ECONOMIC ASPECTS
OF
AUTOMOBILE AIR POLLUTION

by

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ABSTRACT

The automobile is one of the most important and disruptive objects in society. It is capable of damaging life and property through accidents, changing social habits and norms, and promoting "urban sprawl". This paper deals with only one aspect of the automobile problem; its contribution to air pollution. In the first section of the paper, automobile air pollution is shown to be a reciprocal external diseconomy that falls into the category of a "public bad" (the public good being air pollution abatement or clean air). Automobile emissions and their effects on health, vegetation, and property are then examined, with an indication of the costs to society from air pollution damage. Other aspects of controlling automobile pollution are discussed, for example, industry structure, legal situation, consumer role, jurisdictional and geographical attributes.

Public policy alternatives are evaluated in terms of their applicability to automobile air pollution and ability to efficiently internalize external diseconomies. Effluent taxes and a change in the legal delimitation of burden of proof of damage due to the external diseconomies are discussed as Pareto optimal policy considerations. However, they are not currently viable due to the inability to determine marginal damage functions from auto air pollution, the oligopolistic structure of the auto industry, and political constraints. Input taxes and regulations are feasible control policies, but they will not lead to an optimal output of air pollution unless the total number of automobiles in congested areas is limited.

The immediate policy recommendations are that fuel taxes on anti-knock gasoline additives should be implemented. Nationwide regulations requiring compulsory annual vehicle inspection should be passed to ensure that anti-pollution devices are being properly maintained. Current control standards should be made more stringent as both air pollution monitoring improves and knowledge of the effects of auto air pollution on animal life and vegetation increases. A long run policy should consider methods of altering the industry structure, limiting the number of vehicles, and eliminating the internal combustion engine.

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I. INTRODUCTION AND DEFINITION OF THE PROBLEM OF AUTOMOBILE AIR POLLUTION

A. Externalities, Public Goods, and Automobile Air Pollution

There is a long history to the development of the concept of external effects and their incorporation into neoclassical microeconomic theory. Starting with Marshall (and even earlier), there was concern with the ability of the perfectly competitive model to achieve a Pareto optimal allocation of resources. The main impetus to integration of externalities into the theory emanated from Pigou who framed his analysis in the Economics of Welfare in terms of marginal social versus private costs and benefits (10). An externality arose whenever social and private costs or benefits diverged. While debates on externalities (including the "empty boxes" arguments of the 1930s, rising supply curves, pecuniary versus technological externalities, etc.) are interesting, they are not essential to the modern concept of an externality. The basic argument is that even with perfect competition and all its relevant assumptions, a Pareto optimal allocation of resources may not be achieved if an externality is present.

It should be noted that the concept of an externality as presented, is in a partial equilibrium context, assuming that the rest of the economy except that sector under consideration is operating under optimal conditions. This assumption simplifies the analysis, but complicates real solutions to any given externality situation (as would consideration of dynamic adjustments). The rest of the economy will not be in a Pareto optimal equilibrium free of distributional problems, and this will affect policy decisions on the correction of the externality.[1]

An externality arises when the utility of an individual or firm is directly dependent upon activities that it is incapable of controlling.[2] The activities enter the utility function directly, not indirectly through market mechanisms. It is not necessary to have a single externality nor a single externality-generating activity. One's utility can be affected by

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[1] This may imply that only second best alternatives are feasible.

[2] An activity is anything that is measurable, e.g., hydrocarbon emissions from automobiles.

external activities from different sources. Externalities can also be reciprocal. If there are two parties, A and B, A can impose an activity on B and B can do similarly to A. The externality may be identical, that is, A and B impose the same activity on each other, or there may be different activities and hence different externalities.

An externality will have allocative significance at the margin in equilibrium when the marginal utility of the individual or firm is affected by a change in the externality-generating activity. A marginal external economy occurs when a small change in the external activity imposed by B causes A's (the affected party) utility to change in the same direction. A marginal external diseconomy will decrease A's utility with an increase in B's activity. Inframarginal significance occurs when incremental changes in B's activity do not affect A's utility, but the total effect of B's action increases (decreases) A's utility for an external economy (diseconomy). The necessary and sufficient conditions for an optimal output of the external activity will then imply that both marginal and inframarginal utility be equal to zero, and with perfect competition, price equal to marginal cost. If marginal or total conditions are greater (less) than zero, even with price equal to marginal cost, an external economy (diseconomy) occurs and the output of the external activity is too small (large).

The externality is deemed potentially relevant when the activity by B generates a desire on the part of the affected (benefited or damaged) party A, to modify B's behavior by bargaining, trade, coercion, compromise, collective action, etc. The importance of this condition is that A has no recourse to B's activity through the market mechanism. There is no price (even in perfect competition) put upon the activity of B. A cannot internalize the activity, i.e., incorporate it into his utility function as something he can control, without some sort of bargaining or collective action.

This condition has also been referred to as price exclusion or non-appropriability. It is "impossible for private firms and individuals, through ordinary private pricing, to appropriate the full social benefits (or be charged the full social costs) arising directly from their production and/or consumption of certain goods" (27, pp. 203-204).

Non-appropriability also implies to some the "divorce of scarcity from effective ownership" (28, p. 204). This concept stems from F. H. Knight's response to the externality or social cost problem (31). Knight felt that the misallocation of resources was not due to Pigou's divergence of social and private costs, but rather to an absence of property rights to a given asset or the "wasteful exploitation of a scarce resource" (33, p. 5). There continues to be debate and confusion on the issue of whether Pigou's or Knight's approach to the cause (and cure) of externalities is the most valid, and just where the two concepts differ (34). Does the lack of concern for total costs (private and social) of any activity imply an inability to charge a price for all these factors and outputs because property rights are not correctly established? Or, are the two concepts unique and not necessarily related? Perhaps an answer can only be reached with regard to specific cases and types of externalities. The importance of the distinction between the two approaches arises when possible means of internalizing the externality are considered. The Knightian approach would call for legal recourse and delimitation of property rights as a solution to the externality problem. The Pigouvian tradition prefers to tax (subsidize) the external diseconomy (economy) to achieve an optimal allocation of resources.

The concept of the externality is further complicated by the realization that many external effects are also public goods (or bads). As in the case of externalities, the taxonomy of public goods is subject to some confusion and debate. The debates are on what comprises a pure public good and how many public good attributes an activity or good must have to be classified as pure. The current concensus following the work of Samuelson, Musgrave and others, defines a pure public good as one enjoyed in common or where "each individual's consumption of such a good leads to no subtraction from any other individual's consumption of that good" (38, p. 387). A Pareto optimal equilibrium with both public and private goods must then have the sum of the marginal rates of substitution equal to the marginal rate of transformation. This quality of public goods has also been referred to as jointness of supply, indivisibility of product, or inability to exclude individuals from consumption of the good or service.

The question then arises of just what goods fall into this category. National defense has been cited as the main example, but clearly, few goods will fit in this extreme or polar definition of public goods. Goods and services such as hospitals, roads, police and fire protection, and air and water pollution abatement have capacity limitations (congestion or rationing of some sort) and/or provide benefits in relation to the geographical separation of the recipient and source of the good. Therefore, it is accepted that most goods and services that are called "public" are actually quasi-public, that is, different members of the public receive different amounts of the good. The jointness of supply is still present (but in varying amounts) and therefore the optimization conditions are basically the same for pure and quasi-public goods.

• The major problem associated with the presence of public goods (pure or not) is the inability to reach a Pareto optimal allocation of resources through the private market. Private firms may not undertake to supply the optimal quantities of these goods because they may not be able to extract a proper price for them. Once the good is provided, it is available to all. This then has been interpreted as grounds for government or collective provision of public goods. The government must still decide how much of the good to supply and at what price. Because there is no exclusion, individuals will hide their true preference for public goods and understate their demand for them, realizing that they will receive the same amount of public goods and pay less for them through taxes. That is, "individuals know that the price they pay for a public good is dependent on the price others pay for it, in the sense that if others paid more for the good they would have to pay less ... each individual can hope to gain by hiding his true preferences or more specifically by revealing preferences which lead others to believe that he wants less of a given good than in fact he really wants" (21, p. 463). The result is that public goods will be undersupplied.[3] This is the same conclusion that is reached in the case of external economies but for different reasons. Because social costs or benefits are not taken into account and/or property rights are not assigned

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[3]Various alternatives to get individuals to reveal their preferences have been proposed, e.g., voting mechanisms, political interest groups, bargaining. See (22).

by the market, an activity generating external economies will be under-supplied, while that with external diseconomies will be in excess of the optimal amount. Hence, these two causes lead to market failure. The direct relationship between externalities and public goods remains to be explained.

Certain externalities are similar to (or in fact are) public goods because they are supplied jointly. Some economists such as Head (27) feel that non-appropriability (no price exclusion) implies the existence of joint supply but not vice versa, i.e., an externality is by definition a public good, but not all public goods give rise to external effects. The distinction is somewhat trivial and again depends upon the good or activity in question.

• The activity in question in this paper is driving an automobile. The activity generates air pollutants. Automobile air pollutants are external diseconomies because the market does not include the marginal damage to individuals of air pollution in the price of the vehicle and cost of maintanence. There is no mechanism requiring individuals to pay for the damage that their car emissions cause. Therefore, auto air pollution depicts the Pigouvian divergence of marginal private costs and marginal social costs. The private costs are the price and maintanence of the car to individuals while the social costs are estimated by the reduction in marginal utility of other individuals due to the air pollution from the cars. Auto air pollution would also seem to fit the Knightian definition of social costs. There are no rights to the ownership of the air or to air pollution. The driver of the car can use the atmosphere for waste disposal without incurring any charge. The air pollution activity then enters the utility function of other individuals as something they cannot control. Thus the output of air pollution will be too large or the amount of clean air too small. Automobile air pollution is also a reciprocal externality. A's car's pollutants decrease B's utility and B's car imposes the same air pollutants on A. This can be expanded to a large number of As and Bs in any location.

Externality theory then suggests that when the relevant external diseconomy is recognized, some sort of recourse might be taken by the afflicted party. The most direct action would be to bargain with (or

coerce) the externality-generating party to decrease the amount of air pollution his car emits. But auto air pollution is reciprocal and it affects large numbers of individuals within a given area. This tends to make bargaining an extremely costly undertaking for a single individual and implies that collectivized bargaining would be a more feasible means of reducing air pollution.

The case for collective action of some sort becomes even stronger when it is shown that auto air pollution is also a public bad and that its reduction, i.e., air pollution abatement is a public good. Once auto air pollution is generated it is equally available to all within a given geographical limit defined by the concentration of the pollutants. It follows that the abatement of air pollution is a quasi-public good. When the air is purified (air pollutants decreased), individuals share equally in the benefits of this activity within a defined area. Following the public good theory, air pollution (or its abatement) would then be larger (smaller) than the optimal amount indicated by Pareto optimal conditions. Therefore both the externality and public goods theories suggest that the output of air pollution may be in excess of the optimal amount. In order to evaluate public policy alternatives for achieving the optimal air pollution output, automobile emissions and their costs to society will be examined next.

B. Automobile Emissions

> Although our atmosphere always has been polluted to some extent from the decay of animal and vegetable matter, combustion products of forest fires, dust generated by wind storms, and particulate matter and gases discharged from volcanic eruptions, it is the increasing burden of contaminants from the activities of man that constitutes the core of today's air pollution problem (29, *p.* 1).

Air pollution as a social problem, dates back to around the 14th century when coal began to be utilized as a major source of fuel for heat. This problem intensified greatly with the advent of the industrial revolution, due to the growth of industry (e.g., metallurgical, chemical, mining) and the concentration of population into urban areas. As output of air pollution increased, the harmful effects became more severe as

dispersal by the atmosphere could no longer rapidly reduce the enormous amounts emitted and as people clustered near the sources of pollution-generating activities. Since the 19th century, the continuous expansion and development of new industrial processes and products, the tremendous increase in motor vehicle use, plus increasing population growth and concentration in cities has augmented both the amount and complexity of pollutants in the atmosphere.

What is a pollutant? It could be defined as a by-product or residual of production or consumption that in significant amounts, can lead to deleterious effects on human, plant and animal life, and property or other resources. The key aspect is the definition of significant. How much of a certain chemical, noise, or other activity is necessary to constitute a pollutant? There is no simple answer to this question. Any answer involves several value judgments because of insufficient information on the effects of any given potentially pollution-generating activity. The first value judgment is an evaluation by the scientist of the potential damage from the activity. This is followed by the economist's estimate of relative values of effects not given market prices. With regard to the first estimate, scientists have been able to determine the levels necessary to cause acute damage to plants or animals in some cases, but they have had less success in ascertaining the levels contributing to chronic effects.

This inability to evaluate potential effects of residuals is particularly relevant to air and air quality. Air is ubiquitous. It is also greatly affected by geographical conditions. Land forms (mountains, deserts, valleys, plateaus), bodies of water, temperature, vegetation, and meteorological conditions all play a role in determining the air flow and its ability to disperse pollutants. For these reasons, it is extremely difficult to predict how much of a certain compound or particulate matter has to be present to constitute a pollutant. These difficulties do not imply inaction. Definitions and classifications of air pollutants have been made.

> Community air pollution may be defined as a condition of the ambient atmosphere that is due to the presence of substances, liberated by the activities of man, in concentrations sufficient to interfere directly or indirectly with his comfort,

> safety or health, or with the full use and enjoyment of his property (29, p. 3).

The automobile's contribution to air pollution is significant. Of all the sources of air pollution, 61% comes from the internal combustion engine (ICE) (2, p. 25). There are two broad classes of atmospheric pollutants; particulate matter (solid and liquid) and gases and vapours. It has been stated that only about 100 specific compounds have been identified among the thousands that pollute the air as a result of man's activities (29, p. 4). The chemical reaction of contaminants with each other after they leave the source greatly complicates analysis. Most automobile emissions fall into this category.

