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Máca, Vojtěch and Melichar, Jan and Ščasný, Milan and Braun Kohlová, Marketa

Charles University, Prague, Czech Republic

2017

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Vojtěch Máca[1], Jan Melichar, Milan Ščasný and Markéta Braun Kohlová

Abstract

Monetized environmental health impact assessment helps to better evaluate environmental burden of various economic activities. Apart from limitations and uncertainties in physical and biological science used in such assessments, assumptions taken in economic valuation may also substantially influence subsequent policy-making considerations. To demonstrate the effect of these considerations in quantitative terms we show how estimated external costs of coal mining and use of extracted coal in electricity and heat generation vary under different policy-making perspectives and choice of monetary values for impacts in different countries.

Keywords:

air pollution; external costs; impact assessment; impact-pathway approach

Reference:

This paper has been published in: Máca, V., Melichar, J., Ščasný, M., Braun Kohlova, M. (2017), Valuing Environmental Health For Informed Policy—Making. *Rev Env Health* Vol 32, Issue 1-2: 171-175. doi: https://doi.org/10.1515/reveh-2016-0035.

[1] ***Corresponding author: Vojtěch Máca,** Charles University Environment Centre, Jose Martiho 2, 162 00 Prague, Czech Republic, e-mail: vojtech.maca@czp.cuni.cz
Jan Melichar, Milan Ščasný and Markéta Braun Kohlová: Charles University Environment Centre, Prague, Czech Republic

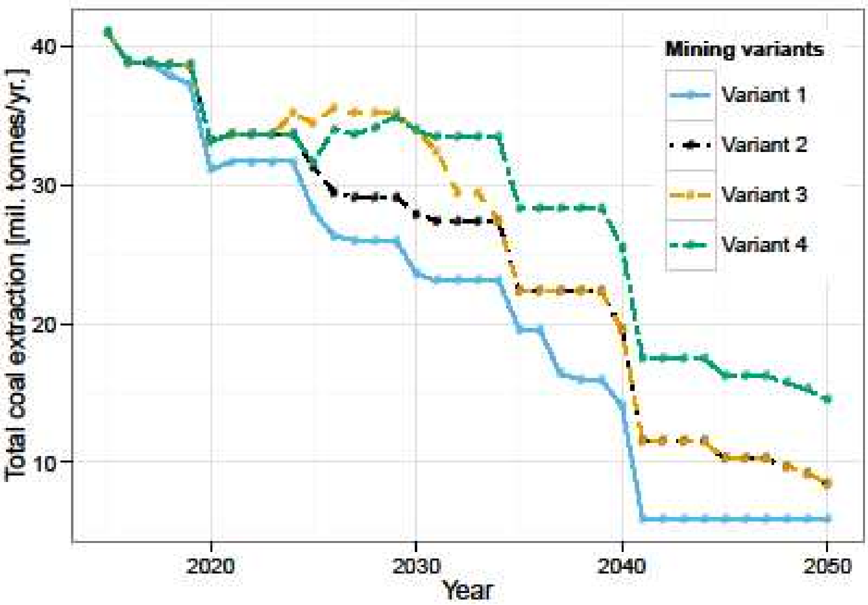
Introduction

Virtually every economic activity brings some benefits and costs but part of these costs are often borne not only by those who directly benefit from that particular activity. When such (say harmful) side-effects affect individuals not involved in that particular activity and they are not compensated for these negative effects by the beneficiaries of the activity, economists speak about external costs. Many such effects are environment-bound, such as air pollution that produces adverse effects on human health with substantial economic costs for society (1).

It is broadly accepted that presence of external costs is a case of market failure that calls for a policy intervention but an obvious question looms – how much such policy intervention should restrict a polluting activity? Monetary valuation of health impacts provides a useful yardstick that may put quantified impacts at par with (private) benefits for which monetary valuation tends to be readily available. Ideally, policy interventions should strive for optimal level of economic activity – a situation when costs imposed on society are compensated by the benefits gained. The reality tends to be more complex though, and one has to resolve several intricate questions, such as whose costs and benefits account for – i.e. should 'the society' be defined by political or rather model boundaries, and, if more than a single country is impacted, whether to take account of impacts in these countries, and if so, what monetary values of health impacts to use – the same as in a single country case or modify them upward for more developed countries and downward for less-developed countries.

