are parameter vectors to be estimated. The subscript i stands for individual districts of the Czech Republic. There are few key differences and extensions compared to the work of Shaw et al. (2005). Firstly, due to the fact that we use data only from one country, our dataset is much more homogenous. Furthermore, in addition to traditional socio-economic and healthcare factors, we have included environmental pollution factors which are neglected in the previous research.
Following Shaw et al. (2005), our dependent variable is the life expectancy at 45 and 65 years. We do not consider life expectancy at birth because child right after birth is mainly influenced by the health conditions of the mother and her healthy or unhealthy habits. Hence it would be very complicated to find proper explanatory variables for life expectancy at birth.
Furthermore, life expectancy is calculated for four year intervals rather than for each year individually. The reason for longer period over which the life expectancy is calculated lies in the aim of excluding incidental phenomena that could have influenced only a small area in one year. The rule is: the smaller the region, the longer the period over which life expectancy is calculated. Therefore the life expectancy which we use in our model is calculated over the period 2008-2012.

2.2 Data description and explanatory variables

In our model we use two sources of data - Czech Statistical Office and Institute of Health Information and Statistics of the Czech Republic. We managed to get an observation for all districts (including Prague). Therefore we estimate our models using 77 observations.
We work with three categories of explanatory variables: socio-economic, healthcare and environmental pollution factors. Those explanatory variables that are expected to have cumulative rather than immediate effects are included with a lag.[2] To deal with gender inequality regarding the length of life (Shaw et al., 2005), we examine life expectancy for men and women separately.
The most often mentioned indicator from the socio-economic category is GDP (Ashraf et al., 2008; Eggleston & Fuchs, 2013; Leung & Wang, 2010). GDP describes the wealth of a nation and there is an implication that the richer the country the more they can invest in the healthcare system which would

[2] We use a 9 year lag, which is the largest one we could achieve with our available data for all explanatory variables simultaneously.

positively influence life expectancy.
Unfortunately there is no direct measure of GDP on district level at least not in the Czech Republic. For this reasons, we use unemployment rate and average wage which are measured on district level instead of GDP.[3] Substitution of GDP by unemployment is supported by e.g. Sogner (2001).
The category of healthcare factors is the most extensive one. We use the number of people per one doctor (Retzlaff-Roberts et al., 2004) as one of the factors, because less people means that doctors have more time for each patient. Other indicator mentioned in the work of Miller Jr. & Frech (2000) is the consumption of pharmaceuticals. They put an equal sign between higher pharmaceutical consumption and longer life expectancy. Other factors that we tried to include were the number of people per hospital, number of people per prescription, number of people per one pharmacist or number of hospital beds per 10000 people.
Tamakoshi et al. (2010) and Miller Jr. & Frech (2000) point out that life expectancy is often influenced by habits that people have. The worst of them is smoking. Other factors that can characterize life style can be found in Shaw et al. (2005) where they introduce the consumption of fruit and vegetable and the consumption of fat. Unfortunately even though those indicators are well-founded, they are not collected on district level in the Czech Republic and therefore we do not include them in our model.
It is generally acknowledged that older population consumes more health services than young population because of greater prevalence of diseases. Therefore following Shaw et al. (2005) we include the percentage of people over 65 in the population as an control variable to capture this effect.
There is one category of variables that have been usually omitted but which are of key importance. This category includes environmental pollution indicators. To our knowledge our study is the first one that examines the influence of the environmental pollution on the life expectancy.
There are two main indicators that can be observed in connection with environmental pollution. First of all we can measure the amount of chemicals in the air or water or we can calculate how much money has been invested in preventing nature from being destroyed. Pautrel (2009) states that environmental pollution shortens the average longevity of people.

[3]Furthermore, Blackman (2011) points out that GDP is not necessarily the best measure of wealth of a country and well-being of people living there. The reason is the lack of equality in distribution of wealth among the whole population.

Table 1 summarizes the variables which we included in our models.

Table 1: Explanatory variables

variable	variable shortcut	variable measurement	hypothesized effect on LE
Unemployment rate	U	percentage	negative
Amount of poisonous oxides in the environment	PoiOx	ton issued per year	negative
Investment into the environment	InvEnv	thousands of CZK	positive
Number of people per doctor	NPpDoc	number	negative
Revenue from pharmaceuticals	RPha	CZK	positive
A percentage of male at the age and over the age of 65	M65	percentage	positive
A percentage of female at the age and over the age of 65	F65	percentage	positive

Source: www.czsu.cz; www.uzis.cz

The complete list of explanatory and control variables, which we have tried to include in our model, can be found together with correlation matrix in appendix D. All appendices can be sent to a reader upon request.