The specific pollutants from automobiles and quantities emitted per year (if known) are as follows:[4]

A. Particulates: 0.5 million short tons, equals 1.8% of total particulate emissions from all sources

1. Dust: from body and wheels of car
2. Lead compounds: from exhaust - 190,000 tons
3. Polycyclic aromatic hydrocarbons: from exhaust
4. Asbestos: from brake linings
5. Carbon particles: from exhaust
6. Motor oil: from exhaust
7. Non-volatile reaction products: from exhaust
8. Nickel, boron, manganese: from exhaust

B. Gases and Vapours

1. Sulphur dioxide: from exhaust - 0.2 million short tons, equals 0.6% of total sulphur oxide emissions from all sources
2. Oxides of nitrogen: from exhaust - 6.6 million short tons, equals 32.0% of total nitrogen oxides from all sources
3. Carbon monoxide: from exhaust - 59.0 million short tons, equals 59.0% of total carbon monoxide emissions from all sources
4. Hydrocarbons: from exhaust - 15.2 million short tons, equals 47.5% of total hydrocarbon emissions from all sources
5. Lead: from exhaust
6. Benzopyrene
7. Plasticizers: from interior of car
8. Oil: from leakage
9. Aldehydes: from exhaust
10. PCBs (chlorinated hydrocarbons): from tires

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[4] (11) is the source of quantitative estimates.

In addition to what the car emits directly, some of these pollutants react with sunlight and produce photochemical "smog". The products of these reactions include ozone, nitric oxide, PAN, and hydrocarbon free radicals. Photochemical air pollution requires much more study as little is known about it. It is predicted to "become a problem on an increasing scale in our urban areas of the future. This trend will be due not only to changing patterns of fuel usage but to the vastly increased concentration of motor vehicles whose numbers are growing at a greater rate than population" (29, p. 38).

The major source of these pollutants within the auto and the one which most legislation deals with is the exhaust. The concentration and quality of the exhaust emissions is quite dependent upon the mode of operation (idle, acceleration, deceleration, cruising). It has been found that emissions of hydrocarbons and carbon monoxide are relatively large during periods when an engine is idling, while oxides of nitrogen increase significantly with acceleration or deceleration. It is the combination of these two modes of operation (idling and stop and start traffic) that typifies most rush hour and urban centre traffic. Thus, the total emissions of these three gases will tend to be greatest when the largest number of people are affected.

The pollutants from the automobile are capable of causing extensive damage to plants, animals, and materials. The basic problems in measuring air pollution are:[5]

1. Determining the geographical extent of the sampling area.
2. Many categories of damage are difficult to measure precisely and where experimental approaches are utilized, results are often misleading.
3. Chronic as opposed to acute effects of air pollution are often undetected and therefore uncounted. These are the effects which in the long run might overwhelm the immediately measurable ones.
4. It is frequently difficult to isolate air pollution effects on humans from other sources of damage, and the problem is compounded when synergistic effects are present.

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[5] (41) is the source for most of the problems. It is especially difficult to isolate variable other than air pollutants which contribute to damage to living organisms, e.g., cigarette-smoking.

5. The indirect costs (benefits) of control may be undetected, let alone measured.

6. The use of data gathered for other purposes often turns out to be grossly inadequate in isolating and measuring air pollution damage especially when surrogates are relied upon.

These stipulations do not preclude action or public response to potential dangers. A brief account (and estimates of cost when available) will now be given of possible and actual effects of automobile air pollution.

1. Epidemiological Effects

Information on the effects of air pollution on health come from three sources: studies made of severe episodes occuring throughout the world in the past 40 years, epidemiological studies of communities subject to long periods of low level pollution, and experimental studies on humans and animals (12, p. 31).

The studies of severe air pollution episodes (Meuse Valley 1930, Yokohama 1946, Donora 1948, London 1952 and 1962, New York City 1953) showed conclusively that at high levels, air pollution does increase mortality and morbidity above a "normal" level, especially for respiratory diseases. Estimates of excess deaths range from 17 in Donora (with 14,000 ill) to 4000 in London's 1952 episode.

"Although the deleterious effect of acute air pollution disasters is well established, it is not possible to extrapolate from these data to the low levels of air pollution which persons are exposed to in a modern urban society" (17, p. 16). Thus the studies of chronic effects are not conclusive. They do indicate an increase in nonspecific infectious upper respiratory diseases, chronic bronchitis, chronic constrictive ventilatory disease, emphysema, and lung cancer. The specific pollutants contributing to these diseases are emitted by automobiles. Particulates affect the respiratory system and may also introduce carcinogens into the body. The effects of sulphur dioxide (the pollutant attributed to have been the major cause of deaths in the severe episodes) range from eye irritation to acute respiratory inflammation. Carbon monoxide (also increased by cigarette-smoking) can, at levels in excess of 30 parts per million for extended periods of time, interfere with the oxygen transport of the blood causing dizziness and impaired judgment and skill. At higher levels it can cause

unconsciousness and death. Oxides of nitrogen and ozone affect the the respiratory system and other bodily functions. Peroxyacetyl nitrates have been related to eye irritation. Polycyclical hydrocarbons, nickel, cadmium, asbestos, and benzopyrene have carcinogenic qualities, linking them with lung cancer.

Lead is an extremely toxic contaminant of the air especially to children. Its effects include damage to the liver, kidney, brain, and central nervous and reproductive systems (23, p. 6). The largest source of airborne lead is in the form of tetraethyl lead, an additive to gasoline. Plasticizers and other plastic compounds are released from the interiors of cars (seats, etc.). While these compounds were initially thought to be inert, they are now suspected of causing a sometimes fatal congestive lung disease.

Ridker has estimated for the United States the costs of these diseases in terms of those costs due to premature death, associated with morbidity, incurred for treatment, and incurred for prevention or avoidance of disease (12, p. 26). Total costs due to these diseases associated with air pollution amounted to approximately $1,989.9 million in 1958 (12, p. 54). About half of this amount was obtained from estimates on treatment and costs of absenteeism. The remainder ($1,025 million) would represent a direct loss, a destruction of human capital that could have produced $51 million in output each year (1,025 million times a 0.05 discount rate used in estimates) (12, p. 53). Comparing this estimate with the net national product in 1958 ($405.9 billion) yields a relatively insignificant percentage loss (0.5%). It must be remembered that the cumulative loss in output would increase as would the total costs of air pollution related disease due to increasing urbanization, industrialization, and car ownership at rates far in excess of air pollution control measures (which should also be calculated in the costs).

2. Effects on Plants

> The significant and sometimes devastating effects of air pollutants on vegetation have long been recognized. In fact, much of our concern with air pollution has revolved around these effects in vegetation. While urban smoke was sufficiently unpleasant to be classified as a nuisance in early ordinances, the failure of crops

and the adverse effects of air pollution (13, p. 401).

There has been much documentation of injury and destruction of vegetation due to air pollution. Effects include acute injury involving destruction of leaf tissue, chronic injury or chlorosis (change in the leaf's green colour due to loss of chlorophyll), alterations in normal growth, inhibition or reduction in photosynthesis, and changes in normal plant metabolism (29, p. 2). All these effects can decrease crop yield and/or marketability.

Unfortunately, very few measurements of the cost of damage and loss of crops due to air pollution have been made. An estimate made in 1961 for California field and vegetable crops was $8 million per year, and on the eastern United States seaboard it was $18 million per year (13, p. 401). A more recent evaluation of California's losses including injury affecting the yield or marketability and indirect effects such as growth reduction and impairment was $132 million per year (13, p. 402). It should be noted that even these estimates are incapable of measuring many of the indirect costs of air pollution on vegetation. One source noted that "if we could do this, the total annual cost would undoubtedly be close to a billion dollars" (13, p. 403).

3. Effects on Property and Materials

The weathering of materials is a natural process that is often accelerated by air pollution. The effects include soiling of clothing, buildings, and machinery, erosion of surfaces (concrete, stone) by particulates, and corrosion, a chemical change that tarnishes and weakens the material (e.g., rust on metals). The air pollutants important in corrosion are sulphur dioxide, particulates, and ozone. Ozone reacts quite readily with almost any substance it comes into contact with, particularly rubber which it cracks and pits. Atmospheric conditions also play an important role in material damage, e.g., corrosion is accelerated in wet climates as compared to dry. Ridker found some evidence that property values also tended to be affected in areas of heavy air pollution and sometimes influenced decisions to move from an area (12, p. 115).

The cost estimates on the air pollution damage to materials vary considerably. A widely quoted figure for the United States is $11 billion

per year or $55 per capita.[6] A British report estimated a 50% increase in the laundry costs in polluted versus non-polluted areas. Cleaning and painting of buildings was estimated at 50 million pounds, corrosion of metals at 25 million pounds, and textile damage at 52.5 million pounds (35, pp. 9-10). Other studies have been done in Pittsburg, Pennsylvania, and other parts of the United States, but none to date for Canada.

Automobile air pollution also contributes to reduced visibility in urban areas. This has meant additional costs for the airline industry in rerouting flights which could not land at smogged in airports, for the public in greater numbers of highway accidents, and the cities in general through such things as a reduction in tourist trade and out-migration of individuals and firms. The concentration of particulate matter suspended in the atmosphere, known as turbidity, can result in a cooling of the air near the ground by several degrees Farenheit (15, p. 103). The effects of this cooling are not completely known. Another problem is that combustion releases carbon dioxide. There is concern over the impact of a significant increase in carbon dioxide over the earth. Some scientists say it will warm the earth, melt the polar ice caps and thus flood major seacoast cities. Automobile fuel consumption is a major source of this rise in carbon dioxide. The long run effects of fuel combustion (even with clean fuels such as methane) may be quite significant. This implies that public policy should consider regulating the number of cars and amount of combustion, as no form of control on air pollutants will prevent an increase in the amount of carbon dioxide in the atmosphere.

In summary, the past three discussions on effects should clearly indicate that air pollution is a costly problem. In terms of a cost benefit approach, this section has presented some of the costs of not reducing or eliminating automobile air pollution. Section II will evaluate the costs of abatement. The benefits of abatement are a cleaner and potentially healthier environment. These are often quite ambiguous and difficult to quantify. But as Allen Kneese has explained, "making important decisions based on economic data does not <u>necessarily</u> require

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[6] (35, p. 9). This figure was extrapolated from 1911 figures on smoke damage and is quite questionable. All figures on damage do not appear to subtract employment benefits of cleaning jobs from the costs.

that we know total costs and gains at all" (41, p. 227). Recognition and definition of the problem is just the first step.

C. Additional Problems of Air Pollution

> Although we are able to compute the volume and weight of air necessary to carry on a variety of activities, we are still unable to gauge the absolute limits to the (pure) air supply likely to be available ... to man and his purposes over any one interval of time. The apparent ubiquity of air, its power to support life and property, its ability to renew itself through natural processes beyond the control of man, the tolerance of human beings and their ability to adapt to a wide but finite range of adverse environmental conditions as well as their pursuit of presumably more important ends, all these factors have tended to work against the development of a public attitude which regards air pollution as a serious problem, until adverse effects become tangible or some "crisis" situation has developed and has been experienced (4, p. 126).

The above quote points out some essential problems involved in air pollution, specifically that from automobiles. First, as has been discussed, there is the lack of information on the effects of auto emissions and at what point they become a threat to life and property. Secondly, there is the tendency on the part of the public to ignore the potential (and actual) effects of their vehicles' emissions. This lack of concern can in part be explained by ignorance of the situation, but a more plausible cause is due to the public good/external diseconomy nature of automobile air pollution. There is no incentive on the part of any individual to clean up his car's emissions let alone stop driving one. He will not take into account the social costs of his car. Similarly, it is in his interest (minimizes his costs) to understate his preferences for any abatement program that is proposed by a governmental authority, in hopes of having other individuals contribute more to the cause.

There is also the legal position of liability for air pollution damage which is of importance. The burden of proof of damage currently rests with individuals and government agencies. The source of the pollution-generating cars, the auto industry, has not had to prove to the consuming public that the vehicle will be safe. The costs incurred by the

individual or government agency to prove damage from air pollution are great, and a significant deterrent to abatement.

Individuals have an option when faced with potential control of cars (which will entail higher operating costs) -- to leave the community in which the regulations are passed. This is another effect of the public good nature of air pollution abatement. As individuals cannot buy the amount of abatement they desire, their recourse is either to vote for a new law-making body (one vote is not very significant) or leave the community in hopes of locating in a place with air pollution laws more suited to their preferences.

The possibility of out-migration, the recognition that air pollution has no jurisdictional boundaries, the fact that the auto industry sells to a nationwide (and international) market, the costs of research on air pollution problems, and consideration of equity and efficiency aspects, all necessitate a control or abatement program at least on a national level. The amount of abatement and the most efficient means of achieving it are the topics of the next section.

II. PUBLIC OPTIONS FOR CORRECTION OF AUTOMOBILE AIR POLLUTION

This section will evaluate alternative approaches for achieving the optimal level of air pollution control. Because air pollutants are dispersed unevenly throughout the country, it is probably more appropriate to define an optimal level of pollution as optimal rate of emission for a given area. Air pollutants from automobiles are diverse and differ in effects on health and property and in rates of diffusion. Ideally, this should be taken into account in adopting a particular control policy. However, because the automobile market is nationwide and individuals quite mobile, it is also important to consider uniform regulations throughout a country.

