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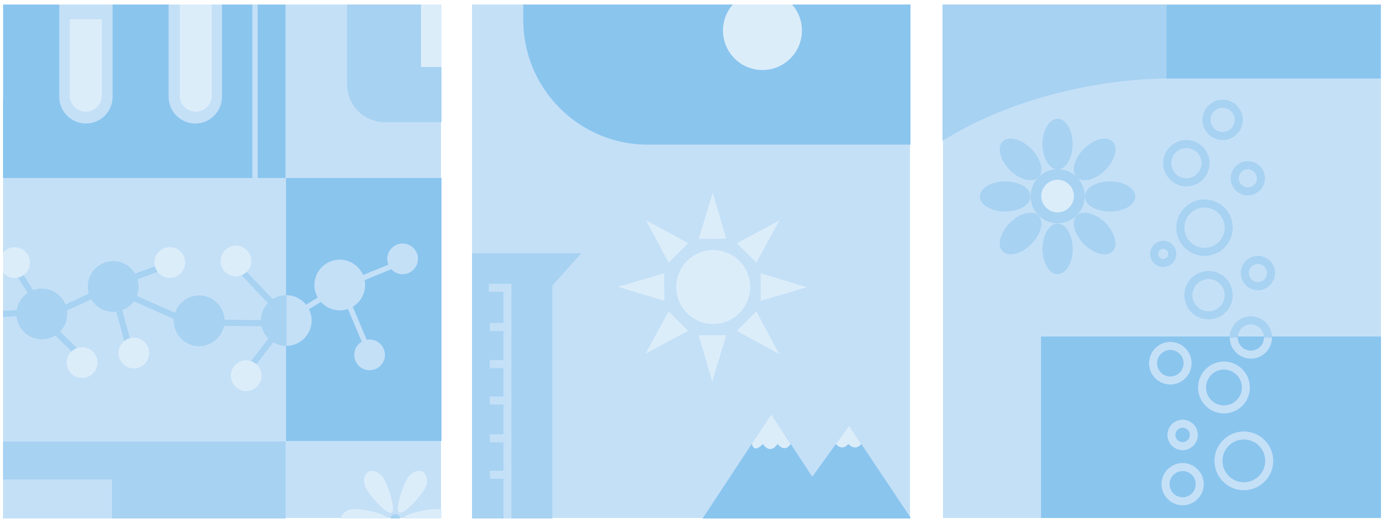
The Environmental Economics of a Global Ban on Mercury-added Products



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The Environmental Economics of a Global Ban on Mercury-added Products

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Förord

Luleå Tekniska Universitet har på uppdrag av Kemikalieinspektionen under våren och hösten 2011 analyserat fördelar respektive nackdelar med de olika sätten att reglera produkter med kvicksilverinnehåll ur ett ekonomiskt perspektiv. Denna rapport redovisar resultatet av denna analys.

Rapporten avser att belysa hur de respektive sätten att reglera produkter, som ett generellt förbud eller genom begränsning av enskilda produkter, påverkas av ekonomiska faktorer. Studien innehåller en teoretisk analys och sammanfattar de fördelar och eventuella kostnader som kan uppstå vid en reglering, oavsett hur den genomförs.

Analysen har sammanställts av professor Patrik Söderholm vid Institutionen för Ekonomi, Teknik och Samhälle (avdelningen för Samhällsvetenskap) på Luleå Tekniska Universitet. Kontaktperson vid Kemikalieinspektionen har varit Anna Fransson, med värdefullt stöd från Lars Drake.

Preface

Luleå University of Technology has been commissioned by the Swedish Chemicals Agency in the spring and autumn 2011 to analyze the advantages and disadvantages of the different ways to regulate products with mercury content from an economic point of view. This report presents the results of this analysis.

The report seeks to highlight how the respective ways to regulate products, as a general ban or as a restriction of individual products, is affected by economic factors. The study contains a theoretical analysis and summarizes the benefits and any costs that may arise from a regulation, regardless of how it is implemented.

The analysis was prepared by Professor Patrik Söderholm at the Department of Economics, Technology and Social Sciences (Department of Social Sciences) at Luleå University of Technology. Contact person at the Swedish Chemicals Agency has been Anna Fransson, with valuable support from Lars Drake.

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Summary

The main objective of this paper is to explore the pros and cons of two regulatory options in the context of a global commitment to gradually phase-out the use of mercury-added products. In the first case no mercury-added products would be allowed unless they are listed in an annex (the negative list), while in the second case all mercury-added products would be allowed unless they are listed in an annex (the positive list). In both cases countries may have time to make the transition away from these products through the use of exemptions.

The paper provides first a conceptual discussion of bans as regulatory instruments and of the use of technology-forcing standards to attain deep reductions in the use of hazardous substances, and we outline a simple theoretical framework within which the above regulatory options for mercury-added products can be analyzed. This framework is employed to analyze some important pros and cons of the negative and the positive list approaches. Specifically, we address a number of factors that may differ across the two options, such as: (a) the potential presence of different types of information inefficiencies; (b) the flexibility in compliance measures granted by the two approaches; (c) the significance of administration costs as well as other relevant policy implementation issues.

The analysis indicates that the negative list approach could facilitate a more cost-effective phase-out of mercury, in part since in this case an individual country seeking exemption would bear the burden of identifying the need for the exemption. With the positive list approach it would be more difficult to induce mercury users to reveal their true costs of substituting to other substances.

Sammanfattning

Målet med denna rapport är att undersöka för- och nackdelar med de två olika förslag som finns i det globala åtagandet att gradvis fasa ut användningen av produkter med kvicksilver. I det ena förslaget skulle inga kvicksilverinnehållande produkter vara tillåtna förutom då de listats i ett annex (den s.k. negativlistan), medan det andra förslaget är att alla kvicksilver-innehållande produkter är tillåtna förutom då de listats i ett annex (den s.k. positivlistan). I båda fallen kan länderna med hjälp av undantag ges tid att fasa ut dessa produkter.