3 Results and interpretation

3.1 Results

The key result of our paper is that environmental variables are significant in all considered model specifications and have a major impact on life expectancy. We consider four distinct models which differ in the choice of dependent variable - life expectancy for male and female at the age of 45 and 65 (labeled correspondingly "LEM45", "LEM65", "LEF45" and "LEF65"). All models are estimated using OLS. We drop all insignificant variables from the models in the presentations of our results. The following synoptic table summarizes our results:

Table 2: Coefficients overview

variable	LEM45	LEM65	LEF45	LEF65
lnU	-0.036***	-0.033***	-0.013***	x
	(0.005)	(0.009)	(0.005)	
lnPoiOx	-0.006***	-0.008**	-0.006***	-0.012***
	(0.002)	(0.003)	(0.002)	(0.004)
lnInvEnv	x	x	x	0.008**
				(0.003)
lnNPpDoc	-0.020***	-0.046***	-0.013*	x
	(0.007)	(0.012)	(0.007)	
lnRPhapP	x	x	x	0.028**
				(0.013)
lnM65	0.107***	0.124***	x	x
	(0.021)	(0.036)		
lnF65	x	x	0.093***	0.127***
			(0.022)	(0.037)
intercept	3.423***	2.828***	3.481***	2.341***
	(0.086)	(0.147)	(0.091)	(0.114)
R^2	0.753	0.585	0.521	0.398
$F_{(4,72)}$	54.81	25.391	19.568	11.893

The assumptions of all models hold and the models are robust to small changes in specification and to leverage points. The exact tests and their results, along with additional robustness checks, sensitivity analysis and leverage points analysis are included in appendices A and C.

3.2 Interpretation of the results

Because the first two models for men at the age of 45 and 65 are exactly the same and the model for women at the age of 45 has only one different variable - instead of percentage of men over 65 years old we consider the percentage of women over 65 years old - we have decided to interpret those models together. The results of the last model LEF65, which is different from the others, will be interpreted separately.

The variable “amount of poisonous oxides into the environment” has the smallest coefficient value. The coefficients of -0.006, -0.008 and -0.006 respectively are implying that if the pollution of the environment (poisonous oxides) increases by 10%, the life expectancy will decrease by 0.06%; 0.08% or 0.06% which means on average for men at the age of 45 the life expectancy would decrease by approximately one week (average LE is 31 years), for men at the

age 65 it would be 4 days (average LE is 15.1) and for women at the age of 45 it would be by 8 days (average LE is 36.3).
Even though those numbers seem small enough to be ignored we have to relate them to the amount of poisonous oxides in the environment. The average amount is 8580.8 t/km^2 but the maximum value in "Ostrava-city" is 107727.8, which means it is more than 12 times the average. This means that if every districts was issuing the same amount as "Ostrava-city" our LE would decrease by 84 days, 48 days or 96 days respectively. We can therefore conclude, that environmental pollution has non-negligible effects on life expectancy and should receive proper attention.
"Unemployment rate" as a replacement for GDP is supposed to represent the economic situation in the particular district. In our case the effects of lnU are -0.036; -0.033; -0.013 respectively. The interpretation in this case is as follows. Average unemployment rate was 10.88% so if we consider an increase in unemployment by 1% we will get the unemployment rate of 10.989%. In this situation the life expectancy decreases by 0.036%; 0.033% or 0.013% respectively. If we want to see the effects in the amount of days it is 4, 1.8 and 1.7. And this was an increase in unemployment rate by only 0.1088%. We can conclude that high unemployment rate can have significant consequences on LE.
Similar interpretation applies to the "number of people per one doctor" and "percentage of male/female over 65" in the population. Surprisingly, the "number of people per one doctor" is the only significant healthcare variable in these three models. In the phase of collecting the data we considered quite a big amount of possible healthcare factors - number of hospitals, number of individual outpatient facilities, number of pharmacists, revenue from pharmaceuticals, number of people per one doctor etc. We have tested many of them to make sure to find the most important ones (robustness check included in the appendix C). The lack of importance of other explanatory variables from the category of healthcare factors can be explained by a high correlation of all other factors with the "number of people per one doctor". This result is of important policy relevance. It reveals that any state policy focused on increasing life expectancy should be composed not only from health but also from environmental policies improving living conditions of inhabitants. The amount of poisonous oxides into the environment was even the only explanatory variable significant across all models.
The difference of the model for female life expectancy at 65 years is that instead

of "number of people per one doctor" we have in this model the "revenue from pharmaceuticals per person" as a health indicator. The effect is on average the same as the effect of "number of people per one doctor" in the previous three models. A possible explanation of this switch of variables may be that for women at the age of 65 the care of doctors is less important than for men because they need just the right pharmaceuticals that they have been using for quite some time. This explanation is supported by Asiskovitch (2010).

