Organisation for Economic Co-operation and Development

ENV/CBC/MONO(2023)4

Unclassified **English - Or. English**

8 March 2023

ENVIRONMENT DIRECTORATE
CHEMICALS AND BIOTECHNOLOGY COMMITTEE

Economic instruments to incentivise substitution of chemicals of concern – a review

Final report

Series on Risk Management
No. 79

JT03513817

OECD Environment, Health and Safety Publications
Series on Risk Management
No. 79

Economic instruments to incentivise substitution of chemicals of concern – a review

IOMC
INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS
A cooperative agreement among **FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD**

Environment Directorate

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Paris 2023

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Foreword

This report was developed as background to the OECD Workshop on Government Approaches to Incentivise Substitution that took place in Paris on 20-21 September 2022 under the auspices of the OECD Working Party on Risk Management (WPRM). The drafting of this report as well as the organisation of the workshop was made possible thanks to a voluntary contribution from Australia.

The report provides an overview of economic instruments used in chemicals management and in other environmental domains that governments could consider to incentivise substitution of chemicals of concern.

The report was prepared by Daniel Slunge, Centre for Future Chemical Risk Assessment and Management, University of Gothenburg. The author would like to thank Thomas Sterner and Joel Tickner for constructive comments on an early draft. It also benefited from input from the workshop participants, the OECD secretariat, as well as members of the WPRM. It is published under the responsibility of the OECD Chemicals and Biotechnology Committee.

Executive Summary

Economic instruments such as taxes and fees have been extensively used in other environmental domains but have so far been relatively sparsely applied to chemicals. However, there is an increased interest in the potential of economic instruments to incentivise substitution of chemicals of concern. This interest is motivated by the ambition to speed up the substitution of substances of concern and to reduce the toxic load from broader groups of chemicals as well as the need to strengthen fiscal revenues and cover costs for chemical management.

This study aims to give an overview of economic instruments used in chemicals management and in other environmental domains that governments could consider to incentivise substitution of chemicals of concern. The study reviews lessons learned from the use of five types of economic instruments: taxes, fees, subsidies, tradable permits, and deposit-refund systems, as well as “hybrid instruments” that combine elements of different instrument groups.

The main benefits of economic instruments are their ability to provide continuous incentives for firms to innovate and substitute to safer alternatives. By incorporating information of environmental and social costs into prices that producers and consumers face on the market, economic instruments can incentivise substitution without stipulating in detail what technology or action each actor should take. However, as economic instruments give authorities less control over how, where and at what quantities chemical substances are used, they should be seen as complements rather than substitutes to other instrument types, such as bans, use restrictions and information.

Despite evidence that environmental taxes and other economic instruments *can* be effective in addressing environmental problems, their actual use is generally far from sufficient to implement the polluter pays principle. New taxes or fees are often challenged by different interest groups leading to sub-optimal design and implementation. Hence, political economy factors need to be considered in the design and implementation of economic instruments.

Building on the lessons learned from the use of economic instruments for environmental and chemicals management, five broad sets of instruments with potential to incentivise substitution of chemicals of concern are discussed:

- *Fees on producers and importers of chemicals to incentivise information provision.* Fee-based registries contribute indirectly to substitution by providing information to market actors and authorities. A key challenge is that the information submitted to the authorities often is of low quality. This could be counteracted by increasing default costs, through imposing (increasing) penalties and enhancing quality controls.
- *Taxes or fees on chemicals of concern with a possibility to use revenues for toxic use reduction programmes.* A tax or fee could be introduced on all substances identified as substances of concern. To avoid “regrettable substitution”, a tax or fee system could in principle be extended to also cover chemicals with a similar chemical structure as listed chemicals of concerns. Revenues from fees could finance toxic use reduction programmes, including research, education, technical support as well as grants to small businesses to support transitioning to safer alternatives.

- *Risk based taxation on substances of concern in products articles and processes*. Evaluations indicate that risk-based taxation – which links taxation more closely to specific environment and health risks – can be effective in reducing the environmental and health effects of chemicals. However, the limited information about substances of concern in articles is a key constraint to broader application.
- *Hybrid schemes combining fees and subsidies in collaboration with industry sectors*. By returning revenues from fees on chemicals of concern to the regulated sector in the form of a subsidy or technical assistance, strong incentives for substitution can be generated in sectors where substitution is challenging. An important feature of these type of hybrid schemes is their potential to create policy support within the regulated industry.
- *Permit systems with trading possibilities*. Tradable permit systems have been used in relation to lead, CFCs and fluorinated greenhouse gases. Similar systems could be designed to incentivise the substitution of other groups of substances of concern or specific uses. One could also envision broader permit markets as all chemicals put on the market occupy a piece of a shared pollution space.

In order to enhance the use of economic instruments to incentivise substitution of chemicals of concern, a policy learning process among OECD-countries could be established. This could involve systematic monitoring, evaluation and information sharing in relation to the use of existing and new economic instruments in chemicals management. This would be an important way to address the existing knowledge gaps on the effectiveness of economic instruments in chemicals management.

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1. Introduction

Despite progress made in terms of legislative frameworks and the management of certain high-risk chemicals, chemical pollution remains a growing challenge (Landrigan et al., 2018; UNEP, 2019). The combined effect on health and ecosystems from low-dose exposure to multiple chemicals is a growing concern. Indicative examples include substantial health and environmental costs associated with the diffuse and widespread pollution from PFAS (per- and polyfluoroalkyl substances) (Goldenman et al., 2019) and large costs linked to the effects of endocrine disrupting substances on male reproductive health and other health endpoints (Bellanger et al., 2015; Olsson, 2014).

Besides the traditional instruments used in chemicals management - bans, restrictions and information provision - there is mounting interest in the potential of economic instruments to incentivise substitution of chemicals of concern. Examples of recent initiatives include the attention paid to fiscal incentives for chemicals management in the Global Chemicals Outlook II (UNEP, 2019), the SAICM review of cost recovery mechanisms and other economic instruments (SAICM, 2020), and the review of policy instruments for enhanced chemicals management and sustainable funding initiated by the Department of Toxic Substance Control in California (Tickner J. et al., 2022).