Rapporten innehåller inledningsvis en konceptuell diskussion om förbud som styrmedel och användningen av tekniktvingande standarder för att uppnå en stor minskning av användningen av farliga ämnen, och skissar också en enkel teoretisk struktur inom vilken ovanstående regleringsmöjligheter för kvicksilverinnehållande produkter kan analyseras. Strukturen används för att analysera några viktiga fördelar och nackdelar med den negativa respektive den positiva listan. Specifikt adresseras ett antal faktorer som kan skilja sig åt mellan de två alternativen, exempelvis (a) den potentiella förekomsten av olika typer av informations-ineffektivitet, (b) flexibiliteten i efterlevnaden i de två metoderna, (c) betydelsen av administrativa kostnader samt andra relevanta policyfrågor för genomförande.

Analysen visar att negativlistan skulle underlätta en mer kostnadseffektiv utfasning av kvicksilver, delvis eftersom i det fallet skulle individuella länder som söker undantag inneha bevisbördan för att identifiera behovet av undantaget. Med den positiva listan skulle det vara svårare att förmå kvicksilveranvändare att avslöja sina verkliga kostnader för att substituera kvicksilver till andra ämnen.

1. Introduction

This paper addresses some of the challenges involved in regulating the use of mercury in society. Mercury and its compounds have adverse effects on the nervous system and its development, as well as adverse effects on the cardiovascular system, immune system, reproductive system and kidneys. Disturbance to the development of the nervous system and toxicity to the central nervous system are the most sensitive and best-documented effects. Mercury is transformed to methyl mercury by natural processes in the environment and is bioaccumulated in the food chain; it is transferred to the fetus, crosses the blood-brain barrier and probably inhibits brain development even at low concentrations. Populations who eat large amounts of fish and marine mammals are particularly at risk (Lutter and Irwin, 2002). Although methyl mercury makes up only a minor share of the total mercury in the environment, it does represent the most significant form of toxic exposure to living organisms.

At the UNEP Governing Council in February 2009, the environment ministers of 140 countries unanimously decided to launch negotiations on an international binding convention on mercury in order to reduce global emissions. The convention will include measures aimed at a number of prioritized areas, among which are direct emissions to air, such as emissions from coal incineration and industries, trade and use of mercury and mercury-added products, and waste treatment. A global solution is motivated for a number of reasons, including that mercury: (a) is volatile and its emissions are spread over long distances in the atmosphere and in the oceans; and it (b) is persistent. The latter implies that once released into the environment, it can essentially not be removed again by human efforts (Nordic Council of Ministers, 2002).[1] Still, whereas most countries agree that enhanced international collaboration would facilitate more effective mercury control, there is significant disagreement among countries about how to regulate the mercury issue at the national and global levels (e.g., Eckley Selin and Selin, 2006).

In this paper we focus primarily on mercury-added products and address the fact that the so-called intergovernmental negotiating committee to prepare a global legally binding instrument on mercury has struggled with the choice between introducing either a "general ban" on mercury in products or a "product-specific" ban. Specifically, in the former case no mercury-added products would be allowed unless they are listed in an annex (the negative list approach), while in the second case all mercury-added products would be allowed unless they are listed in an annex (the positive list approach). In both cases countries may have time to make the transition away from these products through the use of exemptions (UNEP, 2010a).

The main objective of the paper is to explore the pros and cons of these two regulatory options in the context of a global commitment to gradually phase-out the use of mercury. We address in particular the political economy of achieving an efficient transition towards a radical reduction in mercury use, and we make use of some basic insights from previous work in environmental economics to address some potentially important differences across these two policy approaches. For our purposes an "efficient transition' incorporates maintaining strong incentives for mercury phase-out while at the same time taking into account the risk of excessive compliance costs for various users of mercury-added products.

[1] The only sinks for removal of mercury from the biosphere are deep-sea sediments or (possibly) controlled landfilling (Nordic Council of Ministers, 2002).

Before proceeding, a number of important limitations of the scope of the report should be outlined. *First*, it should be noted that the present report does not address the overall benefits and costs of mercury regulation. There is thus an underlying assumption that a complete phase-out of mercury is desirable, the issue concerns rather how to achieve this transition over time in a cost-effective and politically legitimate manner. *Second*, we do not address other potential policy measures to regulate mercury use (e.g., technology standards, taxes, performance standards, emissions trading etc.).[2] In a similar vein, we do not address the nature of different options for the global governance of mercury; the analysis builds on the presumption that a global convention will be the best way forward.[3] *Third*, and finally, much of the discussion concerns mercury use in general but we pay particular attention to the use of mercury in products, e.g., thermometers, fluorescent light bulbs, thermostats, batteries (as oxides), medicals, laboratory analyses reactants etc. (e.g., Nordic Council of Ministers, 2002; Swedish Chemicals Agency, 2004). Mercury in products may be released into the environment during or after their use, and incineration processes can be a significant source of emissions. An important reason for the focus on products is that the use of consumer goods is typically difficult to address under the existing regional regulations.[4]

The paper proceeds as follows. In the next section we provide a conceptual discussion of bans as regulatory instruments and of the use of technology-forcing standards to attain deep reductions in the employment of hazardous substances. Specifically, this section contains a general discussion of the economic efficiency case for a ban on mercury use, and one section in which we outline a simple theoretical framework within which the regulatory options for mercury-added products can be analyzed. Section 3 employs this framework to analyze some important pros and cons of the use of a positive list versus a negative list. Specifically, we address a number of factors that may differ across the two options, such as: (a) the potential presence of different types of information inefficiencies; (b) the flexibility in compliance measures granted by the two approaches; (c) the significance of administration costs as well as other relevant policy implementation issues. Finally, section 4 provides some concluding remarks.

[2] See, for instance, Gayer and Hahn (2006) who compare the costs of regulating mercury emissions from coal-fired power plants using either performance standards (e.g., uniform emission rates) or emissions trading. A related analysis is presented in Lutter et al. (2001). See also Balistreri and Worley (2009), who argue that the U.S. export ban is an inefficient policy measure to control mercury use. The authors' analysis suggests that a direct mercury purchase and retirement policy would achieve the same foreign environmental goals but without adverse impacts on domestic environmental quality.