Furthermore, unemployment is not significant in this specification, contrary to "the investment into the environment", which was not significant in the three former models. The significance of environmental investment, along with high coefficient of "amount of poisonous oxides into the environment" (double compared to LEF45 model) suggests that environmental pollution plays a much bigger role compared to economic conditions for this part of population.

The last thing that we would like to mention is the positivity of coefficients of the percentage of the population over the age 65, which is in contrast to the negative coefficients of Shaw et al. (2005) (who unfortunately do not comment on these results). Our findings can be explained by the fact that older people of today are generally in good shape and suffer mainly from chronic diseases that lower the quality of life but not life expectancy. This is in line with the observation of Crimmins (2004) who points to the differences in morbidity between older people nowadays and thirty years ago.

4 Concluding remarks

The aim of this paper is to find the determining factors of life expectancy in the Czech Republic. Our empirical model is the first one to focus solely on the Czech Republic. Most of the models used in previous literature were international models explaining the variation of life expectancy across countries. Moreover the samples of the countries usually did not exceed 30 observations. Our sample that uses Czech districts is more than double and almost three times as big as the sample of Shaw et al. (2005) which is our benchmark study. Life expectancy determining factors has been investigated for many years without unanimous or time resistant conclusions. Such outcome is natural because of dynamic and enormous changes and development in healthcare.

There have been other changes as well - democratization, introduction of basic hygiene and sanitation and increase in education. In addition to these traditional factors, we decided to include a whole new category of variables.

Environmental pollution is starting to play an increasing role in all of our lives with major impacts on our longevity. We showed that environmental factors are statistically significant determinants of life expectancy in all considered models.

Beside this main conclusion of our paper we tested the impact of pharmaceuticals consumption. We have not found statistically significant relationship in three out of four models, which differs from the research done by Miller Jr. & Frech (2000), who found "consumption of pharmaceuticals" as a crucial variable.

We discovered that the factors influencing life expectancy in the Czech Republic are the same for men at the age of 45 and 65 and women at the age of 45 with a small exception for women at the age of 65, for whom economic factors play lesser role while environmental pollution is more important.

The results offer a relevant policy advice. Besides focusing on improving healthcare, the policy-makers should also not neglect the environment and its protection because the environmental factors are not only significantly correlated with the life expectancy but they are also the most robust group of determinants in our models.

The biggest drawback of our study is the absence of lifestyle factors (consumption of alcohol, tobacco, fruits etc.), which are not easily available for the Czech Republic. Their inclusion is therefore our recommendation for further research.

