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Topic 6c Paper

AN ASSESSMENT OF THE ECONOMIC COSTS OF ALTERNATIVE REGULATORY STRATEGIES

BY D M AMBLER, DEPARTMENT OF TRADE AND INDUSTRY, LONDON

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EXECUTIVE SUMMARY

The purpose of this paper is twofold. The main part of the paper assesses the implications for economic efficiency of a number of regulatory strategies which might be applied to the chlorofluorocarbon (CFC) issue. In addition, the paper analyses and comments upon a number of other economic aspects of regulation which are relevant to policy making.

2 Section B of the the paper analyses the reasons why economic regulation of some description may be appropriate. Essentially, the case depends on the existence of 'externalities' allied to market failure.

3 In all, five alternative regulatory strategies are examined in the paper, these are:

i) production capacity caps;
ii) controls on the overall level of CFC consumption;
iii) emission fees/taxation;
iv) end use controls/bans in particular sectors; and
v) best practicable control technologies

Each is described in turn in Section C and the variety of forms each may take is noted. A broad distinction is drawn between quantity controls, economic incentive based policies and direct controls.

4 Section D describes what is meant by the term economic costs and suggests a framework within which the costs should be assessed. The relative costs of each strategy are considered under three different headings, namely;

i) costs due to the misallocation of resources, of which;

   a) long-term costs - losses in economic surpluses; and
   b) transitional/adjustment costs;

ii) administration/enforcement costs; and
iii) safety costs and accident losses

Attention is focussed on the impact of regulation on the CFC producing and consuming industries. Section E examines the secondary effects on other industries likely to be affected by regulation.

5 Section F of the paper considers a number of other economic aspects of the different regulatory strategies. Specifically, the effectiveness of different strategies is commented upon as is the importance of industrial structure.

Conclusions

6 Although no attempt is made to derive quantitative estimates of the economic costs of different regulatory strategies there are a number of important conclusions that emerge from the analysis. These may be summarised as follows:

- unless marketable permits are introduced, a production capacity cap may give rise to economic costs through inefficiency in production

- unless marketable permits are introduced, overall use controls may not ensure efficiency in the use of CFCs and economic costs will result

- in theory, a system of emission fees/taxes could be designed which is consistent with economic efficiency, but in practical terms this is unlikely to be feasible

- end use controls on particular applications will inevitably lead to inefficiency in the use of CFCs

- the mandatory imposition of best practicable control technologies is unlikely to result in CFC use being reduced at least economic cost

- quantity controls and economic incentive based policies will ensure that there is a continued incentive to reduce CFC consumption in all uses.

- losses in consumers' surplus will be continuing, not simply a one-off

- the loss in consumers' surplus depends on the degree of restriction on CFC use and the price elasticity of demand

- the loss in producers' surplus though only temporary may still continue over a number of years

- the transitional costs of regulation depend in part on the time allowed for adjustment and on the clarity of the signalling

- where regulatory adjustment is needed, the economic costs will be greatest under direct controls (as opposed to quantity controls and economic incentive based policies)

- the costs of administration and enforcement will be lower the smaller the number of companies in the regulated sector and the greater the familiarity of the regulatory strategy.

- quantity controls and economic incentive based strategies will impose a lower economic cost in achieving a given reduction in CFC use than direct controls

7 In theory, regulatory policy towards CFCs should be determined so that the economic costs of regulation just equal the benefits in such a way that economic welfare is maximised. However, the uncertainty surrounding this issue, especially the valuation of the costs and benefits is such that it is simply impracticable to be so precise when formulating policy. In the light of this uncertainty, the regulator is faced with a choice between a policy based on regulating prices/quantities and a policy which imposes direct controls. However, the effectiveness of a policy based on controls of particular end uses in controlling the overall level of CFC emissions is uncertain since the use of CFCs in the non-regulated sector is unconstrained. Therefore, one way in which the aim of regulatory policy might be viewed is as a precautionary policy against significant adverse environmental effects. In such circumstances, on the basis of economic costs, a production capacity cap or an overall use control may offer a superior long-run framework for the control of CFCs.

A INTRODUCTION

One of the aims of the first part of the Workshop in Rome in May was to evaluate the costs and effects of the regulations which have been applied to date to control the production, use and emissions of chlorofluorocarbons (CFCs). In the second part of the Workshop, it is intended to identify and analyse various possible regulatory strategies which might be applied to regulate the use of CFCs in the future. A guidance note prepared by the Steering Committee in Rome suggested a list of alternative regulatory strategies which might be assessed and also proposed a framework within which to assess them.

2 The purpose of this paper is to examine and review the economic costs of a number of possible strategies which might be adopted to regulate the use of CFCs. It also considers the effectiveness of different regulatory strategies in reducing the production, use and emissions of CFCs. Ideally, it would have been desirable to have been able to present quantified estimates of the economic costs and effects of the alternative strategies. However, in the time available since the first part of the Workshop, it would not have been possible to complete the major exercise required to produce such estimates. Moreover, it has to be recognised that it is extremely difficult to provide estimates of costs which are not subject to considerable margins of uncertainty. Instead, this paper seeks to provide a qualitative analysis of the economic costs of the alternative strategies. Wherever possible, the paper indicates the crucial factors affecting the extent of any costs. It also enables the relative costs of the different strategies to be assessed assuming that each is applied so as to be equally effective in regulating CFC emissions.

3 Section B outlines the economic issues relevant to CFCs and then explains why regulation of some sort may be the appropriate solution. Section C identifies and describes the alternative regulatory strategies which are analysed later in the paper. A distinction is drawn between quantity controls, economic incentive

based policies and those involving direct controls. Section D considers the economic costs of regulation on the CFC manufacturing industry and on the consuming industries and individuals. The costs of each of the strategies are assessed under a number of different headings. Section E of the paper considers the wider economic costs and benefits of the alternative strategies, for example, the effects on the upstream chemical industry and the consumers of the final products. Section F considers a number of other economic aspects of the regulatory strategies including effectiveness. Finally, Section G offers some concluding comments.

B THE NATURE OF THE ECONOMIC 'PROBLEM'

4 Before examining the economic costs of alternative regulatory strategies, it is important to consider why the emission of CFCs may be thought of as giving rise to a problem requiring regulation. Essentially, the difficulty arises because of the possible effects that CFC emissions have on the ozone layer and climate change. Although there remains uncertainty about the precise nature and extent of these effects, the crucial point is that the people who suffer from them are not just the producers and consumers of CFCs. These effects are referred to as 'externalities'. Only a summary of the significance of these 'externalities' is presented here but a rather fuller analysis is contained in Annex A.

5 The existence of externalities, in this case external costs, implies that there are effects of the economic activities of CFC producers and consumers which adversely influence the economic welfare of other individuals. But, the commercial considerations of CFC producers and consumers are such that they probably will not fully reflect these effects when taking their decisions about the level of production and consumption of CFCs. The result is that more CFCs are produced and consumed than is socially optimal and hence economic welfare is not maximised.