In the following, we build on our earlier study about health costs of revision of territorial limits on surface mining at two coal mines in North Bohemia – Bilina and CSA – reported in (2) to show how the estimated external costs of coal mining and subsequent use of extracted coal in electricity and heat generation vary under different policy-making perspectives over 2015-2050 period. Four scenarios of revision of territorial coal mining limits were assessed: leaving the limits unchanged (*Variant 1*), revoke the limits at Bilina mine only (*Variant 2*), revoke the limits at Bilina mine and to limited extent at the CSA mine (*Variant 3*), and revoke the limits at both mines (*Variant 4*), as shown in Figure 1.

Figure 1 Annual coal extraction by the variant of mining limit revision



Methods

The quantification of external costs builds upon impact-pathway methodology called ExternE (4). This is a bottom-up integrated environmental health impact assessment (3) that evaluates impacts in a relatively detailed resolution (local and regional meteorological conditions, population density, fuel specification, installed capacity, load hours, etc.). The scope of assessment presented here is restricted to emissions of airborne pollution and noise from coal mining and airborne pollution from coal fired power plants. Using local scale dispersion models of airborne and noise emissions from mining and a regional scale dispersion model of airborne emissions from coal burning in large coal-fired (heating and) power plants effects on air quality were estimated.

To translate exposures of human populations to impaired air quality and soundscape into respective health impacts, a subset of concentration-response functions from the HRAPIE project (5) for PM_{10}, $PM_{2.5}$ and O_3 that are additive in their effects were used to estimate air pollution impacts; exposure-response functions for annoyance from (6) were used to estimate impacts from noise originating from coal mining (see Table 1). Background data for concentration-response functions (population age distribution, mortality and morbidity incidences) were compiled from WHO, EUROSTAT and World Bank for all 64 countries (all European, five North African, five Middle Eastern and two Asian post-Soviet countries) distinguished in the EcoSenseWeb model.

The economic valuation of health impacts entails monetization of impacts on morbidity and mortality, including non-market loss of welfare due to impaired health (or shortened life expectancy) estimated as a willingness to pay to avoid this loss (7). The values for health endpoints used (see Table 1) are transferred from EU-wide unit values originally compiled for a cost-benefit analysis of the EU's Clean Air Policy Package (8). Majority of willingness to pay values originate from earlier multi-country valuation studies, primarily (9,10).

Table 1 Evaluated impacts from airborne pollution and noise exposure and their valuation

Pollutant	Endpoint (*unit*)	CRF (per 10μg/m^3)	EU-wide monetary value (€$_{2014}$)
	Air Pollution: Long-Term Exposure		
$PM_{2.5}$	Adult mortality (loss of life expectancy, *per YOLL*)	1.062	65,066
PM_{10}	Post-neonatal infant mortality (*per case*)	1.04	2,762,767
PM_{10}	Incidence of chronic bronchitis in adults (*per case*)	1.117	60,443
PM_{10}	Prevalence of bronchitis in children (*per case*)	1.08	663
	Air Pollution: Short-Term Exposure		
$PM_{2.5}$	Restricted activity days (*per day*)	1.047	104
$PM_{2.5}$	Work days lost (*per day*)	1.046	147
$PM_{2.5}$	Hospital admissions, respiratory diseases (*per case*)	1.019	2503
$PM_{2.5}$	Hospital admissions, cardiovascular diseases (*per case*)	1.0091	2503
PM_{10}	Incidence of asthma symptoms in asthmatic children (*per case*)	1.028	47
O_3	Adult mortality (*per YOLL*)	1.0029	65,066
O_3	Hospital admissions (65+yrs), respiratory diseases (*per case*)	1.0044	2503
O_3	Hospital admissions (65+yrs), cardiovascular diseases (*per case*)	1.0089	2503
O_3	Minor restricted activity days (*per day*)	1.0154	47
	Noise Exposure	ERF (per dB L_{den})	
	Slightly annoyed (*per year*)	$0.02815 * L_{den}^2 - 1.130 * L_{den} + 11.477$	56
	Annoyed (*per year*)	$0.03270 * L_{den}^2 - 2.121 * L_{den} + 36.854$	112
	Highly annoyed (*per year*)	$0.02523 * L_{den}^2 - 1.886 * L_{den} + 36.307$	187

