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Assessing the economic valuation of the benefits of regulating chemicals: Lessons learned from five case studies

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Assessing the economic valuation of the benefits of regulating chemicals: Lessons learned from five case studies – Environment Working Paper No. 136

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Foreword

This background paper on *Assessing the economic valuation of the benefits of regulating chemicals* was prepared for the SACAME workshop in Ottawa, Canada of 30-31 August 2017, by Ståle Navrud, School of Economics and Business, Norwegian University of Life Sciences.

The workshop was organised in co-operation between the OECD Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology (Joint Meeting) and Working Party on Integrating Environmental and Economic Policies (WPIEEP), and was hosted by Health Canada, with funding from the European Commission.

The paper was revised and takes into account feedback received from Delegates during and after the workshop, and comments received from the Joint Meeting and WPIEEP by written procedure. The author would like to thank Nils Axel Braathen and Eeva Leinala of the OECD Secretariat for comments on previous versions of the paper. Work on this paper was conducted under the overall responsibility of Nathalie Girouard, Head of the Environmental Performance and Information Division. The indispensable support of Elvira Berrueta Imaz, Natasha Cline-Thomas and Stéphanie Simonin-Edwards in co-ordinating the editing and publication process is gratefully acknowledged.

The opinions expressed and the arguments employed are those of the author.

Abstract

This paper reviews and compares five case studies on quantification and economic valuation of benefits in cost-benefit analyses (CBAs) of regulating phthalates, mercury, PFOA (perfluoro-octanic acid) and its salts, NMP (1-methyl-2-pyrroloidine) and formaldehyde. The case studies had all been carried out as part of the SACAME project, and the purpose of the present paper is to draw out cross-cutting findings from these studies.[1]

In most of the original assessments covered in the five case studies reviewed, an impact-pathway or damage-function approach (IPA/DFA) had been used to assess the benefits of regulating the respective chemicals. However, this was often done using a simplified approach, relying on expert assessment, as there is a general lack of exposure data, dose-response functions and value estimates for relevant environmental and health endpoints for these substances. Health impacts, rather than environmental impacts, were the focus of the benefit assessments covered in the five case studies. This is mainly due to a weaker scientific evidence-base for impacts on the environment and ecosystem services.

The case studies show that there are major challenges in estimating the benefits of regulating chemicals. There are very few detailed applications of the full IPA/DFA, even for mercury, which is the chemical with most available assessments among those covered here. The case studies also document that the values used for morbidity impacts are often incomplete, in most cases covering only lost productivity, lost earnings or cost-of-illness, but mostly disregarding the disutility costs of pain and suffering from the illnesses. Finally, benefits transfer estimates are simplistically applied.

The review highlights a need for: i) identification of the potentially most important health and environmental impacts in term of aggregate economic benefits, ii) quantification of the consequences of these potentially most important impacts, iii) new economic valuation studies of these impacts; designed for benefit transfer and use in CBAs, and iv) updated and improved guidance for benefit transfer and treatment of uncertainty in CBAs of chemicals regulation.

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Keywords: Chemicals regulations, impact pathway, damage function, health benefits, ecosystem services, cost-benefit analysis

[1] Socio-economic Analysis of Chemicals by Allowing a better quantification and monetisation of Morbidity and Environmental impacts. www.oecd.org/chemicalsafety/risk-management/sacame.htm.

Résumé

Ce document examine et compare cinq rapports d'étude de cas sur la quantification et l'évaluation économique des avantages dans le cadre d'analyses coûts-avantages (ACA) portant sur la réglementation de chacune des substances suivantes : phthalates, mercure, PFOA (acide perfluorooctanoïque) et ses sels, NMP (1-méthyl-2-pyrrolidone) et formaldéhyde. Ces études ont toutes été réalisées dans le cadre du projet SACAME[2] ; le présent document a pour objectif d'en tirer des conclusions communes

Dans la plupart des cas étudiés, les examinateurs ont eu recours à une analyse du cheminement des impacts ou de la fonction de dommage (IPA/DFA) pour évaluer les avantages, mais souvent en appliquant une approche simplifiée fondée sur l'appréciation d'experts, car on manque généralement de données sur l'exposition, de fonctions dose-effet et d'estimations de la valeur des effets environnementaux et sanitaires pertinents concernant ces substances. Ce sont les impacts sur la santé plutôt que les impacts environnementaux qui sont la cible de l'évaluation des avantages dans ces ACA réglementaires, ce qui tient principalement au fait que les données scientifiques concernant les impacts sur l'environnement et les services écosystémiques laissent davantage à désirer.