6 It is important to note that the determination of the socially optimal level of CFC production and use assumes an ability to establish how the wider economic costs change with the level of CFC

production. However, there are significant difficulties and uncertainties associated with the determination of the relationship between wider costs and output. These arise from a variety of sources. At present, understanding of the atmospheric science linking CFC emissions to wider environmental effects is not as developed and certain as required to be able to determine the relationship between CFC emissions and effects on the environment entirely unambiguously. Even if the environmental effects were fully understood, there would still be some uncertainty attached to the valuation of these effects especially in an international context where countries may differ in their views about the effects and the values they attribute to them. The existence of these uncertainties has important implications for the policy maker when assessing alternative regulatory strategies.

7 Regulation can be regarded as an attempt to ensure that CFC production and use is controlled so that the economic costs of regulation are exactly matched by the benefits of reduced ozone depletion and climate change in such a way the economic welfare is maximised. To achieve this, the regulator needs to be able to forecast not only the economic value to be attached to the benefits associated with regulation but also the economic costs. Hence, the absolute costs of regulation are matched against the economic benefits. But, there are uncertainties associated with the determination of the benefits and further uncertainties are introduced by the need to forecast the effect of regulation on the production, use and emissions of CFCs and to determine the resultant economic costs. Moreover, the policy maker should recognise that to the extent that forecasts are not borne out there will be associated economic costs. For this reason, an alternative view of regulation would be as a precautionary policy against significant adverse environmental effects. In this case, the regulator's objective can be regarded as ensuring that CFC production and use is maintained within scientifically determined limits but at least economic cost. The relative cost of alternative regulatory strategies is therefore important and the major aim of this paper is to assess the relative costs of alternative strategies.

C THE ALTERNATIVE REGULATORY STRATEGIES

8 Essentially, there are three ways in which the level of CFC emissions can be reduced or constrained. The first involves better recovery and recycling of CFCs in the production process. For example, during the manufacture of flexible foams, producers may seek to recover more of the CFC used as a blowing agent. Emissions can also be limited by the substitution of CFCs with other products. The use of hydrocarbons as aerosol propellants has attracted much attention in this respect. Finally, CFC emissions may be constrained by improvements to equipment (for example, in refrigeration and air conditioning equipment) to prevent the escape of CFCs during the product's life.

9 A number of regulatory strategies have been suggested which are intended either to restrain the use and emission of CFCs or to encourage a more cautious approach to CFC use. It is appropriate to distinguish between strategies which are based on quantity controls, those which are economic incentive based and those which involve the imposition of direct controls. However, this distinction is not always clearcut. Strategies based on quantity controls include:

i) production capacity caps - where each nation or group of nations receives a production capacity quota enabling a given output of CFCs to be produced over a specified period of time (An alternative approach would be to specify a maximum level of actual production, rather than capacity to produce); and

ii) controls on the overall level of CFC consumption - where each nation or group of nations is constrained in their level of CFC use (ie production plus imports less exports) in a specified period of time.

Economic incentive based strategies include:

iii) emission fees/taxation - where an appropriate fee (or tax) is imposed on the producer or emitter of CFCs.

Among the direct controls are:

iv) end use controls/bans on particular sectors - where the use of CFCs in specific products or processes is constrained or banned outright; and

v) best practicable control technologies - where specific technologies for limiting CFC emissions are identified and producers are required to adopt them.

10. Whilst this list of regulatory strategies is believed to be reasonably comprehensive, it is recognised that each strategy can take a number of forms. For example, production capacity caps and use limits may be implemented using marketable or non-marketable permits and emission fees may be linear (ie a constant tax per unit of output) or non-linear (ie a tax that varies with output). The precise form of the regulatory strategy will have an important bearing on its economic implications.

11 However, before examining and comparing the economic costs of alternative regulatory strategies, it is useful to consider each of the five strategies in turn so as to understand how each is intended to operate and with what effects.

i) <u>Production Capacity Caps.</u>

12. In its simplest form, a production capacity cap puts an upper limit on the level of CFC output in a nation or group of nations. The effects of a cap obviously depend upon whether or not it is binding. If a capacity constraint is imposed and is immediately binding this will have the immediate effect of creating an inadequate supply of CFCs at the current price. However, there are consumers of CFCs prepared to pay more than the current price for each unit of CFC. The result is that competition amongst buyers of CFCs will drive up the price until supply and demand are once again in balance at the production limit. In so doing, the least valuable uses of CFCs will be sacrificed. The key point, however, is that the operation of market forces serves to ensure that there

is efficiency in the use of CFCs. That is to say, the limited supply of CFCs is used in the most valuable way. Moreover, for consumers of CFCs, the higher price should serve to retain and maybe even enhance the incentive to find and implement new substitutes for CFCs and new ways of recycling/recovering CFCs through research and development and innovation. Where a capacity cap is not immediately binding a similar effect will result but more gradually as the cap begins to bite as demand for CFCs grows.

13 However, a weakness of a capacity constraint is that inefficient production of CFCs may result if rights are allocated administratively. Only if the regulator has full knowledge of both existing and potential CFC producers' cost structures can an efficient pattern of production be assured administratively. The significance of any inefficiency in the production of CFCs lies in the fact that it implies that regulation may impose additional economic costs since it does not ensure that output is produced at least cost. The extent of the inefficiencies, however, depends on the cost differences that exist between rival producers. It may be that significant cost differentials can be sustained in the long term if production rights are allocated administratively. There is, however, one possible remedy. If production rights are marketable then this should serve to enhance the extent of competition between rival producers and thereby help to ensure that the least cost pattern of production is adopted.

ii) Controls on the Overall Level of CFC Consumption

14 In many ways, the effects of overall controls on the use of CFCs are similar to those of capacity constraints. This is especially so if the constraint is adopted globally or if the nations subject to a production capacity constraint ban all international trade in CFCs (and products containing or based upon CFCs) with nations not implementing the capacity constraint.

15 With overall use controls, achieving efficiency in production presents no major difficulties. Instead, the problem, if anything, is to ensure that there is efficiency in the use of CFCs. Again, a

crucial consideration is the method by which rights to purchase and use CFCs are allocated. If this is done administratively there can be no certainty that the regulator will have adequate information to ensure that the limited CFCs available are put to the most valuable uses as efficiency in use demands.

iii) Emission Fees/ Taxation

16 It is possible to design a system of emission fees/taxation which raises no particular theoretical worries in terms of the efficiency of production and use. Provided that the regulator can determine exactly what the 'externalities' imposed by each additional unit of CFC emissions are valued at then it should, in theory, be possible to design a tax system to ensure that the costs faced by CFC consumers making their purchase decisions fully and precisely reflect the marginal social costs. However, there are considerable uncertainties attached to the estimation of the marginal social costs of each unit of CFCs. Also, the marginal social costs may well vary with the level of CFC emissions and with the type of CFC. This, of course, would imply that the marginal tax rate would vary from unit to unit. Thus, the notion of establishing a non-linear tax regime that corrects the 'externality' is not considered further in this paper.

17 There remains the possibility that a tax applied at a uniform rate could achieve the socially optimal output level. Aside from distributional considerations, there is no reason to suppose that, in the absence of uncertainty, a regulatory regime which controls price will differ in its effects from one which regulates quantities. But with uncertainty the picture changes somewhat.