There are many different methods utilizing market and non-market incentives for obtaining optimal emission rates. These include: (1) bargaining between polluters and afflicted parties; (2) subsidizing the use of factors or products which lead to a decrease in air pollution; (3) the imposition of taxes (effluent fees) upon a firm's use of the

factors, production process, or final output causing air pollution; (4) payment to a firm for not using factors or products contributing to air pollution; (5) emission standards limiting the amount of air pollution a firm can produce; and (6) requiring the firm to use certain inputs (input standards) (42, pp. 67-68). Most of these controls will be evaluated with regard to efficiency criteria and ability to provide feasible policies for automobile air pollution abatement.[7] To determine the most viable policy to reduce automobile air pollution, it is necessary to evaluate the impact the alternative controls have on the quantity and quality of emissions and the total costs and benefits of control to society.

A. Taxes, Subsidies, and Bargaining

> The continuing debate among economists over air pollution control has centered on whether polluters of the air, be they businessmen engaged in activities which spew wastes into the air or consumers doing the same in driving automobiles or burning leaves, can be induced to take voluntary measures to eliminate or lessen their pollution in response to market incentives (or coercion), and how predictable the results would be; for under incentive systems there is the option not to be persuaded by the rewards (41, p. 233).

1. Taxes and Subsidies

Taxation and/or subsidy has been the traditional response to externality situations, with a tremendous amount of literature devoted to the use of taxes and subsidies to improve the misallocation of resources caused by externalities. The traditional tax/subsidy model assumes that the externality appears in a perfectly competitive situation. A tax (subsidy) equal to the marginal damage (benefit) caused by the external diseconomy (economy) is imposed upon the firm. The tax (subsidy) internalizes the external cost (benefit) and therefore equates social and private marginal cost. It would also be an incentive to decrease the level of externality in order to decrease the tax. At equilibrium, the marginal expenditure on pollution control would equal the marginal reduction in the tax (28, p. 97). This

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[7] It should be noted that the primary concern is with efficiency. Distributional considerations are generally held constant. It is also assumed that the marginal costs of control are less than the marginal damage costs.

will result in an optimal allocation of resources, that is, an optimal expenditure on abatement.[8]

The traditional model is useful as a reference point for internalizing the externality in a purely competitive situation. For a particular externality problem, the competitive assumption may be violated, necessitating a modification of the model. The automobile industry is oligopolistic which means that the effect of a tax on the output of cars will be different from the competitive case.

A comparison of the effect on welfare of a damage tax on the perfectly competitive firm and monopolist is made by Buchanan.[9] He shows that the monopolist can be viewed as imposing two external diseconomies. His pollution increases costs to other firms or individuals and the tax leads to a decrease in output, increasing costs to buyers. If the second loss is more highly valued than the first, a per unit tax on output will decrease total welfare. This result will hold as long as the corrective tax (assumed to be estimated properly) is less than the difference between the price and marginal revenue at the initial monopoly output.[10]

The model can be applied to automobile air pollution if an estimate of the air pollution damage per car is known. This kind of figure is not currently available, but could conceivably be calculated. Given the value

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[8]This assumes that the rest of the economy is in Pareto-optimal equilibrium; factors are paid the value of their marginal product; price equals marginal cost, etc. If the assumptions are violated, correcting the externality might not lead to the optimal output of the activity in question. The theory then stipulates consideration of second best solutions, which are probably what all the proposals for auto air pollution abatement would be.

[9](24). It is felt that the monopoly model is closer to explaining what would occur with a damage tax applied to the automobile industry than is perfect competition.

[10](24, p. 176). The elasticity of demand for the monopolist's output might also be an important variable contributing to welfare gain or loss. Also a decrease in output would lead to a decrease in the tax, changing the results somewhat. Buchanan neglects to consider changes in input mix or output to reduce the externality and decrease the estimation of damage and the tax rate. A higher tax rate could also be implied to deal with the criteria for welfare gain.

for marginal damage cost, the relevant industry cost curves, and market demand function, the effect of this tax on welfare could be calculated. To my knowledge this has not been done, but it would appear from the attitude of the car-buying public (its fascination and dependence on the auto) that a welfare loss from higher costs for automobiles due to a marginal damage tax would outweigh the gains from alleviation of the air pollution external diseconomy. This is not a static situation as public attitudes towards the environment and costs of keeping it relatively free of pollutants are constantly changing. To thoroughly evaluate the impact on welfare of a damage tax on automobile output, some sort of estimation of utility derived from abatement is required. This might lead to the public good problem of falsely revealed preferences and ultimate recourse to political maneuvering (bargains, political parties, lobbyist groups, etc.). Without the information of consumers' preferences, the tax models will be at best rough estimates of potential impact on welfare.

Additional problems with the damage tax are that information and administration (monitoring, inspection) costs would be quite high. The important elements precluding implementation of a damage tax on automobile air pollutants is however the industry structure and inability to determine marginal (or even total) damage functions.

A second type of tax is one on the input responsible for generating the externality (if this is known). Plott has shown that for the short run, it is important to place the tax on the factor contributing to the externality (36). A tax on output may lead to an increase in the production of the externality-generating activity rather than a reduction. With automobiles, an input tax could be applied to the fuel and fuel additives used in the ICE.

The gasoline combusted by the ICE is currently comprised of many anti-knock additives including lead, nickel, manganese, and boron whose deleterious health effects were noted in the first section. Lead can be (and is in some brands) removed from gasoline, but there is doubt about the safety of its replacement. The technology necessary to refine high octane gasoline without anti-knock additives has been available for twelve years, but has not been implemented because of the estimated conversion costs of over two billion dollars. However, tetraethyl lead now costs the

petroleum industry approximately $450 to $470 million annually and the $2 billion investment in removing lead would be recovered in five years (and they can always raise gasoline prices).[11] This change would also eliminate the other additives again at a potential saving to the industry.

Other types of fuel for the ICE have been investigated and some of them have shown under test conditions to reduce pollutants considerably. One of these fuels is methanol (alcohol) distilled from grain at a cost of about $.60 per gallon. Methanol entails few engine modifications, but has some problems in heating as it needs a high temperature to combust. Another possible fuel is methane (natural gas) which can be obtained from anaerobic decomposition of animal manure. Like methanol, methane gas produces little air pollution. Potentially 1.5 billion tons could be produced annually (1½ times the current natural gas consumption in the U.S.) worth $6 to $9 billion at current prices (20, p. 6).

The input tax would allow the auto manufacturers to determine the most efficient means of altering the production process to cope with the tax. Ideally, the tax should be high enough to make continued use of petroleum fuels and fuel additives more expensive than alternative non-polluting fuels. Subsidies to firms who develop methanol and methane and the auto manufacturers who convert their engines to use this form of fuel might lead to a more rapid substitution of less polluting fuels for the gasoline now used. The administrative costs of this tax should not be too large as gasoline taxes are already in existence in the United States and Canada. These would merely be increased on fuels which contain anti-knock additives and on the gasoline itself. The political implications, i.e., the importance of the petroleum industry in determining public policy might eliminate the fuel tax as a viable control mechanism. This kind of tax may also result in increased prices to consumers if the petroleum industry continues to add lead additives to its gasoline and the auto industry finds it cheaper to leave the design of the ICE unchanged. Whether this will result or not depends on the tax rate and the ability of the industries to pass the tax on to the consumer. Conceivably there is some limit to the price

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[11] (23, p. 6). The petroleum industry is also a rather powerful group that does not like to see any innovations that would increase their costs without increasing sales, even though the change could improve public welfare.

individuals are willing to pay to continue to operate their vehicles.

Effluent taxes on automobile emissions, a third policy consideration, would encourage research and innovation in pollution control equipment. It is to the manufacturers advantage to investigate means of reducing the effluent emissions as this will decrease the tax on the vehicle. Effluent taxes are advocated in other areas where environmental externalities exist because of their flexibility and their imposition of the burden of investigation and decision-making (how much pollution to emit) on firms' management rather than government. This administrative cost of this form of control would be quite high and it is doubtful that effective monitoring devices could be developed to accurately measure automobile air pollution emissions. However a tax of this kind would from a theoretical standpoint be an efficient means of dealing with automobile air pollution, provided the tax actually covered the social costs of the pollution.

Subsidies have also been advocated as a means of dealing with abatement of pollution and have been utilized in the U.S. in some states to encourage development of pollution control devices for automobiles. Typical congressional bills offer a 20% tax credit for capital investment (7% is the normal rate) in pollution control equipment along with a depreciation writeoff of from one to five years (instead of the standard useful life basis of 20 years or more) (25, p. 361). Estimates of cost saving to industry show that $300,000 to $400,000 are received in the form of tax credits for every million dollars spent on the purchase and installation of air pollution control equipment (25, p. 361).

Subsidies of this sort are fraught with problems. One of the foremost is administrative costs. It is difficult to determine how much of the plant's investment should be charged to pollution control and how much to processes designed to increase productivity and only incidentially reduce emissions. Similarly, it requires information about formulation of investment decisions within firms. As one businessman expressed,

> True, if you would base pollution control on a system of incentives, you might be disappointed. The marginal dollar gained for pollution control is hardly as exciting as the marginal dollar gained in expanding sales, creating new products or improving technology. This type of income promises growth and future profits.

> I think that many, if not most businesses have a shortage of key personnel and would rather use this resource to develop the mainspring of their profits than to maximize their pollution subsidies (41, p. 238).

There is also a tendency for firms to install high cost control devices rather than utilize available approaches that have lower costs, e.g., fuel substitution, operation and maintanence expenditures. Other problems include tax loopholes and discrimination against smaller, less capital intensive firms.

2. Bargaining

An alternative to the tax/subsidy approach is to internalize the auto air pollution external diseconomy through bargaining. The Coase paper showed that given perfect competition, profit and utility maximizers, and costless bargaining between parties, a Pareto optimal allocation of resources (excluding equity considerations) will be obtained regardless of delimitation of responsibility for the externality (5). That is,

> If the party imposing external diseconomies and the party suffering them are able and willing to negotiate to their mutual advantage, state intervention is unnecessary to secure optimum resource allocation ... the imposition of a tax upon the party imposing external diseconomies can be a very complicated matter, even in principle, so that the a priori prescription of such a tax is unwise (40, p. 309).

This is a very restrictive case (as Coase admits) as bargaining costs tend to be quite high especially when a large number of people are affected by the externality (e.g., auto air pollution). This is where the legal situation becomes quite important.

Laws can facilitate bargaining and reduce the costs incurred in the bargaining process. The determination of responsibility for the external diseconomy will also affect outcomes both in terms of resource allocation and distribution of income. As was noted in the first part of the paper, the laws relating to auto air pollution presently place the burden of proof of damage on the public. Under this kind of legal situation where pollution is allowed and afflicted parties must bargain with the auto manufacturers to reduce the emission of pollutants, the transaction costs the public incurs will tend to be larger and abatement of pollution smaller,

than with a law that completely prohibited air pollution from cars and the manufacturers had to bargain to allow some emissions.[12] Under the former legal arrangement the "possibility of some limited benefit for the person (s) taking the initiative on behalf of a large and widely dispersed group has to be set against the certain loss of time and effort, and also against a large risk of incurring substantial and irrecoverable expenses ..." (33, p. 23). If the law prohibited automobile air pollution, the bargaining initiative would come from the industry which means that no individual incurs personal risk. A second consideration is that the present law provides little or no incentive for firms to reallocate resources to pollution-reducing research and investment in pollution-free equipment, nor to reallocate inputs from those resources promoting sales and profitable output. This means that firms will "misallocate resources because they tend to ignore all opportunities for social gains made by directing research funds into preventive technology" (33, p. 23). In contrast, the law placing entire responsibility for damage on the firm forces it to incorporate the damage costs into its production function and make pollution research an incentive.

Interesting bargaining processes have occurred with automobile air pollution abatement. The parties in one example were the auto manufacturers versus the Los Angeles Air Pollution Control District officials. The Los Angeles County Supervisor spent roughly eleven years (1953-1964) negotiating with the four major U.S. auto manufacturers and the Automobile Manufacturers Association (the manufacturers' trade association) to begin research into air pollution from automobiles and to develop emission control devices (9, pp. 142-152). Until 1958, the manufacturers claimed that the automobile was not responsible for urban air pollution. The exercise was rather futile for Los Angeles county as the industry and its representatives continually claimed inability to do research and denied that cars were the major source of air pollution. The burden then fell to the Los Angeles Air Pollution Control Board and several million dollars in public funds were spent researching automotive air pollution (9, p. 145).

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[12] See (33, pp. 23-24) for a fuller elaboration of this argument. Manufacturers would bargain or the ICE would have to be abandoned. The current technology is unable to produce a non-polluting automobile using the ICE.

After it had been shown that automobiles were directly responsible for over one half of the total air pollution in the Los Angeles area, the industry continued its evasive response, spending minimal amounts on research and control technology and delaying implementation of abatement devices. Agreement was finally reached on emission control devices and laws passed to enforce their installation, but the process was extremely lengthy, costly to the public, and the control measures inadequate to curtail sufficient amounts of pollutants.

The efficacy of bargaining as a means of reducing automobile air pollution is certainly questionable after considering the history of air pollution regulations. Unless the burden of proof of damage due to air pollution is shifted to the auto industry, bargaining cannot be recommended as a viable air pollution abatement policy.

B. Regulations

Historically, regulations have been the predominant form of auto air pollution control. Most regulations are administered at the municipality level and only recently (in the U.S.) has an attempt been made to enforce uniform regulations on a nationwide scale. Canada delegates the main responsibility for air pollution control to the provincial governments who in turn pass it on to municipalities. Ontario, Alberta, Manitoba, and Saskatchewan are the only provinces with specific air pollution legislation (37, p. 34). Only seven of the forty Canadian cities with a population greater than 30,000 have full-time personnel employed in an air pollution department (approximately one-third of these forty cities do have some sort of air pollution department, operating basically on a complaint basis). Toronto and Hamilton are the only cities with technical staff, laboratories, and sampling devices. Data on air pollution emissions from any source is as scarce as the control agencies. "At present there is not sufficient Canadian data available to clearly determine the extent to which air pollution is increasing in relation to Canada's population growth and industrial expansion" (37, p. 6). This does not indicate that Canadian cities do not have an air pollution problem. Major Canadian cities such as Toronto, Montreal, and Vancouver are often blanketed with photochemical air pollution.