Economic instruments such as taxes and fees have been extensively used in other environmental domains but have so far been rarely applied to chemicals (Slunge & Alpizar, 2019; Söderholm, 2009). The need for speeding up the substitution of substances of very high concern (e.g. European Environmental Bureau, 2022), but also the ambition to reduce the toxic load from broader groups of chemicals (e.g. European Commission, 2020), could motivate increased use of economic instruments in chemicals management.

This scoping study aims to give an overview of economic instruments used in chemicals management and in other environmental domains that governments could consider to incentivise substitution of chemicals of concern. The ambition is not to provide an extensive review of this large field[1], but rather to discuss challenges and opportunities with using economic instruments to incentivise substitution of chemicals of concern, based on indicative examples. The review builds on earlier work, primarily Slunge and Alpizar (2019) and Tickner et al. (2022), which both involve extensive literature reviews.

The term economic instruments refer to instruments that change the relative price of a given activity or input, either encouraging or discouraging its use. Market-based or price-based instruments are other commonly used terms for this group of policy instruments. The review covers five types of economic instruments: taxes, fees, subsidies, tradable permits, and deposit-refund systems, as well as “hybrid instruments” that combine elements of different instrument groups. The five instrument categories are briefly described in Table 1. Liability schemes, offsets, bonds, and other types of financial assurance systems, are not covered in this review.

The report continues as follows: Chapter 2 discusses principles that guide the choice and design of policy instruments in environmental management, including when to use price-based vs quantitatively based instruments, instrument effects on behaviour vs revenue generation, the role of (asymmetric) information and the link between instrument choice

[1] See OECD 2001, 2006 and 2010 for reviews of experiences from using environmental taxes in OECD countries, and Sterner and Coria (2012) for a thorough analysis of policy instruments in environmental and natural resource management.

and innovation. Chapter 3 reviews examples of economic instruments in five different instrument categories used in chemicals management and in other environmental domains. In the final Chapter 4, lessons learned from using economic instruments are discussed and opportunities for using economic instruments to incentivise substitution of chemicals of concern are identified. Chapter 4 also discusses implementation challenges and knowledge gaps.

Table 1. Typology of economic instruments and examples of applications in chemicals management

Policy instrument	Description	Example of application
Tax	By increasing the price of using a chemical, a tax incentivises decreased use. Taxes are levied by the state, with proceeds going to the general budget. The level should reflect the damages caused by the production, use and disposal of the chemical, which in the absence of the tax would not be reflected in the market price of the input or final product.	Pesticides, inorganic fertilisers, chlorinated solvents, batteries
Fee /Charge	Similar to a tax but revenues are typically earmarked. The level of a fee should reflect the cost of providing a specific service – such as processing hazardous waste.	Hazardous waste, pesticide or chemical containers, tyres, batteries
Subsidy	A subsidy is the mirror image of a tax. It can provide incentives to increase the use of alternative chemicals that are less hazardous. In particular, authorities may want to subsidise learning and technology development.	Subsidies for organic farming, lead paint removal.
Tradable permits	An overall level of 'allowable' pollution is established and allocated among firms in the form of permits. These permits can be traded on a market at market prices	Lead in petrol (trade among refineries), ozone-depleting substances (trade among producers and importers)
Deposit-Refund	A surcharge is paid when purchasing potentially polluting products. A refund is received when returning the product to an approved centre for recycling or disposal.	Pesticide or chemical containers, batteries, tyres

Source: Based on Slunge and Alpizar (2019), Stavins (2001), Sterner and Coria (2012).

2. The choice and design of economic policy instruments in chemicals management

2.1. Regulating prices or quantities?

According to economic theory, public policy is warranted to make polluters pay for their environmental damages, unless there can be a negotiated solution between polluters and those affected by pollution. There are in principle many different policy instruments that can be used to enforce the Polluter Pays Principle and address chemical pollution and other environmental problems. It is common to divide environmental policy instruments into the following categories (Sterner & Coria, 2012):

i. Price-based: e.g., taxes, fees, subsidies

ii. Rights-based: e.g., tradable permits, property rights

iii. Direct Regulation: e.g., standards, bans, use-restrictions, liability

iv. Information-based: e.g., labelling schemes, information campaigns, nudges

Understanding marginal damage costs and marginal abatement costs are fundamental to the choice of policy instruments. When there are reasons to assume that the marginal damage cost rises sharply with production or use of a chemical or product (e.g., due to threshold effects) and the marginal cost of reduction or abatement is comparatively low, then a quantitative restriction is generally more efficient than a price-type instrument. When there are reasons to assume that the marginal damage cost is not rising sharply with production or use, but the marginal cost of reduction/abatement is high, a tax or other price-type instrument is usually more efficient than a quantitative instrument (Weitzman, 1974).

The two main textbook arguments in favour of price-based instruments in environmental policy is that they can be more cost-effective and better at promoting innovation than bans, use restrictions and technology standards (Stavins, 2001). These "command and control policies" typically allow for very little flexibility in the means of achieving specific targets. As a result, all firms need to meet the same target, irrespective of how costly the change is. However, the cost for complying with a ban or use restriction often differs between companies, due to, for example, differences in production processes and sunk costs from technology investments. Ignoring these differences in costs for substituting chemicals of concern between firms reduces cost-effectiveness.

By changing the relative price between chemicals of concern and their less hazardous alternatives, economic instruments can provide a continuous incentive for substitution. Companies have an incentive to substitute the targeted chemicals as long as their marginal cost of substitution is lower than the cost of using the targeted chemicals. By allowing firms with different substitution costs to reduce their use of chemicals of concern at different levels of intensity and time scales, economic instruments can incentivise a cost-effective substitution.

While economic instruments have some merits, there are many situations where they are less appropriate, including when the health and environmental costs from exposure to a hazardous chemical is very high, where effects are location-specific and where threshold effects, i.e., an abrupt spike in the damage function after a given threshold, are likely. In such situations, bans and use restrictions are more appropriate (Baumol & Oates, 1988; Weitzman, 1974).

As many problems with chemical pollution fulfil these characteristics (high damage cost, location specific, threshold effects) chemicals policy has mainly involved bans, use restrictions and other quantitative policy instruments. However, the increasing focus on reducing the pressure from low-dose exposure from broader groups of chemicals, often integrated in consumer products, may motivate a larger use of economic instruments in chemicals management.

