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WHAT MAKES A SUBSIDY ENVIRONMENTALLY HARMFUL: DEVELOPING A CHECKLIST BASED ON THE CONDITIONALITY OF SUBSIDIES

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WHEN REMOVING SUBSIDIES BENEFITS THE ENVIRONMENT: DEVELOPING A CHECKLIST BASED ON THE CONDITIONALITY OF SUBSIDIES

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Abstract

Ideally, the environmental effects of removing subsidies are estimated using general or partial equilibrium models, which takes into account the responses of different sectors. This, however, is not always possible and consequently it may be necessary to adopt another approach. The objective of this paper is to develop a checklist that could help identify subsidies for which removal would benefit the environment most. Basically the checklists focuses on two types of interrelated issues: the effects of subsidy removal on producers' and consumers' decisions and the directness of the link between those decisions and the environment.

The effects of subsidy removal on producers' and consumers' decisions crucially depend on the overall policy setting of the subsidy (including environmental policy measures), on its conditionality (i.e. how (much) the various categories of costs and revenues that are impacted by the subsidy); the availability of alternatives and the nature of competition on factor and product markets. This proposition is by no means "new". Such policy and micro-economic considerations underlie all empirical efforts to quantify the effects of subsidy removal on the environment. The checklist only makes them more explicit.

The link between producers' and consumers' decisions and rates of exploitation and pollution also depends on the conditionality of the subsidy. The basic reasoning behind the part of the checklist concerning this link is that the more obtaining a subsidy is contingent on 1) attaining certain levels of input or output, 2) the deployment of a particular technology or 3) the use of a particular environmentally relevant input (such as energy carriers and materials), the closer the link is between the subsidy and its environmental effects. Subsidies that leave freedom to choose environmentally benign modes of production, by contrast, will have a smaller effect on the environment, hence their removal would benefit the environment less. The challenge of developing the checklist therefore is to develop criteria that distinguish between weak or strong linkages between a subsidy to-be-removed on the one hand and the environment on the other. In this respect a distinction is made between removing subsidies to energy, materials, capital equipment that uses only a particular input and other subsidies to inputs.

Unfortunately, since the environmental impacts of subsidies depend on numerous factors, the checklist cannot substitute for a thorough analysis of the subsidies under consideration for removal. It can however serve as a first "quick scan" of subsidies that are likely to yield environmental benefits when removed and identify important elements that should go into an in-depth analysis.

1. Introduction

1.1 Context

1. Ever since the early nineties, reforming or removing[1] subsidies in order to improve the environment have been high on the international political agenda. Since then, many studies on the environmental effects of subsidies are published. For an overview, see Gareth Porter (2002). In this vein, during the years 1992-1997, the OECD embarked on a comprehensive project on the environmental implications of energy and transport subsidies, resulting in numerous case studies and a final summarising report: *Reforming Energy and Transport Subsidies: Environmental and Economic implications* (OECD, 1997). These studies, which applied various elaborate definitions of subsidies, revealed a complex picture and led to the conclusion that previous studies may have overestimated the environmental benefits of their removal. Environmental effects of subsidies appeared to be rather sensitive to circumstances as well as assumptions on which the quantitative analyses were based.

2. In 1995, G7 Ministers requested the OECD to carry out a study on the costs and benefits of eliminating or reforming subsidies and tax disincentives to sound environmental practices in various sectors. This project resulted in a major report, *Improving the Environment through Reducing Subsidies* (OECD, 1998, 1999). This project resulted in, among other things, a rudimentary and not-so-easy-to-apply "quick scan"(OECD, 1998 part II, pp. 37-54) that would allow for selecting those subsidies that were more likely than others to have adverse environmental effects, while having small effects on their stated objectives (notably, employment and income). This "quick scan" more or less automatically emerged when trying to systemise the then available evidence and looking for common factors that have a decisive impact on the environmental effects of subsidy removal. The present study can be seen as an elaboration of this "quick scan", while being confined to environmental effects only.

1.2 Why develop a checklist

3. Developing a checklist may serve two purposes.

1. It could help to focus the attention to those conditions under which subsidy removal could indeed have significant beneficial environmental effects. Identifying those conditions is the prime purpose of this exercise.

2. When eventually developed successfully, governments could apply the checklist to any set of subsidies that they are considering for removal (on whatever grounds)[2] and (provisionally) rank them according to their environmental effects (when removed). Since subsidies are difficult to remove, focusing on the removal of subsidies that have a significant impact on the environment seems important.

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[1] For reasons of simplicity we focus on subsidy *removal* only, and not subsidy *reform*. Subsidy reform is seen to be a combination of removing elements of a subsidy package and replacing those elements with other that have a more favourable environmental profile. A checklist that indicates subsidies for which removal benefits the environment, would facilitate both, pinpointing subsidy elements that should be removed on environmental grounds and avoiding replacing them with subsidy element that could cause environmental harm.

[2] So far subsidy removal is most often based on the negative impacts they have on the efficiency of markets (providing marketable goods and services at lowest costs). Few if any have been removed solely for environmental reasons. If subsidies were to be removed on the basis of environmental considerations, the criterion becomes a broader welfare concept that besides the efficiency of markets, also includes the efficiency of government policies in providing non-marketable goods and services.

4. It should be noted that, given this envisaged use of the checklist, this paper and its underlying reasoning does not give additional guidance on how to define subsidies. Governments have already a list of subsidies according to whatever definition(s) they consider to be appropriate. Also the checklist will not contain items referring to the dose response relations that determine the nature and magnitude of the environmental effects of rates of exploitation and pollution, as well as items concerning the emissions and resource requirements ("environmental profiles") of industries. It is assumed that governments already have that information. The checklist merely lists important questions that must be answered to decide whether subsidy removal is likely to remedy adverse environmental effects, without creating other negative environmental impacts.

5. A checklist that is applicable to many different types of subsidies to many different industries operating under vastly differing circumstances must focus on the commonality in the mechanisms that determine the environmental effects of removing a subsidy. As a consequence, it inevitably will miss several factors that may be decisive, or conversely, will contain items that are not relevant with respect to a particular subsidy. Therefore a checklist cannot substitute for a more thorough analysis that would reveal elements missed in the checklist and would give a much more reliable picture of the effects of removing that subsidy.

6. In summary, if properly developed, the checklist

1. can serve as a "quick scan", allowing governments to concentrate on those subsidies for which removal would most *likely* result in environmental gains;

2. can help in identifying important elements that should go into a more thorough analysis; and

3. can help governments claiming justifiable environmental benefits, and avoiding unjustifiable ones. The checklist should allow identifying reinforcing and mitigating factors that together determine the final outcomes of subsidy removal right from the start.

1.3 Limitations of the checklist and its underlying reasoning

7. Ideally, the effects of subsidy removal should be estimated using general or at least partial equilibrium models, taking the responses of other sectors into account. The checklist, by contrast, only enumerates economic characteristics of subsidies that may serve as predictors for first order effects on those industries that are directly affected by the removal of a certain subsidy. The reasoning behind the checklist ignores wider macro-economic implications, such as the effects of subsidy removal on governments' budgets and consumers' incomes and their effects on the economy when recycled.

8. Subsidies have effects on international trade and therefore on the geographical distribution of economic activities. Removing subsidies in one country therefore will lead to effects in other countries. Analysing the full effects of subsidy removal should include these effects. This is a considerable extension of the analysis, compared to a purely national one. On the other hand, the effects of subsidy removal on these extensions would basically entail the same elements as a national analysis, only being applied at more markets and more (and different) economic and environmental circumstances. Therefore the checklist is only developed having a national analysis in mind. This means, however, that possible effects of the international trade regime on trade flows once a subsidy is removed, have been ignored.

9. The development of a checklist should ideally be based on a thorough meta analysis of ex-ante and preferably ex-post evaluations of subsidy removal, eliminating all the effects of differences in data and methodologies applied in those case studies. This, being a gigantic task, is beyond the scope of this paper. Instead the reasoning in this paper and the checklist is mainly based on previous OECD work (notably

OECD, 1997 a-d; OECD, 1998, 1999 a, b; OECD 2002, and the literature cited in these studies) and basic micro-economic theory. No doubt the attained results are provisional and leave ample room for improvement and refinement.

1.4 Subsidy – Environment linkages

10. The links between subsidies and their environmental effects are very complex. These links vary from being very direct, e.g. if the subsidy is conditional on the production or use of a particular substance that causes environmental harm, while cleaner alternatives are available, to very indirect, if the subsidy is decoupled from production levels. The whole exercise boils down to identifying the factors that determine the directness of the links between removing a subsidy and its environmental consequences. To more precisely describing the reasoning behind the to-be-developed checklist, consider the diagrammatic presentation of the subsidy-environment linkages in Figure 1. Starting from the box "subsidy removal", Figure 1 contains several steps. The checklist focuses on steps 1-3.

1. *A subsidy changes the relative volumes of economic activities and, potentially, emissions and rates of exploitation.* A subsidy increases revenues or reduces costs of the recipient sector, or may even decisive for starting the economic activity in the first place. As a result, at least the composition of (domestic) production and consumption will change. Generally speaking the subsidised economic activity will expand and others will contract (unless the subsidy was granted to a monopoly). The degree in which this happens depends on the final incidence of the subsidy, which in turn depends on numerous elasticities of demand and supply on both factor and product markets. Such a shift in the composition of production and consumption may have significant environmental consequences (even if the total of production would not change), due to the vast differences in resource needs and pollution between industries.