Note: CRF stands for concentration-response function, ERF stands for exposure-response function, *YOLL* stands for year of life lost, L_{den} stands for weighted day-evening-night noise level. Source: adapted from (5,6).

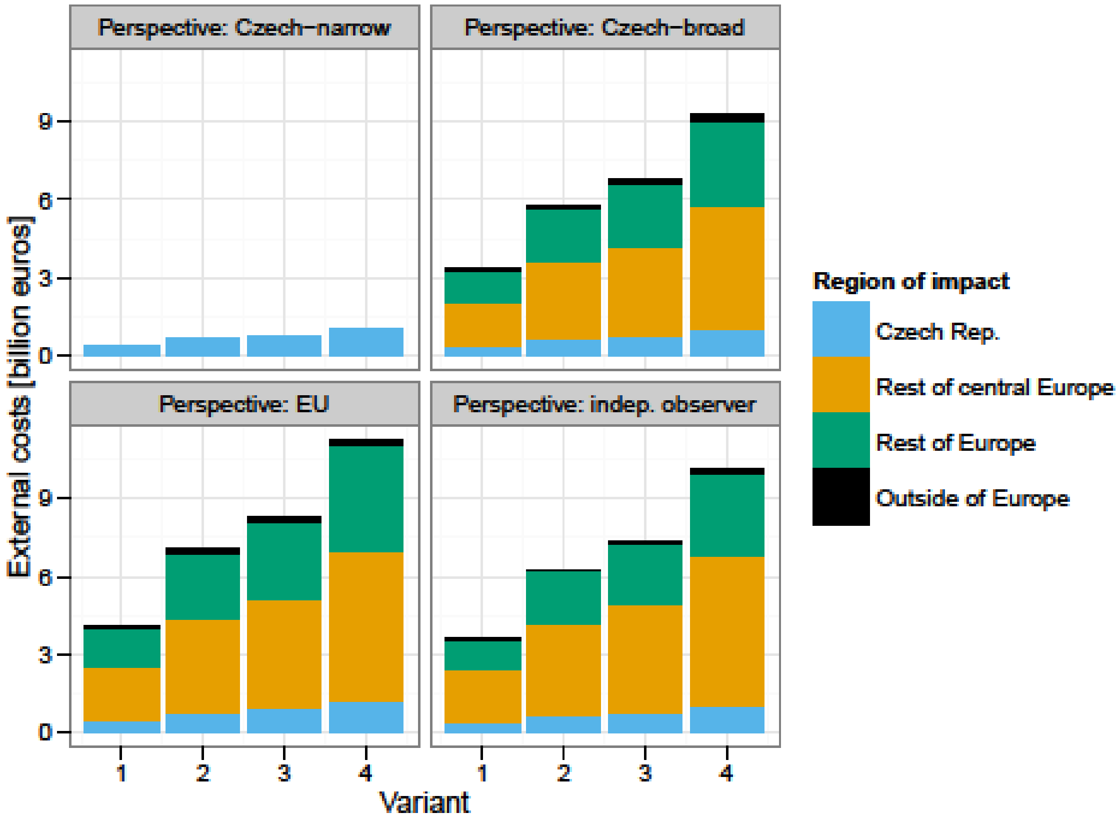
In line with our objective – to illustrate how valuation of environmental health can inform policy-making – we use four alternative but plausible policy-making perspectives. The first perspective is the one of a 'narrowly focused' Czech policy-maker who is concerned with costs and benefits for his voters, i.e. restricted to Czech nationals. As the economic power of Czechs is somewhat lower than the EU average (and willingness to pay is, among other, affected by wealth), we adjust the EU-wide monetary values downwards by the Czech-EU ratio of per capita gross domestic product (GDP) at purchasing parity power (i.e. by a factor ~0.82, reflecting purchasing parity in 2014). The second perspective is a 'broadly focused' Czech policy-maker concerned also with impacts taking place across the Czech boarders. Most likely, our policy-maker will not place higher values on life and health of foreign populations then on life and health of Czechs. For simplicity we use same values for Czechs as for other affected populations (i.e. monetary values from Table 1 adjusted by a factor ~0.82). The third perspective is the one of an EU policy-maker who conventionally prefers to use the EU-wide values of life and health for the entire EU population (we assume for simplicity that these monetary values are used for affected non-EU population as well). Finally, the fourth perspective is that of an 'independent observer' who takes account of all the modelled impacts, irrespective where they occur, and different economic power of populations in different countries. Hence, we adjust EU-wide values by the ratio of country vs. EU GDP per capita at purchasing parity power to obtain country-specific values.