18 When there is uncertainty, the economic effects of regulatory strategies based on price (or tax) are quite likely to differ from those based on quantity controls, as Annex B illustrates. In particular, the two types of strategy may well differ in their ability to ensure that CFC output and use are at, or near to, the social optimum. The crucial factors determining the relative merits of price and quantity regulation are the relative slopes of the demand and cost curves and the uncertainties surrounding their respective positions.

iv) End Use Controls/Bans in Particular Sectors

19 Whereas the three regulatory strategies discussed above leave a clearly defined role for the market mechanism, end use controls are more direct. The immediate effect of a regulation which either bans or imposes a reduction in the use of CFCs in a particular application will be to reduce the demand for CFCs and the emission of CFCs in that application. In the short-term, assuming the industry is competitive, the reduced demand for CFCs may result in a temporary fall in the price of CFCs as producers, faced with reduced demand for their product, seek additional business. Whereas in the long-term equilibrium the industry will equate long-run marginal cost with demand, firms may be prepared in the short-term to reduce prices to the level of short-run marginal cost in an effort to gain extra demand. This may have the effect of boosting demand for CFCs in the unregulated sector of the market but this will only be a temporary phenomenon. In the longer term, no producer of CFCs will be prepared to remain in business if price covers only short-run marginal cost since a normal economic rate of return can no longer be earned on the capital employed in the activity.

20 One of the problems posed by the imposition of an end use ban or control is that it creates distortions in the competitive market process. Consider the industries which use CFCs as inputs in the production process. If they are required to reduce their consumption of CFCs by some designated small amount they will select the least costly methods. For example, products might be abandoned where the closest substitutes are available and there may be increased recovery of CFCs where this is most economic. But, if all the burden of CFC regulation is borne by particular user industries, as it is with end use controls, this effectively means that the required adjustments can be expected to become increasingly costly. In particular, the reductions will occur in uses which are more costly than are available elsewhere in other CFC using industries. The implication is that a given reduction in CFC usage is not achieved at the minimum cost by end use controls.

v) Best Practicable Control Technologies

21 Another way in which the level of CFC emissions can be limited is by identifying existing control technologies which could be adopted to reduce the level of CFC emissions in particular uses. Then, after disseminating information about the nature and purpose of these technologies, users and producers of CFCs would be expected to introduce them wherever appropriate. The regulator faces a choice between the mandatory enforcement of these control technologies and a reliance on firms and individuals to adopt them voluntarily. If the latter approach is adopted, then there must be doubts as to the effectiveness of the strategy in reducing the use and emissions of CFCs. Either the technology will be known and firms/individuals will already have adopted it, in which case the strategy has no effect, or the technology will not be adopted, possibly because it is uneconomic, in which case there is no effect on emissions. However, it is possible that information about the existence of particular control technologies is not widely available internationally in which case the improved dissemination of information may encourage and facilitate the voluntary adoption of the technologies. In such circumstances, it can be shown that the approach is likely to be extremely cost-effective since companies are being encouraged to do something that they find economically attractive. The improved dissemination of information is simply correcting a market failure. Where these technologies are mandatorily imposed then, as will be seen below, this may impose considerable costs on economies.

D THE ECONOMIC COSTS OF REGULATION

22 The purpose of this Section of the paper is to suggest how the economic costs of the different strategies ought to be assessed. It would have been desirable to have been able to quantify these costs. However, there are considerable practical difficulties which prevent this from being done. For instance, it is not clear that the regulatory experience of one country can be translated to other parts of the world where the earlier experience, if any, has been rather different. Furthermore, there exist considerable

uncertainties which make the estimation of costs subject to substantial margins of error. Therefore, the approach adopted in this paper is to develop a conceptual and methodological framework within which to assess the alternative strategies, in particular their relative costs.

23 It is important to understand precisely what costs are relevant to policy making. Essentially, the policy maker should be concerned with economic costs since these reduce society's capacity to produce and consume. This is particularly relevant here since some of the strategies involve transfers of resources and wealth between economic agents. These transfer payments, whilst important when assessing the distributional consequences of different strategies, are not economic costs since they do not result from an increased use of real resources in the economy. They are therefore disregarded in this paper. The aim when determining the economic costs of the alternative strategies may be thought of as an assessment of the impact on (national) economic welfare. This, in itself, represents a rather wider concept than simply national income. It is useful to consider the various possible costs under the following headings:

i) costs due to the misallocation of resources; of which:

   a) long-term costs - losses in economic surpluses; and

   b) transitional and adjustment costs.

ii) administrative and enforcement costs; and

iii) safety costs and accident losses.

24 Initially, attention is focussed upon the costs imposed on the CFC producing industry and its customers. Section E considers the secondary effects of regulation on competing industries, on the upstream chemicals industry, on suppliers of complementary products and on other affected industries and individuals.

25 In analysing the costs of regulatory action the benchmark used is the traditional economic one in which resources are initially allocated efficiently assuming any 'externalities' associated with CFC emissions are disregarded. This simplification is convenient for expositional purposes but overlooks the fact that there has already been some regulatory activity. It is possible, therefore that some of tne costs of a particular regulatory strategy will already have been borne and that extending regulation onto a global basis will not be as costly as the analysis might suggest. Nonetheless, it does not invalidate the analysis since it can be argued that all costs, even those already borne, are relevant when determining policy towards CFCs.

i) Costs Due to the Misallocation of Resources.

26 Ideally, resources should be allocated so that there is efficiency in both production and use. Put simply, this implies that output is produced in the most efficient least-cost manner and that the combination of outputs produced is that preferred to any other by consumers. To the extent that regulatory strategies prevent the achievement of efficiency in either use or production, they impose economic costs.

27 When assessing the economic costs arising from any misallocation of resources it is useful to make the distinction between the continuing long-term costs imposed on the economy and the temporary transitional and adjustment costs. Long-term costs arise where regulation prevents or deters efficiency in the production and use of CFCs on a continuing basis. Temporary costs, on the other hand, accrue in the period during which the markets adjust to the imposition of regulation. Both categories of costs are considered in turn below.

a) Long-term Costs - Losses in Economic Surpluses

28 With a production capacity cap, it has already been noted that inefficiency in production may be a consequence. Whether or not it is depends upon the basis on which production rights are allocated. If marketable permits are introduced, then it is likely that there

will be efficiency in production. But, there may be difficulties with a system where marketable permits are used. For a new entrant, the cost of acquiring the necessary permits heightens the cost of entry into the industry. Thus, the threat of competitive pressure on the existing firms in the industry may be somewhat relaxed though far from removed. Against this, it can be argued that even if the capital requirements for entry into the industry are increased firms should still be able to raise the necessary capital if there are opportunities available provided that capital markets work efficiently. If not, and rights are allocated adminstratively, there is the danger that the least-cost production will not be achieved and maintained, partly because of the regulator's difficulties in obtaining adequate information about the cost structures of rival producers. The nature and significance of these economic costs is discussed more fully in Annex C. It needs to be remembered that these costs will continue to accrue indefinitely until the least-cost pattern of production is restored. There is, however no market mechanism by which this will be achieved.