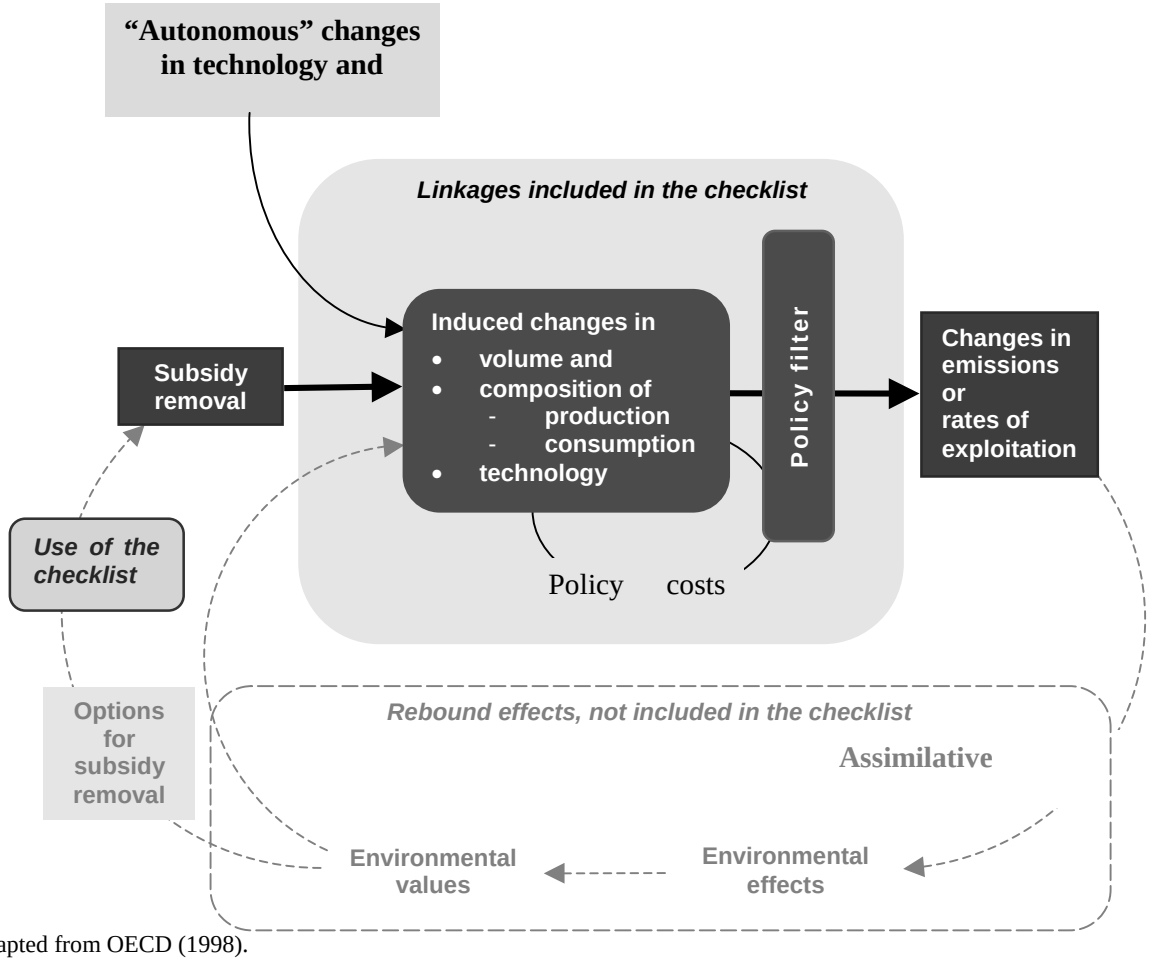
2. *The competitiveness of the subsidised sector may also be influenced by technical change.* In the long run, autonomous technical change as well as changes in market conditions may also change the relative competitiveness of the subsidised and non-subsidised industries. Maintaining the competitiveness of an industry through subsidisation may very well be an uphill fight, defending the industry against ever more efficient competitors. Note that this also applies to subsidies that previously have been installed to favour environmentally benign modes of production. As a result, removing a long-standing subsidy may free the way to the application of novel technologies, which introduction have been blocked by the subsidy. This (only) yields benefits for the environment if the new technologies are more environmentally benign, which, in turn, will be influenced by the effectiveness of environmental policy.

3. *The effects of subsidy removal on emissions or rates of depletion depend also on the prevailing "policy filter".* Subsidisation takes place within a prevailing environmental policy context. This context may consist of a set of environmental measures such as the requirement to adhere to a set of best available technologies (BAT) or other measures that prescribe certain modes of production, like sustainable forestry, or maximum rates of exploitation or production. For example, if BAT requirements prescribe flue-gas desulphurisation, the removal of a subsidy that would lead to an increase of the use of sulphur-rich fuels would have a much smaller effect on tonnes of SO_2-emissions than if those requirements were absent. Likewise, removing a subsidy to fishery may have no effect on fish stocks, if there is a management regime in place that already effectively prevents over-fishing. Other elements of the policy filter would include all other quantity restrictions such as the maximum capacity of infrastructure (in a given period), or planning and zoning requirements.

4. The resulting changes in emissions and rates of exploitation due to subsidy removal may improve the (use) values of the environment. The remaining changes in emissions and exploitation rates due to subsidy removal affect the environment, if the subsidy had environmental effects to begin with (that is, if its detrimental environmental effects had not already been eliminated by policy decisions, or other constraints). This depends on the site-specific assimilative capacity or resilience of the environment (dose response relations). Next, changes in the environment will influence the use values of the environment, which feeds back into the economic structure.

5. Effects of existing subsidies on the (use) values of the environment may constitute a political argument to remove that subsidy. The state of the environment may lead governments to explore whether removing subsidies would improve the environment. Typically this would entail drafting a list of existing subsidies that are likely to cause environmental harm. The next step would be to identify those subsidies that should be removed on environmental grounds. In the majority of cases the decision to remove a subsidy needs a firm argumentation. The environmental case must be stronger the less there are other arguments like the ineffectiveness of subsidies to achieve other policy objectives such as increased income or employment or both.

Figure 1.1. Subsidy removal and environment linkages



Adapted from OECD (1998).

1.5 The basic line of reasoning

11. The basic line of argument concerning the items that should go into the checklist under the box "changes in volumes and composition of output" in the Figure above, is that removing subsidies have the largest environmental impacts if they directly affect the production and use of natural resources or emissions.

12. The directness of the link between the environment (exploitation rates of resources or emissions, or both) and the subsidised activity depends on:

1. Whether the subsidy to-be-removed is conditional on input or output levels. If not, its removal would affect relative incomes, but not having significant environmental impacts (only those that are affected by changes in relative incomes).

2. The input/environment ratio within the subsidised economic activity, which in turn depends on the availability of alternative modes of production. If this ratio is invariable (e.g. [Carbon content of the energy used]/[CO_2-emissions]) removing subsidies to carbon containing fuels would be in order. If the ratio is variable, removing the subsidy or intensifying environmental policy should be considered.

3. The output/environment ratio of the subsidised industry, which also depends on the availability of alternative modes of production. If this ratio is variable only within close limits (e.g. in the case of a capital intensive industry), removing the subsidy to output would have significant effects on pollution or resource exploitation. Otherwise other measures of environmental policy would be the preferred option.

4. The availability of close substitutes for the products of the subsidised industry.

13. The way subsidies influence technical change is of great importance, especially in the long run, as the directness of the link between the subsidy and the environment depends strongly on the availability of alternatives. In this respect a distinction is made between removing subsidies that influence day to day decisions (their removal leading to a continuous new incentive to technical change — resource productivity) and removing subsidies that influence one-off decisions (their removal eliminating the opportunity to install environmentally benign technologies that are available at the time subsidisation starts, but also avoiding that technologies that are not so good after all are being locked-in for a considerable period of time). This distinction coincides with subsidies to environmentally relevant variable costs (energy, materials, water) exercising a continuous disincentive to increasing resource productivity on the one hand and subsidies to capital equipment that can only use a particular input (which make them subsidies to that particular input in disguise), but with a discontinuous disincentive to technical change, and other input subsidies, on the other.

1.6 Structure of the report

14. The remainder of the report is structured in the following way: chapter 2 gives a number of lessons to be drawn from previous studies. Chapter 3 tries to systemise these lessons, applying basic micro-economic theory. Finally, chapter 4 develops the checklist.

2. Lessons learnt from previous work

15. Previous OECD work as well as (many) other case studies yield valuable insights on factors that are particularly important for developing a checklist. The primary lesson is that "details matter". On a less lofty level, other lessons learnt from previous case studies; lessons that when stripped from the specific circumstances from which they are drawn, may be applicable (in various degree) to other cases and are useful as to point at items that should be included in the checklist.

1. The linkages between a subsidy and its environmental effects are complex (see Figure 1.1). As a consequence, a subsidy to an economic activity that gives rise to significant emissions is not necessarily an environmentally damaging one. It is essential to analyse the consequences of subsidy removal and the alternatives that will benefit from it.

2. The final incidence of subsidies can differ strongly from their initial impacts. Subsidies tend to be passed on to suppliers and customers, according to price elasticities of demand and supply. To assess the environmental effects of subsidy removal therefore must entail an analysis of the cluster of economic activities that is linked by input-output relations and is affected by the subsidy.

3. Subsidies are not deployed in isolation. Most often they are part of more comprehensive sectoral policies, aimed at, for example, maintaining certain production or employment levels or at restructuring the sector without too much social hardship. Such policy packages typically contain many more policy measures than just subsidies, such as institutional arrangements, planning and zoning requirements, training. Arguably a number of those measures will lead to subsidisation under a broad definition.

4. Financial support may be the source or the outcome of a policy package. Government brokered contracts deployed in for example coal subsidy programmes, basically stipulate obligatory purchases from domestic suppliers, leading to higher consumer prices and subsidisation of the coal industry (Steenblik and Coryannakis ,1995).

5. Other examples of possible accompanying measures that influence the effects of subsidies or their removal are environmental management regimes and other elements of the "policy filter", mentioned in the previous section. If for example subsidies to fisheries are removed while catches are limited by other measures, or when certain types of subsidies to road or energy are removed, while infrastructure is a limiting factor, the effects of removal may not be significant (Hannesson, 2001; Roy, 2000).

6. Moreover, subsidies also operate under even more general conditions such as the prevailing taxation regimes. As Chen (OECD, 1999, pp 21-45) and Pillet (OECD, 1999, pp 107-126) have pointed out, the same subsidy would lead to different effects on marginal costs, if applied under different taxation regimes. Great care must be taken if one wants to transpose the results of one subsidy study to another tax jurisdiction.