Results

We estimate that total extraction of about 165.6, 288.7, 332.5, and 434.9 million tonnes of coal by respective variants 1 through 4 over 2015-2050 period will bring about the following effects. Airborne PM_{10} emissions from coal mining will – compared to a total of 4.8 kilo-tonnes released in Variant 1 – increase by 115% in Variant 2, by 146% in Variant 3, and by 223% in variant 4. Emissions from electricity and heat generation using the coal extracted at Bilina and CSA mines, totalling to about 10 kilo-tonnes of PM_{10}, 143 kilo-tonnes of NO_x and 152 kilo-tonnes of SO_2 in Variant 1, will rise roughly by 70% in Variant 2, by 103% in Variant 3, and by 178% in Variant 4. A markedly smaller increase in emissions from coal use compared to increases in emissions from coal mining between variants, is mainly due to a gradual tightening of statutory emission limits for large combustion sources and phasing-out of non-compliant ones over time. The noise annoyance impacts from mining activities are rather limited as the population affected does not exceed 200 inhabitants in close vicinity of the two mine pits in any of the variants and decreases in time.

The total external costs imposed on human health due to exposure to air pollution and noise are estimated in a range between 0.5 and 11 billion euros depending primarily on policy-making perspective chosen and the variant of mining limit revision assessed (see Figure 2). By respective variant, the impacts are valued between 0.5 and 4 billion euros for Variant 1, between 0.7 and 7 billion euros for Variant 2, between 0.8 and 8 billion euros for Variant 3, and between 1 and 11 billion euros for Variant 4. In short, the choice of policy-making perspective have a huge impact, up to a factor 10, meaning that the 'narrowly focused' perspective ignores up to 90% of impacts. This 'perspective' difference is even larger than the difference between retaining and fully revoking of mining limits within any perspective chosen – in the 'narrowly focused' Czech policy-maker perspective the difference between Variant 1 and Variant 4 is approximately 0.6 billion euros, in the three remaining perspectives this difference amounts to 6-7 billion euros.

Figure 2 Total external costs by the variant of mining limit revision and policy-making perspective



In all but the 'narrowly focused' Czech policy-maker perspective, more than half of the estimated impacts are borne by central European populations outside of the Czech Republic (especially German and Polish), and further 1/3 is borne by populations in the rest of European countries beyond central Europe. Only 1-2% of impacts are inflicted upon populations outside Europe. There is also a visible effect of whether the EU-wide set of monetary values (and much the same is the effect of using Czech values for all countries) or GDP-per-capita weighting is used. The GDP weighting scales up the impacts in central Europe (from 51% to 57% primarily thanks to affluent German and Austrian populations) and lowers the impacts in non-European countries (from 2% to 1%, i.e. accounting for less developed countries in Europe's vicinity) and in the rest of European countries (from 36% to 31%).

Almost irrespective to perspective taken and weighting of monetary values, the vast majority of impacts (>99%) originate from airborne pollution emitted from electricity and heat generation. The contribution of airborne emissions from coal mining is about 0.1% (or close to 1% if the 'narrowly focused' perspective is pursued) and noise emissions from coal mining adds no more than negligible 0.01% (or up to 0.09% under the 'narrowly focused' perspective).