Rather than dwell on specific standards and regulations, this section will examine the efficiency and cost of regulations as a control method for reaching an optimal emission output. Auto air pollution standards have been imposed on the industry. They have been preferred to market controls for a number of economic and political reasons. One of the justifications is that the costs involved in the continuous estimating, collecting and supervising of corrective taxes is prohibitive (28, p. 97). It should be pointed out that standard-setting also requires estimates, information collection, and supervision of the production of cars to determine if manufacturers are meeting the requirements. There can be little said a priori about the relative costs of market versus non-market controls.[13]

Two papers dealing with pollution standards will be briefly discussed. The first, by Raymond Jackson (28), is a theoretical model to evaluate the maximum increase in production costs an industry could incur to meet a zero pollution standard with a net welfare gain to society. Jackson's paper utilizes Buchanan's approach cited earlier in this paper. He shows the maximum cost of pollution control allowable under perfect competition and oligopoly to achieve a net welfare gain with a prohibitive standard. His model could be modified to include standards allowing emission rates greater than zero and to consider other variation in market power of an industry. Jackson concludes that market power tends to lower the control costs an industry can incur. Inelastic demand for the industry's product will diminish the difference in pollution abatement costs between the perfectly competitive and non-competitive industries. Therefore, the elasticity of demand will be an important element in determining the pollution costs an industry can incur without decreasing social welfare. Jackson also notes that in competitive markets or where market power is low, the cost per unit of output required to eliminate the pollutant can be greater than the marginal damage imposed by the pollutant on others and still result in no welfare loss (28, p. 100).

Jackson's model could be applied to the auto industry. The degree of market power and elasticity of demand for cars could be calculated.

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[13] No study, to my knowledge, has ever been done comparing costs of automobile emission control devices.

Problems again emerge in determining the amount of damage done by auto air pollution. However, these relationships could theoretically be estimated and provide a useful tool for decision-making. Given the costs of control, the maximum standard that would still yield a net welfare gain could be determined. If this standard turned out to be low (which would probably be the case with the oligopolistic auto industry and the high costs of control), a subsidy could be implemented which would allow a higher standard and decrease the marginal cost of control.

A different approach to the determination of optimal air standards has been tried by Kohn (4) with the use of several linear programming models. The first, a cost effectiveness model, determines the total cost of air pollution control for the St. Louis airshed, given a set of air quality standards and abatement methods. The results derived from the model showed that the total minimized control cost is $35,350,000 per year for all air pollutants (4, p. 107). The minimized cost of exhaust, crankcase and nitrogen oxide control systems for motor vehicles would be $16,540,000 or 46.8% of the total control costs (4, p. 109). These figures are derived by comparing estimated emission levels in five categories in 1975 without control to "efficient" levels of control. For example, particulates and sulphur dioxide emissions would be unabated (26 and 14 million pounds per year respectively), hydrocarbon emissions would be reduced 45.2% from 717 million pounds to 494 million pounds, nitrogen oxides, 149 to 93 million pounds (60.2%), and carbon monoxide, 3,326 to 2,247 million pounds (48.0%).[14]

The annual cost of abatement Kohn estimates would require a capital investment of $190,000,000 (4, p. 107). This presents a problem common to most pollution control devices and changing technology.

> As emissions increase over time, it is likely that higher levels of abatement efficiency will become necessary. The least cost method for 1975 may involve the purchase of equipment which will be obsolete by 1980. If it is too costly to obsolete or upgrade this equipment, the cost of air pollution control in 1980 will be higher than it might have been had previous capital expenditures not been made (4, p. 107).

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[14] (4, pp. 108-109). Unfortunately, Kohn's results (given in weights), cannot be compared to California's standards for 1975 cars (given in volumes).

This factor would be a significant deterrent to investment in pollution control. This is based however on the assumption that equipment cannot be modified and is also a justification for the status quo, i.e., doing nothing about air pollution abatement. It could also be interpreted as an argument for the elimination of the ICE and substitution of transportation modes with less pollution.

Kohn's next model determines the optimal air quality standards given a budget for abatement. It simultaneously solves for air quality standards and an efficient set of abatement activities with minimum pollution damage. The analysis was run controlling first one variable, then five. "Assuming a constant marginal damage cost of $150,000 per microgram per cubic meter per year for suspended particles, the optimal air quality standard should be 78 micrograms per cubic meter according to the five-pollutant model, but only 89 micrograms per cubic meter according to the one-pollutant model" (4, p. 114). As the identification of known automobile air pollutants exceeds five, this would imply even higher standards (lower emission levels) with more sophisticated models. It should also be noted that standards are a function not only of pollution damage but also of abatement technology and the strategy for control, i.e., number of pollutant targets.

Standards are invariably difficult to impose. There is also the problem that legislative action takes time and the danger that regulations will be out of date (ineffectual) by the time they are implemented. It has been projected that the U.S. regulations for 1975 cars will only lead to a decrease in hydrocarbons, carbon monoxide, and nitrogen oxides up to 1990, if the number of cars on the road is still increasing (23, p. 10). Regulations cannot alleviate the whole problem if other variables affect the total and marginal emission rates.

This suggests a policy designed to restrict the number of cars and thus decrease the use of air as a waste dipository. Perhaps effluent or damage taxes designed to decrease output would then be preferable to regulations based on current air pollution levels. If standards are employed, questions arise such as should these standards be uniform within a country or only over a given airshed, how should they be enforced, how many pollutants should be controlled, and so on. Some of the answers to these are implicit in the analysis, for example, controls should be

nationwide and regulate as many pollutants as possible. Enforcement is a difficult issue. Legal injunctions and/or criminal penalties require court time which can be long and costly to the public, especially if emissions continue unabated until decisions are reached. Bureaucratic costs would also tend to be quite high in initially determining optimal standards and then getting legislative approval. Of course, these comments could apply equally well to market controls.

III. WHAT CAN BE DONE ABOUT AUTOMOBILE AIR POLLUTION?

Given the information on market and non-market controls for obtaining an optimal level of external diseconomy, the question is now what can be said about controlling automobile air pollution. This section will attempt to summarize some of the specific problems with air pollution from cars and provide some considerations for control.

A. Market Structure

Some important conclusions from the previous section were that industry structure plays a vital role in determining the effect on social welfare of taxes and regulations designed to obtain the optimum level of pollution. It was noted that once the assumption of perfect competition was dropped, a welfare loss was obtained if consumer evaluation of the damage from air pollution was less than the evaluated loss in consumer surplus due to higher prices and decreased output of automobiles. A non-competitive industry would also decrease either the strength of a standard or the allowable costs of pollution abatement. There are still other problems emanating from a non-competitive industry which will hamper imposition of any pollution abatement policies.

The automobile industry is a powerful economic and political force within the United States and possibly in other countries as well. General Motors is the largest industrial firm in the U.S. The industry is a "tight oligopoly, displaying many of the text book symptoms and problems of oligopoly," with the four major producers (General Motors, Ford, Chrysler, and American Motors) producing over 99% of the U.S. domestic passenger cars (14, pp. 1,5). The industry's pricing pattern while not rigid, does

tend to one of price leadership by General Motors (14, p. 111). Price differentials do exist because of the number of competing models.

The industry also tends to follow a leader with respect to pollution control. This is evidenced by their unwillingness to cooperate with public officials to install control devices and by their formation in 1953 of a joint committee (through the Automobile Manufacturers Association) to study air pollution and subsequent signing of a cross-licensing agreement to provide for the use of any patents in pollution control without royalty (14, p. 231). This tacit agreement minimized risks for the industry and, as the U.S. Justice Department said when filing suit against the four manufacturers for violation of the restraint-of-trade section of the Sherman Act, it also delayed the development and installation of anti-pollution devices.[15]

It is not in the interest of the automobile industry to speed the installation of control devices. These merely add costs that would not be compensated by an increase in sales as would style changes or luxury additions.[16]

> The industry left it to others to discover the harmful side effects of the product it manufactures, refused to recognize the need for prompt and effective remedy, and moved in the direction of emission control only under the compulsion of law and imminant competition.[17]

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[15] (9, p. 160). The case was finally settled by a consent decree which, to the dismay of state and municipal air pollution control agencies and some of the public, fined no one, ordered no change in industry structure, did not speed up control device installation; in short, merely got the industry to admit that they were wrong and that they would not do it again.

[16] In an interesting article (26), Gramm developed a theory that oligopoly would have an incentive to install pollution control devices because this was a means of sales promotion. The theory was based on the questionable assumption that consumers were informed about the effects of the pollutants and desirous of controls even though they would mean higher prices. The four auto manufacturers <u>do</u> tell the public they are concerned with the effects of their product on the environment, but unfortunately the words are unaccompanied by action in the form of research and development on control devices, and negated by their continued unwillingness to make changes and meet imposed standards.

[17] (9, p. 150). The competition was from independent engineering firms who developed effective control devices years before the industry claimed it could be ready.

The market structure is definitely an important aspect of automobile air pollution. Substantial innovation would be disruptive to the industry. The change would hardly benefit them. Barriers to entry into the industry due to high capital requirements and vertical integration also imply little competition for the development of control devices and new abatement technology.

The auto manufacturers have also spent some of their advertising expenditures on informing consumers that they will have to pay substantial amounts for the control devices. The approximate cost for blowby, exhaust and evaporation devices which would decrease hydrocarbon emissions to one-fifth of uncontrolled levels and carbon monoxide to less than a third of original levels would be $50-$60 per car.[18] The public is rarely given actual cost information and is led to believe that their "pleasure" from driving cars will somehow be reduced with control devices. This leads to some consumer resistence (or at least lack of interest) in auto air pollution control. Thus, the auto industry is a serious deterrent to the implementation of any air pollution abatement policy.

B. Recommendations

Based on the information in section II and the recognition of the strength of the auto oligopoly, this final section will consider some proposals for automobile air pollution abatement.

Assuming that the ICE will not be replaced in the near future, controls should be placed on fuel components used by the ICE. Prohibition or input taxes on lead and other additives would force the industry to make the switch to the technology available. A change in gasoline components does not however reduce the emissions of all other pollutants emitted from the automobile. The ICE, even at its best, will continue to yield pollutants especially if the number of cars increases. It is therefore quite important to consider both limiting the number of cars and alternatives to the ICE. A number of studies on alternative forms of

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[18] (14, p. 233). These control devices cost less than a radio. It should be noted that the devices are not entirely satisfactory as they lead to an increase in emissions of nitrogen oxides due to an increase in the engine temperature.

energy production are being investigated, including steam engines (external combustion), flywheels, and electric battery-powered vehicles. There is also the mass transit alternative and gradual elimination of private vehicles in highly congested urban areas. Unfortunately, none of these proposals have advanced to a stage of practical utilization. One reason is that research funds from the government (and the auto industry) have not been devoted to these alternatives. The vested interests in the ICE preclude support for research into these other engines.

As has been noted, the problems from automobile air pollution increase with the volume of traffic in congested areas, i.e., where pollutants are being emitted at a rate faster than the wind can disperse them. Therefore, taxes or fees should be charged for entry into the congested districts of major urban areas. This could be accomplished by high parking fees. These fees to date have not been much of a deterrent and also neglect to curtail transient traffic. Perhaps a superior method would be the installation of electronic devices to photograph the licenses of cars entering a congested area. Bills could then be sent to the driver at a fixed flat rate per entry that would be greater than the prevailing public transport fare (which would enter tax free). This would discourage use of the private auto and the fees collected could be used to support development of efficient, inexpensive mass transportation systems. The drawback to this proposal is the potentially high administrative costs.

A change in the legal situation, placing the burden of proof of damage on the manufacturer and in effect prohibiting automobile production, would probably be the most economically efficient yet politically inexpedient control device. California almost succeeded in prohibiting the operation of ICE powered vehicles. Of course there would be too little pollution and immediate welfare losses would be enormous, but action on automobile emissions would be extremely rapid. Regulations and taxes on the ICE will not result (unless they are so high as to discourage continued production) in an elimination or even tolerable reduction of automobile air pollution. The costs to consumers and industry of trying to maintain an inefficient form of vehicle will increase as the population rises. Health effects and damage to vegetation and property will increase both as a result of rising population levels and as measurement and evaluation of

these effects becomes more accurate. Temporary losses in welfare could be justified if the long run gains offset them. Unfortunately, no one can predict just what will happen if current trends are continued. People should be informed about potential costs and benefits of abatement. But if the prevailing power structure continues to dominate policy decisions, the ICE will not be abandoned and our air quality will continue to deteriorate. Alternative forms of transport should receive attention and support. This might lead to the development of less polluting vehicles and also offer some competition to the auto industry.

A policy that reduced the market power of the auto industry might lead to an increase in air pollution abatement and should therefore be considered. If marginal damage from automobile air pollution could be evaluated, effluent or damage taxes should be implemented to decrease the production of cars. This would also tend to reinforce the fee structure on entry into heavily polluted areas. As the theories explained, damage taxes lead to a loss in welfare under monopoly unless the tax rate is greater than the difference between the original price and marginal revenue. This then implies high per unit taxes. Public transportation might at that point become a viable alternative to the consumer and the industry would find it advantageous to consider producing vehicles that emit much less pollution.

In the meantime, some other approaches might be implemented before these politically less viable suggestions are accepted. Fuel taxes should be imposed. Regulations on automobile emissions should be strengthened and made uniform throughout the country. Annual inspection of all motor vehicles should become mandatory and fines imposed for failure to comply and maintain air pollution control equipment. The fee system for entry into congested areas should be considered. However, these solutions will not be sufficient in the long run if both population and vehicle traffic continue to increase. The more extensive alternatives should be used.