In practice, many context-specific factors – such as information constraints, administrative costs, distributional effects, and stakeholder support – determine which policy instruments are most effective and feasible to implement, and thus, policy instrument design needs to be context and problem specific.

2.2. Challenges in making taxes reflect the external costs caused by chemicals of concern

In theory, an environmental tax should be designed so that the environmental and health costs caused by the production, use and disposal of the chemical are reflected in the price of the chemical or the products containing the chemical. In line with the polluter-pays principle, the tax thereby creates an incentive for economic actors to internalise the full cost into their decisions. Even in complex pollution scenarios with multiple pollutants, it is in principle possible to design a system with taxes equal to the marginal damages caused by chemicals. For example, Sadler (2000) outlines a system of risk-based taxation where each chemical is charged depending on the risk they cause for human health or the environment.

In practice, several factors make it difficult to accurately estimate the health and environmental costs of the production, use and disposal of chemicals. First, understanding the degree to which chemicals are toxic, persist, bioaccumulate and have endocrine-disrupting properties is crucial for estimating the damage caused by their use. However, data on the hazard and exposure of specific chemicals are not always available and data on combination effects when chemicals interact in specific environments are even more scant. Second, the damage costs also differ with different uses. In some cases, the main damage stems from point sources, such as industrial plants for production or recycling. In other cases, the damage costs arise from diffuse sources when millions of consumers use products containing chemicals. There may also be large spatial variations in damage costs from for example the use of fertilisers and pesticides (Söderholm, 2009).

The technical complexity of the design of policy instruments varies across the different stages of a chemical's lifecycle. From an economic efficiency point-of-view, it is desirable to target policy instruments to specific environmental or health damages as closely as possible. But, typically, the number of economic actors increases further down the chemical lifecycle. The damage costs from non-point source pollution from millions of users of chemical products can be difficult to assess as they may vary with how, where and by whom the products are used. It can therefore be complicated to develop differentiated taxes based on specific damage estimates for different uses. Alternatively, an input tax can lower the overall use of a specific chemical and can be easier to administer as the number and diversity of producers is far more limited than at later stages. However, an input tax may risk unduly restricting less harmful applications of the targeted chemical (Macauley et al., 1992).

Balancing the benefits of a targeted approach against its transaction costs is a key dilemma in policy instrument design (Vatn, 1998). While taxing actors early in the chemical life cycle can in some cases be reasonably cost-effective second-best measures (Söderholm, 2009), regulatory design needs to carefully consider the technical and political complications associated with the distribution of regulatory costs and benefits resulting from targeting actors at different stages of the chemical life cycle (Coria, 2018).

2.3. Behavioural effects vs revenue generation

In addition to incentivise behavioural change, governments may choose to use taxes and fees to generate revenue for chemicals management. However, there may be important trade-offs between these objectives.

If the demand for a polluting good (e.g., a good involving substances of concern during production or use) is inelastic (insensitive) to price increases, then a tax will have a limited effect on the demand for the good. The reason for this is that abatement or substitution is costly or difficult for other reasons. For example, some studies have found that the demand for certain pesticides is inelastic to price increases, at least in the short run due to lack of good alternatives (Finger et al., 2017). This does not necessarily mean that a tax is not an adequate policy instrument. Because the demand is inelastic, other instruments would also encounter difficulties in achieving significant substitution. In this situation, a tax can provide a continuous incentive for innovation while generating fiscal revenue. The revenue from the tax can also in principle be used to subsidise the development and use of alternatives to the targeted chemicals of concern.

If, on the other hand, demand is elastic (sensitive) to price increases, then a tax will lead to a big reduction in the use of the taxed chemical and therefore also to a rapidly diminishing tax base. Since substitution in this case is easy, tax revenues are likely to be small and decreasing.

There may also be situations where a tax can incentivise reduced demand for a chemical or product of concern among economic actors with low substitution costs but continue to generate fiscal revenue from actors with higher substitution costs. For example, petrol taxes fall into this category (Sterner & Coria, 2012).

2.4. Access to information and asymmetric information

Access to correct information is essential in a market economy, and imperfect or asymmetric information (e.g. where producers and consumers of a good have different information) is considered a market failure that may motivate government intervention (Sterner & Coria, 2012). In relation to chemicals of concern, this type of market failure is common. If, for example, consumers have limited information about the chemical content of the products they buy, it is difficult to choose a safe product. Similarly, small firms may continue to use a polluting technology if they lack information about the existence of alternative technologies (Akerlof, 1970).

The relationship between companies placing chemicals, products and articles on the market and regulators is also characterized by asymmetric information. Firms may have information about the cost of reducing or substituting certain chemicals and the availability of alternatives but do not disclose this information to regulators. This makes it more challenging to predict the effects of an economic instrument. Studying the price elasticity of demand using market data can be one way for regulators to obtain the information needed. If such data is not accessible, regulators may have to resort to observing market reactions to a specific tax level and then adjust the tax level to reach the objectives set.

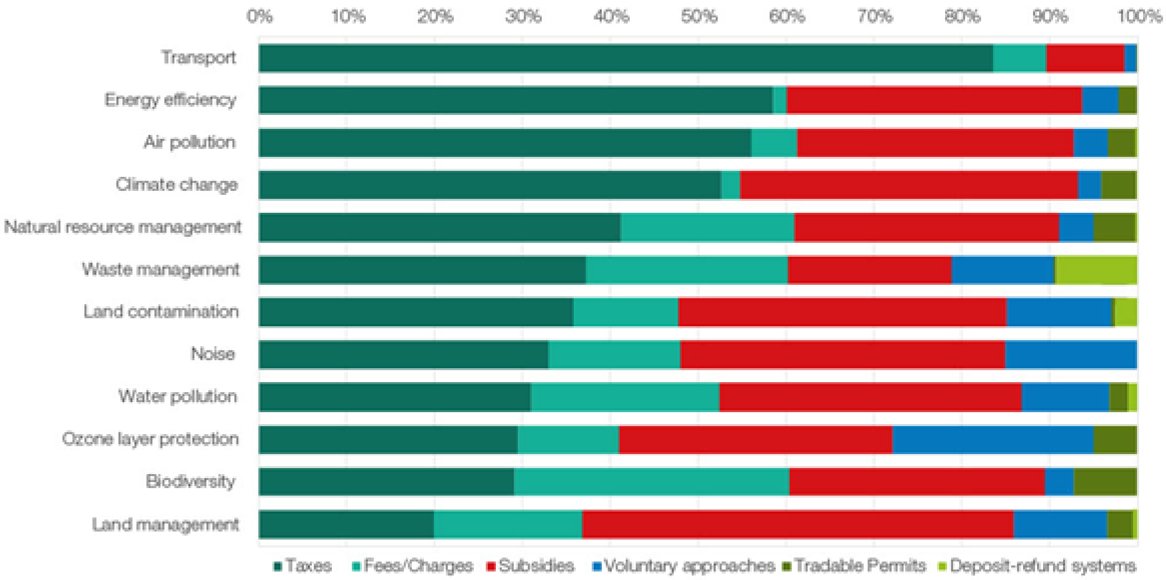
2.5. Economic instruments and innovation