29 With a capacity constraint, a firm upper limit is placed on the level of CFC production and emissions. Once this begins to bite there will be upward pressure on CFC prices. This will serve to enhance further the incentives to find substitutes for CFCs; to research new ways of recycling and recovering CFCs; and, to innovate and introduce new methods of controlling CFC emissions. There should continue to be efficiency in the use of CFCs.

30 However, where a production capacity cap is binding there will be a loss in consumers' surplus. This is one of the principle economic costs associated with a capacity constraint. The effect of a capacity cap is to push up the price of CFCs and to reduce consumption. The loss in consumers' surplus is measured by the amount that consumers of CFCs would have been prepared to pay for the CFCs they are no longer able to consume due to regulation less the amount they would have had to pay for these CFCs in the absence of regulation. The loss in consumers' surplus:-

i) increases non-linearly with the degree of restriction;

ii) varies inversely with the elasticity of demand for CFCs (This in turn will depend heavily on the elasticity of demand for the CFC-based products and the ease with which other inputs can be substituted for CFCs in these various products); and

iii) depends, in the longer term, on the rate at which demand for CFCs grows since this will determine the degree of restriction in the long term.

It is important to note that so long as the capacity constraint is binding, and CFC prices are higher than they would otherwise be, there will be a loss in consumers' surplus.

31 In contrast, overall controls on the use of CFCs raise few problems in terms of the efficiency of production. They do, though, raise concerns about the efficiency of the use to which CFCs are put. Again, the crucial issue is the manner in which permits are allocated. If this is done administratively there can be no guarantee that CFCs will be used in their most valuable ways and economic costs will arise as a result. The nature of these costs is similar to that of end use controls and is discussed further below. However, provided that permits exist and are tradeable, these costs can be avoided.

32 It is illuminating to compare the loss in consumers' surplus arising from an overall use control with that of an equally restrictive capacity cap. If the capacity cap is global or if international trade in CFCs and CFC based products is constrained, it can be shown that the effect of an overall use limit on the price of CFCs will be the same as that of an equally effective capacity cap and there will be no difference in the consumer surplus loss. If international trade is not constrained the loss in consumers' surplus will be smaller but the policy will be less effective. In the short term, however it is possible that the effectiveness of the two policies may differ because of the accumulated stocks of CFCs but this should only be a temporary factor. Again, though, the loss in consumers' surplus is a long-term phenomenon.

33 The practicality of having an emission fee/taxation system was considered earlier. Whilst a system of fees which 'corrected' the price of CFCs so that the price faced by consumers reflected the economic costs of using the product was regarded as economically efficient, it was thought to be impractical because of the considerable uncertainties and the practical difficulties of operating a system of taxes where the rate varied from unit to unit of output. However, the option of a uniform tax remains for consideration.

34 Assuming there is no uncertainty, it is possible for the application of a tax (or emission fee) at a uniform rate to ensure that the output of CFCs is at the socially optimal level. Moreover, there are no reasons why producers should not achieve efficiency in production and consumers achieve efficiency in use. However, with uncertainty, the policy maker can no longer be confident of being able to determine the appropriate tax rate to ensure that the socially optimal level of production is achieved. As a result, there may well be a misallocation of resources within the economy. The imposition of a tax raises the price of CFCs and gives rise to a loss in consumers' surplus in the same way that a capacity cap does.

35 The effect of end use controls on particular sectors or applications on the allocation of resources should not be overlooked. In terms of the efficiency of production, an end use control, such as an aerosol ban, causes no particular problem since incentives remain to ensure that in the long-term production is undertaken at least cost. The difficulties arise because of the inefficiency induced in the allocation of CFC production between alternative uses. The nature of the associated costs is illustrated in Annex D. However, the essential point is that for resources to be allocated efficiently between alternative uses, it is necessary that their value to the consumer at the margin is the same in all instances. Only in very exceptional circumstances will the imposition of an end use control (or ban) fail to upset the previous equilibrium. More usually, it will mean that the value of an additional unit of CFCs in the regulated sector will exceed the value in alternative uses in the non-regulated sector. Economic

welfare could therefore be boosted by switching one unit of CFCs from the non-regulated to the regulated sector without increasing overall use of CFCs. These economic costs will continue to accrue so long as resources continue to be misallocated.

36 If end use controls on particular applications are contemplated, then for a given reduction in CFC use and emissions, the loss in consumers' surplus is likely to be more severe than with an equally restrictive control on overall CFC use. This follows from the result that losses in consumers' surplus will be minimised only if there continues to be efficiency in CFC use. Since this would most likely not be the case in the event of a ban on a particular use the least valuable uses of CFCs will not have been given up. Indeed, unless demand for CFCs in a particular use is entirely unresponsive to price, it is generally true that economically the most efficient and least costly way of reducing CFC emissions is by sharing the burden across all uses and not by singling out particular uses.

37 Finally, where best practicable control technologies are enforced, this too will result in economic costs as a result of the misallocation of resources. If CFC users and producers are obliged to make investments in the technologies which they would choose not to undertake otherwise, presumably because they are unattractive economically, then this will increase the costs of production and ultimately the resource costs. As such, the costs of making the necessary investments and operating improvements - the compliance costs - represent resources devoted to this activity which cannot be used elsewhere but which are not being used in an efficient way. The cost to the economy is therefore the reduction in the returns earned through applying the resources to controlling CFC emissions as compared to those attainable elsewhere in the economy in the preferred use. Moreover, if the enforcement of these technologies increases the costs of production this will mean that the price of the product in question will rise in the longer term. This, in turn, will result in a consumers' surplus loss, again on a continuing basis.

b) Transitional and Adjustment Costs

38 Besides a continuing adverse impact on resource allocation in the economy, regulation also imposes temporary transitional and adjustment costs. These costs take a variety of forms and it is easiest to consider each strategy in turn.

39 With a production capacity cap, short-run economic costs may arise as a result of the immobility of the factors of production (capital and labour). Specifically, if a capacity cap which is immediately binding is suddenly imposed, the outcome may be that firms are unable to adjust their production structures sufficiently quickly to eliminate excess capacity. If the resources devoted to CFC production cannot immediately be switched to alternative activities then there will be opportunity costs in the sense that the returns to these resources are being foregone. However, these costs will exist only so long as labour resources cannot be re-employed or until capital loses its economic value. Similar effects will result from the imposition of overall use controls and emission fees/taxation of CFCs.

40 In the case of end use controls, the transitional and adjustment costs fall into a number of categories. Where the use of CFCs in a particular product or process is banned or heavily restricted then substitute products and processes will be developed. However, the resources devoted to these activities are being used inefficiently when compared to their alternative possible uses in the absence of regulation. For example, in the case of a ban on the use of CFCs in aerosols, resources will inevitably be devoted to the reformulation of the products to use non-CFCs as propellants and to the conversion of filling lines to use non-CFCs. But, without an aerosol ban, it is quite likely that these resources would be devoted to alternative more profitable uses.