7. Assessing the consequences of introducing or removing subsidies implies that one has to compare a factual with an unknown counterfactual situation that serves as a benchmark. The assumptions underlying the counterfactual situation may have strong effects on the outcomes. Assume a subsidy that favours a certain technology (such as coal-fired power generation). That subsidy will depress the deployment of new technologies. Answering the question what would happen if the subsidy were to be removed, implies answering the question what technologies if any, would have replaced coal-fired power generation. Since that is a difficult

question to answer, even ex-post analyses of subsidy removal tend to be based on arbitrary assumptions underlying the counterfactual situation (see Annex 1.item 2). The longer the subsidy has been in place, the larger the potential effects of missed technical improvements tend to be.

8. Changing subsidies related to production or input levels into subsidies that are decoupled from inputs and outputs) may not change things very much. Subsidies get capitalised in the price of the least elastic factor of production, land for example in the case of agriculture. Removing a subsidy therefore will lower the price of that production factor, leading to a more extensive use of it. However, if that subsidy is replaced by another, this new subsidy will get capitalised in the price of the same production factor. As a consequence, removing a subsidy to for example irrigation water (conditional on input use) and replacing it with a subsidy based on historical entitlements (decoupled from actual input or production levels), may not change the price of land. As a result, production will remain as land intensive as it was, possibly leading to the same, levels of irrigation water use (see for example Rainelli,1998).

9. Liberalising trade may not have the opposite effect of installing subsidies. A study on the effects of liberalising trade in agriculture on Dutch agriculture (Massink and Meester, 2002) reveals that trade liberalisation would lead to significant income transfers, changes in the composition of Dutch agricultural production and to a further *intensification* of agriculture, this while subsidisation is widely believed as to have had increased intensification.

10. Subsidies, especially to capital intensive industries, may lead to strong lock-in effects. Once such an industry has established or expanded its capacity, not utilising that capacity may lead to high costs. Indeed continuing subsidisation may be cheaper than not recuperating the sunk costs, but not more efficient in the long run (Naughten et al., 1997, in OECD, 1997b, pp 143-222),.

11. Pollution and resource use are parts of substance flows through the economy. In fact all environmental effects stem from substance flows (Ayres and Ayres, 1996). Subsidies to energy carriers and materials, including water are the most directly linked to substance flows. Subsidies to technologies that are bound to use particular energy carriers or materials may also be very closely linked to substance flows. Subsidies that leave room for choosing more environmentally benign modes of production may be less detrimental for the environment, provided an effective environmental policy that prevents choices for ever more damaging options.

12. Subsidies may have different initial points of impact, such as output, input and profits and income. Initial points of impact matter for two reasons. Subsidies to inputs affect different markets than subsidies to outputs or profits and income (OECD, 2001b). Generally speaking, subsidies that directly impact materials flows have more direct effects on forward linkages than subsidies to output or profits and income. (It should be noted that such subsidies leave less options for more benign modes of production than subsidies to output or income). Second, if input subsidies are conditional on the use of particular energy carriers or materials (including water), or particular types of capital equipment that require only certain types of energy carriers or materials, they will discourage materials and energy saving, on which the success of environmental policy is highly dependent.

13. Subsidies tend to cast technologies in stone, especially if they are meant to shelter industries that deploy technologies that are not economically viable. Even subsidies that favour new and better technologies may lock-in technologies that in the long run may prove to be inferior to even newer and better non subsidised technologies.

16. In the next section an attempt is made to systemise these lessons, using some standard economic reasoning.

3. Merging theory with evidence

3.1 Introduction

17. Subsidies are always conditional on something, be it output, inputs, profits and income, or factors that influence demand (see Table 3.2). The various types of conditionality lead to different points of impact of the subsidy. Different points of impact in turn, lead to different responses of the subsidised firms. And generally, the effects of subsidy removal depend strongly on the overall policy setting, as well as circumstances (the policy filter in Figure 1.1). In some detail this is described in sections 3.4 – 3.7.

18. Before dealing with the conditionality of a number of subsidy types, two general observations should be made.

1. Subsidies may have lock-in effects, meaning that they can cast technologies in stone by protecting relatively "dirty" technologies. Since the success of environmental policy greatly depends on the development and deployment of new more environmentally benign technologies, this is an important source of environmental harm done by certain types of subsidies (section 3.2.).

2. Economic theory suggests that a firm's responses to changes in variable (marginal) costs differ from those in fixed costs. In section 3.3 the implications of this distinction are indicated.

3.2 The lock-in effect

19. Reducing the environmental impacts of economic activities depends on reducing volumes of production and reducing emissions or input requirements per unit of production.[3] The latter is often called "decoupling". Basically, decoupling can be achieved by: increasing resource efficiency ("making more with less"), deploying abatement (end-of-pipe technologies), or both. These strategies are described in some more detail in Table 3.1 (taken from OECD, 1998, Part II).

20. All of the strategies delineated in the table mentioned above have strong and weak points. Which strategy will be the best solution in any given situation will depend largely on the particular circumstances of the environmental problem it is required to address. Sometimes the choice of available strategies will be limited. Preventing pollution and waste from being generated (through process integrated solutions) is often cheaper than trying to reduce their toxicity and dispose of them after their generation — hence, in general, increasing resource productivity is more cost effective than end-of-pipe technologies (but there are

[3] Note that these requirements include, materials and energy used in "cleaning" during the production process or afterwards.

exceptions). Where there is dissipative use of materials (e.g. detergents, fertilizer, pesticides), pollution prevention may even be the only option to reduce pollution levels.

21. The bottom line is that success in environmental policy is largely dependent on changes in substance flows through the economy. By consequence, subsidies that stifle technical change are likely to harm the environment in the longer run, provided that environmental policy ensures that new technologies compare favourably with the older ones in their environmental effects. The more a subsidy fixates on a particular technology, the more suspect it is.[4] These subsidies include subsidies to a particular input and subsidies to a particular type of capital good. Note that often there is a rather close link between a particular type of machinery and the inputs that are suitable for that machinery (e.g. type of machinery and the fuel it runs on). Subsidies that favour certain technologies over others add to the "lock-in effect".[5] The longer a subsidy is in place, the stronger it will add to the lock-in effect.

Table 3.1 A typology of the main technological strategies of environmental policy

Category	Main Strategies of Environmental Policy	Examples
End-of-Pipe Treatment (Pollution Control)	1. **Reducing the toxicity of pollution and waste** Transforming pollution and waste into emissions and waste streams that are less hazardous, or managing them in a more environmentally-benign manner	Waste water treatment, flue-gas desulphurisation, remediation activities, sequestration and disposal of waste in "safe" disposal sites
Increasing Resource Productivity (Pollution Prevention)	1. **Dematerialisation** More efficient use of a given material for a given function	Energy saving measures, less fertiliser and/or pesticide use per unit of agricultural output, increased vehicle fuel efficiency of (including the reduction of vehicles weight), micro-miniaturisation in the electronics industry
	2. **Materials Substitution** Substitution of a given material by another, less hazardous (including less energy -intensive) one	Substitution of glass or aluminium fibre for copper wire, replacement of CFCs by other materials, use of less malign pesticides, use of aluminium or other light weight materials in vehicles construction
	3. **Recycling** Repair, re-use, remanufacturing and recycling of products	Recovery of metals from discarded products, recycling of paper and glass, energy recovery by incineration of discarded products
	4. **Waste Mining** Recovery of materials from production waste	Recovery of elemental sulphur from flue-gas desulphurisation, recovery of limestone from scrubber waste, recovery of fertiliser by applying closed production systems in agriculture

Source: OECD (1998), adapted from Ayres and Ayres (1996).

4 There is a strong similarity with permitting policies. Permit requirements that prescribe a certain technology are less dynamic efficient than permit requirements that stipulate environmental performance.

5 The lock-in effect means that a certain technology simply by being applied (widely) has a competitive advantage over other (new) technologies. The lock-in effect plays a role in the path dependency of technical change.

22. It is difficult to asses lock-in effects quantitatively, since one has to compare a "with-situation" with a counterfactual "without-situation". But subsidies that are maintained for a long period are much more likely to have strong lock-in effects, especially when they also directly influence the choice of materials and energy.

3.3 The importance of distinguishing between variable and marginal costs

23. Standard economic theory tells us that *output* is determined by the equalisation of marginal costs and marginal revenues — the price of the product; *profitability* is determined by the difference between average costs and average revenues — the price of the product. The equality of minimum average costs and marginal costs determines the *optimal scale of the firm and the optimal offer price* at the same token. Hence subsidies to fixed costs have different effects on total quantities used or produced by the entire industry compared to subsidies to variable costs. Over the long run, however, all costs are variable and these differences will disappear.

24. There are, however four reasons to distinguish between subsidies to variable costs on one hand and to fixed costs on the other.

1. *Short and long term versus long term effects only:* Removing subsidies to variable costs increase *marginal costs*. This immediately affects day-to-day production decisions, since only operations which revenues exceed marginal costs increase profits or reduce losses. Removing subsidies to fixed costs (i.e. subsidies that lower the cost of capital —e.g. low interest loans—, the costs of buildings, capital equipment, land), by contrast, generally affects only *new investments* in the industry, since one cannot undo past acquisitions of assets. As a result, their effect will kick in only gradually.[6] Their full effects may take even decades to materialise.

2. *Continuous versus discontinuous change:* Removing subsidies to materials and energy can work only into one direction: encouraging resource efficiency[7]. The effect will be *continuous*, spurring the emergence of ever more resource efficient modes of production. This is likely to have large environmental impacts since the industries engaged in the early phases of production (extraction, energy and materials production) are among the highest polluting industries. By contrast, removing subsidies to capital equipment affects "one-off" investment decisions and fixates technical change over the life times of the subsidised capital goods.

3. *Always right, or sometimes right:* Whereas the removal of subsidies to environmentally relevant variable cost always work in the right direction, removing subsidies to fixed costs, in particular capital equipment, may temporarily damage the environment (if they favour environmentally more benign modes of production), or conversely improve the environment (if they favour relatively "dirty" modes of production). Note that the positive effect is likely

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6 Consider for example a subsidy to energy that is used to pump irrigation water. If that subsidy is removed the costs of irrigation water rises immediately. If the acquisition price of the pump had been reduced by a subsidy, removing that subsidy would not alter the sunk costs of the pump and therefore would not raise the costs of irrigation water. The existing irrigation practices will only reduce once the pumps in use are scrapped.