[3] Eckley Selin and Selin (2006) compare three options for the global governance of mercury, including: (a) a global mercury convention; (b) the regulation of mercury under the Stockholm convention on Persistent Organic Pollutants; and (c) voluntary partnerships for mercury control.

[4] In the European Union the Directive on waste electrical and electronic equipment (WEEE) and the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) are central examples. For instance, RoHS stipulates that mercury (and other toxic substances) is strictly limited in electrical and electronic equipment that has entered the common market after 1 July 2006. Still, the European Union is striving towards even more extensive controls on mercury.

2. Economic Efficiency of a Mercury Ban: A Conceptual Discussion

2.1 The Case for a Ban

In this section we discuss the economics of choosing between different environmental policy instruments for controlling the release of hazardous substances. Several types of instruments may come into question here, including, for instance, economic instruments (e.g., taxes, deposit-refund schemes etc.), information provision, performance standards, technology standards, voluntary agreements, liability etc. (e.g., Perman et al., 2011). The two policy options that are under scrutiny in this paper fall under the category of so-called command-and-control instruments. Both options rely on banning certain uses of mercury, and this is an extreme form of performance standard in that for the selected uses, no emissions (or included substances) are permitted.

Clearly, if there is a risk of serious and irreversible damages, then precaution may dictate the use of some very direct instruments, like a strict performance standard or even ban. Before turning to the comparison between the negative and the positive list approaches, it is useful to ask under what general conditions bans represent an economically efficient policy instrument in the case of mercury. An economically efficient policy instruments is an instrument that provides a proper balancing of the damages caused by the substance and the costs associated with reducing use (i.e., the abatement costs).

Figure 1 is based on Weitzman (1974) and provides a simple economic model for analyzing the economic efficiency of pollution taxes and performance standards *in the presence of uncertain abatement costs*. For our purposes this model is useful for clarifying some key concepts in the efficient choice of policy instruments in general, but also a starting point for further analyzing the choice between a negative and a positive list (for the latter, see section 3). An economically efficient pollution abatement level requires that the level of abatement, A, is at the level where the marginal abatement costs, MC_A, equals the marginal benefits of pollution abatement, MB_A (thus corresponding to the value of the avoided environmental damages at the margin). We assume that the regulator can properly identify MB_A, but she is assumed to have incomplete knowledge about MC_A. For this reason we introduce a distinction between the expected marginal cost curve MC_A^E, and the true marginal cost curve, MC_A^T. Based on these assumptions we can now identify two different situations, one in which the marginal benefit curve is fairly flat and the marginal cost curve is relatively steep (see graph (a)) and one where the opposite holds (see graph (b)). As shown in Weitzman (1974), the relative slopes of these curves will influence the expected efficiency of price- versus quantity-based policies.

This can be illustrated by first noting that in each of the two graphs, the regulator assumes that $\overline{A}^E$ represents the efficient level of pollution abatement. In practice, however, the true marginal abatement costs are higher than expected, and the efficient level of A is therefore lower and equals $\overline{A}^T$. If the regulator uses a pollution tax to achieve the $\overline{A}^E$ target, the tax level will bet set at s. However, at this support level only A^T units of abatement will be achieved. The difference between the actual and the (true) efficient abatement level leads to an efficiency loss, which equals the area represented by the left triangles in graphs (a) and (b).

If instead a performance standard is implemented, this would be set at $\overline{A}^E$. The shadow price of abatement will equal s¢, which is higher than the tax level that would be chosen by the regulator. The higher-than-expected marginal cost of abatement implies that actual abatement following the implementation of the performance standard will be higher than the efficient level, resulting in an efficiency loss equaling the right, shaded areas in graphs (a) and (b). The two examples in Figure 1 illustrate the important result that when the regulator is uncertain about the locus of the (linear) marginal abatement cost curve MC_A, quantitative performance standards are likely to be more efficient than tax policies if MC_A is relatively flat as compared to the slope of the (linear) marginal benefit curve MB_A. This is the case in graph (b), while in graph (a) the situation is reversed and price-based policies will be preferred.[5]

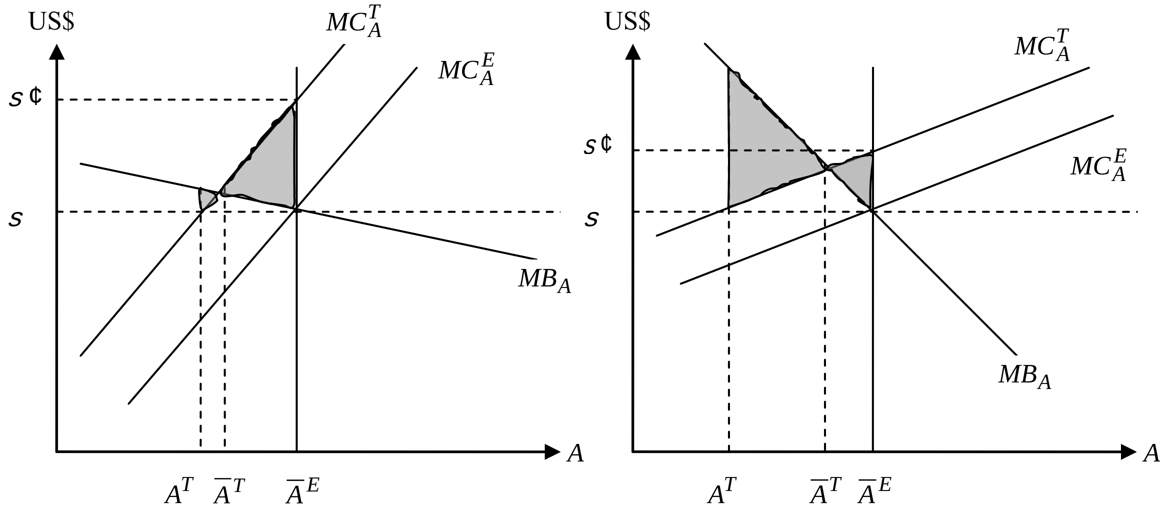

Figure 1: The Efficiency of Pollution Taxes and Performance Standards under Uncertainty

The intuition behind this result is that if the slope of MB_A is steep an increase in MC_A will justify only a fairly small decrease in the quantity of emissions abated since the value to society of avoiding further emissions is high. Hence, in this case the performance standard that was thought efficient in the erroneous *ex ante* assessment will still turn out to be nearly correct. This concern is particularly important in the regulatory control of the emissions of hazardous substances for which there typically exist critical threshold levels that should not be exceeded (e.g., Söderholm and Christiernsson, 2008). Moreover, the case for a command and control policy will be further strengthened if the (uncertain) marginal cost curve is relatively flat, since in this case firms' overreaction following a tax policy will be great, thus generating either too much or too little abatement depending on the realization of the stochastic element of the model.