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ECONOMIC GROWTH AND EXTERNAL DISECONOMIES
A STUDY OF "GOVERNMENT FAILURE"
IN THE
U.S.S.R. AND CANADA

by

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ABSTRACT

Under current government policies, external diseconomies are an inevitable consequence of economic growth in both socialist and capitalist economies. Both systems fail to calculate social costs in their objective functions for economic growth and development. This hypothesis is tested by an analysis of irrigation projects in Canada and the Soviet Union. In the arid regions studied, irrigation is necessary before any large scale expansion of agriculture or industry is possible and is typical of projects generating external diseconomies. Before discussing the specific projects in detail, a general background on irrigation, the regions under study, and the problems of project evaluation is given. Data on the magnitude, costs, and objectives of each project follows. The external diseconomies generated by each project, e.g., the evaporation of inland seas, salination, and decreased agricultural output, are then described and evaluated.

Alternative explanations for the emergence of external diseconomies in both systems are then analyzed. It is found that decision-making conflicts between agencies and political jurisdictions, inefficiency, and ineptness in administration of laws and regulations might contribute to the generation of external diseconomies. But these factors may also represent deliberate attempts of government decision-makers to ignore social costs and encourage economic growth.

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I. INTRODUCTION

The attempts of national governments to stimulate the growth of productive capacity and output through regional development and exploitation of natural resources can give rise to external diseconomies. Plans for rapid economic growth ignore social costs in the decision-making process because they are often incompatible with growth and therefore conflict with government objectives. Given the desire for growth and the observation that external diseconomies emerge in projects designed to stimulate growth, two questions arise. First, are the external diseconomies a necessary consequence of economic growth, or can they be explained by other factors in the economy? Secondly, will the emergence of external diseconomies depend upon the type of economic system under consideration?

This paper will attempt to answer these questions by examining development projects in a capitalist and socialist economy to show how external diseconomies arise. Large scale irrigation projects in Canada, the capitalist example, and the Soviet Union, the socialist case, are chosen for the analysis. Irrigation is used because it represents the explicit desire of the governments of both countries to stimulate growth in relatively undeveloped regions of each country by providing the water necessary to expand agricultural production and by utilising power from irrigation dams for industry. The examples chosen are the South Saskatchewan River Project in Saskatchewan and various irrigation projects in southern Kazakhstan and Central Asia in the U.S.S.R. These projects are typical of a wide variety of schemes to encourage economic growth within these countries and therefore the conclusions drawn by the paper are not unique, but represent a situation common to many economic growth proposals.

II. IRRIGATION PROJECTS: THE CENTRAL ASIAN REPUBLICS AND KAZAKHSTAN IN THE U.S.S.R. AND THE SOUTH SASKATCHEWAN RIVER PROJECT IN CANADA

A. Project Background

This section provides background on irrigation, the regions under study, and problems of evaluation.

1. Irrigation

"The demand for water for agricultural irrigation cannot be considered in isolation from other water uses ... As supplies become scarce relative to demands ... agricultural irrigation must compete with other water uses" (33, p. 159). Irrigation, the application of water to assist the growth of crops, is one of the major uses of water in multiple purpose river development. Multiple purpose development is a means of viewing the exploitation of the water resource in terms of all potential uses. The uses of water besides irrigation include hydroelectric power, flood control, navigation, domestic and industrial water supplies, pollution control, and also fisheries, provision for wildlife, and recreation. Relationships among the uses may be competitive, complementary, or supplementary (14, p. 150). The important task of any agency dealing with the development of the water resource is to ascertain these relationships and apply this to determination of the development desired; a procedure which is quite complex.

Industrial and agricultural users of water for example, must compete with each other for the water in places where it is in scarce supply. This requires development of criteria to determine the allocation of the water. The theoretical solution is to allocate the water to the use which values it the most, i.e., to the sector which can make the greatest productive use of it. This procedure, while economically efficient, does not take into account externalities of water use including downstream pollution effects and depletion of the resource. Under capitalism, the allocation of water is therefore usually done by one or more government agencies which determine development according to cost benefit analysis (CBA) or other methods of project evaluation. Under socialism, the government planning agencies determine water use

according to norms similar to CBA.[1]

In areas where water is scarce, irrigation often accounts for a large percentage of total water use. It is estimated that irrigation is responsible for one half of the total water use in the Canadian prairie provinces (33, p. 149). In 1965, irrigation accounted for 61.4% of total water use in the U.S.S.R. (13, p. 81), and in the Central Asia and Kazakhstan regions the figure is also estimated at over 50%. Related to the significance of irrigation is its consumptive nature: much of the water used for irrigation is not returned to the river or water body from which it is drawn. The amount of irrigation water removed from the water body is a function of the irrigation system itself, i.e., efficiency of operation, amount of land preparation and upkeep, and of the topography and soils of the irrigated land.

Irrigation water can be developed in three basic methods: (1) pumped from underground sources via wells; (2) drawn from the natural flow of streams; and (3) damming and regulating the flow of streams (4, p. 1). The cost of these methods varies. In general, damming and the construction of reservoirs is the most expensive method and the method most frequently used in multiple purpose development. It is also the procedure used for the irrigation projects studied in the U.S.S.R. and Canada. This procedure is subject to diminishing returns as marginal cost increases rapidly with the increase of irrigation flow, especially when the number of dams on any given river increases. Damming allows for the largest amount of irrigation water to be distributed (relative to other methods), but often "what is gained by building large water storages is, however, to a considerable extent lost again in the costs of the distribution network and of land levelling which are necessary to accompany them" (4, p. 68).

Because of the high costs of the reservoir construction and the irrigation network of canals, ditches, gates, etc., this type of

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[1] Irrigation is an extremely long run type of project, taking anywhere from 10 to 100 years to complete. This time uncertainty makes decision-making based on CBA quite difficult under capitalism and socialism. And given a positive discount rate, the net benefits may not turn out, *ex post*, to be very large.

irrigation development often coincides with hydropower generation from the dams. "The close relationship between new irrigation and hydroelectric power development has been referred to by some writers as a "partnership". This expression emphasizes the fact that most future irrigation projects are economically feasible only if earnings from power sales are available to pay part of the construction costs" (14, p. 151). Power users are subsidizing irrigation development to the extent that the hydropower revenues are used to repay the construction costs of irrigation (14, p. 174). This accounting practice could then lead to development of irrigation on lands that are inferior to those in areas either not suited to hydropower or where power revenues did not supply a sufficient irrigation subsidy.[2] The combination of hydropower and irrigation uses in one project thus tends to complicate computation of their respective costs, and the economic returns to irrigation.

The demand for irrigation water should be considered in determining the returns to irrigation projects. Theoretical demand for irrigation by the farm unit is a function of the cropping pattern, the costs of supplying and using water at the farm gate, the efficiency of operations, the price of other inputs, and the demand for the irrigation crops (33, p. 152). Cropping pattern is in turn a function of topography, soil type, fertilizer use, tillage practice, and method of irrigation. In the cost of water, both the application and removal costs must be considered. The costs are again determined by topography, soils, method of irrigation, and degree of field and soil preparation. As was indicated, water, like most factors of production, yields negative marginal returns if used past the intensive margin. This must be related to the price of labour and capital faced by the farm operation and to the marginal productivity of the three.

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[2] An example of an inferior set of projects accepted because of hydropower is the Columbia River Basin. Also, most of the irrigation projects in the U.S.S.R. are adopted on the basis of their hydropower potential.

2. Comparability of Projects

The ideal comparison of irrigation projects between capitalist and socialist systems would have the projects from each economy at the same stage of development, with similar natural and human resources, climate, and terrain. The economies of the regions studied should be similar and methods of determining costs of development projects comparable or the differences identifiable. The projects discussed in this paper do not fulfill all these criteria, but there are sufficient similarities to make the comparison valid. Before discussing Canadian and Soviet irrigation projects, the comparability of Central Asia and south Kazakhstan versus the prairie region in Saskatchewan is assessed, and problems of comparison noted.[3]

a. Population[4]

The population density of the Central Asian republics varies from less than three persons per square mile to a few dense regions with more than 260 persons per square mile (8, pp. 129-130). The higher density regions are confined to a rather small percentage of the total land area with over half the area having fewer than three people per square mile. In southern Kazakhstan, the relationship is similar except that there are virtually no regions where population density exceeds 30 persons per square mile (8, pp. 129-130).

The Ssaskatchewan population density is quite similar to that of the U.S.S.R. regions. The density ranges from 2 to 25 persons per square mile, with an overall density of 4 persons per square mile (35, p. 2406). Although these population densities appear to be comparable to the Soviet Union, there is a difference. In irrigated areas of Central Asia and Kazakhstan, large collective farms have been set up which often employ thousands of workers (56). This population and economic collectivization does not occur in Saskatchewan, where under irrigated conditions, single families or farm units with relatively few employees and more capital equipment are the norm. Thus the capital to

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[3] See Appendix, Figures 1 through 3 for areas of study in both countries.

[4] The source of the information unless otherwise noted is (11).

labour ratios in the regions vary.

b. Geography and Natural Resources

The topography of the Soviet regions relevant to the study includes desert and steppe. Highlands above 3000 feet border on mountainous regions to the east. The climate is dry and ranges from desert conditions of long hot summers and mild winters in southern Central Asia to steppe (prairie) conditions with short hot summers and long severe winters in northern Central Asia and southern Kazakhstan (8, pp. 51-53). Precipitation varies from 8 to 15 inches annually.

Saskatchewan has no deserts, but there are stretches of sand dunes around the project area. The climate is dry and is also classified as steppe. Conditions range from mild summer and cold winter in the northern parts of the project area to hot summer, cold winter conditions in the south. Precipitation is 10 to 20 inches annually.

The exploitable minerals in the Soviet regions include petroleum, natural gas, lead, uranium, copper, zinc, and coal. These resources have not been extensively developed, but there is indication that they will be in the future. Saskatchewan has oil deposits, natural gas, and lignite, with some potash and uranium. Development of these deposits has not been extensive and most do not compete with agricultural land. There is however, potential for further development of minerals which would lead to competition for water between industrial and agricultural uses.

The most important natural resource to compare is water. Central Asia's water resources are quite restricted as the precipitation figures indicate. While the region has 17.8% of the total land area in the U.S.S.R., its stream flow is only 2.5% of the U.S.S.R. stream flow (52, p. 14). The figures would be similar for Kazakhstan. The major rivers of the region are the Amu Darya and Syr Darya, both of which originate in the highlands and mountains bordering on China and drain into the Aral Sea. Other important rivers are the Vakhsh, Chu, Ili, and Zeravshan.

Southern Saskatchewan's surface water supply is similar to that of Central Asia and Kazakhstan although the precipitation is somewhat

higher. The major river is the Saskatchewan with its south and north branches. Both branches start in the Canadian Rocky Mountains in Alberta; join east of Prince Albert in Saskatchewan and flow into Lake Winnipeg.

c. Economy of Regions

The major economic activity in both regions is agriculture. The type of agricultural development is largely a function of the amount of water available with the region and the climate and soils. Activity varies from ranching to dry land cultivation of cereal crops to intensive irrigated cultivation of rice (U.S.S.R. only), technical crops (cotton, flax), and speciality crops (beets, vegetables). The agricultural productivity in parts of these regions is marginal, requiring large acreage to sustain small numbers of individuals. This is more so for Saskatchewan than the U.S.S.R. regions as most of the agricultural activity in the latter is on state and collective farms which cultivate extensively, but support more individuals.

Irrigation in Central Asia and Kazakhstan represents 63% of the total utilised irrigable land in the Soviet Union (7, p. 207). Saskatchewan's contribution to total irrigation is roughly 30% of total Canadian irrigation excluding the potential acreage from the South Saskatchewan project. Where land has been irrigated in the Soviet Union, crop yields are said to increase significantly (at least in the short run). The U.S.S.R. has invested heavily in developing huge irrigation schemes. The importance to the national economy (as evaluated by Soviet planners and politicians) of the Central Asian crops, especially cotton, has required these large capital expenditures.[5] The same argument does not appear to apply to Saskatchewan as "the productivity of irrigated land does not at present sufficiently exceed that of non-irrigated land to make many large-scale projects worthwhile" (3, p. 218).

The major irrigation crops in the Soviet Union are cotton, rice,

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[5]The last two statements represent the comments from a variety of Soviet sources. All failed to give specific information on just what was a significant increase and how much was invested.

wheat, sugar beets, fruits and vegetables. Irrigation is also used on pastures. Saskatchewan plans to develop large scale irrigation to shift agriculture from the extensive dry land farming of wheat, other cereals, and forage crops to more intensive practices involving vegetable cultivation. Existing irrigation in Saskatchewan is on a relatively small scale and used for developing pasture for grazing, and to provide some additional water for forage crops. The climate is not suited to technical crops such as cotton.

Industrial development within the regions in both countries is limited, but efforts are being made to increase this activity. The development of water resources is one of the first steps for making industry viable.

3. Problems of Evaluation

Most of the problems of comparing the socialist and capitalist system emerge from the paucity and unreliability of Soviet data, the latter largely due to the lack of prices which reflect scarcity values, market values, opportunity costs, etc. Natural resources have not been valued in the Soviet Union until recently. Land and water are not priced in many areas including Central Asia and Kazakhstan, making any monetary comparisons between the value of irrigated versus nonirrigated land under both systems impossible.

Output yields are a potential means of evaluating land value, but they may not be valid due to the effects of exogenous factors other than water on crops. This is why it is important to have geographic and climatic conditions in the various regions similar. The other factors can then be assumed constant and yields compared. As Soviet planning is still on an output and materials balance basis, this approach would seem preferable to monetary comparisons even when they do exist. Nonetheless, as some cost data is available, it will be mentioned with the stipulation that it is not reliable.