7 Note that removing market price support will decrease the price of the previously subsidised goods. Nevertheless, such removal will spur the development and deployment of novel technologies, since market price support must be accompanied by measures to ensure production levels above market equilibrium.

to be temporarily, because autonomous technical change eventually may render modes of production that once were environmentally benign into ones that are relatively "dirty".

4. *Closeness of the link between the subsidy and the environment:* The link between energy and materials use on the one hand (categories of variable costs), and pollution and exploitation of natural resources on the other, is more direct than the link between fixed costs and environmental impacts, unless the subsidy is conditional on the deployment of a narrowly defined type of capital equipment that uses only one specific type of material or fuel. Arguably then it is an indirect subsidy to that input. An example in case would be a subsidy to a coal-fired power plant. Such plants are very capital intensive, but coal is a cheap fuel compared to gas. Subsidising the coal-fired plant therefore can be seen as an indirect subsidy to coal to the detriment of the cleaner fuel, gas. Subsidies to types of fixed costs that do not implicitly lock-in modes of production, such as subsidies to land, buildings and the cost of capital, leave the firm choices for environmentally more benign modes of production while being subsidised. Removing such subsidies is likely to have comparatively small beneficial effects.

25. As a rule of the thumb, removing subsidies to environmentally relevant variable costs (materials, energy, water) have a greater immediate impact on the environment than subsidies to fixed costs. This also applies to subsidies to types of fixed costs that implicitly lock in the use of certain materials and energy carriers.

3.4 Conditionality: the main points of impact

26. Subsidies are always conditional on something. The various types of conditionality or *points of impact* (Table 3.2) of the subsidies may lead to different responses of producers and consumers with respect to their modes of production, production and consumption levels and as a consequence to differences in the changes in levels of pollution and rates of exploitation. The purpose of this section is to explore the differences in likely responses of firms due to removing subsidies that have different points of impact.

27. Usually the following broad categories of points of impact are distinguished: output, input, and profits and income.[8] Such a characterisation always has arbitrary elements, because details of the subsidies at hand are not easily captured in such broad categories. Moreover, at the end of the day, all subsidies translate into either revenue increases or cost reductions. The usual break-down of subsidies, however, highlights some important differences in subsidies: revenue increases conditional on the volume of production (output); revenue increases irrespective of volumes produced (profit and income); and production cost reductions (input use).

28. We have introduced another criterion, namely points of impact that lie "within the firm" (affecting the individual firm's own cost and revenue structure directly) and "outside the firm" (affecting demand and thereby indirectly its revenues). In the first case, the firms avail themselves on the subsidy by making certain choices of its own, in the latter case the subsidies benefit the industry collectively, giving the firm less influence on the volume of the subsidised product to be produced. In terms of economic analysis, in the first case the changes are along the demand curve, whereas in the latter case the demand curves themselves shift.

[8] The latter include "existence subsidies" that are independent of production

Table 3.2 Main points of impact / support conditionality

Categories	Main initial points of impact	Effects on sales, costs and rents
Within the firm[1] (affecting costs and revenues of the firm that avails itself on the subsidy)		
1. Output	▪ Market price support o Border protection o Market access restrictions o Government brokered contracts ▪ Deficiency payments and sales premiums	Create revenues proportional to actual production volumes (increase production levels)
	▪ Production quota	Off-sets production increase; creates rents (market value of quota)
2. Input use	▪ Materials, energy ▪ Short lived equipment	Reduce variable costs
	▪ Particular types of fixed capital ▪ Access to natural resources below opportunity costs	Reduce fixed costs
	▪ Low interest loans ▪ Research and development	Reduce variable or fixed costs, or both
3. Profit and income	▪ Historical entitlements ▪ Preferential low rates of income taxes ▪ Preferential low rates of capital taxes ▪ Debt write off ▪ Allowing insufficient provision for future environmental liabilities ▪ Exemptions from (environmental) standards ▪ Start of an operation	Create revenues, irrespective of actual production volumes (increase profits)[2]
	▪ Low rate of return requirements	Reduce fixed costs and revenues
Outside the firm[1] (increasing demand, thereby affecting revenues of the industry collectively)		
4. Demand	▪ Low rates of VAT ▪ Marketing and promotion by government ▪ Provision of government produced infrastructure below costs	Stimulate demand

Source: Adapted from OECD (1998).

1) By "firm" we mean an organisation that produces a certain product. In case of vertical integration a firm in the judicial sense may contain several "firms" we are referring to in this table.

2) Such subsidies include "existence subsidies", which purpose it is to maintain the subsidised activities without them producing anything for the market (but for producing non-marketable values).

3.5 Removing a subsidy conditional to quantity of output

29. *Market price support*, which represents a very important part of subsidies granted (agriculture, fisheries, coal), is either given to ensure certain output levels of domestic production that exceed volumes or to ensure a certain price level above the level without the market price support, or both. Removing such

subsidies will reduce output of the previously subsidised product. If no change in technology occurs, this reduction equals the decrease in pollution or resource exploitation associated with the previously subsidised economic activity. At the same time, a proportionate reduction is to be expected in the supplying industries, leading to smaller environmental impacts. Removing market price support will lead to shifts in the geographical distribution of production locations with the associated changes in local environmental quality.

30. All volume effects are dependent on both price elasticity of demand and price elasticity of supply of the subsidised product. The largest effects occur if both demand and supply elasticities are large. Medium effects would result if either one elasticity is large and the other is small (see OECD, 1998, Part II, pp. 46-48, and Annex 2). Of course the net effect on the environment depends also on what products will replace the previously subsidised ones. For example, what alternative crops will be grown, what alternative species will be caught, and would the previously subsidised coal be replaced by imported coal or by an entirely different fuel?

31. Removing output subsidies leads to a loss of producers' surplus and a decrease of production volumes (unless the latter continue to be limited by quotas or other environmental management regimes). In agriculture this is likely to lower the prices of farm land that (if sufficiently large, and translated into rents) may in turn stimulate farmers to produce less intensively. In other sectors the prices of other factors that have an inelastic supply will decrease. Usually, however such second order effects are relatively small.

32. Subsidies (not only market price support) are not applied in a vacuum. In a number of cases they are accompanied by various production limitations such as: exploitation or production quotas (e.g. in agriculture, fisheries, forestry); limitations of the available infrastructure (e.g. in energy and transport); planning and zoning requirements (e.g. in industry, agriculture, energy, transport); pollution limits (all sectors). These all are elements that have been labelled the "policy filter" in Figure 1.1. If those limitations are maintained, it may be *them* that determine the overall effect of subsidy removal. This will be the case if for example production limits have been set to avoid over production even at the higher prices that result from market price support (such a as milk or fish quota). By contrast, removing both the subsidy *together with the production limit* will result in an increase in production volumes, if the production limit was below production limits that correspond with market equilibrium after subsidy and production limit removal.[9]

33. *Deficiency payments and sales premiums*, also being mechanisms to bridge the gap between a politically determined price and the market price have similar effects on production volumes as market price support.

3.6 Removing a subsidy to input use

34. *Materials (including water), energy*. Removing these subsidies are likely to have substantial environmental benefits. Their removal increases variable cost, which effects are felt immediately and continuously; remove the lock-in effects that block developments towards more resource productivity which in turn; reducing the environmental impacts of the extracting, energy producing and materials producing industries.

[9] All subsidies that distort trade lead to a geographical relocation of environmental impacts. This means that the environment within the country that removes its subsidy could be put under more or less strain. Likewise the "world environment" could be better or worse off. The checklist allows for identifying such developments, if applied to include all the relevant sites of production.

35. *Short lived equipment.* Removing these subsidies likewise increases variable costs. Whether they have the wider effects on resource efficiency that characterise the removal of subsidies to energy and materials, depends on the degree to which they are linked to specific materials or energy uses.

36. *Capital equipment.* Removing these subsidies will slow down new investments which could have a *negative* impact on the environment if those new investments would be more environmentally benign. Such a subsidy removal generally applies to new investments only, therefore the full effects will be felt only in the long run, if a significant portion of the old investments have been replaced by new (non-subsidised and therefore more expensive) equipment. Whether the environment will benefit from higher costs of equipment in the long run, depends on two other factors as well: its effect on total production levels and substitution of factors of production towards more labour or more materials inputs, or both. Removing such subsidies may also have environmentally beneficial effects if the previously subsidised capital equipment has become relatively environmentally harmful. The more the previous subsidy has been conditional on narrowly defined types of equipment and the longer it has bee in place, the more it is likely to have locked-in particular presently "dirty" technologies. Removal of such subsidies are to be expected to have stronger beneficial effects than the removal of subsidies that applied to broadly defined categories of equipment.

37. *Access to natural resources below opportunity costs* (e.g. exploitation concessions below opportunity costs —forestry, mining, water extraction etc., government purchased access to foreign owned fishing grounds). Removing such subsidies decreases the rates of exploitation of the natural resources concerned. They may have an immediate effect (e.g. in the case governments no longer paying for access to foreign fishing grounds) or a long term effect (e.g. if governments sell new concessions at higher prices). Removing such subsidies often will have a decisive effect on the start or the continuation of the affected economic activity.

38. *Low interest loans.* Low interest loans are a subsidy to capital. Usually they will reduce the (sunk) cost of fixed assets and they may lower the internal rate of discount. They, however also make funds available for other acquisitions. Whether their removal results in an increase of fixed or variable costs is difficult to determine. Since these subsidies (if not conditional on specific types of equipment) leave the firm free in choosing more environmentally benign modes of production, they may not have been as environmentally damaging as their effects on production volumes might suggest. As a consequence, it is more difficult to assess beforehand whether their removal would benefit the environment. More detailed analysis would be necessary.