In sum, the above shows that on economic efficiency grounds a mercury ban will be preferred (over a price-based policy) if the marginal damage curve is very steep (due to the presence of a critical threshold effect) *and* the economically efficient abatement level (i.e., $\overline{A}^T$ in Figure 1) represents a complete phase-out of mercury (i.e., a 100 percent reduction). In stating this one must, however, carefully acknowledge the fact that our model is static while the issue of

[5] Uncertainty about the position of MB_A will also lead to efficiency losses, but the magnitudes of these losses will typically not differ depending on the pollution control policy chosen. Thus, the choice between price- and quantity-based policy instruments is not affected by such uncertainty.

mercury control very much is a dynamic problem. Specifically, mercury represents a so-called stock pollutant, i.e., it accumulates in soils, aquifers and biological stocks and subsequently in the human body, causing major damage to human health. Moreover, for mercury the so-called pollution decay (i.e., the degradation of the substance into harmless form) is low.[6] This means that at some point in time the authorities would have to require that emissions be permanently set to zero to avoid the prospect of intolerable damage.

2.2 An Efficient (and Achievable) Mercury Phase-out

The above suggests that for our purposes a useful starting point for the comparison between the two policy approaches is that eventually mercury needs to be (more or less) completely phased out at some point.[7] The relevant question is therefore which policy strategy – the negative list approach or the positive list approach – can best facilitate the efficient transition towards this ultimate policy goal. In this sub-section we illustrate the policy challenge facing the relevant regulatory authorities, and in section 3 we explicitly discuss some of the pros and cons of the above policy strategies.

Figure 2 illustrates the policy challenge facing current efforts to phase-out mercury. Specifically, it shows a situation in which the regulator faces a deep emission reduction target, $\overline{A}$, which in turn can be motivated by perceived high marginal damages reaching a critical level unless this amount is abated. The three MC_A curves show the marginal cost of abatement for a representative polluting firm for available ('off-the-shelf') abatement technologies (see also Nentjes et al., 2007). In the case of mercury these technologies can be said to represent well-known substitutes, although with uncertain costs (e.g., the use of composite resins instead of dental amalgam). The solid straight line represents the envelope of these immediately available technologies, implying thus a continuum of existing abatement technologies. In the mercury case these curves represent the (extra) cost of replacement materials. For instance, there are other dental filling materials available which could replace dental amalgam and thus meet the needs encountered in dental care (Swedish Chemicals Agency, 2004).

However, for some uses it is hard to identify available substitutes, and for these a ban may be difficult to implement. For instance, mercury compounds are used for various kinds of analysis, and in some of these uses (e.g., certain medical diagnosis) there is no alternative to mercury. The three dashed straight lines in Figure 2 represent extrapolations of the above envelope, and they depict expectations about new technologies, which can only be employed following future R&D efforts. Still, whether R&D will be successful in providing these new technologies is uncertain. The above implies that the regulatory challenge consists of implementing a technology-forcing policy, i.e., a policy which ensures that a more ambitious mercury reduction target is met than currently available technologies can offer (but a reasonable cost). Thus, in this case the regulatory instruments' innovation-promoting impacts constitute an important policy selection criterion.

[6] Mercury released will typically take anywhere from hundreds to thousands of years to return to the deep reservoirs in the Earth where it would no longer pose a threat to humans and/or the environment.

[7] In the case of mercury there are few scientific controversies, and basically scientists agree that mercury is a significant problem that motivates policy intervention, Still, this does not imply that there is no discussion on whether the benefits of stringent mercury control to public health and ecosystems overweigh the costs of a ban on mercury use (e.g., Lutter and Irwin, 2002).

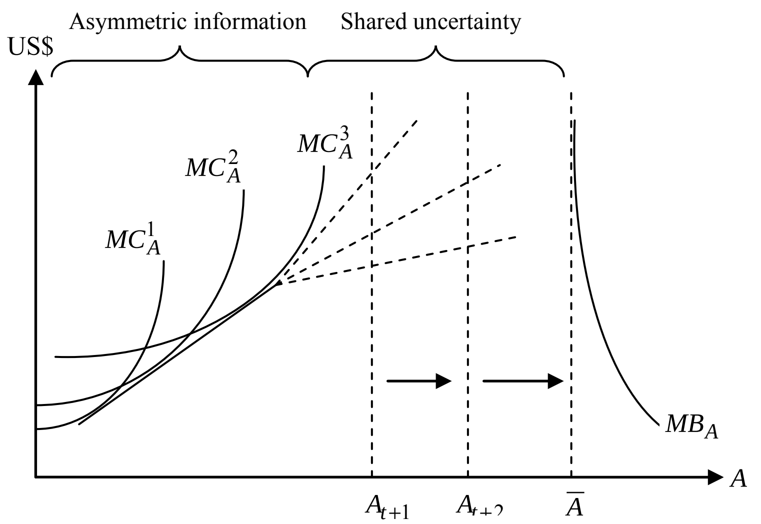

Figure 2: Marginal Abatement Costs Associated with a Transition towards a Deep Emission Cut