Even output, acreage and other measures within the Soviet Union are often difficult to interpret. An example of the confusion and inconsistency of terminology used by Soviet sources is in reporting the

extent of irrigated area. In Soviet statistics, "land with an irrigation network includes not only land with a suitable irrigation system, but also land on which the irrigation system is in disrepair or possibly not tied in with a reliable source of water. The most precise term used is irrigable land receiving water and includes land utilized in agricultural production and properly irrigated" (7, p. 208). Canadian data also suffers from inconsistencies and with government subsidies, land values may be overstated (or irrigation costs understated).

The importance of recognizing these problems goes beyond comparibility of data. It is often a source of faulty planning, due to decisions based on data that is not representative of actual conditions. It is interesting to note that the amount of land to be irrigated in the South Saskatchewan River Project varies depending on the author's definition of capacity for irrigation. The estimates have fallen by one half from the time of construction of the dam to its completion.

Figures for the U.S.S.R. on the costs of irrigation are insufficient to make any kind of cost and benefit comparison between the Soviet and Canadian projects. It also makes evaluation of the significance of external diseconomies rather difficult. Section D will therefore deal more with qualitative estimates of damages with values reported when available. Noting these difficulties, the specific projects in the U.S.S.R. and Canada will now be discussed.

B. Central Asia and Kazakhstan

There are numerous irrigation/hydropower projects in Central Asia and Kazakhstan. Due to insufficient information on any one scheme, comments will be made on projects on the Amu Darya and Syr Darya rivers, the Nurek power station on the Vakhsh River, and the hydro-irrigation project on the river Ili.[6] The development of the water resources of these rivers has been multiple purpose with the three major objectives being irrigation, hydropower, and regulation of water flow.

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[6] See Appendix, Figure 2, for the irrigated areas.

1. Syr Darya River

One of the two major developments of the Dyr Darya river basin has been in the Uzbek Republic in what is known as the Hungry or Golodnaya Steppe region.[7] A series of hydropower stations and reservoirs have been constructed in the region which traverses parts of Kazakhstan and Tadzhikistan in addition to the major part of the project in Uzbekistan. The project dates back to the 1880s, but development of the area was not an important goal of the Czarist regime. Greater interest was taken by the Soviets. In 1918, Lenin signed a decree allocating 50 million rubles to the Hungry Steppe for irrigation. The hydropower projects were designed to electrify the region for both agricultural purposes and to stimulate industrial development in the region. Development has not been consistent. Lack of coordination between the three republics has caused delays in implementation of irrigation to many areas. Khrushchev wanted the region developed more intensively. Accordingly, more funds were transferred to the area. Disputes between the republics apparently were solved by transfer of 40,000 square kilometers of Kazakh land to Uzbekistan.

In 1965, the cultivated area of the Steppe under irrigation (mainly cotton) was reported to be 12,500,000 acres. This estimate is subject to doubt, as another source asserts that the full development of the Steppe is planned to be only 1,976,000 acres. The main irrigation canal is 136 kilometers long and it is from this that the major land cultivation under irrigation will occur.

The other major irrigation/hydro development of the Syr Darya is in the Fergana Valley to the east of the Golodnaya Steppe. Again, three republics (Kirgizia, Uzbekistan, and Tadzhikistan) have pieces of the irrigated area. Development of this region began after World War II. Cotton is the principle crop, occupying two-thirds of the cultivated land. The area also produces sugar beets, wheat, rice, fruit and vegetables. The Kayrak Dam's reservoir is tapped for irrigation water for the Fergana basin as well as for the Golodnaya Steppe. However,

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[7] (7, p. 210) is the source of data for this region.

the major irrigation in the Fergana comes from the Great Fergana Canal. The region is said to be the largest continuous irrigated area in Central Asia, but no precise estimates were found for irrigation acreage and output.

2. Amu Darya River

Virtually the entire length of the Amu Darya is surrounded by irrigation. Numerous dams have been built on the river and its water diverted into massive canals. The most recent hydrodam construction projects on the Amu Darya (Tyuya-Muyun and Takhia Tash) are near the delta of the river just below the Aral Sea in Uzbekistan. These provide reservoirs which retain the flow of the Amu Darya and ensure irrigation water during the dry season for approximately 5,434,000 acres of land devoted to rice production (7, p. 213). Construction of Takhia Tash dam began in 1965 and by 1970, the reservoir was to provide water for three million acres in the lower area of the river (3, p. 173).

The canals utilising the river's water are quite extensive. The most famous is the Kara Kum Canal which stretches 1500 kilometers into the previously unarable Kara Kum desert, which occupies 9/10 of the total land area in Turkmenistan. Electric power stations have been constructed on the canal to provide pumping facilities for irrigation. The canal was begun in 1954 and completed in 1962 (7, p. 215). 370,500 acres of new lands are being developed and are producing cotton. In 1965, an extension of the canal from Ashkhbad to the Caspian Sea was proposed. This region of Turkmenistan contains oil and gas deposits which have been unexploited due to the lack of water. Also, another 1,235,000 acres of land will be developed for agriculture. It is expected that the extension will be completed by 1980 (7, p. 218).

3. Vakhsh River - Nurek Hydroelectric Station

More complete information is available for the Nurek Dam in Tadzhikistan. The project has been heralded for its "enormous possibilities for irrigating new lands" (7, p. 151). Irrigation will lead to cultivation of 494,000 acres of new land in Tadzhikistan and 247,000 acres in Uzbekistan (7, p. 151). An estimate of the installed capacity

of the dam is 2.5 million kilowatts (54, p. 157). The project is supposed to produce electricity relatively cheaply; from 0.1 to 0.2 kopeks per kilowatt hour versus the 0.8 kopeks per kilowatt hour average for existing Central Asian hydroplants (54, p. 157). The dam was scheduled for completion in 1971.

4. Ili River - Kapchagaisk Dam

The Kapchagaisk hydroelectric station was started in 1956, in the Kapchagay basin, 70 kilometers north of Alma Ata, the major industrial city of Kazakhstan (7, p. 156). The reservoir on the Ili will contain 28.1 cubic kilometers of water (44, p. 320). Irrigation from the reservoir will make cultivation possible for one million acres of Kazakh land, of which 600,000 would be sown to rice. An estimate of the value of these crops is 240 million rubles per year (44, p. 319). The dam took about 14 years to build and as will be seen, has had a rather significant impact on this part of Kazakhstan.

C. The South Saskatchewan River Project (SSRP)

The SSRP was designed to be a "large-scale, multi-purpose water conservation project" to develop south-central Saskatchewan (25, p. 1). The project's objective was "to make better use of the water resources of the river through irrigation, power, river control, urban water supply, and recreation" (26, p. 1), with irrigation planned as the major use. Construction began in 1959, and in 1967 the construction of impounding works and the reservoir was completed. There are two major dams. The main dam (Gardiner Dam) is located between the towns of Elbow and Outlook.[8] The second dam has been built at the divide between the South Saskatchewan and Qu'Appelle rivers. The cost of the dam and reservoir as of 1967 was $105.3 million, and has been shared by the Province of Saskatchewan and the Government of Canada, 25% and 75% respectively. The province is responsible for developing the facilities to utilise the reservoir water (e.g., irrigation canals, pumping stations, recreational development). The reservoir is 140 miles long,

[8] See Appendix, Figure 3.

with a shoreline of nearly 500 miles, and a surface area of 116,000 acres.

The history of the project is rather long and complicated. Plans for development of the South Saskatchewan River go back to the 1890s and interest has been present in some sort of project ever since.[9]

The major objective of the project is to develop irrigation on a large scale. Presently, 285,650 acres are proposed for irrigation development of which 73,000 are currently under development and between 12,000 and 16,000 irrigated acres produced crops in 1972 (57). The crops currently being grown include (in decreasing order of sown acreage) barley, soft wheat, rapeseed, hay, potatoes, forage seed, silage corn, irrigated pasture, and horsebeans. Future plans envisage more vegetable cultivation with sugar beets a potential crop, and more land devoted to cattle grazing. Irrigation water is pumped from the reservoir into high-level main canals and from these, it flows into smaller distribution canals to farms. The cost to the private land-owner of providing irrigation to an acre of land is running from $60 to $130 per acre, depending on the type of development (levelling, border dykes or corrugations, or sprinkler systems).[10] The cost for a section (640 acres) is therefore between $64,000 and $115,200 including a deduction for a government grant of $35 per developed acre. As was mentioned in the background, irrigation development is a long run proposal. Plans for this project foresee at least a 30 year period before full development of irrigation potential is achieved.

The power aspect of the project will yield an installed plant capacity of 187,500 kilowatts and provide 800 million kilowatts of electricity per year. The purpose of the power development was to coordinate operation with existing thermal plants to meet peak demand loads, not to increase power generation. The reservoir is designed to store water so that these peak loads can be met in periods when the

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[9] See (29) for the history of the project and a comprehensive background.

[10] Correspondence with D.A. Roll, SSRP agricultural specialist for the project.

natural flow of the river is low and demand for electricity high (winter). Future plans for hydro development foresee a series of dams and reservoirs downstream from the Gardiner Dam to an existing hydro-power dam at Squaw Rapids (31, 35).

Recreational use is provided for in the project. The reservoir (Lake Diefenbaker) is designed to provide water-related recreation in an area where this sort of leisure activity is scarce. Access to the reservoir is relatively poor. No value as yet has been put on this use. Marginal uses of the project include distribution of water for household and industry consumption to Regina and perhaps other urban centres. In summary, the project is seen as a multi-purpose development on the South Saskatchewan River that will lead to further use of the river and development and stabilization of Saskatchewan's agricultural economy.[11]

D. External Diseconomies and Irrigation

The projects described give rise to external diseconomies. This section will illustrate external diseconomies arising from each project, then review the social costs common to both countries' irrigation schemes.

1. U.S.S.R.

The most important external diseconomy resulting from the Central Asian and Kazakhstan projects is the effect of irrigation water consumption on the Soviet inland seas and lakes. The Amu and Syr Darya empty into the Aral Sea and are its sole sources of water. The diversion of these rivers' water for irrigation (and 40% of the irrigation in Central Asia depends on these rivers, 7, p.214) has severely decreased the flow of water to the Aral. It is forecast that by the end of this century, the water resources of the Syr and Amu Darya will be virtually exhausted, that shoaling of the Aral will begin, and the Aral will finally disappear into a salt bed (48, p. 14).

The effects of this decreased flow to the Aral include a decrease in fisheries' productivity (to zero if water depletion is complete) due

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[11] The benefit:cost ratio of the project as estimated in 1964 was 3:1 (30, p. 197).

both to the lowering of the water level and resultant increase in salinity of the remaining water. The irrigation and power reservoirs also decrease the flow of silt and nutrients to the Aral deltas which reduces agricultural and fishery productivity. It is estimated that the fish catch in the Aral has decreased from 40 metric tons in 1962 to 20 metric tons in 1967 and to 6 to 8 metric tons in 1970 (13, p. 235). Total loss of the fishing industry would be valued at 60 million rubles (44, p. 317). The muskrat population around the Sea is also diminishing and this results in a potential loss of 10 million rubles if the population is extinguished.[12]

Another effect, potentially more costly and less readily quantifiable, is the change in climate, predicted from the loss of the Aral Sea. Geographers have warned that the continentality of the climate will increase, yielding longer winters and shorter, hotter summers throughout the Central Asia, Kazakhstan region (44). If this occurred, there would be additional social costs; a decrease in agricultural productivity, increase in clothing and heating costs, and possibly psychological and physiological effects which would make the region difficult to populate and develop. There is evidence from the Soviet press that these regions are not very desireable to live in currently (47). If the climate in fact became harsher, either more people would leave, or the government would have to offer rather substantial bonuses to encourage workers to remain, as has been done in Siberia.

The same drying-up process is occuring in Lake Balkhash as a result of the Kapchagaisk Dam. The Ili River is the source of 75% of the lake's water and once this source is tapped for large scale irrigation projects, the flow of fresh water to the lake is drastically reduced. The lake currently provides (or provided) the residents of the town of Balkhash (population: 77,000) with water for household consumption and industrial

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[12](44, p. 317). This figure and the preceeding one are taken from a Soviet source that was trying to justify the loss of the Aral based on a potential value of the agricultural yield which exceeded the loss of the fishery and muskrat furs. The relevance of any of these figures to real values is questionable.

use. It also supported a fishing industry with an average catch of 17,000 tons per year and provided recreational benefits to those in the town and adjoining areas (44, p. 319). The evaporation rate on the lake is quite high and this alone tends to increase its salt content. With the building of the dam and retention of the Ili waters, the salt content increased and began to affect the water supply of the town.

Protest by Balkhash residents over the irrigation/hydro project had no impact on the construction of the project. Dam construction continued even though it was found that the agricultural benefits of irrigation were overstated. Additional problems emerged. The dam's regulation of the stream flow prevented the spring floods from reaching the delta area. This could result in the loss of 750,000 to 1,500,000 acres of presently productive agricultural land in two years.[13] To offset these losses, the Ministry of Electrification (in charge of the project) changed the emphasis of the development from irrigation to power generation and recreational benefits from the reservoir.[14] This necessitated an increase in the height of the dam, causing greater retention of water to Balkhash. Power generation capacity then increased from 250,000 to 434,000 kilowatt hours because "the construction planners did not want to risk the criticism that the generating capacity of the power station would be too low to justify its construction" (44, p. 320). It might also be interesting to note that the alleged demand for this power was coming from the industrial city of Alma Ata which already had thermal plants fulfilling its needs without apparent difficulty, and at a lower cost than the Kapchagaisk hydropower. The dam is completed and reservoir filling underway, and already the lake's salt content has increased 8% in one year. Thus, the chain of events depicted above is no doubt underway.

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[13](44, p. 319). Goldman often fails to cite his sources of information, so again, the figures are subject to debate.