39. *Research and development.* Assessing the effects of removing these subsidies also requires more detailed analyses. On the environmentally beneficial side, subsidies to research and development can be directed towards environmentally more benign production modes. On the other hand they may postpone a change to fundamentally different technologies that are even more benign. Worse even, if these subsidies would be sufficiently large that they work like a subsidy to operating costs, while conditional on the prevailing line of operations, they are likely to have serious lock-in effects. The effects of removing these subsidies on fixed or variable costs are difficult to determine (during the research and development stage, as well as when the results of the research and development efforts are put into practice).

3.7 Removing a subsidy to profits and income

40. *Historical entitlements*. These subsidies are independent on actual production volumes. However, they get capitalised in the prices of factors of production in inelastic supply such as land.), in which case removing them may have a downwards effect on these factors of production and might change modes of

production and production levels. Assessing the environmental effects of removing these subsidies requires a rather detailed analysis, taking the details of production functions of firms into account.

41. *Preferential low rates of income or capital taxation and debt write offs.* Such subsidies improve the *profitability* of the firms concerned (assuming that they are not also conditional on particular technologies and input uses) and will prolong the life-span of firms that are not economically viable in the absence of these subsidies. Consequently, removing them will make the least efficient firms (possibly also the most polluting ones) to leave the sector, possibly reducing the total output of the sector with favourable environmental consequences (if the reduction in supply is not filled with supply from other even more polluting or resource inefficient firms). Firms that use environmentally more benign processes may enter the industry, thus removing the lock-in effects of subsidies to profits and income. Again, we are faced with a mixed bag of potential outcomes and rather detailed research is needed to establish the environmental effects of removing these subsidies.

42. *Allowing insufficient provision for future liabilities and exemptions from (environmental) standards.* Removing these subsidies are likely to have strong beneficial effects on the environment. They contain examples of measures to shore up the profitability of economic activities that otherwise would not have been economically viable, deliberately at the expense of the environment. Removing exemptions from environmental standards may increase marginal costs.

43. *Start of an operation.* In order to lure an investor to start an operation, apart form other subsidies, a lump sum subsidy may be granted. No longer giving them would reduce investments in that particular jurisdiction. Of course the (local) environmental effects depend on the nature and scale of that operation. The effects of removing such subsidies, therefore, are hard to predict.

44. *Low rate of return requirements.* These subsidies are applied to government owned utilities forcing producers to reduce their offer prices, most often in conjunction with low interest loans. They serve as a means to pass on preferential the low interest rates to consumers. In fact they lower the internal discount rate for the entire operations (or reduce the break-even price). Removing them will result in a shift to (less capital intensive, and therefore more flexible) technologies with higher rates of return. Depending on the environmental characteristics of the alternative production processes, removing low rate of return requirements may have beneficial or adverse effects on the environment. It should be noted however, that investments with shorter economic life spans, open the way to more frequent adaptations to new technological options, and possibly to their development.

3.8 Removing a subsidy that increases demand

45. Preferential low VAT rates, the provision of infrastructure below costs as well as other governments services below (long term marginal) costs, such as government paid marketing and product promotion. Removing these subsidies (to consumers) do not affect the subsidised firms directly but decrease the demand for their products. If the supply curve is inelastic, a decrease in demand due to the removal of the subsidy will have little effect. This could be the case when governments decide to have road users to pay more for using congested roads, while there are also no or limited possibilities to increase the capacity of other modes of transport. In the first case, congestion will have depressed demand, while being subsidised. If the roads were not congested, the effect of charging more for the use of infrastructure, is likely to be significantly larger.

3.9 Conclusions

46. Subsidy removal has a larger impact if: the subsidies have been implemented for a long time; they have been targeted at environmentally relevant variable costs; they have had (upstream) effects on industries that are relatively polluting or resource intensive by themselves and have been applied to existing production capacity, not just new additions. Subsidy removal, by contrast, have lesser impact if: there are other environmental constraints that are not removed together with the subsidy; they have been in place for a short time; they have not affected relatively polluting or resource intensive sectors. In table 3.3 the results of the previous analysis are summarised in more detail.

Table 3.3 Overview of to be expected effects of subsidy removal

Categories	Main points of impact	Environmental effects[1)]		Remarks
		Short term[2)] reduction in emissions or rates of exploitation, due to:	Long term[2)] reduction in emissions or rates of exploitation, due to:	
1. Output	▪ Market price support	Lower production levels	Lower production levels	Consumer prices will drop, in spite of lower production levels. Less input requirements may lead to strong environmental effects in the production of materials and energy phase. Production may shift to areas of low cost production, leading to a possible displacement of the environmental burden
	▪ Deficiency payments	The same as above	The same as above	
	▪ Sales premiums	The same as above	The same as above	
2. Input use	▪ Materials, energy	Higher marginal costs of all subsidised "firms"; immediate discontinuation of some production activities. Exit of the least efficient production units, if marginal revenues drop below marginal costs	Disappearance of the lock-in effect, which frees the way to substitution and savings on inputs. If accompanied by effective environmental policies this creates a window of opportunities for environmental improvement[3)]	Strong effects may be expected due to reductions in the production of materials and energy or rates of exploitation that often are relatively environmentally harmful
	▪ Short lived equipment	The same as above	The same as above	
	▪ Particular types of fixed capital	Exit of the least efficient production units, if marginal revenues drop below marginal costs	Disappearance of the lock-in effect, depending on the specificity and duration of the conditionality	If substitution of capital equipment opens the way to more efficient use of materials or energy (or the substitution of less harmful ones), strong effects upstream may be expected

(Table 3.3. continued)

	▪ Access to natural resources	Increases the price of natural resources for downstream users, increasing their resource efficiency	Higher barrier to entry or disappearance of the least efficient production units, or both	Strong effects on entry with possibly large beneficial effects on rates of depletion
	▪ Low interest loans	Possibly a (limited) effect on marginal costs	Higher barrier to entry or disappearance of the least efficient production units, or both	
	▪ Research and development		Deployment of environmentally more benign technologies, if accompanied with effective environmental targets.	If the subsidy is large, it may be an exploitation subsidy to capital costs in disguise. In those cases the effects are unclear
3. Profit and income[4)]	▪ Preferential low rates of income taxes	Possibly somewhat lower marginal costs. If so, exit of the least efficient production units, if marginal revenues drop below marginal costs	Higher barrier to entry. Higher prices reduce demand	
	▪ Preferential low rates of capital taxes	The same as above	The same as above	
	▪ Debt write off	The same as above, unless it is a one-off write off	The same as above, unless it is a one-off write off	
	▪ Allowing insufficient provision for future environmental liabilities	Exit of the least efficient production units, if marginal revenues drop below marginal costs	Higher consumer prices and more environmentally benign modes of production	
	▪ Exemptions from (environmental) standards	The same as above	The same as above	
	▪ Low rate of return requirements		Higher consumer prices and higher internal discount rates. The latter shortens the planning horizon of the “firm” and thereby the lock-in effect	

(Table 3.3. continued)

4. Demand	▪ Low rates of VAT	Exit of the least efficient production units, if marginal revenues drop below marginal costs	Undetermined, since dependent on externalities	Some “up stream” effects may be expected
	▪ Marketing and promotion by government	The same as above	The same as above	The same as above
	▪ Provision of infrastructure below costs	The same as above	The same as above More decentralised production close to the place of consumption; different technologies	The environmental effects depend also on site specific environmental conditions

.

1. As stated before, elements of the policy filter (quota, limitations in infrastructure) may become, or remain the limiting factors to production and thereby to the environmental effects of subsidy removal. In this table this is ignored.
2. In the sort run, technology remains the same. That is, there is no substitution between factors of production or inputs for that matter.
3. Choosing a particular input often casts the technology in stone and vice versa.
4. Removal of subsidies based on historical entitlements, or direct payments to producers in exchange for production(modes) that are environmentally beneficial have been omitted from the table, because such removal is likely to damage the environment

4. Developing the checklist

4.1 Introduction

47. As stated before, the checklist does not contain elements that determine whether one is dealing with a subsidy or not, neither contains it items that indicate the nature and severity of the environmental damage (pollution or resource depletion). The checklist only helps in answering the question whether the removal of a subsidy is likely to result in environmental benefits.

48. The checklist is based on Figure 1.1. The subsidy removal affects prices and volumes produced and may reverse some directions in technical change that have been stimulated by the subsidy. Next the effects of subsidies may have been mitigated or reinforced by accompanying policy measures (that include building of infrastructure). Finally, "autonomous" technical change may have resulted in environmentally more benign alternatives which deployment have been prevented by the subsidy. Following this overall view, three clusters of questions suggest themselves:

1. What restrictions to production, pollution or resource depletion levels result from the policy filter, and of course, what will happen to the policy filter once the subsidies are removed.

2. What technologies and products are likely to replace the previously subsidised products and modes of production, and subsequently how do the environmental profiles of these competing products and modes of production compare with those of the previously subsidised ones.

3. What are the likely the response of the previously subsidised industries in terms of production volumes, rates of exploitation of natural resources. This depends on size and conditionality of the subsidy as well as the distribution of market power.

49. This results in the following simple flowchart that underlies the checklist (Flowchart 4.1). First, it should be investigated if other restrictions (either politically or technical in nature) that counteract the subsidy removal will remain in place. If so, subsidy removal will have no or a limited effect. Second, it should be investigated whether there are environmentally more benign alternatives available in the short and long term. Of course long term availability may be a matter of judgement. If so, the third step would be to look into the subsidy itself. What precisely is the conditionality of the subsidy and what the responses of the firms will be if the subsidy were to be removed. This seems analytically the most demanding task. This more detailed analysis will also reveal 4) whether subsidy removal will be difficult to predict because of market power. Developing a checklist for such cases was beyond the scope of this paper.

50. Step 3, investigating the role of conditionality (initial points of impact) on the directness of the link between subsidy removal and its environmental effects is based on the basic reasoning laid down in section 1.5 and chapter 3. Summarising the results of those sections, part 3 of the checklists emphasises the following issues:

1. Availability and potential environmental impacts of close substitutes for the products of the subsidised activities, once the subsidisation stops, and that, by consequence, are likely to replace (some of the) previously subsidised products.