Moreover, mercury users typically differ in terms of their compliance costs, and firm-regulator information asymmetries are normally present. In other words, these users know far better than the regulator what it will cost to restrict use or abate emissions (and they have no incentive to reveal this information).[8] For this reason it is virtually impossible for the regulator to allocate abatement efforts to the actors who find it cheapest to reduce emissions. Figure 2 shows, though, that while asymmetric information is likely to be a significant concern in the case of existing technologies,[9] it may be less prevalent in the situation where new technology needs to be tested and developed. The presence of a large shared firm-regulator uncertainty as well as concentrated industrial sectors in which the heterogeneity in pollution abatement activities is low, will facilitate an efficient reliance on cooperative regulation based on negotiations and/or voluntary agreements (Glachant, 1999). Information asymmetries can however never be removed at a reasonably low cost for the regulator. Furthermore, performance standards permit flexibility for firms to identify the cheapest compliance strategies, but improved regulatory competence is likely to increase the regulators' ability to negotiate tighter standards (and remove existing exemptions) over time. As will be discussed below, these considerations will likely be important for mercury control.

This brings us also to the role of the regulatory process in the context of technological uncertainty. Here it is useful to consider the work of Nentjes et al. (2007), who build on the public choice literature and outline a model in which the regulator act as a 'bureaucrat' with competing objectives. Specifically, the regulator is assumed to be concerned not only by economic efficiency but she will also be careful in not imposing too large economic burdens on the affected industry sectors due to competitiveness concerns. An important policy variable in resolving this trade-off is the allowed transition period (Kemp, 1997). A longer transition period (e.g., in the form of time limited exemptions from a ban) implies a less rapid emission

[8] Thus, the regulator must also use up resources to – as far as is found necessary – acquire the information that existing polluters and users already possess. The fact that firms – in the presence of information asymmetries – will have an incentive to signal high abatement costs to avoid the likelihood of more stringent future regulations is sometimes referred to as the ratchet effect (e.g., Kolstad, 2000).

[9] The information advantage of the polluting firms will not necessarily relate so much to the characteristics of the abatement technologies as such, but rather to the ways in which this technology affects production costs at, for instance, a production plant once implemented in a given process.

reduction, but at the same time firms have time to reduce uncertainty and compliance costs by engaging in R&D and technology demonstration activities.[10] In Figure 2 this is illustrated by assuming that in time period *t* the regulator imposes an performance standard A_{t+1} that cannot be met by employing the technologies available in that period. However, firms are allowed to develop and test new technology during a probation period. With technical progress the regulator can impose stricter standards, e.g., A_{t+2}, but again in combination with an extended transition period. This regulatory strategy requires that the environmental authorities possess relevant information on abatement technology and its costs as well as on any associated information uncertainties.[11]

The above discussion has at least four important implications for the comparison between a negative versus a positive list approach. Specifically, we note that the analysis ought to address:

- the interaction between the regulator and the mercury-using countries and firms in terms of asymmetric information about the availability and cost of various compliance measures.
- the flexibility granted to users for identifying the most efficient ways to avoid the negative health and ecological impacts of mercury.
- how much and in what ways the respective policy options induce the relevant firms to continuously invest in R&D activities, in turn leading to improved knowledge about how to comply with future stricter targets.
- the incentives of the regulator to implement stricter targets, i.e., abandon exemptions or introduce bans for new products, during the phase-out in the presence of, for instance, lobbying activities.

[10] The notion that the costs of innovation can be reduced by extending the R&D period has been illustrated in, for instance, Kamien and Schwartz (1982) and Viscusi et al. (2005). The extended period permits the firm to avoid errors in the innovation process, and to mitigate diminishing returns of additional scientific and engineering manpower.

[11] Kemp (1997) develops the model by Nentjes et al. (2007) (originally presented in Nentjes, 1988) by comparing the innovation effects of a performance standard and a pollution tax. He concludes that under most circumstances the performance standard provides stronger incentives to innovate in pollution abatement technology than does the tax. The reason has to do with the fact that under a pollution tax firms must pay for non-abated emissions, implying that policy burden for the industry is often higher under a tax policy than under the performance standard. For this reason the regulator (again concerned about industrial competitiveness) is likely to implement a comparatively low tax, and firms will undertake less R&D in pollution control than in the performance standard case. In other words, the extra tax costs that firms face withhold the regulator from technology-forcing that it could have undertaken if non-abated emissions had been free.

3. The Pros and Cons of a Negative versus Positive List Approach to Mercury Phase-out

In this section we explore the advantages and disadvantages of the two ban-based approaches to regulate mercury in products. The analysis builds upon the theoretical framework outlined in section 2, and a key issue is to compare the ability of the two approaches in maintaining strong incentives for mercury phase-out while at the same time taking into account the risk of excessive compliance costs for various users (and producers) of mercury.

Before proceeding, however, it is useful to highlight an important similarity between a positive and a negative list approach to mercury control, which may at least partly provide some perverse incentive effects. Both cases contain a ban on the use of mercury, but goods that are already on the market or are in use may continue to be used. While this may be a practical approach, it also implies that with the ban for new products existing users face a stronger incentive to prolong the life of existing mercury-added products rather than invest in new mercury-free ones. This is known as the grandfathering effect, and is due to the stricter regulations for new versus existing uses.[12] There are also worries that mercury could become more intensively used in a less controlled manner in countries with less stringent legislation (Nordic Council of Ministers, 2002). While these concerns do not in itself weaken the case for any type of ban on mercury-added products, they suggest that global mercury control must likely need to rely on a mix of well-designed policy instruments.

The remainder of this section addresses some potentially important differences between a negative and a positive list approach to a ban on mercury-added products. We discuss: (a) the presence of different types of information inefficiencies; (b) the flexibility in compliance measures granted by the two approaches; and (c) the significance of administration costs and other relevant policy implementation issues.