[14]It seems rather odd that the recreational benefits from an existing body of water were not counted.

2. Canada

In 1952, the Royal Commission studying the SSRP found that the "economic returns to the Canadian people on the investment in the proposed South Saskatchewan River Project (Central Saskatchewan Development) are not commensurate with the cost thereof" (29, p. 6). The project was built anyhow. In the twenty years since the Commission's report came out, the costs of the project (both internal and external) have risen. There are many benefits accruing to private individuals and society, but the net effect at this point is questionable. The external diseconomies of the SSRP are somewhat more complex than those in the U.S.S.R. because they go beyond environmental costs to relatively unquantifiable external effects on human welfare and income distribution. This may also be true in the Soviet Union, but lack of information precludes a more thorough analysis.

One of the Commission's warnings was that "Those farmers who are successfully farming large acreages by dry farming methods are unlikely in many cases to take kindly to having their farms broken up into small blocks suitable for irrigation" (29, p. 3). If this happens, and the evidence is that it has, the project will either fail to achieve its irrigation acreage plans, or the government will have to appropriate the lands of farmers unwilling to change. As the former course would seriously undermine the major justification of the project, the latter was chosen.

Dry land farming is an unstable agricultural technique in the sense that it is almost completely dependent on the vagaries of the weather, especially rainfall. Some years there is a bumper crop, in other years, nothing. In the 1930s there were many years of crop failure in the Canadian prairies and much of this was caused by the dry land techniques which were more destructive than those practiced today.[15]

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[15] Acreage was also insufficient to support viable farm units. The homesteading plans of the federal government after World War I often allocated quarter sections (160 acres) which were incapable of supporting families in this semi-arid region.

To combat this economic chaos, the Government of Canada established the Prairie Farm Rehabilitation Administration (PFRA) in 1935 to "find ways and means of overcoming drought on the prairie and to alleviate the depressed conditions that prevailed" (26, p. 6). The PFRA has done quite alot to enable farmers to work with the climate and sustain a living. But sometimes their objectives fail to consider the utility functions of the farmers.

When the SSRP was proposed, it was hailed as a "mighty project ... dedicated to the service of man" (26, p. 1), a means by which dryland farming would be superseded by irrigation farming. The problem is that many dryland farmers do not want it that way. To these people, there is often no alternative use for their land or their labour. The farmers do not want the land "reconstructed" into irrigation plots (21, p. 286). By 1972, 62 units have been established as irrigation farms in the project area. Twenty-six local families developed their own land and 36 units were developed by people from other parts of Saskatchewan and other provinces (57, p. 3). The Saskatchewan government compels farmers to sell them their land if they do not wish to irrigate. These acquisitions amount to half of the land in the developed project acreage near Outlook.[16] The disposed farmers receive a payment for their land, but how does one value the loss of a life style, a means of support, and the necessity to find urban employment (or unemployment)?

In other areas of the project not yet developed (approximately 209,100 acres), the Department of Agriculture is meeting resistence to irrigation farming. The land is currently viable for dryland methods and the existing landowners either do not want to change or cannot afford the $64,000 to $115,200 per section investment for irrigation development. In this area, these farmers will probably be displaced. The benefits of the government approach become questionable when it is recognized that a viable agricultural unit is being sacrificed for the

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[16]There are no figures to date on exactly how many dryland farmers were required to sell. It is assumed that their land was purchased by the government at a fair market price.

production of crops that may either have a limited market or are not produced cheaply enough to be competitive in existing markets. This This would be a trivial matter if total benefits of the project (including benefits to new people who do irrigate) outweigh these costs. But it is not clear that total benefits do outweigh total costs.

3. External Diseconomies Common to Socialist and Capitalist Projects

"It has turned out that, while accomplishing important national economic tasks, hydrotechnical construction has given rise to a number of serious and largely unforeseen consequences" (43, p. 3). In the Soviet Union and Canada, large scale irrigation development has been accompanied by some potentially severe external diseconomies. Although the SSRP has yet to exhibit many of these effects, the potential is present. The U.S.S.R.'s external costs are being realized now.

Irrigation is an important water use because of its consumptive nature. This consumption gives rise to external diseconomies. The examples of the Aral Sea and Lake Balkhash have already been mentioned. A more complicated relationship exists between irrigation, soil salinity, agricultural productivity, and other water uses. Land with a high mineral salt content and impeded drainage should not be irrigated due to the movement of the salts up through the soil by capillary action to the surface. This can result in injury to crops and possible contamination of the irrigation water returned to the river. Yet land with poor drainage and high salt content is being irrigated in Central Asia and Kazakhstan, Saskatchewan and Alberta.[17] As much of the soil in the SSRP area has poor drainage and high salt content, salinity is a potential problem.

In the Soviet Union, scientists report that the economic effect from the extensive development of irrigation in Central Asia and southern Kazakhstan has not been as favourable as expected. The desert soils which have poor drainage have been over-irrigated and increased soil salinity has decreased crop yields and made land unarable (43, p. 4).

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[17] For example, the Bigstick Lake region in southwest Saskatchewan.

In 1963, 50,300 hectares[18] of new lands out of 56,300 hectares fell out of agricultural use through salination, and cotton harvest yields on the Hungry Steppe fell by 54% from 1958-1962 due to salination (7, pp. 214-215). Goldman notes that "several Russian economists estimate that in Central Asia, as much land has been lost through flooding and salination as has been added through irrigation and drainage" (13, p. 225).

Water consumption by irrigation also decreases the availibility of water to downstream users. Water consumption is high in semi-arid regions due to high evaporation rates in reservoirs, in irrigation ditches, and on farm land. There is concern in Saskatchewan over the loss of hydroelectric generating capacity due to the retention of water behind the Gardiner Dam (21, 31, 35, p. 24). Present consumption of water for irrigation may also preclude its use for future industrial development, thereby imposing external costs on alternative water users.

Reduction of water flow decreases the ability of the river to disperse pollutants. Water quality affects industrial and agricultural uses, personal consumption and recreation. Decreased water quality can be compensated for on agricultural land by increasing the irrigation water (leaching) if contamination is not too severe. This however, increases water demands and requires additional drainage facilities. There is also substantial evidence that agricultural activity contributes to water pollution with its use of fertilizers and pesticides in both the U.S.S.R. and Canada (33, 49). Irrigated land tends to require more fertilization than dryland farming, and this can lead to such things as nitrate contamination of the water.

The most significant external diseconomies resulting from irrigation water consumption could result from attempted solutions to the water scarcity problems, namely, through large scale diversions of rivers. Both the U.S.S.R. and Canada have schemes to divert water from the rivers normally flowing to the Arctic Ocean into the rivers of the projects discussed. In the Soviet Union, plans are underway to divert part of the flow of the Ob, Yenisei, and Irtysh rivers into Kazakhstan

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[18] One hectare equals 2.47 acres.

and Central Asia (53). In Canada, schemes exist to divert the Athabaska and Peace Rivers' flow into the North Saskatchewan River, then to the SSRP reservoir (31, 35, p. 2423). Although scientists are undecided as to the actual effects of these diversions, there are predictions that local climate could be affected as could the temperature of the Arctic Ocean. Another possible effect is an alteration of the earth's rotation. Less speculative external diseconomies include loss of agricultural and forest lands through inundation by canals and reservoirs, changes in water temperature, loss of fish habitats and spawning grounds, lost deltas (of the rivers diverted), and local geologic stress (due to the weight of the water).

• External diseconomies caused by large scale reservoir construction include the loss of land and soils through inundation, erosion, and abrasion, the loss of nutrients downstream, health hazards, and an increase in river siltation. The loss of land under cultivation due to the SSRP reservoir amounted to 16,500 acres, valued (1972 prices) between $1,072,500 and $1,402,500 (26, 29). In the Soviet Union, millions of hectares of agricultural and forest lands have been inundated by reservoirs, with salination, swamps, destruction of shorelines, and spread of erosion causing the land around the reservoirs to deteriorate (43, p. 3, 45). In 1970, reservoirs throughout the U.S.S.R. covered 12 million hectares of land, of which 6 million could have been used for agriculture (13, p. 258).

III. ALTERNATIVE EXPLANATIONS FOR THE EMERGENCE OF EXTERNAL DISECONOMIES

From the previous section, it can be concluded that development projects in both socialist and capitalist economies give rise to external diseconomies. This section will examine and evaluate additional explanations for externality generation.

A. Planning and Decision-Making

The first step in evaluating other possible explanations for the emergence of external diseconomies is to consider the planning of irrigation and water resources in Canada and the U.S.S.R. It will be shown that the inadequacy, lack of coordination, and incompetence in planning agencies give rise to externalities.

"Most of the problems of water resource management that have arisen in Canada relate to the increasing competition for the use of the nation's water resources, the division of authority in water matters between several jurisdictions, and the non-coincidence of political and natural boundaries" (21, p. 263). Canada's water resource development is complicated by the division of jurisdiction over water between federal and provincial authorities. The British North America Act granted the provinces jurisdiction over the resources within their boundaries, but the federal government retained exclusive jurisdiction over the use of water for navigation and fisheries, in international and interprovincial relations, and concurrent jurisdiction with the provinces over agriculture (21, pp. 263, 327-328). The federal government also indirectly affects the provinces' authority over recreation, power, industrial and household uses through its power to make conditional grants. Thus it would appear that "Water development is becoming a recognized instrument of economic policy, designed not merely to provide power or irrigation water, or domestic and industrial water supplies, but to achieve certain broad economic and social objectives" (21, p. 264). Another interesting factor is that at present, there is no way for a province to bring another province or the federal government to court, unless both parties agree to litigation (21, pp. 264, 382).

These policies lead to conflicts between authorities due to confusion over which authority is responsible for a particular function (21, pp. 264-265). This generally results in either costly delays in initiating projects or hasty acceptance and construction of projects in one province before other provinces decide to develop the water passing through their boundaries. The jurisdictional setting is also

> Characterized by a wide array of institutions and policies on private, provincial, and federal levels, many with interests in planning and development. Each of these interest groups has its own particular economic and social objectives ... Coordination within either the federal or the provincial network appears weak and there is a lack of clearly defined responsibilities among the various levels of government. There is also a lack of lucid resource development policies (21, p. 328).

At the federal level there are nine departments with some responsibility for water management, each with associated branches and agencies, and a number of Crown corporations. In many provinces, more than twelve agencies deal with water matters (21, p. 269). Attempts to coordinate policies and functions have met with little success. Therefore, with any specific project, no one is quite sure who is responsible for what, especially for determining social costs. CBAs when done, have not been rigorous and are often accused of improper specification of costs and benefits (21, p. 333).

The lack of social cost calculation in the planning of the project is partially explained by interprovincial and interagency conflicts. In the initial discussions of the SSRP, it was found that Alberta objected to this single province, multiple-purpose use of a river that passed through Alberta, Saskatchewan, and Manitoba. Alberta favoured a proposal which would enable irrigation development within its boundaries and Saskatchewan. The Royal Commission's report on the SSRP supported Alberta's claim that the project did not make the best use of the river. The dispute was settled by the promise of federal funds which would finance 75% of the project. It seemed that the funds were allocated because Saskatchewan had not received any federal

aid for some years.[19] The Government of Saskatchewan (supported by the PFRA) asked for the project on the grounds that

> Saskatchewan has been largely by-passed in federal resource development programmes since the early days of its settlement despite its wealth of undeveloped resources and actual known projects awaiting development ... It would not only be unjust to Saskatchewan but detrimental to the nation if part of the waters of this great river were not utilized in the Province of Saskatchewan (21, p. 332).

The government's argument was not based on any economic criteria, but the need for development for its own sake regardless of findings that the project would have very little impact on the economy of Saskatchewan other than inflation, loss of farm units, etc. (29, 55). The government felt that stabilization of all parts of the nation was identical with the most profitable and economically efficient use of the water resource (21, p. 333). What occurred was the acceptance of a project based on political criteria and lack of concern for social costs. The myriad of water agencies were either ineffectual or unable (legally) to oppose the project. Thus, agency ineptness in Canada, while not necessarily the direct cause of external diseconomies, allows the lack of social cost calculation in economic growth decisions to persist.

In the Soviet Union, agency coordination is also a major problem. Three sets of central agencies have water development responsibilities; the Ministries of Land Improvement and Water Supply, Ministries of Energy and Electrification, and Ministries of Inland Water Transport (12, pp. 8-9). Each of the ministries has counterpart regional agencies within the republics. As the irrigation projects discussed here are part of multiple purpose development, all of these agencies would be involved in determining the location and implementation of projects. In addition, the Ministries of Agriculture would become involved once the project was completed. The Ministries of Energy and Electrification

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[19] Diefenbaker and the Progressive Conservative Party contested a Federal General Election in 1957 and one of the campaign promises was to construct the SSRP. The party won, the federal grants made, and the SSRP was started in 1959 (55, p. 37).

play a dominant role in water planning, and generally have precedence over the other agencies. At the regional level, special boards and river basin inspection departments are "responsible for the planned utilization of surface and underground water resources, prevention of their exhaustion, pollution by industrial and commercial sewage. They supervise measures to combat flooding, waterlogging, soil erosion, and other harmful effects of water" (12, p. 9).

The agencies appear to be incapable of fulfilling their responsibilities. Water resources are mismanaged and give rise to external diseconomies. "The shortcomings of water management are attributable to poor coordination of water consumption by different branches of the economy and by enterprises. The distribution of economic activities frequently takes place without sufficient thought for the availability of water, particularly with regard to the long-term development of the enterprise" (12, p.31). Thus it would seem at though the ministries were poorly coordinated and could not solve conflicts between water uses.