2. The forward and backward linkages of the industry that loses a subsidy.

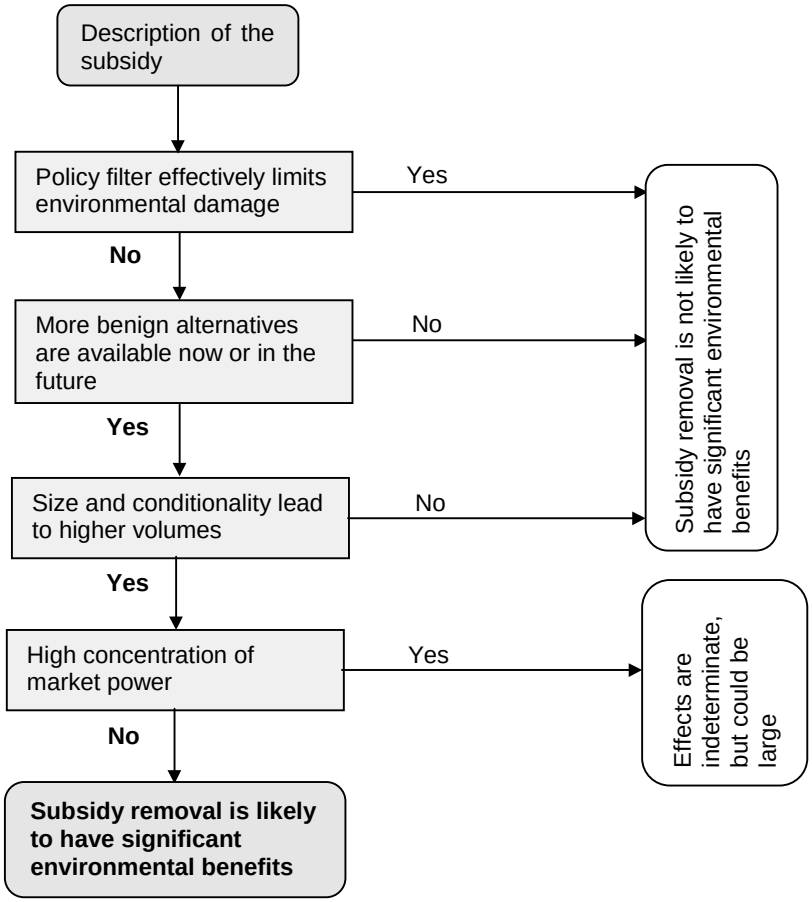
3. The restoration of incentives to continuous technical change by subsidy removal. Hence items are included to identify subsidies that are contingent on environmentally relevant categories of variable costs (energy, materials, water).

4. Identifying subsidies to capital equipment that are implicit subsidies to certain inputs that are environmentally relevant.

5. The effects of subsidisation on one-off decisions such as starting an operation or investing in capital equipment with a long life span. These decisions can have large environmental effects, but whether they are detrimental or beneficial to the environment depends on the alternatives that may come to the market after the subsidy has been granted. Such subsidies may lock in technologies that are not so "clean" after all.

6. Identifying subsidies which removal would influence day-to-day decisions and would have an immediate effect on the environment and conversely subsidies which removal would affect decisions that only gradually would affect the environment.

Flowchart 4.1 Subsidy removal that is likely to have environmental benefits



51. The items in the checklist (Table 4.1) are meant to facilitate answering the above mentioned three clusters of questions. Applying a checklist like the one developed here serves as a "quick scan". More definite answers can only be arrived at, applying more detailed analyses preferably using general equilibrium models. In fact several items under step 3 can only be answered more or less convincingly by applying such models. The checklist maybe of some help in deciding whether such more elaborate analyses are demanded for and what items should be included. Since the effects of subsidies depend on so many factors, this first attempt to arrive at a checklist is likely not to be complete.

4.2 The checklist

Table 4.1 Factors that determine the environmental effects of subsidy removal

Main item	Item	Crucial factors	Remarks
		Step 1. Policy filter	
Effective policy measures that reduce emissions or rates of extraction	Tradable pollution or extraction quota	The size of the quota after subsidy removal Clear definition and strict enforcement	Removal of a subsidy to the industry may have a limited or no environmental effect, if the quota *was* and remains the limiting factor after the subsidies have been removed. (The prices of quota will drop which has varying effects (e.g. depending on being product quota or pollution quota). However the environmental effects remain the ones associated with the number of quotas issued.)
	Production or extraction limits	The level of the limits Clear definition and strict enforcement	Subsidy removal may have a limited or no effect, if the quota was and remains the limiting factor after the subsidies have been removed
	Emission standards	The level of the standards Clear definition and strict enforcement	Ancillary benefits by means of reductions in other emissions may not occur if they are already (sufficiently) restricted by regulation
	Environmentally based taxes, charges or fees	Rates of taxation Demand and supply elasticities of the taxed item	Maintaining such taxes may reduce the effect of subsidy removal
Other limitations to production or use	Shortfall in infrastructure	Size of the shortfall Options for expanding infrastructure Costs of the expansion Time needed for expansion of infrastructure	Subsidy removal may have a limited or no effect, if the available infrastructure was and remains the limiting factor after the subsidies have been removed.

Table 4.1 continued

	Shortfall in other limiting factors of production: i.e. qualified labour, space	Size of the shortfall Options for expanding the supply of the limiting factors Cost of the increase in supply of the limiting factors Time needed for expansion of supply of the limiting factors	Subsidy removal may have a limited or no effect, if the limiting factors of production continue to pose limitations to production after the subsidies have been removed. (Note that the resulting high prices of the limiting factors may trigger additional supply of those limiting factors, if possible)
Step 2: Availability of environmentally more benign alternatives: Identifying lock-in effects			
Alternative products	What competing products would benefit form the subsidy removal	Environmental profile of the subsidised product Environmental profile of the readily available competing products that would benefit from the subsidy removal Probable environmental profile of emerging alternative products Time span the subsidy has been in place	Removing subsidies opens the way to the development of more environmentally benign alternatives. Long standing subsidies are likely to be the most damaging. Enhancing the effectiveness of environmental policy (financial and no-financial instruments) with respect to emerging technologies may be needed to reap the benefits of technical change
Alternative modes of production	What modes of production would benefit from the subsidy removal	Environmental profile of the subsidised mode of production Environmental profile of readily available alternatives Probable environmental profiles of emerging alternatives Time span the subsidy has been in place Points of impact of the subsidy	Temporary subsidies to the development of emerging products and modes of production may be called for to enhance the effectiveness of subsidy removal. Investigating the available options for environmentally benign modes of production includes looking into the items listed under “conditionality” In case of alternative modes of production, the points of impact of the subsidy determine which alternatives would benefit from the subsidy removal

Table 4.1 continued

Step 3: Higher volumes due to size, duration and conditionality of the subsidy			
Size of the subsidy	Monetary value of the financial subsidy relative to turnover	Elasticities of supply and demand	Market price support can be expressed in terms of monetary value.
Duration of the subsidy	Number of years the subsidy is in place	Technological development in competing products or modes of production outside the subsidised sector	The longer the subsidy is in place, the stronger its lock-in effect is likely to be, thus the larger the potential environmental gains if the subsidy were to be removed
Conditionality:			
Variable costs	Specified energy supplies, and materials	The quantitative effect of the subsidy removal on variable cost Substitution elasticites between alternative energy supplies and materials Environmental profiles of the actual supplying industries Environmental profiles of the energy and materials supplying industries that would replace the actual suppliers	"Materials" include (irrigation) water Removing energy and materials subsidies shift the industries supply curve upward and therefore immediately reduce supply at all levels of demand of the (finished) product. It will also reduce entries and eliminate lock-in effects. The environmentally beneficial effects of the reduction in production of the (finished) good may be diminished if other suppliers step in at prices only slightly above the (previously) subsidised supplies, especially if their environmental profiles are less benign
	Specified short lived equipment	The quantitative effects of the subsidy removal on variable costs Effects on the environment of the deployment of alternative types of short lived equipment	Removing these subsidies have the same effects as removing subsidies to energy supplies and materials. If, however they have been conditional on energy or materials saving characteristics, the effect will be ambiguous

(Table 4.1 continued)

Fixed costs	Specified types of fixed capital Specified types of fixed capital that allow for the use of low cost, environmentally damaging inputs Specified types of fixed capital that require the use of a particular environmentally relevant input	The quantitative effect of the subsidy removal ▪ on fixed costs ▪ on variable costs (if applicable) The (negative) effect of the subsidy removal on entries	Removing subsidies to fixed capital reduces the profitability of the subsidised sector and will discourage entries. However if the profitability of the subsidised sector remained low, while subsidised, the effect of the subsidy removal on entries would be small or negligible. Often the choice for a particular type of fixed capital also implies certain inputs to be used. In some cases capital subsidies may allow for using cheaper inputs, thereby changing variable costs. Removing such subsidies (to fixed costs) eliminate possibly strong lock-in effects.
Total costs	Royalty concessions	The quantitative effect of the subsidy removal ▪ on fixed costs ▪ on variable costs (where applicable) Environmental profiles of the subsidised activities and their alternatives	Adjusting royalty concessions to their market value will reduce future demand for these royalties When adjusting royalties to their market price involves concessions for extraction, a strong effect may be expected on rates of depletion Since this removal may result in higher prices for inputs for downstream activities, variable costs of these downstream activities may be lowered with strong volume effects
	Low interest loans	The quantitative effect of the subsidy removal ▪ on fixed costs ▪ on variable costs (where applicable) Environmental profiles of the subsidised activities and their alternatives	If low interest loans are used to reduce the costs of fixed capital, removing such subsidies will have the same effects as removing other subsidies to fixed costs If granted to incumbents as well as newcomers, there will be no barriers to entry created. Dependent on the relative profitability of the sector, this may lead to effects on production volumes

(Table 4.1 continued)