41 Just as additional resources are required to develop substitute products or processes for those based on CFCs so existing capital may also be made redundant. If output is reduced as a result of regulation, any capital made redundant may lose its

economic value. Where this occurs, then the foregone returns on these capital resources should be added to the other costs when assessing the economic costs of an end use ban (or restriction). It may be noted, however, that with the passage of time, the significance of non-recoverable costs diminishes. As alternative uses for CFCs develop in the unregulated sector, alternative uses for the idle factors of production emerge thus allowing at least partial recovery of costs in later years. Equally, the normal replacement of capital over time implies that initially immobile equipment will become economically irrelevant at some point in the future. Thus, the costs are only transitional.

42 An important consideration in assessing the significance of these transitional costs is the nature and timing of the regulatory announcement. If regulation is anticipated, or if it is not immediately binding, then this provides the opportunity for adjustment and the costs may be diminished accordingly since it allows time to develop alternatives to CFCs and more importantly perhaps, it reduces the extent of non-recoverable costs. Also important is the restrictiveness of the regulations imposed. The more restrictive is the policy the greater will be the transitional and adjustment costs.

ii) Administrative and Enforcement Costs

43 Generally, enforcement is cheapest in industries where there is a small number of producers. If anything, this favours a capacity cap since the CFC industry is relatively heavily concentrated with a small number of producers worldwide. By comparison, the CFC using industries are more fragmented with more companies and manufacturing sites.

44 Second, direct controls tend to be more difficult and costly to modify than economic incentive based strategies which work through their effects on prices and quantities. The importance of non-recoverable costs cannot be ignored and changes to direct control strategies will inevitably involve significant additional costs. But, changes to economic incentive based strategies cannot be made without cost. The more regulators choose to - or have to

due to the uncertainty surrounding the issue - manipulate prices (through changes in taxes or fees) and/or quantities the greater the uncertainty this may give rise to regarding the regulatory signal. Investments may be deferred and this may have an adverse effect on economic efficiency in the longer term.

45 The cost of implementing a policy may also depend upon how familiar a policy is to the regulatory agency. It is usually thought that the most familiar policies have some cost advantages. In the case of CFCs though, this does not obviously favour a particular strategy since different nations have adopted different approaches to regulating CFCs.

iii) Safety Costs and Accident Losses

46 Consideration also needs to be given to the health and safety aspects of the products and processes used to replace CFCs. One particular concern has been the flammability of hydrocarbons which have been used as substitute aerosol propellants in North America and Scandinavia. Another concern that has been expressed is the possible carcinogenic qualities of certain products sometimes used as alternatives to CFCs (for example methylene chloride). Whilst these are obviously legitimate concerns of the policy maker evidence as to the costs they impose is limited.

47 In a sense, these 'risk trade-offs' may be regarded as another separate regulatory issue if they give rise to 'externalities'. Their implications for the control of CFCs therefore depend in part, at least, upon how well they are regulated. If they are already adequately and appropriately regulated there is no real problem provided, of course, that the regulations are able to cope satisfactorily with any upsurge in the use of the potentially hazardous chemicals as a result of the regulation of CFCs. It is also possible that customers are aware of the potential risks of the alternative products and reflect this in their consumption decisions with the result that the 'externalities' may be partly internalised in the sense that they are reflected in the price.

E THE SECONDARY EFFECTS

48 The analysis so far has concentrated on the effects of the different regulatory strategies on the CFC producing industry and on the consumers of CFCs. Since CFCs are essentially intermediate products little attention has been paid to the final consumer. Nor, more importantly, has attention been paid to the upstream chemical industry and other input suppliers; to the industries producing alternatives to CFCs; and, to the producers of goods complementary to CFCs (for example, aerosol cannisters and valves).

49 Assuming that the different regulatory strategies are applied so as to be equally effective in reducing the level of use and emission of CFCs, it is not obvious that one particular strategy should impose greater costs on the suppliers of inputs than any other. All should result in the level of demand for intermediate inputs such as fluorspar, sulphuric acid, carbon tetrachloride and chlorine, being lower than it otherwise would be by a similar amount. However, it is, of course, possible that different strategies will result in different impacts on the demand for each of the family of CFCs and this may have different implications upstream. Nonetheless, while there may be little difference between strategies of a given effectiveness on the supplier industries, this does not mean that there are no associated economic costs. The costs will derive largely from the lower economic returns in the affected industries but these will only be temporary as resource allocation can subsequently adjust.

50 Whilst regulation of the CFC producing and/or consuming industries will inevitably impose economic costs on those industries, it is worth noting that there will be some positive impact (benefits) on the industries supplying alternatives (substitutes) to CFCs. Additionally, those industries supplying equipment to enhance the recovery and recycling of CFCs may also benefit from regulation. The extent to which these groups of industries derive economic benefit depends upon the nature of the regulatory strategy and on its effects. In particular, it is important to determine the degree to which the strategy encourages the substitution of CFC-based products and the recovery/recycling of CFC for further use.

51 The economic costs of a production capacity cap and overall use controls - assuming that the policy is adopted globally or international trade in CFCs and CFC based products is constrained - will be similar, given the same level of effectiveness. If they are binding, both will work to push up the price of CFCs and the market will determine whether CFCs are saved by enhanced recovery/recycling or by substitution. The least cost solutions will be selected. In contrast, where either best practicable control technologies are enforced, or end use controls (including bans) are applied to particular uses, the effects will inevitably be somewhat different. Crucial factors will be the basis on which the control technologies are chosen, the end use selected and the degree of restriction imposed. It may be that all the control technologies are intended to enhance the recovery of CFCs in which case the principal beneficiaries will be the suppliers of control equipment.

52 To quantify these benefits of regulation is inevitably a complex task. However, it is evident that the extent of the benefits will vary from use to use and control technology to control technology. But, a priori, the economic benefits from these spin-off effects of regulation are most unlikely to be anything like sufficient to offset the costs imposed elsewhere on the economy, particularly on the CFC producing and consuming industries, because they will only be temporary.

53 In much the same way that the suppliers of inputs to the CFC producing industry will suffer economic costs as a result of regulation so suppliers of products complementary to CFCs will also be disadvantaged. The extent of this effect will depend on a number of factors. If a particular application of CFCs is heavily restricted, or banned, there will be reduced demand for complementary products. But, if control technologies are imposed which increase the cost of the end product, the price elasticity of demand for the end product will be important. Inelastic demand will mean relatively little effect on demand for complementary products. With quantity controls and economic incentive based policies, an increase in the CFC price may change the pattern of demand. However, this will reflect the price elasticity of demand

for the final product and the importance of CFC costs in overall costs. Where CFCs are only a small proportion of the total costs, the sensitivity of complementary product demand can be expected to be small. To the extent that substitution is encouraged as a result of regulation, demand for the complementary products of the substitutes will be boosted thus resulting in economic benefits which partly offset the other costs. But, again, these costs and benefits will only be temporary.