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Appendix A Leverage points

Figure A1: Leverage points M45

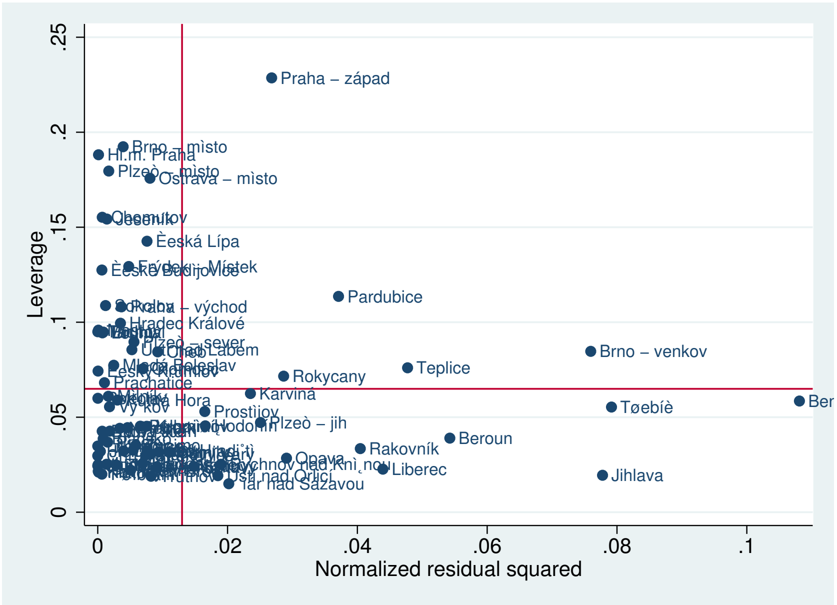


Figure A2: Leverage points M65

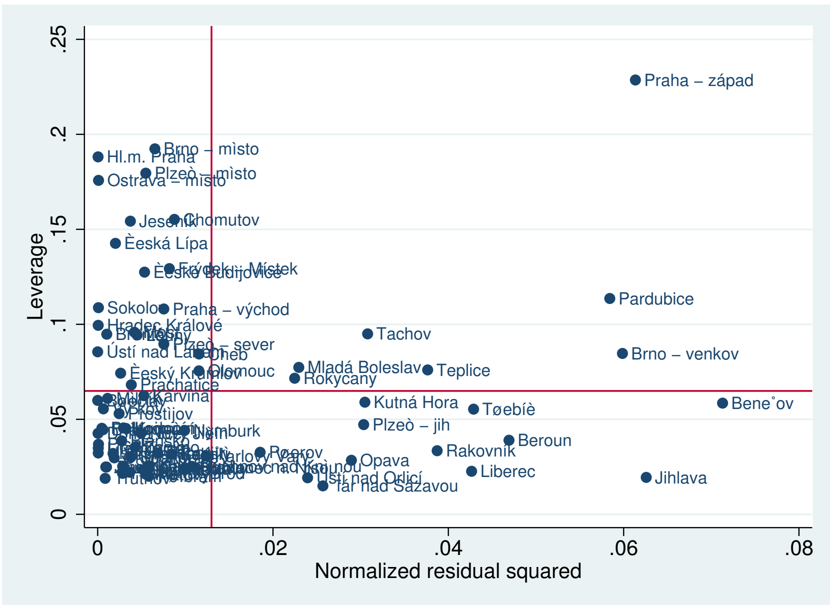


Figure A3: Leverage points F45

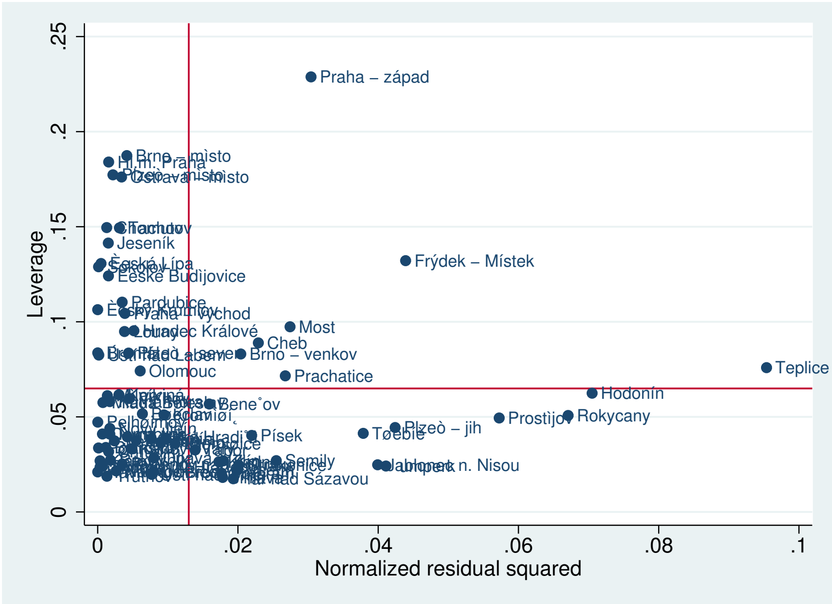
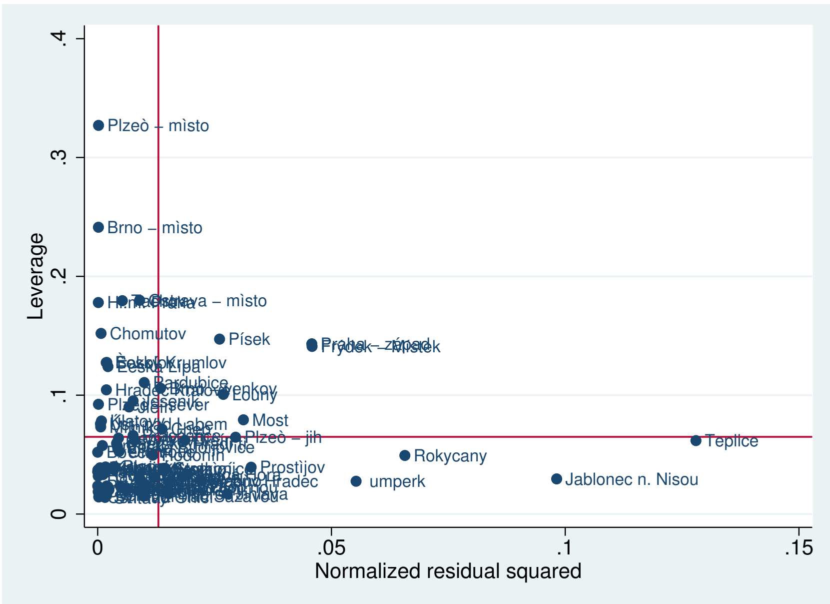