3.1 The Presence of Information Inefficiencies

As has been noted by UNEP (2010a) a key difference between the two policies concerns the entity that bears the burden of action. With the negative list approach, the default rule would be that all mercury-added products should ultimately be banned or restricted (at least over a certain transition period).[13] In this setting we therefore expect the following:

> "At the international treaty level, an individual country seeking an exemption would bear the burden of identifying its need for the exemption and obtaining it. At the national implementation level, an individual manufacturer or user would bear the burden of demonstrating its need for an exemption and obtaining it from the national Government." (UNEP, 2010a, p. 4)

[12] For instance, in the power-generating sector the strictest standards have often been set for new plants, and with this approach it is not certain that, say, SO_2 regulations will encourage a switch to more environmentally benign gas fuels. Coal-fired plants equipped with pollution control will compete against new gas-fired power generation purely on the basis of their variable costs. This implies, *de facto*, that existing generators will receive the rents corresponding to the scarcity of environmental resources, and it creates an incentive to prolong the lives of existing plants above the point at which life extension is economically justified (Ellerman, 1996).

[13] According to the draft elements of a global legally binding instrument on mercury (UNEP, 2010b), so-called allowable-use exemptions would be available for both the negative and the positive list approaches. These exemptions would last for five years and could be renewed, subject to review of the Conference of the Parties.

With the positive list approach, though, the default rule would be that no mercury-added products are banned unless a decision is made to add them to the list of banned products. UNEP (2010a) concludes that:

> "At the international level, either the intergovernmental negotiating committee or, after the instrument's entry into force, the Conference of the Parties would bear the burden of agreeing upon each product or product class to be added to the annex. At the national implementation level, each Government would bear the burden of satisfying applicable legal requirements for adding a product to its list of banned or restricted products." (UNEP, 2010a, p. 4)[14]

While UNEP (2010a) does not elaborate on the potential consequences of the above differrence, we argue below that it may play a critical role in the presence of various types of information 'failures'. *First*, in section 2 we noted that the presence of firm-regulator (or individual country versus the Conference of the Parties) information asymmetries can have important implications for the efficiency of various environmental policy instruments.[15] In brief, if firms or individual countries have a clear information advantage over the relevant regulator (concerning compliance costs etc.), the regulator faces two options: (a) invest in own competence to overcome the information disadvantage; or (b) implement policy instruments that give firms and individual countries little reason to exploit their information advantage (e.g., by exaggerating compliance costs).

It is probably fair to conclude that in this respect the negative list approach would (ceteris paribus) be more efficient than the use of a positive list. With the negative list the burden of action is on *all* individual countries and firms, and the party requesting a so-called allowable-use exemption should provide justification showing that this exemption is justified. Those countries and firms that feel particularly hit by the ban will have a good reason to apply for an exemption, and therefore invest time to convince the regulator (and the committee) that the resulting compliance costs are prohibitive. Thus, in this policy setting the Conference of the Parties (the regulator) would not have to 'guess' in advance which firms and countries will be negatively affected; clearly this option would still suffer from significant information asymmetries but this would most likely be a greater problem in the case of a positive-list ban. Specifically, in the latter case more firms with low compliance costs would 'risk' end up being non-listed (and these would have no incentive to reveal this to the regulators).[16] Moreover, in the case of the negative list approach the regulator would also learn more about the available options to replace all types of mercury-added products, and this new knowledge could be transferred from one user to another with the regulator as a mediator (and of course also help in partly overcoming remaining information deficits).

The *second* type of information 'failure' concerns the case of bounded rationality. For our purposes this means recognizing that individuals within firms will often economize on scarce cognitive resources by utilizing routines and rules of thumb. In other words, they will tend to

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[14] Clearly in this case, once a product has been added to the list of banned products the burden for seeking an exemption would shift to the individual country (at the international level) or the manufacturer of user.

[15] The implementation of the mercury ban requires appropriate institutional arrangements, and these will likely include a conference of the Parties, subsidiary bodies and a secretariat, the latter assisting in the regulatory process (UNEP, 2010b). In the reminder of this paper we simplify and refer to the Conference of the Parties (and the associated secretariat) as the "regulator".

[16] Indeed, with the positive list approach firms may allocate too much effort on convincing regulators about their high compliance costs in order to avoid being listed, and too little effort on identifying new solutions or practices.

make satisfactory decisions rather than expend time and effort searching for the optimal decision. According to the organization and management literature, this leads to path dependent behaviour, thus recognizing that "history matters". Thus, a firm's previous investments and its repertoire of routines constrain its future behaviour (Teece et al., 1997). In other words, firms continue to perform business as usual. This can be because of sunk costs or technical inter-relatedness, i.e., whole systems are seldom replaced at once which raises the probability of continuing to do the same (Lambert and Tikkanen, 2006). Organizations develop patterns of behaviour, often referred to as routines or set of rules, to respond to problems as they arise. Once a set of rules is developed it is reinforced by, for instance, in-house training and incentive structures.

This observation is relevant for our discussion since it implies that mercury-using countries and firms who face few incentives to evaluate current practices may miss out on low-cost compliance options. For instance, mercury uses that are not banned (or exempted over a certain time period) may involve processes in which substitution to other products is efficient over the long-term but in the absence of a strict regulation (including a clear anticipation of an upcoming regulation) these opportunities are simply overlooked. This thus also tends to speak in favour of the use of the negative over the positive list approach, since it provides incentives for all countries and firms to evaluate its existing practices.

One must acknowledge however that an important risk with a negative list is that some countries and firms may come to face a ban with little prospects for cost-effective compliance. Just as the regulator will not be able to perfectly identify the uses and the countries with low compliance costs it will also experience difficulties in pin-pointing all those uses for which mercury has a very high value and few low-cost substitutes. Even though there is plenty of knowledge about the technical characteristics of various mercury substitutes (e.g., Swedish Chemicals Agency, 2010), there may still exist considerable uncertainty concerning the often context-specific costs of implementing these substitutes in practice. In using market-based policy instruments (e.g., emissions trading) regulators have the option to introduce, for instance, price caps (so-called safety valves) to avoid the presence of high shadow prices on emissions (e.g., Roberts and Spence, 1976). In the case of a mercury ban the transition period represents an important 'safety valve' in that it provides firms an opportunity to identify and/or develop, for instance, new substitutes to mercury. This suggests therefore that the regulator must impose tough transition periods while at the same time allowing fore renewed periods to provide flexibility to high-cost compliance countries and firms. Thus, used properly these transition periods could provide some short-run relief from excessive costs, while at the same maintaining strong incentives to learn more about alternatives in the long-run.