Les études de cas montrent que l'estimation des avantages liés à la réglementation des produits chimiques rencontre plusieurs obstacles majeurs. Premièrement, l'analyse IPA/DFA a été très peu mise en œuvre dans son intégralité, y compris pour le mercure qui, parmi les produits chimiques examinés ici, fait l'objet des évaluations les plus nombreuses. Deuxièmement, les études révèlent que les valeurs utilisées pour évaluer les impacts sur la morbidité sont souvent incomplètes, car elles se contentent le plus souvent de couvrir uniquement la perte de productivité, les pertes financières ou les coûts imputables aux maladies et ne s'intéressent pas aux coûts de désutilité des souffrances qu'elles engendrent. Enfin, les estimations des transferts d'avantages sont utilisées de façon rudimentaire

Il est nécessaire : i) d'identifier les impacts sur la santé et l'environnement qui sont potentiellement les plus importants en termes d'avantages économiques agrégés, ii) de quantifier les incidences de ces impacts les plus importants potentiellement, iii) de réaliser de nouvelles études d'évaluation économique de ces impacts, conçues dans l'optique du transfert d'avantages et d'une utilisation dans le cadre d'ACA ; iv) d'actualiser et d'améliorer les orientations concernant le transfert d'avantages et le traitement de l'incertitude dans les ACA de la réglementation des substances chimiques.

Codes JEL : Q51, J17, Q53, Q57, D61

Mots-clés : réglementation des substances chimiques, cheminement des impacts, fonction de dommage, avantages pour la santé, services écosystémiques, analyse coûts-avantages

[2] *Socio-economic Analysis of Chemicals by Allowing a better quantification and monetisation of Morbidity and Environmental impacts* (analyse socio-économique des produits chimiques fondée sur la quantification et la monétarisation de leur morbidité et de leurs impacts pour l'environnement).

Table of contents

Foreword **3**
Abstract **4**
Résumé **5**
1. Background and objectives **7**
2. Similarities and differences across the case studies **7**
3. Conclusions and the way forward **12**
References **14**

Tables

Table 1. Comparison of the findings of the five case studies 9

1. Background and objectives

As part of the SACAME[3] project, the OECD commissioned five case studies reviewing the literature on the quantification and economic valuation of benefits from regulating the following substances:

- Phthalates[4]
- Mercury[5]
- PFOA (perfluoro-octanic acid) and its salts[6]
- NMP (1-methyl-2-pyrroloidine)[7]
- Formaldehyde[8]

The objective of this paper is to review the key messages from these five case studies, discuss the similarities and differences across them, and assess their consistency with respect to endpoints and valuation methodology. The extent to which the five case studies address the costs of regulatory measures is also reviewed.

2. Similarities and differences across the case studies

2.1. Introduction

The original papers reviewed in the five case studies varied significantly in terms of the data and methodologies employed to develop estimates of the benefits of regulation. Table 1 summarises and compares the results of the five case studies with respect to:

i. whether they have found economic benefit estimates for health and environmental impacts of regulating the substance in question
ii. the number of such studies
iii. the general valuation approach and the benefit valuation methods used
iv. whether non-monetary assessment of impacts was carried out for impacts that were not valued (qualitative, quantitative or none)
v. whether dose-response functions are available for the impacts
vi. whether the costs of regulation were considered.

[3] Socio-economic Analysis of Chemicals by Allowing a better quantification and monetisation of Morbidity and Environmental impacts. www.oecd.org/chemicalsafety/risk-management/sacame.htm.

[4] Holland (2018[9]), *Socio-economic assessment of phthalates*.

[5] Dubourg (2018[10]), *Economic assessment of the benefits of regulating mercury: A review*.

[6] Gabbert (2018[11]), *Economic valuations and assessments of environmental and health impacts caused by PFOA and its salts*.

[7] Hunt and Dale (2018[13]), *Case study: Economic Valuation in 1-Methyl-2-pyrrolidone (NMP) Regulation*.

[8] Hunt and Dale (2018[12]), *Case study: Economic Valuation in Formaldehyde Regulation*.