54 In assessing the economic costs (and benefits) of the possible regulatory strategies, the effects outside the CFC producing and consuming industries need also to be considered. There are both costs and benefits. However, it is likely that the magnitude of these effects will be relatively small by comparison with the effects on the industries principally affected. One important reason why this is so is that these economic costs and benefits of regulation are also only temporary phenomena. In the short term, capacity utilisation and the returns to the resources employed may well be affected by the imposition of regulations on the CFC producing and consuming industries. But, in the longer term, as the resources employed lose their economic value or are re-employed in other activities or cease to earn higher returns regulation will cease to impose costs and benefits on the sectors of the economy not directly affected by regulation. A further complication in determining the economic costs and benefits of regulation is the need to be able to identify the transfer payments that arise. These payments may be significant but do not represent economic costs; rather they reflect the redistribution of income and wealth in the economy as one industry benefits at another's expense. They therefore need to be excluded from the assessment of the economic costs and benefits. Overall there seem to be no strong reasons for presuming that, given the strategy's effectiveness, one regulatory strategy is preferable to the others in terms of its secondary effects.

F OTHER ECONOMIC ASPECTS OF REGULATION

55 The preceding discussion has focussed on the nature and scale of the economic costs of alternative regulatory strategies. There

are, however a number of other economic aspects of the strategies worthy of comment.

i) Effectiveness

56 So far, no comment has been made as to the effectiveness of the different regulatory strategies in controlling CFC emissions. Instead, the effectiveness has been taken as given. There are though, a number of points which ought to be borne in mind. The nature of the regulatory strategy adopted can have an important impact on the pattern of CFC use and emissions over time. A global capacity cap can place an upper limit on the level of CFC use. In the short-term, it may have no impact on use if it is not immediately binding but in the longer term its effect may well become more pronounced. An overall use control will have a similar effect. But, with emission fees, end use controls in particular applications and mandatorily enforced control strategies there can be no assurance that use and emissions will be similarly constrained. For instance, with an end use control on a particular application there is no reason to suppose that demand for CFCs in other uses will not grow in such a way that overall demand continues unrestrained. Indeed, in the short-term, the fall in demand for CFCs in one particular application may reduce prices and foster new uses elsewhere. However, this will only be a short-term phenomenon. If emission fees, end use controls and mandatorily enforced control technologies are to be as effective a constraint on CFC use as a capacity cap, regular adjustment of the regulatory framework may be required. But, this may heighten uncertainty and increase the economic costs associated with regulation.

57 There is a link between the economic costs of regulation and its restrictiveness (or effectiveness). As the restrictions on CFC use or production are increased, the associated economic costs rise too, probably more than proportionately with the degree of restriction. Of course, the benefits from the restrictions may also increase. An instance of the trade-off between the effectiveness of a strategy and the costs is the application of control technologies. The regulator faces a choice between applying the controls to all uses or only to new sources. The

former, which involves retrofitting existing facilities, will be more effective all things being equal. But, applying the regulation only to new sources will be less costly, though it will give rise to distortions between the two types of operation.

58 There is an important distinction between the production (and use) and emissions of CFCs. The use to which CFCs are put is important and affects the timing of CFC emissions. In some cases, it may take a number of decades before CFCs reach the atmosphere. There is therefore a banking effect. However, if CFCs were banned outright now, CFCs would continue to be emitted from the bank for some time to come but the amounts would be small.

ii) Equity and Distribution

59 In examining the economic costs of the regulatory strategies, no comment has been passed on the distributional and equity implications. This is not to say that they are not important or do not exist. On the contary, they raise complex issues which fall outside the scope of this particular paper. It is, however worth noting that distributional consideration are particularly important where economic incentive based strategies are being contemplated. For instance, an emission fee will result in significant transfer payments. So too will capacity caps and overall use controls especially where accompanied by marketable permits.

iii) Industrial Structure

60 Comment has already been made that the costs of administering and enforcing a regulatory policy will be minimised the smaller the number of firms affected. This will tend to favour the regulation of concentrated industries. There are, though, other reasons for preferring that the burden of regulation falls on larger rather than smaller companies. It is believed that if the burden of regulation falls on small companies, the resulting economic consequences are more severe than if the burden is borne by larger companies. At least part of the reason is that small firms have insufficient resources with which to respond and adapt to the burden placed on them.

61 Another distinction can be drawn between the effect of mandatorily imposed control strategies and economic incentive based strategies and quantity controls. Mandatorily imposed controls will, if anything, tend to increase the fixed costs of production for CFC consuming industries. In turn, this will tend to raise the optimal scale of production. Incentive based strategies and quantity controls, however, raise the variable costs of production since CFCs now cost more. Whether this should be a concern of regulators depends on the view taken as to the nature of the competitive process and the efficacy of competition policy.

62 Concerns have been expressed about detriments to competition believed to result from the use of marketable permits. Specifically, the possible dangers of monopolisation, and collusion have been highlighted. However, the effectiveness of the regulatory strategy is not threatened by potentially anti-competitive practices. Nonetheless, additional costs may be imposed on the economy.

63 The possibility of monopolistic abuse arises if permits are concentrated in the hands of a small number of firms. But the likelihood of this occurring can be assessed by considering the returns attainable from the abuse of a dominant position against the costs of achieving that position and by examining the nature and efficacy of existing competition policy. It seems unlikely that the rewards of monopolisation of the permit market will be sufficient to justify the considerable costs associated with the establishment of a dominant position. Similarly, any adverse effects of collusion in the market for permits seem unlikely to affect the effectiveness and implications for economic efficiency of the regulatory strategy though they may have implications for distribution.

G CONCLUSIONS

64 This paper has discussed and analysed the economic costs of a number of regulatory strategies which might be adopted to control the use and emissions of CFCs. A broad distinction has been drawn

between quantity controls, economic incentive based policies and direct controls. Consideration has also been given to the effectiveness of these strategies and to the uncertainties that underlie the whole issue. The emphasis has been on developing an analytical and conceptual framework within which to assess the economic costs of the different strategies. No attempt has been made to derive quantitative estimates of cost-effectiveness. There are, though, a number of important conclusions that emerge from the analysis. These may be summarised as follows:

- unless marketable permits are introduced, a production capacity cap may give rise to economic costs through inefficiency in production

- unless marketable permits are introduced, overall use controls may not ensure efficiency in the use of CFCs and economic costs will result

- in theory, a system of emission fees/taxes could be designed which is consistent with economic efficiency, but in practical terms this is unlikely to be feasible

- end use controls on particular applications will inevitably lead to inefficiency in the use of CFCs

- the mandatory imposition of best practicable control technologies is unlikely to result in CFC use being reduced at least economic cost

- quantity controls and economic incentive based policies will ensure that there is a continued incentive to reduce CFC consumption in all uses.

- losses in consumers' surplus will be continuing, not simply a one-off

- the loss in consumers' surplus depends on the degree of restriction on CFC use and the price elasticity of demand

- the loss in producers' surplus though only temporary may still continue over a number of years

- the transitional costs of regulation depend in part on the time allowed for adjustment and on the clarity of the signalling

- where regulatory adjustment is needed, the economic costs will be greatest under direct controls (as opposed to quantity controls and economic incentive based policies)

- the costs of administration and enforcement will be lower the smaller the number of companies in the regulated sector and the greater the familiarity of the regulatory strategy.