In the case of mercury users for which few substitutes exist and for which therefore substantial R&D efforts are needed, the possibility of transition period extensions may be particularly important. As was noted above, the extended period permits the firm to avoid errors in the innovation process and to lower costs. Similar to the above, a negative list approach is likely to provide stronger incentives for all (including new) users to invest in R&D as well as demonstration activities, while the use of a positive list could leave out users with potentially high returns to future R&D investment in the field. The R&D phase is likely to in part be characterized by shared firm-regulator uncertainty (rather than asymmetric information) about the future potential for cost-effective mercury reduction. This may at least to some extent facilitate the assessment of country- and/or firm-initiated claims for extensions of their transition periods.

Nevertheless, it is well-known that many international intergovernmental environmental secretariats are seriously under-funded (Eckley Selin and Selin, 2006), and this could make it difficult for the 'global regulator' (the Conference of the Parties) to assess R&D and proposals for renewed transition periods from different countries. Regulatory competence is likely to be a key to an efficient phase-out of mercury, and this requires adequate funding.

3.2 Flexibility in Compliance Measures

Both the negative list approach and the positive list approach do generally not induce a cost-effective use of compliance methods, this since they do not provide any incentives to undertake mitigation measures at the user or disposal stage (i.e., end-of-pipe solutions).[17] They "only" provide incentives to reduce mercury use as such, and thus lower the emissions of mercury in this way. Only in (unlikely) cases where no abatement technologies exist will a ban on use be the most efficient pollution policy (e.g., Sterner, 2003). In this section we show that these concerns may have some – although perhaps limited – relevance for the choice between the use of a negative versus a positive list.

A ban on mercury-added products based on a negative list denies users the flexibility to make use of end-of-pipe solutions to avoid the negative damages of the substance. Specifically, in selected instances it could be economical to permit mercury use and instead rely on strict regulations concerning the proper and safe disposal of end-of-life products and waste. In other words, although the use of transition periods permits the regulator to address the absence of substitute substances there is an implicit assumption that in the end limiting use is the most cost-effective way to avoid the mercury-associated damages. The above implies in turn that users (including potential new ones) do not face any incentive to identify and/or develop effective end-of-pipe solutions, and similarly innovators will have no incentive to invest in end-of-pipe related R&D. Even though the efficient long-term goal may be a complete phase-out of mercury use,[18] end-of-pipe solutions may represent cost-effective interim solutions that permit regulators to gradually impose more stringent regulations.

Under a positive list approach the above typically applies only to a subset of all mercury-added products, and other (e.g., domestic) regulations could promote the use of also end-of-pipe measures. In this way the use of a positive list may provide more flexibility for individual countries and (ultimately) users to employ the most efficient compliance measure. For instance, consider an environmentally-concerned country for which one specific use of mercury is very important. Under the negative list the default policy is to restrict this use to zero, at the least over a given transition period, and it would probably not be worthwhile for this country to pursue and/or develop end-of-pipe solutions to address the mercury problem (even if the rate-of-return on these investments are high prior to the ban being introduced). If a positive list is introduced instead, though, this specific use could be non-listed and the country would find it more useful to implement and develop efficient end-of-pipe strategies as well (e.g., following domestic regulations).

[17] These measures include, for instance, safe disposal, but we do not here mean various 'sanitation' measures. Once released into the environment, mercury can hardly be removed again by human efforts, although one exception concerns soil decontamination at high costs on industrial properties (Nordic Council of Ministers, 2002).

[18] The Swedish Chemicals Agency (2010) evaluates the Swedish ban on mercury (as of 2009), and concludes that for most applications it has been possible to introduce adequate substitutes, although this evaluation does not address compliance costs explicitly.

Nevertheless, for many mercury-added products it may be difficult to identify and implement safe end-of-pipe strategies. Many countries attempt to encourage efforts to separate products with high mercury contents from the general waste stream, but it remains difficult to attain high separation and collection rates for consumer products such as, lamps, batteries, thermometers etc. (Nordic Council of Ministers, 2002). Irrespective of collection set-up, separate collection and treatment also implies significant extra costs for the society (e.g., in the form of information campaigns) (see also Mukherjee et al., 2004).[19] Clearly, for controlled uses (e.g., laboratory analyses reactants) safe disposal will probably be considerab-ly easier to implement, and in these cases bans on use could impose high costs of compliance.

In sum, the negative list approach denies mercury 'polluters' the option to make use of end-of-pipe solutions (at least over the longer-run), and in this respect the positive list approach may be less constraining. However, in the case of many (although far from all) mercury-added products the scope for encouraging safe disposal behaviour may be severely limited. For this reason this particular difference between a positive versus a negative list can be marginal in practice (at least in the case of mercury-added products).

3.3 Administration Costs and Policy Implementation Issues

The costs of administering a policy instrument can be significant, and it is useful to comment on whether these costs are likely to differ across our two policy options. This question is virtually impossible to answer, and the answer will be determined by a number of context-specific factors. Nevertheless, some remarks may be in order.

UNEP (2010a) notes that in the case of a positive list approach (with initially only a few products listed), the regulator would need to develop and adopt mechanisms for nominating and evaluating other mercury-added products (including new uses). These drafting challenges are well-exemplified by the introduction of new types of mercury-added products. The use of a positive list will require a provision on new products, and this could be cumbersome since it would first of all not be easy to decide exactly on how to define a "new" product. All new products would then need to be evaluated, something which is not needed in the case of a negative list.