With respect to the specific benefit-valuation methods in point iii) above, a distinction is made in Table 1 between studies based on:

1. stated preference approaches (i.e. contingent valuation and choice experiments) used to elicit willingness-to-pay (WTP) to avoid a negative impact
2. observed market prices
3. implicit valuation approaches (based on abatement costs or break-even analysis)
4. estimates of averting expenditures
5. replacement costs
6. hedonic price analysis
7. the travel costs method.

For health impacts, a distinction is made between estimates of morbidity and mortality costs found in the case studies. The avoided morbidity (illness) costs from regulation consist of:

1. avoided health treatment costs, called cost-of-illness (COI)
2. avoided productivity loss or loss of earnings
3. avoided disutility-of-illness (usually elicited using stated preference methods).

For mortality impacts, a distinction is made between two monetary valuation approaches:

1. value-of-a-statistical-life (VSL) combined with estimated changes in mortality risks
2. value-of-a-statistical-life-year (VOLY) combined with estimates of the numbers of years of life lost.

In some cases, health impacts are quantified, but not monetised, in terms of quality-adjusted life-years (QALYs) or disability-adjusted life-years (DALYs).

For environmental impacts, a distinction is made between use values and non-use values (i.e. existence and bequest values). If environmental impacts are reported in the original papers in terms of types of ecosystem services (ES), a distinction is also made between provisioning, regulating and cultural ES.

The next sections of this chapter discuss the main findings from the comparison presented in Table 1.

Table 1. Comparison of the findings of the five case studies

Case study substance	Economic benefit estimate (Y/N)	No. of studies considering benefits	Benefit valuation approach	Non-monetary assessment of impacts (quantitative, qualitative, none)	Dose-response functions (Y/N)	Costs of regulation estimate (Y/N)
Phthalates - Health - Environment	 Y N	6	Impact-pathway approach (IPA) / Damage-function approach (DFA) Cost-of-illness (COI) and loss earnings for morbidity impacts, some studies use human capital method for mortality impacts; expert assessments to determine impacts and attributable fractions	Quantitative	N (relies on Attributable Fractions (AF) from expert assessments N	N
Mercury - Health - Environment	 Y Y	13	IPA/DFA (COI, Loss of earnings, expert assessment (disability weights). Stated Preference studies of selected endpoints, as well as impacts on recreational and commercial fishing)	Quantitative	Y (for IQ points lost; uncertain for cardiovascular effects) Y (for impacts on fish)	Y (changes in both producer and consumer surplus)
PFOA and its salts - Health - Environment	 N N	0 No benefit estimates (due to lack of quantified impacts), but 2 out of 10 studies on costs of regulation assume abatement costs to be a proxy for social benefits	Integrated multimedia stock pollution model (Similar to IPA/DFA) (Implicit valuation, i.e. assuming that abatement costs reflects policy makers - and thus people´s - willingness-to-pay (WTP) to avoid environmental and health impacts.	None None	N N	Y (direct costs to industry and government; one study on wider economic impacts like employment)
NMP - Health - Environment	 Y N	1	DFA, but Break Even Analysis (BEA) for reductions of number of low birth weight and pregnancy loss due to lack of dose.-response functions (but with unit value estimates from ECHA (2014a))	None None	N N	Y
Formaldehyde - Health - Environment	 Y N	2	Cost-of-illness (COI) and Disutility for nasopharyngeal cancer and eye irritation	DALY None	Y (for nasopharyngeal cancer and eye irritation); but not for nose/mouth/throat irritation, risks to female fertility, bronchitis, pulmonary function, skin allergies and asthma attacks N	Y (costs for producers; not consumers)

2.2. Ecosystem lags

When chemicals are released in the environment, there could be ecosystem lags of up to a few decades that ought to be accounted for. For example, mercury persist in freshwater and

marine ecosystems for a long period (US EPA, 2005[1]). The social discount rates applied to the costs and benefits of regulation then become particularly important. Even with low social discount rates (e.g. around 2-4%), the time lags could significantly reduce the present value of economic benefits of regulations of chemicals. In contrast, the costs of regulation would occur much sooner and would mostly not be subject to such discounting. Thus, the expected net benefit of the regulation would be lower than what studies that do not take these ecosystem time lags could suggest.