- quantity controls and economic incentive based strategies will impose a lower economic cost in achieving a given reduction in CFC use than direct controls

65 In theory, regulatory policy towards CFCs should be determined so that the economic costs of regulation just equal the benefits in such a way that economic welfare is maximised. However, the uncertainty surrounding this issue, especially the valuation of the costs and benefits is such that it is simply impracticable to be so precise when formulating policy. In the light of this uncertainty, the regulator is faced with a choice between a policy based on regulating prices/quantities and a policy which imposes direct controls. However, it has already been noted that the effectiveness of a policy based on controls of particular end uses in controlling the overall level of CFC emissions is uncertain since the use of CFCs in the non-regulated sector is unconstrained. It is therefore suggested that one way in which the aim of regulatory policy might be viewed is as a precautionary policy against significant adverse environmental effects. In such circumstances, on the basis of economic costs, a production capacity cap or an overall use control may offer a superior long-run framework for the control of CFCs.

ANNEX A: THE NATURE OF THE ECONOMIC 'PROBLEM'

A1 In the main text, it is argued that the existence of external costs causes producers and consumers, motivated by commercial considerations, to produce and consume more CFCs than is economically and socially optimal. The purpose of this Annex is to explain why this is so.

A2 In figure (i), the cost to producers of manufacturing an incremental (or marginal) unit of output, including an allowance for a normal return on capital, is related to the level of output and the relationship is represented by the marginal cost curve, CC. For simplicity, CC is drawn as a horizontal line implying that, in this case, incremental costs are independent of the level of output. The relationship between the demand for CFCs and their price is given by the demand curve, DD. Now, in such circumstances, with profit maximising CFC producers, the industry's equilibrium output will be A. At no other output will profit be greater.

A3 The regulatory problem arises because the possible adverse effects of CFC emissions are not fully taken into account by CFC producers and consumers when determining their output and consumption patterns. However, if the incremental external costs (net) of CFC production are added to the incremental private costs of CFC producers this yields the marginal social cost curve (CS in figure (i)). In these circumstances, the economically and socially optimal level of output is B. This is the output at which the marginal social cost and demand curves intersect. At no other output will economic welfare be greater. It is assumed here that incremental external costs are readily determined but, as the main paper discusses more fully, this is not necessarily so.

A4 It can be seen that, in the conditions depicted above, an unregulated market would exhibit a socially excessive level of CFC output. The magnitude of the economic losses associated with the excess production (A less B) is equal to the area between the marginal social cost curve and the demand curve over the relevant production. The area is shaded in figure (i).

ANNEX B: THE INFLUENCE OF UNCERTAINTY ON THE EFFECTS OF PRICE AND QUANTITY CONTROLS.

B1 Reference is made at several points in the main text to the important influence of uncertainty on the choice of regulatory strategies. The purpose of this Annex is to illustrate one aspect of this by considering how the effects of price and quantity based regulatory strategies may differ when there is uncertainty about the demand for CFCs.

B2 Consider figure (ii). Suppose for the purpose of illustration that the position of the demand curve for CFCs is not known with certainty. The point D is the initial (observed) unregulated equilibrium in the market for CFCs. DD* represents the central estimate of the demand curve for CFCs. DD(H) and DD(L) represent two other estimates of the position of the demand curve. The marginal private cost of producing CFCs is represented by the line CC and the marginal social cost is given by the curve CS.

B3 In these circumstances, the implications of imposing a quantity control at Q* (the social optimum if the central estimate of demand proves to be correct) can be compared with the application of a uniform tax rate, t. This will also lead to the socially optimal output if the central demand estimate is correct. However, if demand turns out to be high (DD(H)) equilibruim output under a tax secheme will be Q. The resulting losses (relative to the relevant social optimum) are given by the shaded area, LMN. For the quantity control scheme, the losses are represented by the area, NOP. If demand turns out to be low (DD(L)), the losses under the tax scheme and the quantity control scheme are given by the shaded area EFG and the area GOH respectively. In this particular example, the quantity control scheme is preferable to a tax (price) scheme since the losses from a failure to produce an equilibruim output at the socially optimal level are smaller. More generally, the relative merits of price and quantity regulation depend on the relative slopes of the demand and cost curves and upon the uncertainties surrounding their respective positions.

ANNEX C: THE ECONOMIC COSTS DUE TO INEFFICIENCY IN PRODUCTION.

C1 One of the ways in which economic costs may result from regulation is through inefficiency in production. The purpose of this Annex is to provide an illustration of this point.

C2 In figure(iii), the marginal cost curves of two groups of firms (A and B) are represented by C(A) and C(B) respectively. Under a production capacity cap, assume that each group of firms is only allowed to produce half of the output (that is $\frac{1}{2}$ Q*). It is clear that if the two groups of firms were unrestricted in their ability to produce then the costs of production would be minimised if group A firms produced all the output. The resource cost saving that this represents is shown as the shaded area in the diagram. This saving would continue so long as the inefficiencies remained.

ANNEX D: THE INEFFICIENCIES AND ECONOMIC COSTS OF END USE CONTROLS

D1 One of the criticisms levelled at the application of end use controls to particular uses of CFCs is that it does not ensure that CFCs continue to be used efficiently. The purpose of this Annex is to explain this inefficiency and to assess the economic costs that it imposes.

D2 As an illustration consider figures (iv(a)) and (iv(b)) which represent the demand and cost conditions for the same CFC in two different uses (A and B). Without regulation, equilibrium output for use A is half that for use B. The cost conditions are, of course, common. Suppose that a one third reduction in overall use of the CFC is being sought. One possibility would be simply to ban its use in A. The costs of doing this are the foregone consumer surplus in use A. The consumer surplus is the difference between the price the consumer is willing to pay for a particular unit of CFC and the price actually paid. It is therefore represented by the area beneath the demand curve and above the pre-regulation price, triangle EJH in figure (iv(a)).

D3 However, this solution is inefficient because it does not minimise the costs of meeting the required reduction in CFC use. To minimise the costs, the marginal value of a unit of CFC should be equal in both applications. This is only achieved if the height of the demand curve is the same in both uses at the equilibrium output. In the diagrams, a reduction of output for use A from Qa to Qa* and for use B from Qb to Qb* achieves this since the height of the demand curve at the new equilibria (OF) is now the same in both uses. Total output, Qa* plus Qb*, is two thirds of the original output. The loss in consumer surplus in use A is the shaded triangle IGH in figure (iv(a)) and in use B the consumer surplus loss is the shaded triangle RST (figure (iv(b))).

D4 Figure iv(c) illustrates the additional cost if use A is forced to bear the entire burden of the reduction in CFC use, as in an end use ban. Starting with figure (iv(a)), the shaded triangle from figure (iv(b)) is superimposed. Now, it is known that the increase in price for CFCs from P1, to P2 (EF) is the same in both

uses, assuming a competitive market. Thus, EF must be equal to RS. Also, the reduced consumption in use A (Qa*) must just equal the reduction in consumption in use B since the total reduction in consumption is required to be equal to Qa (or one third of the original overall consumption). Therefore, the distance RT must just equal the distance EG which is also equal to Qa*. Therefore, the loss in consumer surplus in use B equals the triangle EFG and the additional loss in consumer surplus resulting from an end use ban (as opposed to an overall use ban) is represented by FGIJ, the shaded quadrilateral in figure (iv(c)).