Discussion and conclusion

The goal of this exposé is to show that apart from many limitations and uncertainties in environmental health impact assessment stemming from the physical science, the (socio-)economic part, and the assumption taken there, may have a huge influence on policy-making considerations. While practitioners trained in physical and social science would define the framework and perspective of this assessment by the model(s) boundaries, this may not hold for policy makers, who might prefer political boundaries instead (e.g. country or regional boarders). For a policy-maker it seems indeed clear-cut to be concerned with costs and benefits for those he represent in the first place. Yet, as we demonstrate this might imply that – depending on whether the decision is taken at national level or at EU level – policy-makers would base their consideration on monetized impacts different by a factor of 10.

However difficult it can be to accept such a huge difference, there are no hard and fast rules for defining the geographical boundaries for the summation of monetized environmental impacts. A basic rule proposed in the OECD's manual on environmental cost-benefit analysis (11) is that costs to all nationals should be included, whilst costs to non-nationals should be included under certain conditions only. This latter situation is likely to be a case if a policy relates to an international context in which there is a treaty of some kind (such as on acid rain or global warming), or if there are some accepted moral, ethical or strategic reasons for counting benefits and costs to non-nationals (12).

The rule may also be read as a recommendation to split impact assessment in two-parts, in one limited to the country in question, in the other one also including impacts beyond the country borders. If this is a satisfactory approach is to be seen, very likely in a related environmental problem – when developing national commitments to climate change mitigation.

Acknowledgement

A support for manuscript preparation from PRVOUK-P02 programme of Charles University is gratefully acknowledged.

References

1. WHO Regional Office for Europe, OECD (2015). „Economic cost of the health impact of air pollution in Europe: Clean air, health and wealth". Copenhagen: WHO Regional Office for Europe.

2. Máca, V., Melichar, J. (2016). „The Health Costs of Revised Coal Mining Limits in Northern Bohemia". *Energies* 9(81): 1-20.

3. Briggs, D.J. (2008). „A framework for integrated environmental health impact assessment of systemic risks". *Environ Health* 7(1): 61.

4. Bickel, P., Friedrich, R. (2004). „ExternE: Externalities of Energy. Methodology 2005 Update". Luxembourg: Office for Official Publications of the European Communities.

5. WHO (2013). „Health risks of air pollution in Europe – HRAPIE project". Copenhagen: WHO Regional Office for Europe.

6. Miedema, H.M.E., Vos, H. (2004). „Noise annoyance from stationary sources: relationships with exposure metric day-evening-night level (DENL) and their confidence intervals". *J Acoust Soc Am* 116(1): 334–43.

7. Ščasný, M., Máca, V. (2016). „Monetary and Non-Monetary Measures of Health Benefits from

Exposure Reduction“, in: Pacyna, J., Pacyna, E., eds. (2016). „Environmental Determinants of Human Health“, Cham: Springer Nature, 133–150.

8. Holland, M. (2014). „Cost-benefit Analysis of Final Policy Scenarios for the EU Clean Air Package“. Available at: http://ec.europa.eu/environment/air/pdf/review/TSAP CBA corresponding to IIASA11 v2.pdf.

9. Desaigues, B., Ami, D., Bartczak, A., Braun-Kohlová, M., et al. (2011). „Economic valuation of air pollution mortality: A 9-country contingent valuation survey of value of a life year (VOLY)“. *Ecol Indic* 11(3): 902–10.

10. Ready, R., Navrud, S., Day, B., Dubourg, R. et al. (2004), „Benefit transfer in Europe: How reliable are transfers between countries?“, *Environ Resour Econ* 29(1): 67–82.

11. Pearce, D., Atkinson, G., Mourato, S. (2006). „Cost-Benefit Analysis and the Environment“. Paris: OECD Publishing, 318pp.

12. Pizer, W., Adler, M., Aldy, J., Anthoff, D., et al. (2014). „Using and improving the social cost of carbon“. *Science* 346(6214): 1189–90.