Figure A4: Leverage points F65



Appendix B Complete list of variables

We have estimated our models using following explantory and control variables:

- Number of people per hospitals (NPpH)
- Number of people per outpatient facilities (NPpOF)
- Number of people per one doctors (NPpDoc)
- Number of people per one pharmacy (NPpPh)
- Number of people per prescriptions (NPpPre)
- Revenue for pharmaceuticals per one person (RpPhapP)
- Number of people per one pharmacists (NPpPhar)
- Number of hospital's bed per 10000 people (NPp1HP)
- Average monthly salary before taxes (AW)
- Unemployment rate (U)
- Percentage of deaths in the population (D)
- Percentage of people over 65 in the population (M65+ or F65+ depends on the sex)
- The amount of solid particels issued into the environment (t/km^2) (solid)
- The amount of poisonous oxides (SO_2, NO_2, CO) issued into the environment (t/km^2) (PoiOx)
- Index of aging (IAM/IAF for male/female)
- Investment into the environment (InvEnv)

The description and of the variables follows:

- Expected length of life at 45/65 (dependent variable) - "The life expectancies at the age 45 and 65 years express the average number of years to be lived by the table person at given age. They are the results of completed life tables prepared for each administrative districts of municipalities with extended powers separately for men (ExpLfM45, ExpLfM65) and women

(ExpLfW45, ExpLfW65) using the indirect method of calculating the probability of dying, one-year age interval, and for the reason to eliminate random fluctuations they are calculated for five-year calendar period. Detailed methodology of computation of all indicators of life tables is the part of the regular annual publication Life tables for the Czech Republic, Areas and Regions (http://www.czso.cz/csu/2013edicniplan.nsf/engp/4002-13; as "alpha" fixed value (0.86) was used, corresponding to the long-term average of this indicator for the whole Czech Republic). The numbers of deaths, live births and inhabitants (as of midyear) by sex and age in each calendar year of given period were input data. Population figures used since 2011 are based on the final results of the Population and Housing Census 2011."

- Average salary before taxes - This variable is expressing average salary of employees during the year 2003 before taxes, excluding enterprises with 20 employees and fewer. (Enterprise method)
- Unemployment rate - Unemployment rate is expressing the percentage of people in a work force that on average did not work during the year 2003.
- Index of aging - This variable is describing the average percentage of people over 65 in the population during the year 2003.
- Number of people per one doctor - By this variable we can measure the number of people that one doctor has to take care of on average during the year 2003.
- Poisonous oxides - By this variable we are expressing the amount (in tons per square kilometer) of poisonous oxides (SO2, NO2, CO) that had been drained into the atmosphere during the year 2003.
- Solid particles - This is as well environmental variable revealing the amount (in tons per square kilometer) of solid particles that had been drained into the atmosphere during the year 2003.
- Investment into the environment - Amount of money invested into the environment in CZK during the year 2003.
- Pharmaceutical revenue - This variable shows the amount of money paid on average by one person for pharmaceuticals during the year 2003.