Making prices reflect true social and environmental costs is essential for incentivising innovation in green technology, including green chemistry (Rusu A. et al., 2021). By increasing the cost of using chemicals of concern, taxation changes relative prices and the rate of return of investments in alternative technology. However, there are also additional reasons for governments to actively encourage green innovation. Due to imperfect information and knowledge spillovers, innovators usually do not reap the full benefits of their efforts, which lowers the incentives to invest in innovation (Jaffe et al., 2005). Also, due to path dependency, brown technologies have a productivity advantage, which provides an additional argument for government investments in directed technical change (Acemoglu et al., 2012). By providing tax credits for expenses related to research and development or by providing favourable treatment of capital or labour expenses, governments can generate additional incentives for research and innovation. These measures normally form part of broader policy packages encouraging innovation, such as investments in research and education or more targeted innovation programmes (OECD, 2010).

3. Review of economic policy instruments in environmental and chemicals management

Economic instruments are used in environmental management in a wide variety of sectors in OECD countries (Figure 1). Taxes is the instrument most commonly used, followed by subsidies and fees. The use of economic instruments in chemicals management is relatively limited, and most frequent in relation to hazardous waste management (Slunge & Alpizar, 2019). This chapter highlights examples of five categories of economic instruments used in environmental and chemicals management. The examples can provide insights for the design of instruments generating incentives for chemical substitution.

Figure 1. Environmental policy instruments per type and environmental domain in OECD 2018.



Source: OECD, Pine database. https://www.oecd.org/environment/indicators-modelling-outlooks/policy-instrument-database/

3.1. Taxes

Environmentally-related taxes are defined by the OECD as "any compulsory, unrequited payment to government levied on tax bases deemed to be of environmental relevance, i.e. taxes that have a tax base with a proven, specific negative impact on the environment" (OECD, 2016). This means that the tax does not necessarily need to have environmental improvements as the main objective. An environmentally related tax can be imposed on specific emissions, materials, goods, services, or activities. The tax can be flat or graduated, that is, increasing based on the volume/intensity/hazard of materials, goods, service, or activity.

3.1.1. Examples of uses in other environmental domains

Environmentally-related taxes are common in OECD countries, but revenues generated account for only around 2% of GDP on average (OECD, 2015b). About 90% of this revenue stem from taxes on motor vehicle fuels and motor vehicles. Other areas where environmental taxes are applied include air-pollution (e.g., on emissions of nitrogen oxides and sulphur dioxides), HFCs and ozone-depleting substances, VOCs (incl. chlorinated solvents), batteries and waste[2].

3.1.2. Examples and experiences from the use of taxes to incentivise chemical substitution

Several OECD countries have implemented taxes on waste disposal to incentivise reuse and recycling. One example is the Waste Disposal Tax in Austria, which covers landfills, incineration, storage as well as exports of waste to avoid a shift from one form of waste disposal to another. The tax rate is differentiated to reflect the environmental costs of the different disposal alternatives, with a higher tax for landfill (€ 9.2 - € 29.8/ tonne) than incineration (€ 8/tonne). The tax revenue (€ 69 million in 2019) is earmarked for financing the remediation or protection of sites contaminated before 1989, when the original tax came into force (European Commission, 2021a).

The US Superfund chemical excise taxes were reinstated on July 1st, 2022, and require manufacturers, producers, or importers of a taxable chemical to pay an excise tax on the sale or use of "taxable chemicals" and an excise tax on the sale or use of imported "taxable substances". The tax rate for 121 listed substances is graduated ($3-20 USD per tonne), based on the hazardous properties of the chemical or substance. The revenues from the tax are earmarked for the clean-up of contaminated sites in the US. The Superfund, and the related tax mechanism, was originally created in 1980. In 1995, the US Congress voted against renewing it. While effective in generating revenue, the previous Superfund excise taxes were not directly linked to the generation of hazardous waste, and provided limited incentives to minimise waste generation or to manage waste more responsibly (Industrial Economics Inc, 1994). The new 2022 tax rates are also comparatively low and not likely to have a strong effect on substitution of chemicals of concern.

Danish Risk-based Pesticide Tax: In 2013, Denmark revised its pesticide taxation to make the tax level for each pesticide better reflect the external cost. Instead of distinct risk categories, the tax level is set by an environmental load index ranging from 0 to 40 based on human health risks, toxicity to non-target organisms and the environmental fate of the pesticide. The load indicator and tax level are calculated for each pesticide product. The heterogeneity in tax levels is high, ranging from €25.5/ha to €0.57/ha, which has resulted in large price increases for some pesticides and decreases for other pesticides. Evaluations, based on data up to 2018, find that the tax has led to substantial load reductions due to comprehensive substitution towards less harmful products. Farmers raised several concerns during the reform process, and land taxes were lowered as part of the tax reform in order to compensate farmers (European Commission, 2021a; Nielsen et al., 2020). Norway, France, and Mexico have also implemented risk-differentiated taxation of Plant Protection Products to incentivise farmers to use less hazardous products. The mixed experiences illustrate the importance of instrument design as well as political economy aspects for achieving the intended outcomes (Böcker & Finger, 2016; Finger et al. 2017; OECD, 2017).

[2] See (OECD, 2001, 2006); OECD (2010) for comprehensive overviews and European Commission (2021a) for a recent review of environmental taxes in the European Union.