The persistence, bio-accumulative and toxic (PBT) properties of some chemicals also have to be accounted for in CBAs of regulation. The case study on PFOAs and it salts outlines a benchmark CBA model considering these substances (and others with PBT properties) as stock pollutants, assessing the time path of pollution stocks in different media and their environmental and health impacts.

2.3. Environmental impacts and endpoints

A common feature of the case studies is that environmental impacts are rarely quantified or valued in the original papers they reviewed. The main reason for this is the lack of knowledge about the dose-response relationships between the concentration of chemicals and ecosystem effects, and the resulting environmental impacts. In the future, with an increasing focus on ecosystem services, research on the environmental impacts of chemicals should be directed towards quantifying effects on relevant provisioning, regulating and cultural ecosystem services.

2.4. Health impacts and endpoints

The literature reviewed in the five case studies clearly shows that health impacts, rather than environmental impacts, are the focus of benefit assessments of chemicals regulation.

There is a wide variety of morbidity endpoints considered across the case studies. In most cases, lost productivity or lost earnings are valued, sometimes together with COI in terms of public expenditures (also private expenditures in a few cases) on medicines and treatments. However, the five case studies have found very few examples of value estimates of the disutility of experiencing the illness – the third component of morbidity costs. As a result, health benefits are likely to be underestimated in most CBAs of regulating the selected substances.

Regarding mortality, most of the valuation studies look at the reduced mortality risk (i.e. the change in the risk of dying prematurely) multiplied by a unit value for the VSL. However, there are also studies that use estimates of the number of life-years saved (quantified in terms of the number of QALYs or DALYs) multiplied by a unit value for the VOLY. The value of a VOLY used in the studies reviewed in the case studies vary considerably. This seems to be due to different methodological approaches rather than spatial and temporal variation in people's preferences and valuation of a life-year gained. One can also question the validity of valuing aggregated QALYs and DALYs with VOLY. In some CBAs, only the number of QALYs or DALYs is reported as an added non-monetised benefit of regulating the substance in question.

In the CBAs where the reduction in mortality risks have been quantified and multiplied with VSL estimates, the VSL estimates are often not based on the most recent VSL stated preference study for the country (or group of countries in question), nor on transferred

estimates from the OECD's global VSL database (OECD, 2012[2]) using meta-analytic value transfer according to value transfer guidelines (Lindhjem et al. (2011[3]), Lindhjem and Navrud (2015[4])).

2.5. Lack of impact-pathway or damage-function approaches

In most of the assessments considered by the five case studies, an impact-pathway or damage-function approach (IPA/DFA) was used. However, often a simplified IPA/DFA approach is used, based on expert assessments of impacts rather than going through all steps of the DFA from emissions through dispersion, exposure and dose-response functions to impacts. Sometimes the impact assessment is presented in qualitative rather than quantitative terms, which makes it hard to value. The most comprehensive and detailed use of an IPA or DFA framework found in the five case studies is the US EPA's analyses of mercury (US EPA (2005[1]), (2005[5]) and (2006[6])).

2.6. Transferability of economic values

In many of the CBAs of chemicals regulations covered by the five case studies, economic values from a study conducted a number of years ago, often in a different geographical area and environmental context, are used unadjusted. If the values from the earlier study *are* adjusted before being used in a new assessment, they are often not adjusted according to current guidelines for value transfer. Also, the values from the earlier study were often expressed in terms of health impacts *per kg* of a chemical. Since the transferred value is not the value *per case of a given health impact*, information from all steps of the DFA is in practice transferred.

This procedure is implicitly based on a strict assumption of similar relationships at all steps of the DFA at the policy site or application one is transferring *to*, as at the study site one is transferring the benefit estimate *from*. This includes assumptions of similar relationships between emissions and dispersion through different environmental media (water, air, soil), human exposure and avertive and adaptive behaviour, as well as similar sizes of the exposed human population (and, implicitly, the population density). It also implies an assumption of a similar individual valuation of the disutility of being ill, productivity loss and COI.

Similar assumptions apply to environmental impacts, to the extent these impacts are valued and included in such unit benefit estimates. Often these unit values are subtotals, as not all impacts have been identified, quantified or valued. In addition, often only point estimates are reported. At best, there are some sensitivity analyses applying lower and higher values for e.g. the economic values, but seldom for the other parts of the DFA, and the numbers are presented without any information about the probability distribution for the high, central and low values. Just a range of values, without the probability distribution, might nevertheless be useful if the costs of the regulation are either well above or well below this range of the benefits (in terms of avoided damage costs) of regulating the chemical.