Table C3: Tests' results

test	LEM45	LEM65	LEF45	LEF65
Variance inflation factor (Mean VIF)	1,41	1,41	1,27	1,29
Cameron & Trivedi's decomposition of IM-test (total p-value)	0.6525	0.2802	0.6252	0.6474
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity ($Prob > \chi^2$)	0.2047	0.4286	0.6650	0.2235
Shapiro-Wilk W test for normality of data ($prob > z$)	0.43036	0.39701	0.93985	0.81736

Appendix C Model tests

We test several crucial OLS assumptions: multicollinearity, homoskedasticity and normality. The results are summarized in table C3.

Multicollinearity was tested using the variance inflation factor (VIF). In our case we have not found any evidence of multicollinearity. Homoscedasticity was tested by the White's and Breusch-Pagan tests showing no presence of heteroscedasticity. Normality was tested using the Shapiro-Wilk test and we could not reject the normal distribution of residuals. As a result, since all assumption of OLS are fulfilled, we concluded that using OLS is appropriate in our case and the estimation is efficient.

In addition to testing our model from various perspectives it is useful to look at the data on its own. The summary of leverage points and outliers can be found in appendix A. The biggest outlier seems to be the district "Prague-West". Nevertheless because this observation does not have a major impact on the results, we have decided not to drop it.

Further we check the robustness of our model. Because of the rich dataset of potential influential factors, we pick one or two additional factors from each category of socio-economic, healthcare and environmental pollution factors and look at the effects. To summarize the results we have created four tables for each of the model. In the first column of the table there are explanatory variables and the dependent variable is the variable indicated in the heading of each table. In each column of the table we added one variable to the original model. In the last column we estimate the model with all of the explanatory variables together.

Table C4: Robustness test LEM45

lnU SE	-0.0356271 (-0.0054298)	-0.0360216 (-0.006605)	-0.0350928 (-0.0055355)	-0.0352762 (-0.0056165)	-0.0356364 (-0.0054709)	-0.0359475 (-0.0073087)
lnPoiOx SE	-0.0056185 (-0.0019768)	-0.0054865 (-0.002345)	-0.0060384 (-0.0021186)	-0.0061515 (-0.0027987)	-0.0056352 (-0.002018)	-0.0065471 (-0.0035317)
lnNPpDoc SE	-0.0200022 (-0.0071423)	-0.0203528 (-0.0079102)	-0.0186644 (-0.0075506)	-0.0203841 (-0.0073257)	-0.0193127 (-0.0153864)	-0.0167959 (-0.0160255)
lnM65 SE	0.1068915 (-0.0209966)	0.1063434 (-0.0217599)	0.1092842 (-0.0215099)	0.1074188 (-0.0212225)	0.1064547 (-0.0228323)	0.1071193 (-0.0245746)
lnAW SE		-0.0029893 (-0.0280776)				-0.0119964 -0.0339684
lnInvEnv SE			0.0012066 (-0.0021183)			0.0018446 (-0.0024813)
lnSolid SE				0.0014588 (-0.0053862)		0.0020275 (-0.0058395)
lnRpPhapP SE					0.0008474 (0.0167185)	0.0038094 (-0.0176849)
cons SE	3.422541 (-0.0856641)	3.454356 (-0.3110308)	3.397386 (-0.0967367)	3.417886 (-0.0879169)	3.412865 (-0.2094809)	3.461798 (-3717298)
R^2 $adjusted R^2$	0.7528 -0.739	0.7528 -0.7354	0.7539 -0.7366	0.753 -0.7356	0.7528 -0.7354	0.7551 -0.7262

Table C5: Robustness test LEM65

lnU SE	-0.0333348 (0.0093012)	-0.0328319 (0.0113147)	-0.0308204 (0.0093394)	-0.0333018 (0.0096261)	-0.0331082 (0.009337)	-0.0333722 (0.0122906)
lnPoiOx SE	-0.0077253 (0.0033862)	-0.0078936 (0.0040171)	-0.0097017 (0.0035744)	-0.0077755 (0.0047967)	-0.0073146 (0.003444)	-0.0093962 (0.0059391)
lnNPpDoc SE	-0.0463952 (0.0122348)	-0.0459482 (0.0135507)	-0.0401 (0.0127391)	-0.0464311 (0.0125554)	-0.0632717 (0.0262597)	-0.0537698 (0.026949)
lnM65 SE	0.1240479 (0.035967)	0.1247465 (0.037276)	0.135308 (0.036291)	0.1240975 (0.0363728)	0.1347403 (0.0389679)	0.1400674 (0.0413255)
lnAW SE	0.0038102	 (0.0480985)				-0.0282501 (0.0571224)
lnInvEnv SE			0.0056784 (0.003574)			0.006771 (0.0041727)
lnSolid SE				0.0001373 (0.0092313)		0.0022677 (0.0098199)
lnRpPhapP SE					-0.0207434 (0.0285332)	-0.0134877 (0.0297395)
cons SE	2.827503 (0.1467422)	2.786951 (0.5328132)	2.709126 (0.1632116)	2.827065 (0.1506787)	3.064356 (0.357518)	3.133785 (0.6251131)
R^2 $adjusted R^2$	0.5852 0.5621	0.5852 0.556	0.5994 0.5712	0.5852 0.556	0.5882 0.5592	0.06039 0.5573