	Research and development	The size of the subsidy relative to total operating costs Effects of the removal of the R&D-subsidy on ▪ on fixed costs ▪ on variable costs Effects of the removal of the subsidy on diminishing the environmental profile of the subsidised activity	If the removed subsidy was large compared to operating costs, it would have been a subsidy to operating costs in disguise If the subsidy removal would imply less technical progress towards more environmentally benign technologies, the ultimate environmental effects of subsidy removal is ambiguous
Profit and income	Preferential rates of taxation Debt write-offs	The effect of the subsidy removal on profitability The profitability of the sector while subsidised The environmental profiles of the subsidised and the alternative competing economic activities The environmental profiles of up-stream and down-stream economic activities	Decreased profitability due to the subsidy removal will discourage entries, but if entries had already been discouraged because of low profitability of the sector while subsidised, the effects on entries will be small, if not negligible When the sector produces energy and materials, downstream effects of removing the subsidy may be strong, dependent on the offer prices of the competitors
	Insufficient provision for future environmental liabilities	The nature of environmental liabilities The effect of imposing sufficient provision of future liabilities on variable and fixed costs by means of changing modes of production, or adequate insurance The environmental profiles of up-stream and down-stream economic activities The environmental profiles of the (previously) subsidised sector and its competing alternatives	Imposing sufficient provision for liabilities can render entire industries unprofitable. The environmental effects of the subsidy removal depends on the environmental profiles of the alternatives that will replace the previously subsidised sector Strong effects on downstream sectors may be expected if the previously subsidised sector supplies energy or materials, dependent on the offer prices of competing energy supplies and materials
	Exemptions from (environmental) standards	The quantitative effect of removing the subsidy on profitability and variable and fixed costs The effect of reduced profitability on the production volume of the sector The environmental profiles of up-stream and down-stream economic activities	Removing these exemptions obviously benefit the environment immediately through reducing the emissions or input use of the previously subsidised industries. Moreover the volume effects on production volumes in up-stream and down-stream industries will benefit the environment

(Table 4.1 continued)

	Low rates of return requirements	The effect of removing the low rates of return requirements on the internal discount rate of the firms	Higher internal discount rates favour shorter lived investments. As a result, new technologies will be deployed more rapidly (and reduce the lock-in effect). If environmental policy ensures that those new technologies are more environmentally benign, reducing the lock-in effect will benefit the environment.
Demand	Low rates of VAT; Marketing promotion by governments	The tax differential relative to sales prices The effects of marketing promotion on sales volumes The price elasticities of demand and supply	Demand will decrease because of subsidy removal. Its effect on production and input volumes depend on the relevant price elasticities In the long run, the supply curve of the entire industry will be influenced by the occurrence of external effects and barriers to entry
	Provision of infrastructure below cost	The quantitative effect of internalising the cost of infrastructure on demand The price elasticity of supply Geographical "hot spots" where infrastructure fall short or the use of infrastructure cause high emission levels or congestion or both The environmental profiles of the products that use that particular infrastructure	In the long run, the supply curves of the industries that have benefited form the provision of infrastructure below costs (e.g transport firms and those industries whose products are shipped) will be influenced by the occurrence of external effects and barriers to entry. Introducing full payment for infrastructure can increase exits from the industry Possibly, the decrease in demand will not be sufficient to eliminate congestion or other signs of shortfall of infrastructure; thereby reducing the environmental benefits.
Step 4: Market power			
Market power	Market power on factor and finished goods markets	Degree of concentration	If the previously subsidised sectors face suppliers or customers or both that wield much market power, the outcomes of removing any type of subsidy will be hard to predict. Ancillary measures are probably needed

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ANNEX 1. SELECTED CASE STUDIES

Introduction

Unfortunately, quantitative assessments of the effects subsidies vary over extremely wide ranges, even if they apply to the same sort of subsidies (see for example OECD, 1997a-d). This is partly due to differences between *definitions* of a subsidy and the comprehensiveness of the *policy package (policy design* of the particular subsidy) under study. Other explanations are the *circumstances* under which the subsidies are applied (see Figure 1), the differences between the *models* (e.g. top-down or bottom-up)[10], and the economic and technical *assumptions* which underlie the calculations. Often the differences between the assumed alternative technology or economic activity that will emerge when the subsidy is removed (the benchmark) has a strong effect on the outcomes of the analyses (See for example OECD, 1997a). Looking at numerous case studies, however, reveals factors that seem to be important in many analyses[11]. The simplified and by no means comprehensive descriptions that follow in the next paragraphs only serve to highlight the various ways subsidies may affect volumes produced and consumed. It is selective, including only those elements that the author thinks have a strong bearing on the environmental effects of subsidy removal. These elements are elaborated upon in chapter 3.

1. Agriculture

Few areas, if any, have been studied in more detail than agricultural subsidies. The OECD's work on the "Policy Evaluation Matrix", based on transfer efficiency formulas, and using a vast amount of available statistical data, has revealed the remarkable differences between the effects of various types of subsidies (basically: deficiency payments, market price support, subsidies to acreage, subsidies to other inputs) on the incidence and transfer efficiency of agricultural subsidies (see for example OECD, 2001b). This leads to an important conclusion regarding the economic characteristics that make subsidies environmentally harmful. A very large portion of support leaks away to input suppliers, non-farming landowners and other sectors of the economy and leads to significant upstream changes in production volumes. In addition, subsidies that lead to lower agricultural prices are implicit subsidies to the food processing industries. Studying the total environmental effects of subsidies to agriculture therefore must involve the supplying sectors. Another conclusion would be that these subsidies, while not efficient in improving farmers' incomes lead to more production, if not restricted by other measures or circumstances.

Although there are several studies indicating that production and input subsidies lead to more intensive farming practices (see Porter, 2002), there are few studies that investigate the effects of subsidy removal.

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10 Top-down models are based on the usual demand and supply functions. Bottom-up models start from descriptions of technological alternatives and use an algorithm to calculate optimal solutions

11 Reviewing all available case studies is beyond the scope of this paper. The reader is referred to review studies, such as Porter (2002).

Rainelli (1998) argues that replacing a subsidy to irrigation water by a subsidy on historical revenues will not reduce the use of irrigation water, since the new subsidy will not decrease the prices of land, therefore continuing to contain an incentive to intensive farming. However the need for irrigation water might be reduced as investments to increase the efficiency of irrigation become more profitable). After all, the mode of production chosen by the farmer depends on the relative prices of factors of production.

A recent study for the Netherlands (Massink and Meester, 2002), based on comparing several policy scenarios of which one is a recourse to free trade, indicates that total subsidy removal would lead to significant income transfers, changes in the composition of Dutch agricultural production and, especially relevant to the subject of this paper, a *further intensification* of agriculture.[12]
Apparently, neither changing subsidy regimes nor abolishing subsidies altogether automatically will reverse the incentive towards intensification that has resulted from agricultural policies that included the subsidies. This asymmetry between introducing and removing subsidies, necessitates closely examination of the "economics on the farm level" and more precisely defining the all the relevant policy changes made. Very unfortunately, details matter.

2. Energy: electricity and coal

The OECD report on *Reforming energy and Transport Subsidies: Environmental and Economic Implications* (1997) includes two large case studies regarding on the benefits of removing subsidies that lead to different conclusions.

DRI (1997), studying the impacts of phasing out coal subsidies in OECD countries using the PSE definition of subsidies and applying a top-down trade model structure, found small environmental effects. Phasing out coal subsidies (of the market price support type) would mainly result in using imported coal in stead of domestically produced (and subsidised) coal. According to this study due to the economics of fuel use, coal would remain the preferred fuel for electricity generation, both in the short and long run.

By contrast, Naughten et al. (1997), using a bottom-up (linear programming) model for Australia, based on a database of technologies; and defining subsidies as the difference between the minimum cost of an optimal combination of technologies that satisfy a certain level of electricity demand, on the one hand, and the costs of policy-determined alternatives on the other, analyse the effects of various elements of energy policies. These policy elements include a deliberate choice for a certain fuel (coal) for a newly built power plant, capital subsidies and trade distortions. For each of such policy elements, the subsidy is defined as the wedge it creates with the least-cost solution for generating the demanded electricity.

They find that removing subsidies that are implicit in energy policy — notably loan guarantees, provision of loans at below market rates to (government-owned) coal-fired power stations and trade restrictions between Australian states that prevailed before regulatory reform — would result in a significant fuel shift towards combined cycle gas turbine (CCGT) electricity generation. This result is based on the higher capital intensity of coal-fired electricity generation, shorter lead times in building a CCGT-plant compared to a coal-fired plant, as well as the more modular character of CCGT generation which makes it more economical if production has to respond to changes in demand. Removing the subsidies to capital and privatising power plants, would result in higher rate-of-return requirements (from 8% to an assumed 15%) and therefore would result in a shift to gas, even if coal would remain the cheapest fuel per Kwh, if power plants are designed according to their technical optimal size.

[12] The environmental effects of increased intensification are probably ambiguous, since larger areas may become available for less environmentally damaging uses.

It is important to realise that subsidies to energy producers and energy products (such as low preferential tax rates) will be (at least partially) passed on to industries and households. Removing them will affect downstream emissions.

3. Irrigation water

Removing subsidies to irrigation water generally can have two distinct effects: agriculture on previously irrigated land would cease to be profitable if not becoming entirely impossible, or lead to inefficient use of water, or both. Increased efficiency, of course, can mitigate the effect on profitability. Most studies have focused on optimal pricing of water using either the yardstick of full-cost recovery or the marginal value product of the water, which equals the value of the incremental volume of production due to the use of one unit of water.

Little is known about the environmental effects of removing water subsidies (by whatever definition), and what information is available is difficult to generalise because of the country and site specificity of the institutional arrangements, the multiple uses served by water infrastructure and environmental conditions. Presumably the following conclusion could be drawn. Both the feasibility to arrive at water pricing systems that reflect more the costs of water or its marginal productivity and its environmental effects is strongly interwoven with other policies and comprehensive water management systems. As is stated in OECD (1999b, p.3), referring to Australian experiences, "water pricing reforms must be accompanied by other important mechanisms, in absence of which pure pricing mechanisms might yield few benefits."

Existing infrastructure represents sunk cost. Removing subsidies that consists of users not paying in full for that infrastructure shifts the financial burden from the taxpayer to the consumer, which may lead to firms leaving the industry. If that leads to a reduction in demand, under-utilisation of existing infrastructure may arise. The "optimal" price structure when subsides are removed, therefore may differ from the "optimal" price structure if no subsidies had been granted. Secondly the environmental effects of the waterworks do not disappear when the subsidies are removed.