Most of the assessments covered by the five case studies have been carried out in the United States or in Europe. Hardly any assessments have been carried out in Asia, which in many cases has the highest production of the chemicals considered (e.g. formaldehyde). Since there are few valuation studies of relevant impacts in Asia, most CBAs in Asia have to rely on benefit transfer from the US and European studies. Thus, guidance on benefit transfer from one country to another is needed (see e.g. Ready and Navrud (2006[7])). While there has been recent research and expert discussions on the transfer of VSL estimates from high-

to low- and middle-income countries (especially with regard to which income elasticity of WTP to use), as well as for morbidity impacts in CBAs of ill health interventions in general,[9] there is still limited empirical evidence on the validity of such transfers.

The case study on PFOAs and it salts recognises the persistence, bioaccumulative and toxic (PBT) properties of these and other substances, and that the sheer number of these substances precludes full impact assessment and economic valuation. The case study suggests that the analysis could be conducted for groups of chemicals with similar PBT properties, and thus transferred from one, or a few, selected, chemicals in each group to all other individual substances in the group. However, this demands a set of assumptions about similarities in all the different steps of the DFA from emission and dispersion through exposure patterns in different media to people's preferences for health and environmental endpoints in different countries – which have different income, differences in other socio-economic variables as well as different institutional and cultural contexts. It also requires assumptions regarding the size and behaviour of the exposed human population; and extent of the affected ecosystem services. Thus, value transfer guidance would have to be developed for this specific purpose; rooted in general value transfer guidelines.

3. Conclusions and the way forward

Overall, the five case studies suggest that within the impact-pathway approach (IPA) or damage-function approach (DFA), the major uncertainty is the lack of dose-response functions, rather than a lack of monetary values of the impacts. However, economic valuation studies of relevant health endpoints are also scarce and incomplete, especially concerning the disutility costs, but also regarding the cost-of-illness; as compared to e.g. the comprehensive valuation studies regarding health impacts of air pollution.

For environmental impacts, which should be valued in terms of impacts of chemicals exposure on ecosystem services, the lack of both dose-response functions and economic valuation studies is even greater. According to the five case studies, these impacts are not at all assessed quantitatively nor valued (with the exception of selected ecosystem service impacts from mercury).

Furthermore, in the CBAs where the health benefits from regulation have been valued, both COI and disutility estimates are based on simplified procedures for value transfer. This is true for both morbidity and mortality impacts.

Mortality impacts are often assessed in terms of the number of QALYs and DALYs gained, rather than the number of statistical lives gained, which could be valued using benefit function transfer from OECD's meta-analysis of stated preference studies of VSL.

A main challenge in CBAs of the five selected substances, based on the current knowledge-base, is how to best present the non-quantified or non-monetised impacts, as well as the uncertainty in all steps of the IPA or DFA, to allow for regulatory management decisions

[9] https://sites.sph.harvard.edu/bcaguidelines/.

under incomplete information and high uncertainty. However, these five case studies clearly identifies the knowledge gaps, provides good examples of how to apply the IPA or DFA approach; and serves as priors that can be updated as new information and research emerges.

With regards to the way forward in CBAs of regulation of chemicals, there is a need for:

1. Identification of the potentially most important health and environmental impacts in term of aggregate economic benefits. These are determined by the size of the exposed or affected population through different media (air, water, soil), the number of cases of negative impacts (from expert assessment or dose-response functions) and the potential economic value of each of the health and environmental impacts.
2. Quantification of the impacts of these potentially most important impacts; through expert assessments or Delphi methods, and development of dose-response functions (and more specifically for health impacts; exposure-response functions).
3. New economic valuation studies, based on the recent guidelines for stated preference studies (Johnston et al., 2017[8]) of the quantified impacts (especially disutility from acute and chronic morbidity impacts) in terms of health endpoints. The health endpoints which are *not* quantified due to lacking or highly uncertain exposure-response functions (ERFs), but that could potentially be large should also be valued in new studies, in order to be available once new evidence of the ERFs emerge. The same applies to the environmental impacts in terms of effects on ecosystem services.
4. Updated and improved guidance for benefit transfer with uncertainty bounds; based on a guidance document on benefit transfer similar to the one on stated preference studies (Johnston et al., 2017[8]).

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