Table C6: Robustness test LEF45

lnU	-0.0126644	-0.0145025	-0.0120322	-0.0124802	-0.0126024	-0.0162573
SE	(0.0046448)	(0.0056583)	(0.0046502)	(0.0048127)	(0.0046945)	(0.0061388)
lnPoiOx	-0.0055056	-0.0048581	-0.0063726	-0.0058052	-0.0055587	-0.0058161
SE	(0.0018949)	(0.0022125)	(0.0020036)	(0.0026562)	(0.0019397)	(0.0032441)
lnNPpDoc	-0.0126508	-0.0143842	-0.0101822	-0.0128688	-0.0107166	-0.0050967
SE	(0.0067156)	(0.0073912)	(0.0069565)	(0.006894)	(0.014431)	0.0147484
lnF65	0.0926524	0.089884	0.0954668	0.0929838	0.0916471	0.0855989
SE	(0.0215433)	(0.0221743)	(0.0215586)	(0.0217866)	(0.0226806)	(0.0236074)
lnAW		-0.0151783				-0.0430381
SE		(0.0264239)				(0.0314914)
lnInvEnv			0.0025177			0.0042753
SE			(0.0019607)			(0.0022997)
lnSolid				0.0008276		0.0012117
SE				(0.0051065)		(0.0053995)
lnRpPhaP					0.002326	0.010341
SE					(0.0153372)	(0.0158815)
cons	3.480754	3.642941	3.435175	3.477918	3.453759	3.739104
SE	(0.0909071)	(0.2967535)	(0.0972128)	(0.093186)	(0.2000944)	(0.351415)
R^2	0.05209	0.5231	0.5317	0.521	0.521	0.5466
$adjusted R^2$	0.4943	0.4895	0.4988	0.4873	0.4873	0.4931

Table C7: Robustness test LEF65

lnU		-0.0116115				-0.0188174
SE		(0.008199)				(0.0108833)
lnPoiOx	-0.0121421	-0.0110075	-0.0119805	-0.0119319	-0.0159165	-0.0105556
SE	(0.003542)	(0.0036076)	(0.0035752)	(0.0036427)	(0.0049047)	(0.0057514)
lnNPpDoc			-0.0129887			-0.0165066
SE			(0.0259767)			(0.0261473)
lnF65	0.1266814	0.1052391	0.1295073	0.1268028	0.1256457	0.0957435
SE	(0.0370663)	(0.0398024)	(0.0376871)	(0.0373083)	(0.0370182)	(0.0418533)
lnAW				-0.0124875		-0.0676845
SE				(0.0444909)		(0.0558307)
lnInvEnv	0.0076871	0.0072836	0.0073258	0.0081835	0.0085297	0.009621
SE	(0.0034278)	(0.003416)	(0.0035207)	(0.0038768)	(0.0035053)	(0.004077)
lnSolid					(0.0099989)	(0.0042301)
SE					(0.0090034)	(0.0095726)
lnRpPhapP	0.028338	0.0298911	0.0163437	0.0294306	0.0311612	0.0227285
SE	(0.0129233)	(0.0128807)	(0.0272798)	(0.0135768)	(0.0131504)	(0.0281561)
cons	2.341179	2.40983	2.508682	2.444295	2.279315	3.198035
SE	(0.1136816)	(0.122863)	(0.3539506)	(0.3847882)	(0.1264308)	(0.6230195)
R^2	0.03479	0.4144	0.4	0.3985	0.4081	0.4353
$adjusted R^2$	0.3644	0.3732	0.3577	0.356	0.3665	0.3689

The output of the robustness check can be summarized as follows:

- LEM45: lnPoiOx reacts on change in lnInvEnv and lnSolid
- LEM65: Inclusion of lnInvEnv changes the influence of lnPoiOx, however we cannot say the same thing about lnSolid. The other remark

that should be made here is that the addition of lnRPhapP changes the influence of other health factor lnNPpDoc

- LEF45: Same as in the previous model lnPoiOx reacts on inclusion of lnInvEnv. The other interesting change happens when we include economic factor of lnAW, in that case we can see increase in coefficients of lnU

- LEF65: the situation is similar to the case of model of male at the age 65. Environmental pollution factors lnPoiOx and lnInvEnv are responding to addition of lnSolid and the health factor lnRPhapP changes due to the inclusion of lnNPpDoc

The changes in the coefficients are small and also R^2s does not change much so we regard our model as fairly robust.

Appendix D Correlation Matrix

	NPpH	NPpOF	NPpDoc	NPpPh	NPpPre	RpPhapP	NPpPhar	NPp1HP	AW	U	D	F65r	M65r	Solid	PoiOx	ExpLfM45	ExpLfM65	ExpLfW45	ExpLfW65	IAM	IAF	InvEnv
NPpH	1																					
NPpOF	0.08	1																				
NPpDoc	-0.02	0.67	1																			
NPpPh	0.20	0.57	0.47	1																		
NPpPre	-0.00	0.55	0.74	0.54	1																	
RpPhapP	-0.09	-0.58	-0.73	-0.47	-0.62	1																
NPpPhar	0.01	0.66	0.74	0.57	0.78	-0.63	1															
NPp1HP	0.07	-0.02	-0.32	-0.05	-0.25	-0.04	-0.26	1														
AW	-0.05	-0.07	-0.25	0.00	-0.00	0.45	-0.09	0.05	1													
U	-0.10	0.14	-0.05	0.12	-0.11	-0.12	0.10	0.17	-0.22	1												
D	-0.20	0.04	-0.03	-0.13	-0.13	0.13	-0.07	0.01	0.11	-0.15	1											
F65r	0.10	-0.22	-0.27	-0.26	-0.33	0.36	-0.45	0.01	0.07	-0.48	0.56	1										
M65r	0.05	-0.26	-0.26	-0.29	-0.29	0.45	-0.45	-0.05	0.16	-0.59	0.51	0.94	1									
Solid	0.12	-0.06	-0.14	-0.06	-0.10	0.06	-0.13	0.29	0.20	0.21	-0.07	-0.14	-0.12	1								
PoiOx	0.05	-0.00	-0.15	-0.01	-0.10	0.13	-0.09	0.22	0.27	0.41	-0.02	-0.21	-0.20	0.88	1							
ExpLfM45	0.11	-0.29	-0.14	-0.17	-0.09	0.34	-0.36	-0.04	0.22	-0.78	0.09	0.65	0.73	-0.23	-0.38	1						
ExpLfM65	0.12	-0.35	-0.26	-0.15	-0.15	0.38	-0.46	0.00	0.23	-0.62	-0.01	0.60	0.64	-0.17	-0.29	0.92	1					
ExpLfW45	0.17	-0.31	-0.13	-0.11	-0.18	0.29	-0.43	-0.08	0.04	-0.57	-0.02	0.61	0.60	-0.17	-0.32	0.79	0.80	1				
ExpLfW65	0.18	-0.40	-0.23	-0.13	-0.24	0.35	-0.49	-0.02	0.09	-0.44	-0.09	0.50	0.48	-0.08	-0.20	0.69	0.77	0.94	1			
IAM	0.06	-0.25	-0.29	-0.29	-0.30	0.43	-0.41	-0.02	0.20	-0.59	0.56	0.93	0.96	-0.13	-0.19	0.67	0.57	0.55	0.44	1		
IAF	0.03	-0.35	-0.43	-0.33	-0.41	0.56	-0.53	0.04	0.28	-0.46	0.55	0.94	0.91	-0.13	-0.15	0.62	0.59	0.58	0.51	0.92	1	
InvEnv	0.01	-0.27	-0.35	-0.10	-0.16	0.38	-0.27	0.10	0.63	-0.03	0.01	0.10	0.10	0.14	0.18	0.16	0.24	0.13	0.24	0.11	0.32	1

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Univerzita Karlova v Praze, Fakulta sociálních věd
Institut ekonomických studií [UK FSV – IES] Praha 1, Opletalova 26
E-mail : ies@fsv.cuni.cz http://ies.fsv.cuni.cz