Figure (I)

The nature of the economic 'problem'

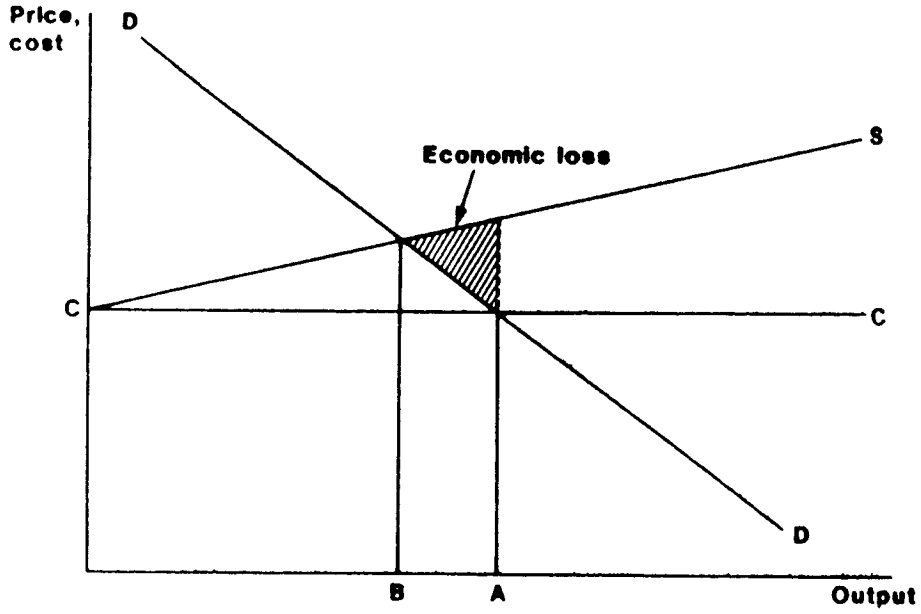


Figure (II)

The influence of uncertainty on the effects of price and quantity controls

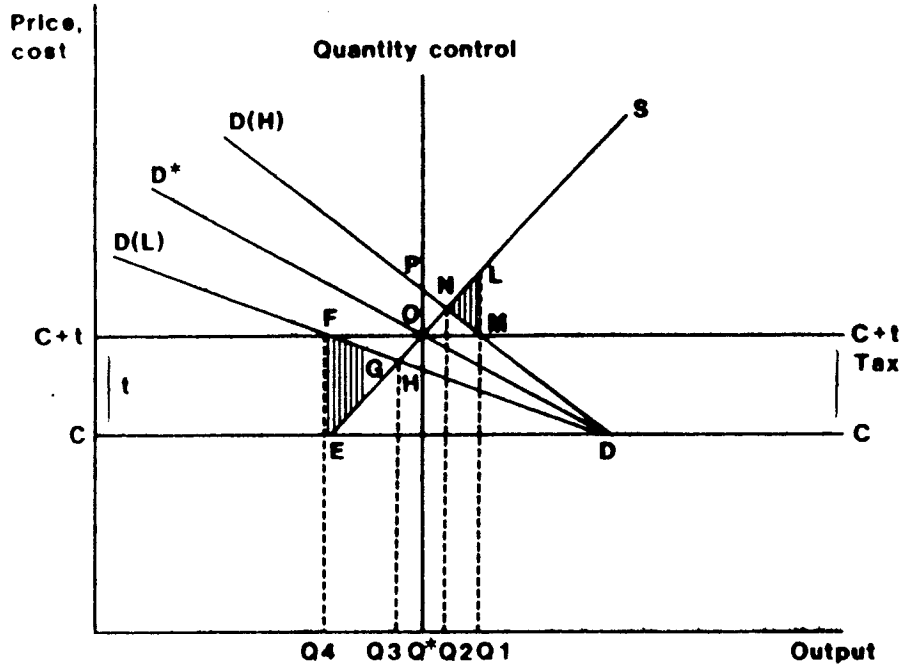


Figure (III)

The Economic costs due to inefficiency in production

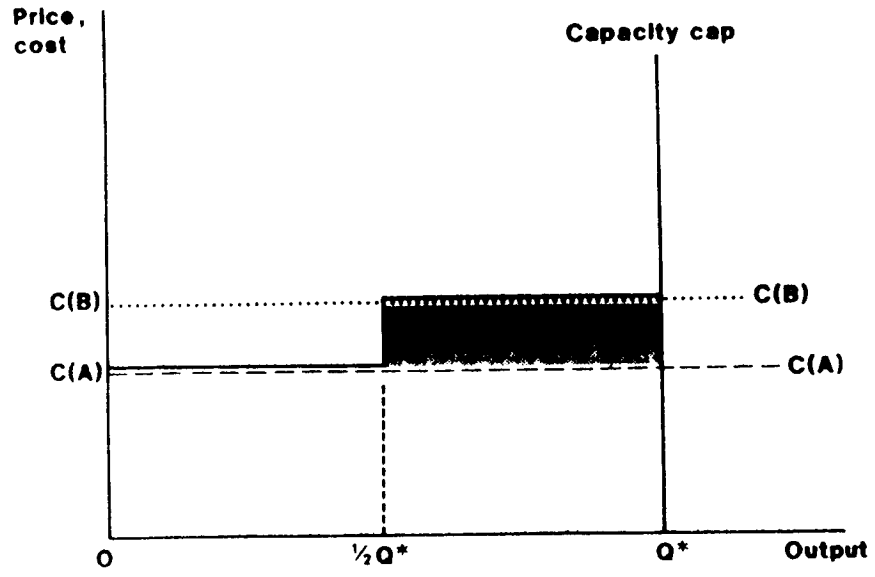
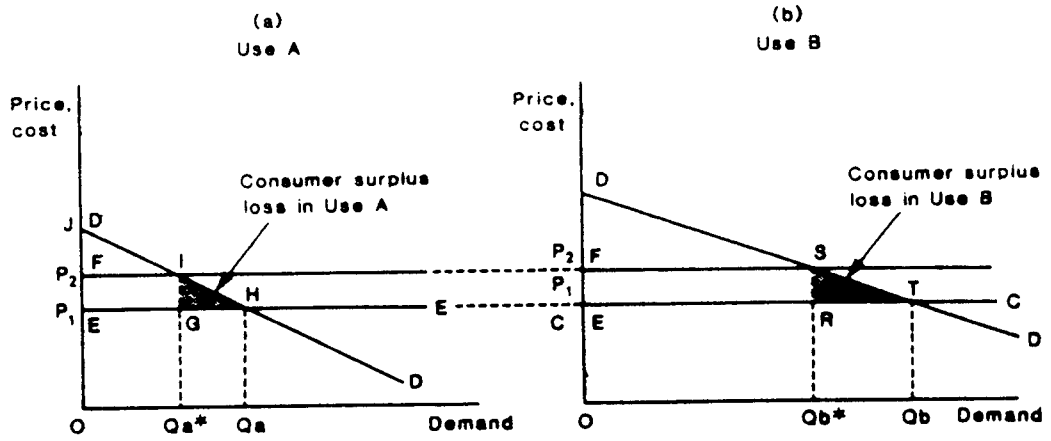


Figure (iv)

The inefficiencies and economic costs of end Use controls



(c)