Swedish tax on hazardous chemicals in electronic products[3]: Sweden introduced a tax on certain chemicals in electrical and electronic products in 2017. The aim was to reduce the occurrence and spread of, and exposure to, dangerous flame retardants in people's homes. Since the regulator did not have access to information on the amount of hazardous chemicals in the different products put on the market, the tax was designed to make the producers provide this information. Producers and importers of the listed electronic products pay an excise duty of around 0.8 EUR per kilogram for kitchen appliances and 12 EUR per kilogram for other electronic products. There is a maximum charge of 32 EUR per item. If producers and importers can prove that the electronic products do not contain additive compounds of bromine, chlorine, or phosphorus, they can get a 50 % tax deduction. If they can also show that the products do not contain reactive added bromine or chlorine compounds, they are entitled to a 90 % tax deduction. A recent evaluation (Swedish Tax Agency & Swedish Chemical Agency, 2020) indicates that companies have started substitution activities partly because of the tax, but many are still on one of the first steps of the substitution ladder. However, the tax was assessed to be administratively burdensome and not cost-effective. Modifications of the design of the tax are likely to be implemented in 2022.

Norwegian tax on Tax on trichloroethene (TCE) and Perchloroethylene (PERC): In the year 2000, Norway introduced a tax of 50 NOK per kilogram (around 5 EUR) TCE and PERC produced or imported. The tax is calculated based on the product's net weight and the proportion of TCE and PERC in the product. The tax incentivised a rapid decrease of the use of TCE and PERC (Slunge and Alpizar, 2019).

3.2. Fees

Fees[4] are defined as compulsory requited payments to the government that are levied more–or-less in proportion to the services provided. A fee can be similar to a tax, however fees are paid for government services directed at a specific beneficiary, while taxes are used to raise revenue to fund general (or specific) government expenditure (OECD, 2016).

3.2.1. Examples of uses in other environmental domains

Fees are a common instrument in several environmental domains. Fees are generally used in the water sector to *recover the cost* for providing clean water to consumers. As fixed costs for water systems are typically high and running costs low, it is common to have a fixed fee to finance the utility, and a variable fee to cover the marginal costs of providing water and to incentivise water saving. For example, the water user fees charged by the water utilities in Sacramento, USA, are set to cover capital expenses and operating costs. Fees can also be charged for *accessing a resource* (e.g., land, groundwater, fisheries) and to cover costs from a polluting activity (e.g., costs for evaluating or addressing the impacts). It is also common to use fees for registration, filing, or obtaining a license or a permit (e.g., Environmental Impact Assessment fees). Such fees are often set to cover costs for administration, monitoring, analysis, enforcement, and technical assistance.

[3] Other example of taxes on chemicals in products include the Danish tax on products containing PVC and phthalates from year 2000 and the Swedish 2019-proposal on a tax on chemicals in clothes and shoes.

[4] The terms "fees" and "charges" are often used interchangeably.

3.2.2. Examples and experiences from the use of fees to incentivise chemical substitution

Fees are also common instruments in chemicals management and have been used by authorities to cover costs for services such as maintaining registers, performing inspections, processing authorisations and licenses (SAICM, 2020). For example, 70% of the operational costs of the European Chemicals Agency (ECHA) between 2006-2020 were covered by various fees and chemicals cost recovery fees financed 50 % of the administrative costs of the Swedish Chemical Agency in 2017 (SAICM, 2020). Fees can be levied annually on companies placing chemicals on the market or as fees for specific services. While cost recovery is often the primary aim of chemical management fees, these can also influence the substitution of chemicals of concern by increasing the cost of using these chemicals (EFTEC, 2022). For example, the fees companies are required to pay to obtain a REACH authorisation, in combination with other requirements, have incentivised a shift to substances not requiring an authorisation (European Chemicals Agency, 2022). However, the particular design of the fee matters for the incentives it imparts. A fee per tonne on the use of a chemical of concern is likely to have a stronger effect on substitution than a fee based on the turnover or number of employees of a firm.

The *revenue*s generated from chemical management fees can also be earmarked for uses that incentivise substitution, by providing actors with information, advice or by financing research and innovation on safer chemicals. One example is the Massachusetts Toxics Use Reduction Act (TURA), which requires that facilities using large amounts of toxic chemicals[5] are required to report on their chemical use, conduct toxics use reduction planning every two years, and pay a fee. The fee structure is based on the number of employees and the number of toxic chemicals used, with limits in place. The fees paid by TURA filers support the work of the TURA implementing agencies, which are used to provide a wide variety of services, including training, grant programmes, and technical assistance programmes (note, this programme uses multiple policy instruments, not just filing fees). According to the TURA statute fees should be annually adjusted to reflect changes in the Producer Price Index (PPI). However, this adjustment has never been implemented so the fees have not changed since 1991, despite the increase of PPI by 66% between 1991 and 2020 (TURA, 2022). An earlier evaluation of the programme during 1990-2010 indicate that firms have dramatically reduced their use of toxic chemicals such as TCE by 96%, PERC by 96%, formaldehyde by 91%, and cadmium and cadmium compounds by 94%, among others (Tickner J. et al., 2022; TURI, 2013). However, the programme is challenged by resource constraints, and without an adjustment of the fee-levels, it is unclear whether the earlier effectiveness of the programme can be maintained.

Another example is the California Childhood Lead Poisoning Prevention Program, which is funded through a fee on manufacturers and others historically engaged in commercial activities related to lead or lead-containing products (i.e., paint and gasoline) as well as settlements. Revenue collected is deposited into the Childhood Lead Poisoning Prevention Fund with a cap of $16 million/year. The programme engages in case management and source identification for lead poisoned children and outreach and education to the community and targeted groups. The fee is based on past and present responsibility for environmental contamination, including market share responsibility. The fee was also upheld by the California Supreme Court as a reasonable regulatory fee (Tickner J. et al., 2022).