4. Transport

In the transport sector much attention have been paid to the social costs of transport (such as pollution, accidents, congestion). Not internalising these marginal social costs have been labelled by some as (implicit) subsidies. Apart from subsidies arising from any incomplete internalisation of these social costs, very substantial subsidies are the result of non-internalisation of the costs of infrastructure. The costs of infrastructure is particularly relevant because of the high ratios of fixed to variable costs and high sunk costs (Porter, 2002).

As a result, much recent work concerning subsidy removal (e.g. Roy, 2000), predominantly boil down to removing the inequalities in the treatment of the cost of infrastructure, although other elements such as preferential low tax rates on particular fuels and tolls may cause distortions in variable costs as well. Generally there is over-pricing and under-utilisation of rail and under-pricing and over-utilisation of roads.

The ways subsidies to infrastructure lead to higher transport volumes, transport-related pollution and congestion is quite complex. This can be illustrated by a simplified example.[13] If, for example, a road between points A and B is constructed or improved, transport costs (and time) between the two points is reduced. Moreover, demand for road transport between A and B increases, either because a latent demand

[13] See for example the description of the TRENEN model in Roy (2000).

is activated (a shift along the original demand curve) or because the lower costs of transportation by road attracts transport demand that previously was satisfied by other modes of transportation (a shift of the demand curve itself). If road transport does not pay for the improvement of this road infrastructure, a new subsidy is created that increases demand. Quite possibly this higher level of demand leads to more congestion on the road between A and B, but also on other roads leading to A or B which in turn will lengthen the travel time, and hence costs, between A and B as well as to A or B. This will be accentuated if at the same time, there exists subsidies to particular road users, such as preferential tax rates on fuel, capital or labour.

The environmental effects of subsidies to various modes of transport consist of two distinct categories: the effects on transport volumes and the effects on the level and geographical distribution of economic activities. Studies reveal that the price elasticities of demand for transport strongly depend on the availability of alternative modes of transport and other route dependent factors. Estimating the environmental benefits of changes in the price structure of transport therefore, require rather detailed modelling. The other environmental effects of removing subsidies to transport, those related to the level and geographical distribution of industrial emissions, are even harder to predict. Needles to say that they can have significant effects on local environments.

5. Fisheries

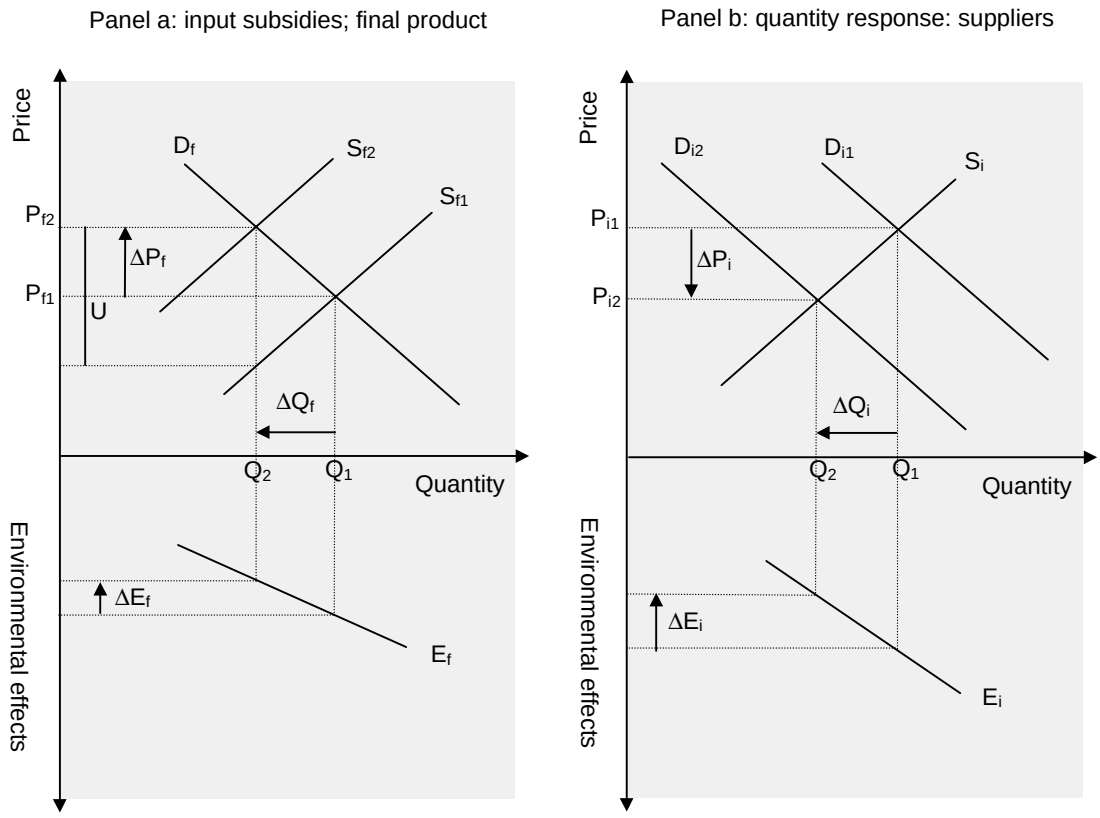
Hanneson (2001) points to the importance of management regimes on the effects of subsidy removal on fish stocks. He distinguishes three such regimes: (1) *open access*, where there is no control over the quantity of catches nor over fishing effort. It is probably no longer very representative for OECD countries; (2) *catch control*, where the total amount caught is regulated; and (3) *effective management*, under which the amount of catches is set at an economically optimal level and the costs to catch this amount are minimised, for example by means of individual transferable quotas. If the total amount of allowed catch is perfectly enforced, (a big "if") subsidy removal will not lead to less catches under the catch control or effective management regime, provided that the regime poses limits on the catches below the level that would occur after the withdrawal of the subsidy. Under open access, by contrast, removing cost-reducing subsidies could very well lead to new entrants and continued over-fishing. In all these cases, removing cost reducing subsidies have little effect, if at all.

As is true in most sectors, subsidies come in a wide variety (WWF, 2001), and the responses of fishermen to these various types of subsidies may differ strongly. Subsidies to fuel, for example, immediately affect the cost of each trip and deprive more energy-efficient propulsion and refrigeration from some, if not all, its cost advantage. Removing them is likely to have an immediate effect. Removing subsidies that affect the costs of the vessel, by contrast, will primarily reduce the entrance of new vessels. Fishing port infrastructure is likely to open up or enlarge markets with no costs for the fishermen; stimulating demand and supply, and removing them can make fishermen leaving the sector. Foreign access payments by governments enlarge their fishing grounds at no cost to the fishermen. Substantial subsidies are paid for alleviating the hardships of restructuring the fishing industry. Although they may not be as effective as desirable, removing them could make reducing capacity politically even more difficult as it is. Holland et al. (1999) highlight the importance of differences in design and other circumstances for the effectiveness of fishing vessel buy back schemes. This sounds as a warning that policy design and circumstances might be decisive for the effectiveness of other removals of subsidies.

ANNEX 2: THE ROLE OF ELASTICITIES

Subsidies leak away from their intended recipients. Suppliers will raise their prices in view of increased demand and customers will pay less if supply is increased. When subsidies are removes, generally, the opposite will occur. The degree in which this happens depends on the price elasticities of both supply and demand for the final product of the subsidised sector. In Figure 3.8a and b the role of price elasticities, as well as the effect of forward linkage is illustrated.

Figure A1. Quantity responses of suppliers due to subsidy removal



Key

D:	Demand curve	P:	Price
S:	Supply curve	Q:	Quantity
E	Environmental effect curve	U	Subsidy
Suffix 1, 2:	With and without a subsidy respectively		
Suffix f, i:	Final product, input respectively		
ΔQ_f, ΔQ_i:	Quantity decrease in the sales of the final product and the input respectively		

Assume no substitution between inputs (not change of technology). Then the decrease in sales of the final product equals the decrease in input sales. The total environmental burden then decreases with the sum of ΔE_f and ΔE_i. If the production of the input has a larger environmental burden per unit of output which is often the case, then the larger portion of the environmental improvement caused by the reduction in the demand for the input.

$\Delta Q_{f \text{ and } i}$ depends on the size of the subsidy and the elasticities of supply and demand of the final product as follows:

In panel a, let β_f be the price increase due to the loss of the subsidy U, and γ_f be the relative volume decrease related to the relative price increase in terms of the withdrawn subsidy U.

$$\beta_f = \frac{\Delta P_{f1}}{U}; \text{ and } \qquad \gamma_f = \frac{\Delta Q_f / Q_{f1}}{U / P_{f1}}$$

The price elasticities of demand and supply (absolute value) are:

$$\eta_f^d = \frac{\Delta Q_f}{\Delta P_f} * \frac{P_{f1}}{Q_{f1}}; \text{ and } \qquad \eta_f^s = \frac{\Delta Q_f}{U - \Delta P_f} * \frac{P_{f1}}{Q_{f1}}$$

Then:

$$\beta_f = \frac{\eta_f^s}{\eta_f^s + \eta_f^d}; \text{ and } \qquad \gamma_f = \eta_f^d * \beta_f$$

In panel b, the relative price increase of the input is

$$\frac{\Delta P_i}{P_{i1}} = \frac{1}{\eta_i^s} * \frac{\Delta Q_i}{Q_{i1}} = \frac{1}{\eta_i^s} * \frac{\Delta Q_f}{\Delta Q_{i1}}$$

Of course this is a very much simplified model. In reality the weighted average of the supply elasticities of the inputs equals the supply elasticity of the final product. But this (over0 simplified model, nevertheless, illustrates the role of the demand and supply elasticities in determining the effects of the removal of a subsidy that lowers marginal production costs. The quantitative relationships between subsidy removal and volume effects can only be established using partial or , preferably, general equilibrium models.

The conclusion remains that the removal of a cost reducing subsidy might have significant upstream environmental effects. All other things being equal, this is the more so, the larger the supply elasticity of the input.