These evaluation procedures could be time-consuming and costly to implement. It has also been noted that: "the parties to other chemicals-related conventions have experienced significant challenges in bringing additional substances within the scope of those conventions after their entry into force," (UNEP, 2010a, p. 10). The above-mentioned under-funding of many intergovernmental environmental secretariats may explain this outcome (Eckley Selin and Selin, 2006). Another reason, though, may also be that once an initial list of banned products has been announced, the regulator would put itself into a difficult 'negotiating position' since the first list tends to signal that the products that are not on the list are not judged to be important or particularly hazardous (otherwise they would already appear on the original list). The latter would clearly be less of a problem for the negative list approach as already discussed in section 3.1.

The above does not however imply that the use of negative list implies lower overall (i.e., global) administration and implementation costs. A negative list approach – with the burden of action put on mercury-using countries – would make the above nominating and evaluating

[19] This paper deals primarily with mercury-added products (and not overall mercury use), and the concerns over safe disposal are likely to be particularly severe for these often diffuse uses.

procedures less needed, but at the same time it would mean that the cost burden for identifying any justification for exemptions is simply shifted to a larger number of parties. If there is evidence of economies-of-scale in these activities this could mean that the aggregate administration costs are higher in the case of a negative list. However, this would be offset by the notions that: (a) decentralizing the product-evaluation procedure could generate better reports; and (b) evaluations of some banned products that no party is inclined to seek exemptions for will not need to be carried out. Indeed, the often-cited under-funding of the responsible intergovernmental secretariats tends to speak in favour of the first of these arguments.

Finally, it is also useful to comment briefly on the political economy of an environmental policy based on bans and prohibitions. The literature recognizes that the use of bans in chemicals policy may occasionally be ineffective and lead to lobbying rather than research into new technologies (e.g., Slunge and Sterner, 2001). Specifically, some bans survive simply because they tend to be watered down by several exemptions, especially if the health or environmental damages are not particularly dramatic and/or international opinion more coordinated. The regulating agencies may also suffer loss of prestige vis-à-vis the complying companies, and spend a lot of time ruling on the parties' applications for exemptions. Besides wasting inspectors' time, this opens up the possibility for arbitrary decisions and, in theory, even corruption.

The presence of intensive lobbying will likely be prevalent in both policy approaches considered in this paper, not the least since both of these involve time-limited transition periods. In the mercury case the negative health and ecological effects tend to be undisputed, but this does not necessarily hold for the views on how to regulate this substance effectively and legitimately. Consider a scenario in which the relevant regulatory agency underestimates future compliance costs, e.g., by overestimating the availability of well-functioning substitutes, and therefore proposes a negative list with relatively few allowable-use exemptions. In this situation lobbying activities aiming at additional exemptions (and/or renewed transition periods) would be intense, and if the regulator falls through and grants many of these proposals, its credibility to impose stricter regulations in the future could be lost. This could potentially be less of a problem under a positive list since then the regulator would (at least in theory) be able to gradually impose stricter regulations without having to face a sudden massive opposition from several sectors and actors (the latter likely to give rise to extensive media coverage as well). Again, though, it is inherently difficult to project future lobbying activities, and these would likely be influenced largely by the way the bans are implemented rather than only by the ways in which the two options are designed on paper.

4. Concluding Remarks

In this paper we have attempted to shed some light on the role of a ban on mercury-added products in achieving a transition towards an efficient phase-out of mercury. The analysis addresses some differences between two types of bans: (a) no mercury-added products would be allowed unless they are listed in an annex (the negative list); and (b) all mercury-added products would be allowed unless they are listed in an annex (the positive list). It is however useful to note that these two policy approaches share many features. Most notably, both approaches can assist in avoiding the future blooming of abandoned or new applications of mercury, while at the same time allowing applications of mercury for which substitutes have not yet been commercialized. This represents a delicate trade-off, though, since the regulator (the Conference of the Parties) can be assumed to possess only limited knowledge about the availability and not the least the costs of effective compliance measures (e.g., the extra cost of substitutes to mercury).

We noted above that in the presence of asymmetric information about compliance costs, the regulator faces two options: (a) invest in own competence; and/or (b) implement policy instruments that give firms and individual countries little reason to exploit their information advantage. The above suggests that most likely a reliance on a mercury ban means that it is best to pursue both these strategies. A ban (whether based on a negative or a positive list) can never be designed so as to induce mercury users to reveal their true costs of compliance although we have argued that on this point the use of a negative list is likely to be the preferable choice.

Specifically, the negative list approach could facilitate a more cost-effective phase-out of mercury, in part since in this case an individual country seeking exemption would bear the burden of identifying the need for the exemption. With the positive list approach it would be more difficult to induce mercury users to reveal their true costs of substituting to other substances, and this implies, for instance, that mercury uses associated with low costs of substitution would 'risk' end up being non-listed. For both policy approaches, though, substantial investments in regulatory competence will be needed; this requires in turn that adequate and stable funding during the policy process.

The analysis has also covered the issue of flexibility in compliance measures, and it is suggested that the negative list approach denies mercury 'polluters' the option to make use of end-of-pipe solutions (at least over the longer-run), and in this respect the positive list approach may be less constraining. However, in the case of many (although far from all) mercury-added products the scope for encouraging safe disposal behaviour may be severely limited.

Moreover, the paper has also commented on some important policy implementation issues, such as the costs of administering the ban and the potential for intense lobbying. Based on this analysis it is difficult to conclude that one of the approaches should be better than the other. We note, though, that in the case of a positive list approach the regulator would need to develop and adopt mechanisms for nominating and evaluating other mercury-added products (including new uses). A provision on new products could be cumbersome since it would not be easy to decide exactly on how to define a "new" product. All new products would then need to be evaluated, something which is not needed in the case of a negative list. In addition, once an initial positive list of banned products has been announced, the regulator would be in a difficult 'negotiating position' since the first list tends to signal that the products that are not on the list are not judged to be important or particularly hazardous.

Finally, the presence of lobbying will likely be prevalent in both policy approaches to mercury phase-out, not the least since both of these involve time-limited transition periods. Here there is a risk that a ban on mercury will survive simply because it tends to be weakened due to several exemptions**.** This could possibly become less of a problem under a positive list since then the regulator could be able to gradually impose stricter regulations without having to face a sudden massive opposition from several users.

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