[5] 25,000 lbs or a chemical on the TURA list of toxic chemicals or 1,000 lbs of a “higher hazard” chemical

3.3. Subsidies and subsidy removals

A subsidy is the opposite of a tax and can take many different forms, including direct payments, tax reductions or exemptions and favourable loans. Subsidies do not fulfil the Polluter Pays Principle and involve an opportunity cost of public funds. Moreover, once introduced, reducing, or removing subsidies is often difficult since these encourage the formation of lobbies made up of beneficiaries striving to protect the subsidies. Subsidies can also lead to rebound effects by attracting more suppliers to the industry. However, subsidies tend to be popular and may be feasible from a practical standpoint when it is difficult to implement other policy instruments (Sterner and Coria, 2012). Many countries provide substantial agrochemical subsidies to promote agricultural production and increase food security, as well as fuel subsidies. However, these subsidies can have severe negative environmental effects and imply a high fiscal burden. Hence, 'subsidy removal' can be classified as a policy instrument in itself (Sterner and Coria, 2012).

3.3.1. Examples of uses in other environmental domains

Feed-in tariffs are one type of subsidy used to promote the supply of renewable energy. By offering long-term contracts to renewable energy producers, often at above market prices, and providing price certainty, feed-in tariffs incentivise investment in renewable energy technologies (Jenner et al., 2013).

3.3.2. Examples and experiences from the use of subsidies to incentivise chemical substitution

The OECD Policy Instruments for the Environment database contains many entries for 'environmentally-motivated subsidies' that can have an indirect effect on the use of chemicals. Examples include tax exemptions for pollution or hazardous waste control, subsidies for energy savings and subsidies for clean-ups of contaminated sites (OECD, n.d.). In the US, several states subsidise the removal of lead paint from private properties. In for example Massachusetts, a "Lead Paint Removal Tax Credit" is available for property owners.

3.4. Tradable permits

Tradable permits allocate pollution rights and can be issued under a trading system. In a cap-and-trade system, an upper limit on allowances is fixed, and the permits are either auctioned out or distributed for free according to specific criteria (OECD, 2016). By setting a maximum level of pollution allowed and letting market actors trade permits at market prices, incentives for cost-effective emission reductions are created. Besides pollution rights, other tradable permit systems include individual transferable quotas in fisheries and tradable depletion rights to mineral concessions.

3.4.1. Examples of uses in other environmental domains

There are several interesting examples of systems with tradable permits. The EU Emission Trading System, launched in 2005, is the world's biggest market for tradable carbon permits. A tightening of the cap for the total carbon emissions allowed has led to a significant increase in the permit prices. However, to reach EU targets of 55% net reduction of carbon emissions by 2030, the cap will need to be reduced further and cover additional sectors. Tradable permits have also been applied for non-point source nitrogen pollution in Lake Taupo in New Zealand. Public funds to gradually acquire emission rights and finance environmental protection initiatives. Explicit rights have been assigned to producers based on their performance in previous years to allow them to generate a certain pollution load. Thus, those who need to increase their nitrogen emissions beyond their allotted quota need to buy quotas from other producers (OECD, 2015a).

3.4.2. Examples and experiences from the use of tradable permits to incentivise chemical substitution

Tradable permits systems have only been very sparsely applied in relation to hazardous chemicals. An early example is the tradable permit system for refineries used to phase-out lead in the United States in the 1980s (Newell & Rogers, 2003). The tradable permit system offered a flexible system and possibilities for smaller refineries to invest in the required technology for producing unleaded petrol (Sterner & Coria, 2012). The system reduced the phase-out time of lead in petrol and is estimated to have been highly cost-effective (Newell & Rogers, 2003).

A more recent example is the tradable quota system for fluorinated greenhouse gases in the EU. Since 2015, a quota is required for producers and importers placing at least 100 tonnes of CO_2 equivalent of HFCs in bulk on the market in a calendar year. The total amount of quotas was originally planned to be reduced in steps to one fifth of the 2014-levels by 2030. However, in a new proposed regulation, the European Commission suggests a sharper reduction path, as well as measures to reduce smuggling and other illegal activities which have surfaced alongside the implementation of the quota system (European Commission, 2022). Despite several identified problems, a recent evaluation indicated that a system with tradable quotas can be a cost-effective way to reduce the total amount of fluorinated greenhouse gases in the European Union (Gschrey et al., 2022).

3.5. Deposit-refund and other hybrid instruments

Hybrid instruments combine properties from two or more instrument categories. Deposit-refund schemes (DRS), the most common type of hybrid instruments, combine a product charge (the deposit) with a subsidy for recycling or proper disposal (the refund) generally with the objective to discourage illegal or improper disposal (OECD, 2016). Commonly, revenues from taxes and charges are recycled back to industry or consumers.

3.5.1. Examples of uses in other environmental domains

Deposit-Refund schemes have been applied to beverage containers in many countries, including small plastic bottles in the Netherlands and cans, PET, and glass bottles in Finland (European Commission, 2021b). There are also several DRS applications for batteries, tyres, oil, and other hazardous materials (see below).

Refunded emission payments are another example of a hybrid instrument. Revenues generated from a tax or a fee on industrial pollution are returned to the same group of polluters in proportion to output or another measure. One example is the Swedish charge on nitrogen oxides introduced in 1992. All larger stationary combustion plants pay a high fixed charge (~5 EUR per kg NO_x), and revenue is refunded to the paying plants in relation to their respective fraction of total useful energy produced by regulated plants. As a result, plants with low NO_x emissions in relation to energy production are net receivers of funding, while plants with high emissions are net payers. The design hence promotes competition among plants for attaining the lowest NO_x emissions per amount of energy produced (Sterner & Turnheim, 2009).

Bonus-Malus systems is a third type of hybrid instruments. In the Bonus Malus system for passenger cars, light trucks and light buses in Sweden, vehicles with relatively low CO_2

emissions (up to 60 g/km) are rewarded with a “bonus” (a rebate) of a maximum of approximately 6 000 EUR. The bonus is combined with a “malus” of an increased vehicle tax for the first three years for petrol and diesel class I and II passenger cars, light buses, and light trucks to disincentivise their use.

3.5.2. Examples and experiences from the use of hybrid instruments to incentivise chemical substitution

In hazardous waste management, deposit-refund schemes are often applied to end-of-life vehicles (ELV) and lead acid batteries. Denmark, Norway and Iceland have deposit-refund schemes in place for ELV (Bragadóttir et al., 2014). In most US states, lead acid batteries used in motor vehicles are collected within deposit-refund schemes. The customer pays a deposit for a new battery and the fee is paid back to the customer upon return of a used battery. These programmes have increased the recovery rate of lead acid batteries in the US (Walls, 2011).

The non-toxic dry cleaning incentive program in California combines a fee on manufacturers and importers of perchloroethylene (Perc) for dry cleaning operations with a subsidy to dry cleaners in substituting to non-toxic and non-smog forming cleaning technologies. The revenues have also been used to finance information campaigns and demonstration of alternative technologies. The programme started in 2003 with a fee of $3 per gallon of Perc sold. The fee, which was raised by $1 per year and then fixed at $12 in 2012, has generated around $3.6 million in revenue. The programme will run until 2023 when all Perc dry cleaners are required to have been replaced (California Air Resources Board, 2020).

Another hybrid instrument focused on dry cleaning is the Alabama State Dry Cleaning Environmental Response Trust Fund. This fund was created to reimburse participating entities for the clean-up of sites contaminated by dry cleaning activities. Dry cleaners and other who elect to participate pay an initial registration fee of $5,000 and an annual fee thereafter equal to 2% gross receipts, with a maximum limit of $25,000 per year. The fund has developed criteria for reporting suspected contamination and requirements for investigation, assessment, and remediation (Tickner J. et al., 2022).

4. Discussion

4.1. Lessons learned from using environmental taxes and other economic instruments

After several decades of experience from the implementation of environmental taxes and other economic instruments, it is clear that these instruments *can* be effective in addressing environmental problems *if properly designed*. By incorporating information of environmental and social costs into prices that producers and consumers face on the market, economic instruments can incentivise more environmentally friendly behaviour without stipulating in detail what technology or action each actor should take. Box 1 includes broadly accepted design principles for effective use of environmental taxation, elaborated by the OECD.

Box 1. Design principles for environmental taxation

- Environmental tax bases should be targeted to the pollutant or polluting behaviour, with few (if any) exceptions.
- The scope of an environmental tax should ideally be as broad as the scope of the environmental damage.
- The tax rate should be commensurate with the environmental damage.
- The tax must be credible and its rate predictable in order to motivate environmental improvements.
- Environmental tax revenues can assist fiscal consolidation or help to reduce other taxes.
- Distributional impacts can, and generally should, be addressed through other policy instruments.
- Competitiveness concerns need to be carefully assessed; coordination and transitional relief can be effective responses.
- Clear communication is critical to public acceptance of environmental taxation.
- Environmental taxes may need to be combined with other policy instruments to address certain issues.

Source: *Environmental Taxation - A Guide for Policy Makers* (OECD, 2011).

Despite the evidence of effectiveness, the actual use of environmental taxes and other economic instruments is far from sufficient to internalise external costs, as evidenced by the growing costs from climate change and chemical pollution (Moottershead, 2021;

UNEP, 2019)[6]. This may be because the design and implementation of environmental taxes is far from a purely technical exercise. In an early review of the political economy of environmental taxation, it was noted that *"concerns about effects on sectoral competitiveness and distributional impacts have impeded a more extensive use of environmental taxation*" (OECD, 2006). Since then, and especially after the "yellow-vest protests" against the introduction of a climate tax by the French government in 2018, concerns about the distributional impacts and social acceptability of environmental taxes have received a growing interest (Bergquist et al., 2022). As it is generally difficult to design one single instrument that is effective in addressing both environmental problems and distributive concerns, there is a growing interest in policy packages or instrument mixes. For example, the revision of the Danish pesticide tax in 2013 was combined with a revision of land-taxes (Pedersen et al., 2020). It can also be considerably easier to implement environmental taxes if it forms part of a broader tax reform. This was the case in Sweden when the ambitious carbon tax and several other environmental taxes were implemented in the 1990s. There is also growing recognition that more attention needs to be paid to the potential of economic instruments and other environmental regulation to provide incentives for technology innovations needed for large scale transitions of technological and social systems (e.g. Dechezleprêtre, 2017.)

As chemical policy has targeted the prevention of health and environmental damage from a limited number of highly hazardous chemicals, bans and use restrictions have been the most common policy instruments. Economic instruments give the regulator less certainty about effects on the quantity used of a specific substance and have therefore been considered less appropriate for addressing chemicals of very high concern. Nevertheless, in some cases, taxes and other market-based instruments have provided important complements to bans and use restrictions, also in relation to very hazardous substances, such as lead.

The main benefits of economic instruments are their ability to stimulate cost-effective substitution and spur innovation. In many cases, it can be beneficial to combine economic instruments with restrictions on hazardous chemical exposure. Introducing a tax or fee that creates incentives for substitution and innovation can also ease the implementation of tougher use restrictions or bans at a later stage. The non-toxic dry cleaning incentive program in California is one example. An important lesson from the use of taxes on chemicals in consumer products is that supply chain transparency and access to information on chemical content in products are important pre-requisites for effective design and implementation of economic instruments. Hence, economic instruments should be seen as complements rather than substitutes to other instrument types, such as bans, use restrictions and information in chemicals management.

4.2. Opportunities for using economic instruments to incentivise chemical substitution

Drawing on the lessons learned from the use of economic instruments for environmental and chemicals management, this section discusses five sets of instruments with potential to incentivise substitution of chemicals of concern. The instruments incentivise substitution through three key mechanisms: (i) making chemicals of concern more expensive by internalising environmental and health costs in the prices facing producers and consumers; (ii) generating revenue that can be used for information diffusion, technical assistance, and capacity building on alternatives; and (iii) generating revenue that can be used for research

[6] See Moottershead (2021) for a comparison between external costs and environmental taxation in the EU.

and innovation in alternatives. The economic instruments discussed below are not meant to be prescriptive, but should be regarded as policy options which need to be elaborated and adjusted to specific contexts.

- *Fees on producers and importers of chemicals to incentivise information provision*

Access to information on chemicals placed on the market (as bulk chemicals, or in products, articles, and processes) is essential for market actors to make informed choices about risk management and substitution as well as for authorities in the design of policy instruments. A transition to more circular material flows makes access to information on chemicals even more important. Currently, there are many existing platforms for information collection and diffusion on chemicals, including, the US Toxic Release Inventory, the European system for registering chemical dossiers within REACH, the European SCIP database on substances of concern in articles and products as well as national product registries.

Most of these initiatives are financed through fees on the actors placing chemicals on the market. Generally, these fees do not directly incentivise substitution since the fees are too low and do not differentiate between hazards or risk levels. However, fee-based registries contribute indirectly to substitution by providing information to market actors and authorities. A key challenge is that the information submitted to the authorities often is of low quality. This could be counteracted by increasing default costs, through imposing (increasing) penalties and enhancing quality controls.

- *Taxes or fees on chemicals of concern with a possibility to use revenues for toxic use reduction programmes*

It is common that authorities maintain lists of chemicals of concern, which forms the basis for regulatory action to reduce the risks from the listed substances. One example is the European Candidate List of substances of very high concern for Authorisation. The lists send signals to the market that regulatory action is to be expected in relation to the included substances. However, there is often a considerable time between the listing of a chemical of concern and the implementation of measures that incentivise risk management or substitution.

In this context, a tax or fee could be introduced on all substances identified as substances of concern. Such an instrument could be motivated as a way to internalise external health and environmental costs into prices and to enhance effectiveness in phasing out the listed substances of concern. The tax or fee could be differentiated according to hazard properties of the substances or to the risk posed by the substances. Alternatively, a lower uniform fee that increases over time could be implemented. Even a small fee per kilogram used, may incentivise the phase out of hazardous substances, as a large share of companies may face low substitution costs (Slunge et al., 2022; Slunge & Sterner, 2001). The cost of designing and implementing a system with differentiated taxes or fees should be balanced with administrative costs.

Another challenge is that lists of substances of concern stimulate the replacement of chemicals of concern by non-listed substances with similar chemical structure, thus limiting the benefits of substitution (Fantke et al., 2015; Tickner et al., 2015). Examples include the substitution of trichloroethylene with perchloroethylene (Slunge et al., 2022) and Bisphenol A with Bisphenol S (den Braver-Sewradj et al., 2020). The European Chemical Agency and other authorities have moved towards group-based approaches to chemical substitution as a way to address this challenge (European Chemicals Agency, 2020). Rudén et al. (2019) suggests that chemicals that have a similar molecular structure as an identified substance of concern should be flagged as “suspected SVHCs”, and that producers and importers would be given a grace period to prove that their substance should not be grouped with a listed substance of concern. A tax or fee system could in principle be extended to also cover these substances flagged as “suspected SVHCs”. Even a low fee would send a signal to the market that these substances may become subject to stricter regulation in the future and incentivise firms to look for other alternatives.

There are several options for how revenues from this type of tax or fee may be used. Tax revenues would by default enter the general budget and could then be used to finance the priorities of the government. Alternatively, revenues can be earmarked for financing toxic use reduction programmes such as the TURI programme in Massachusetts or specific substitution initiatives. Programmes could involve research, education, technical support as well as grants to small businesses to support transitioning to safer alternatives.

- *Risk based taxation on substances of concern in products articles and processes*

Evaluations indicate that risk-based taxation – which links taxation more closely to specific environment and health risks – can be effective in reducing the environmental and health effects of chemicals. The Danish pesticide tax is an interesting example in this respect. It is possible that instruments that require actual emission measurements will become more popular in the future, as developments within information technology can reduce monitoring costs.

There are limited experiences from using taxes to incentivise substitution of substances of concern in consumer products. Existing studies indicate that limited information on the existence and concentrations of substances of concern in products leads to a lack of precision and high administrative costs associated with these taxes. However, these initiatives may provide important lessons for future policy instrument design and should be studied further.

It could also be possible to combine a risk-based tax - that would internalise the cost of pollution and waste generation - with a fee that would cover the cost of authorities for maintaining registries, control, monitoring, and licensing. Such a combination would resemble water pricing schemes, where a fixed fee covers the costs of running the utilities and a variable fee incentivises water saving behaviour.

- *Hybrid schemes combining fees and subsidies in collaboration with industry sectors*

Experiences from the Swedish NOx charge and other hybrid instruments indicate that schemes where revenues from fees are returned to the regulated sector in the form of a subsidy or technical assistance can be effective. Initiatives, such as the non-toxic dry-cleaning incentive programme in California, could potentially be scaled up or multiplied to cover other industries and groups of substances where substitution is challenging, such as hexavalent chromium plating. An important feature of these type of hybrid schemes is their potential to create policy support within the regulated industry. This support can go beyond the firms receiving subsidies and technical assistance if, for example, industry associations are involved in design and implementation and there is a transition period during which substitution can take place.

- *Permit systems with trading possibilities*

Experiences from the European emission trading system show that permit trading systems can be effective in incentivising behavioural change among a large number of actors. While tradable permit systems have been limitedly applied in relation to hazardous chemicals, there are some interesting examples in relation to lead, CFCs and fluorinated greenhouse gases. Similar systems could be designed to incentivise the substitution of other groups of substances of concern or specific uses. One advantage with tradable permits is that the authorities can focus on setting the allowable quantity of emissions, but do not need to calculate the optimal price as this will be set by the market. The potential to further use permit markets to incentivise chemical substitution needs to be further explored.

One could also envision tradable permit markets covering a large share of the chemicals on the market. The starting point for a broader permit market would be that all chemicals put on the market occupy a piece of a shared pollution space. Currently, there is no system in place to make companies pay for using this pollution space. In for example Europe, companies pay a registration fee for substances with volumes above 1 tonne, but the fee is not linked to the toxicity and the projected emission or damage. In line with the Polluter Pays Principle, the right to put a chemical on the market could be accompanied with the need to buy pollution permits in proportion to the pollution space needed for the type of substance and the volume put on the market. It could also be possible to allow for trading of permits, but there needs to be a mechanism that prevents the concentration of pollution to certain regions or ecosystems.

4.3. Key knowledge gaps

While the review identifies several economic instruments that could have a substantial effect on incentivising the substitution of chemicals of concern, it also points to important knowledge gaps. There is generally a lack of comprehensive evaluations of the effectiveness of various instruments. As the performance of economic instruments depends on context-specific factors such as price elasticities, market structure, the availability of substitutes and legal framework, one should be cautious in the interpretation of results and in the transfer of experiences between countries.

It would be important to establish a policy learning process among OECD-countries with systematic monitoring and evaluation of the effectiveness of economic policy instruments in incentivising chemical substitution. Such a policy learning process should also encompass and identify institutional and political economy factors (e.g., how to ensure policy acceptance among stakeholders), that are critical during instrument design and implementation.

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