Agency conflicts are also important at the project level. External diseconomies such as salination, excessive evaporation and seepage, siltation, and fertilizer pollution of irrigation canals occur because the state and collective farms do not know how to cope with these problems. One article (about Tadzhikistan) attributed the problems to the incompetence of the water resource agencies that were running the irrigation projects on the farms (48, p.24). The critic of these occurrences, who incidentally was the head of the agricultural department of the Tadzhik Communist Party, felt that the irrigation operation should be turned over to the agricultural ministry. Evidently, there is a long history of conflicts between water resource agencies and agricultural agencies over the operation of irrigation works. As a result, society suffers the damage caused by these disputes (51, p. 30).

Related to bureaucratic ineptness, is the inability of laws and regulations to prevent the emergence of external diseconomies. Laws can be formulated by planners, but if they are not enforced, their effectiveness is limited. The laws themselves may also be inadequate to deal with the externality problems. Part of this latter cause is

explained by the lack of agency coordination and the possibility that the government decision-makers are just placating dissenters without any plans to ever enforce the laws.

Prior to 1970, the Soviet Union's water laws were characterized as being numerous and meaningless.

> In the existing legislation the norms of the law of water use are distributed throughout numerous legislative acts, passed at different times on different issues. Most of these norms are contained in legislative acts of the Union Republics and in rules, regulations, and instructions issued by Ministries and Departments of the USSR and Union Republics. There would be nothing wrong with this if all the material were corrdinated and consistent. But unfortunately the reverse is the case. The norms contain contradiction, legislation has failed to regulate a number of matters, and so on, which in the final analysis only serves to reduce the effectiveness of legal regulation (12, p. 108).

In the late 1950s and early 1960s when domestic protest began condemning the government's exploitation of resources without any regard for the environment, the governments of many republics responded by passing laws, decrees, and regulations on resource use. In the Russian Soviet Federated Socialist Republic between 1956 and 1960, 19 executive decrees were issued on conservation, with punishment in the criminal codes stipulated for offenses. A conservation propaganda movement arose (sponsored by the government), yet degradation of the environment through lack of social cost calculation continued (12, p. 83). On the Amu Darya River, water is being misallocated, overconsumed, and polluted because the laws of the republics of Uzbekistan, Turkmenistan, and Tadzhikistan are uncoordinated, often advocating exploitation and conservation simultaneously (51, p. 30). Reservoir laws are also quite erratic and uncoordinated. In some republics, they are special regulations enacted by the Councils of Ministers and capable of being powerful means of control. In other republics, reservoir regulations are merely departmental guidelines, and ineffectual in controlling either the construction or use of reservoirs (12, p. 109). Agricultural water regulations exist in many republics including Uzbekistan, Turkmenistan,

and Kazakhstan. Although the legislation is more developed than the other branches of water law, it still "inadequately defines the rights and obligations of water users concerning the rational use of water resources ..." (12, p. 109).

In 1970, a set of water laws for the entire country was adopted. These laws were designed to make water regulations uniform and enforceable at the national level. At least one source (12) feels that the new legislation will not solve the problems for the following reasons. The Soviet approach to environmental problems is mainly preservationist, with a tendency to focus on resources as isolated entities. Interrelationships are not seen. If a law is challenged by favoured enterprises of the country (e.g., electricity and petrochemical industries), the laws are not enforced. This implies that regulatory mechanisms are inadequate under conditions of rising demand for natural resources. Combine this with the inefficient operations of agencies (some of which both regulate and develop the same resource), and externalities emerge.

It would appear from the preceeding discussion of ministry and regulation problems that incompetence and inefficient planning give rise to many external diseconomies. However, one must not lose sight of the fact that the central planning agency, Gosplan, is ultimately responsible for all development and exploitation of resources. This suggests two things. The incompetence at the republic and regional levels is a function of Gosplan incompetence, and that Gosplan and the central party decision-makers are responsible for setting the conflicting goals the ministries must follow. The latter situation implies that the objectives of central planning do not include social cost calculation because it interferes with the industrialization and growth of the economy. In fact, it seems that the Soviet press is deliberately placing blame on ministries and planners.

> Instead of explaining the damage to the natural environment in terms of party-sanctioned priorities, in terms of a deliberate sacrifice of the natural resources to an industrial-technical base, the Soviet writers pin the blame on planners-technicians and economic managers for mislocating

> plants, failing to install purification devices, and so on (12, p. 88).

Water resource development follows central planning priorities which deliberately omit social costs to achieve desired goals. This is manifested most clearly in the dominance of electricity-generation over any other use of water. In December 1920, Lenin initiated the plan (GOELRO) for the electrification of Russia. The top priority measures included accelerated mechanisation and electrification of the railroads and basic industrial processes, then heavily labour intensive; accelerating the erection of power stations and networks to supply electricity to the main industrial regions and centres of the country; and to draw into the energy balance the "enormous potential hydraulic power resources by building a series of hydroelectric stations" (49, p. 4). Hydropower was developed throughout the period 1920-1940 (according to Lenin's plans as interpreted by Stalin after Lenin's death) in the form of multiple plants on the European rivers. With the advent of the Second World War and danger from German invasion, Stalin initiated plans to move hydrodevelopment eastward to Siberia, Kazakhstan, and Central Asia. In the postwar Stalin period, the "Great Construction Works of Communism" (16) was the dominant electrification scheme. Gigantic hydroelectric and thermal stations were built and the ones destroyed by the war, rebuilt. The literature at the time stressed the cheapness and abundance of water, the advantages of capital-intensive production, and the necessity to transform nature to develop the economy (24, p. 1, 16, pp. 6-7).[20]

Irrigation systems accompanied the huge hydroelectric stations. The period is characterized by enormous growth of power-generating capacity, hundreds of thousands of irrigated hectares, and no regard for the possible external effects of the operations. The desire to build up the productive capacity overwhelmed any concern for the degradation of natural resources. After Stalin, development pressure was marginally abated. Khrushchev continued to expand hydropower development

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[20] There was an additional goal; the conversion of the peasantry to communism.

and irrigation (e.g., the Virgin Lands scheme in Kazakhstan) with similar results, that is, tremendous growth accompanied by external diseconomies.

The electrification ideal is still a significant factor in development. "The features which characterize the present and immediate future stages of the development of productive forces are firstly the constant raising of the level of electrification in the country and secondly, the increase in the ... percentage of electricity in the total consumption of all forms of energy" (39, p. 1). The regions of the country relatively less developed such as Central Asia and Kazakhstan are the areas of massive electrification effort. This helps to explain the proliferation of irrigation/hydro projects in these regions. It may also explain some of the inability of agencies with goals conflicting with electrification to account for social costs.

B. Economic Incentives

The usual explanation for the emergence of external diseconomies is market failure. The following section shows how the Canadian and Soviet governments have failed to correct market failure.

1. The Price of Water

There is no real market for water, no market price, and little comprehensive planning of water resources. The real demand for irrigation water is therefore unknown or obscured. The Canadian government seems to be making matters worse. Critics of Canadian water and irrigation policy have charged that the price paid for water is far below its real value to society. The unprofitable production of certain crops in dry areas is made possible by direct or indirect subsidy (21, p. 285). Indirect subsidies can be excessive land taxes and power rates. As noted previously, hydropower profits often allow construction of irrigation projects that would not otherwise be undertaken. In effect, the power-users are subsidizing irrigation. If the price of water is low relative to other factor input prices, it will be used intensively and possibly inefficiently. There is no incentive to conserve water if its price does not reflect its scarcity value. Irrigation might not be

the most efficient use of water, resulting in resource misallocation and external diseconomies such as salinity, water pollution, and excess consumption.

The government also tends to allocate water according to "needs" that are unrelated to economic criteria. In Saskatchewan, the provincial government claimed that the farmers and province needed the water development. With the federal government grants paying 75% of the construction costs and giving grants of 27% to 58% of total irrigation installation costs to farmers, actual demand cannot be determined.[21] The governments of Canada have taken over development of water resources, but this does not mean that water prices should be kept artificially low, and huge irrigation projects built. However, the case is generally that "Rational re-allocation of existing supplies of water, such as would occur if prices were raised in response to scarcity, is almost never considered as an alternative to new construction" (4, p. viii).[22]

Prior to 1967 in the Soviet Union, water and all natural resources were considered free goods. Thus, the same overconsumption of water has taken place in the socialist system as in the capitalist system. Central planning of all inputs and output quantities and prices could prevent the misuse of water in theory by regulating the water consumption and price charged to each consumer.

> Given the proper circumstances, the centralization of price setting can be an important tool in protecting a country's resources ... So far, however, there seems to be little evidence that the Russians have adopted such a policy in their pricing procedures. Generally it seems fair to say that such questions have been ignored in the price-setting process. In fact, at least until July 1967, prices on raw materials were often set below the direct costs of production ...

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[21] From section II-D, it appears that the demand for irrigation on the SSRP has been a lot smaller than predicted even with the subsidies. If accurate prices had been used to begin with, the project may not have been built.

[22] Prices can also affect resource allocation and external diseconomies in another way. Uncertainty about future crop prices and the cost of capital can lead to overuse of the irrigation water in the present.

> Just because a state organization has the power to set prices, it does not necessarily follow that it will use this power wisely or for the promotion of conservation (13, p. 52).

Since 1967, attempts have been made to value water and natural resources. Economists Strumilin and Khachaturov advocate a differential rent scheme with prices "completely determined by the social costs of the outlays on developing such resources" (45, p. 57). The differential rent proposals are somewhat difficult to understand. They involve some opportunity cost valuation with capital effectiveness norms, and are still within the ideology of the labour theory of value. Water resources are supposed to be valued on the basis of real capital and current outlays on water supply and on the purification costs of polluted water. In arid regions with scarce water supplies and irrigation, "payment for water should be sufficiently high to stimulate the economy of water and the use of water, first and foremost, for the most effective production processes ..." (45, pp. 66-67). Theoretically this all sounds plausible, but when applied to actual situations, problems may still emerge; specifically, with the calculations of effectiveness (whatever that really means). The 1970 water legislation makes a provision for water charges under certain conditions. A charge was levied in a Kazakh river diversion scheme, but it was not uniform as there is reluctance to charge farmers and peasants for water.[23]

2. The Profit Motive

The low value of water might not lead to overconsumption and external diseconomies if individuals and enterprises incorporated the social costs of this misuse in their consumption and production decisions. But there is no incentive to do this in either the capitalist or socialist systems, due to the lack of social cost planning or imposition of taxes and regulations to curtail externality generation. Although profits in the U.S.S.R. do not accrue to individuals, some individuals

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[23](13, p. 114). Water fees were tried in 1949 and were very unpopular with the peasants who viewed the fees as burdensome taxes. When Khrushchev came to power, the fees were converted to subsidies.

do tend to benefit when an enterprise is successful, i.e., when its output quotas are met or overfulfilled. Thus, it is possible to compare motives for personal gain in Canada and the Soviet Union. These motives imply that external diseconomies will not be taken into account on the microeconomic level because to do so would diminish the return to the individual by increasing costs or decreasing output. This is perfectly rational behavior under both systems.

The Soviet bonus system has been particularly successful in stimulating external diseconomies. The incentives place maximum emphasis on increasing production and other objectives such as minimizing costs or including social costs are of secondary importance. However, the bonus system may be changing to incorporate more objectives, for example, profit maximization subject to cost constraints.

The Canadian government does not plan agricultural output. To be sure, wheat boards, egg boards, and quota systems exist, but the market is still the major determinant of profits. It continues to benefit the farm unit which can produce the largest quantity at the lowest cost. There is nothing wrong with this except that external diseconomies tend to be excluded in the decision-making process. This suggests that there is no real difference between the capitalist and socialist personal utility maximization motive. Both serve to stimulate production and economic growth and in so doing, give rise to external diseconomies, given the existing institutional structures.

The main solution usually offered to this problem is government planning and regulation to internalize externalities. But, as the first part of this section indicated, planning and regulations are also ineffectual. The reason (other than incompetence) is that government decision-makers place the highest relative value on growth and development; the cheapest short run path to this goal excludes consideration of external diseconomies.

IV. CONCLUSION

This paper has shown that external diseconomies are an inevitable result of economic growth, given the present form of government decision-making in both a capitalist and socialist economy. Other factors such as planning and administrative inadequacy contribute to the problem, but are not the major source of external diseconomies. Both countries' governments, in making their decisions about the use of natural resources to obtain economic growth, fail to calculate the potential welfare losses from the social costs of development. The exclusion of these external diseconomies was found to be the result of two major factors.

First, there is often a conflict between a government's growth objectives and the inclusion of social costs in the planning processes. If the calculation of the damage from potential external diseconomies in any project diminishes the value of the project as perceived by the government, the calculations are omitted. Thus, the social costs of the projects are ignored by the government in order to obtain its primary goals. This situation was depicted for the Soviet Union by the dominance of the electrification goals. These goals overwhelmed careful estimates of social cost in water resource development. In Canada, the federal government's desire for regional expansion precluded the development of water resources according to their real social costs and benefits. The conflicts appear to be the major cause of the failure to calculate external diseconomies.

A second and related point is that often a government's objective function is not well defined over relevant external diseconomies. This is the result of both faulty planning and the inability to correctly determine the economic returns from a project which will generate external diseconomies. In the Soviet Union, agricultural output is actually decreasing as irrigation development is increasing. Other industries (e.g., fishing, recreation) are also suffering from the irrigation projects in Central Asia and Kazakhstan. Canada's South Saskatchewan River Project may eliminate viable farming units to bring into production irrigated acreage that has not been shown to increase the value of agricultural output. These projects have indicated that

the exclusion of externalities leads to the acceptance of projects which will not achieve the governments' goals of economic growth (when measured in a meaningful way). The projects may in fact decrease output and employment.

This suggests that the governments of Canada and the U.S.S.R., in refusing to calculate social costs and properly consider externalities, undertake projects which can lead to potentially large social welfare losses. In addition, by such action, the governments of both countries may fail to meet their own objectives.

VI. APPENDIX

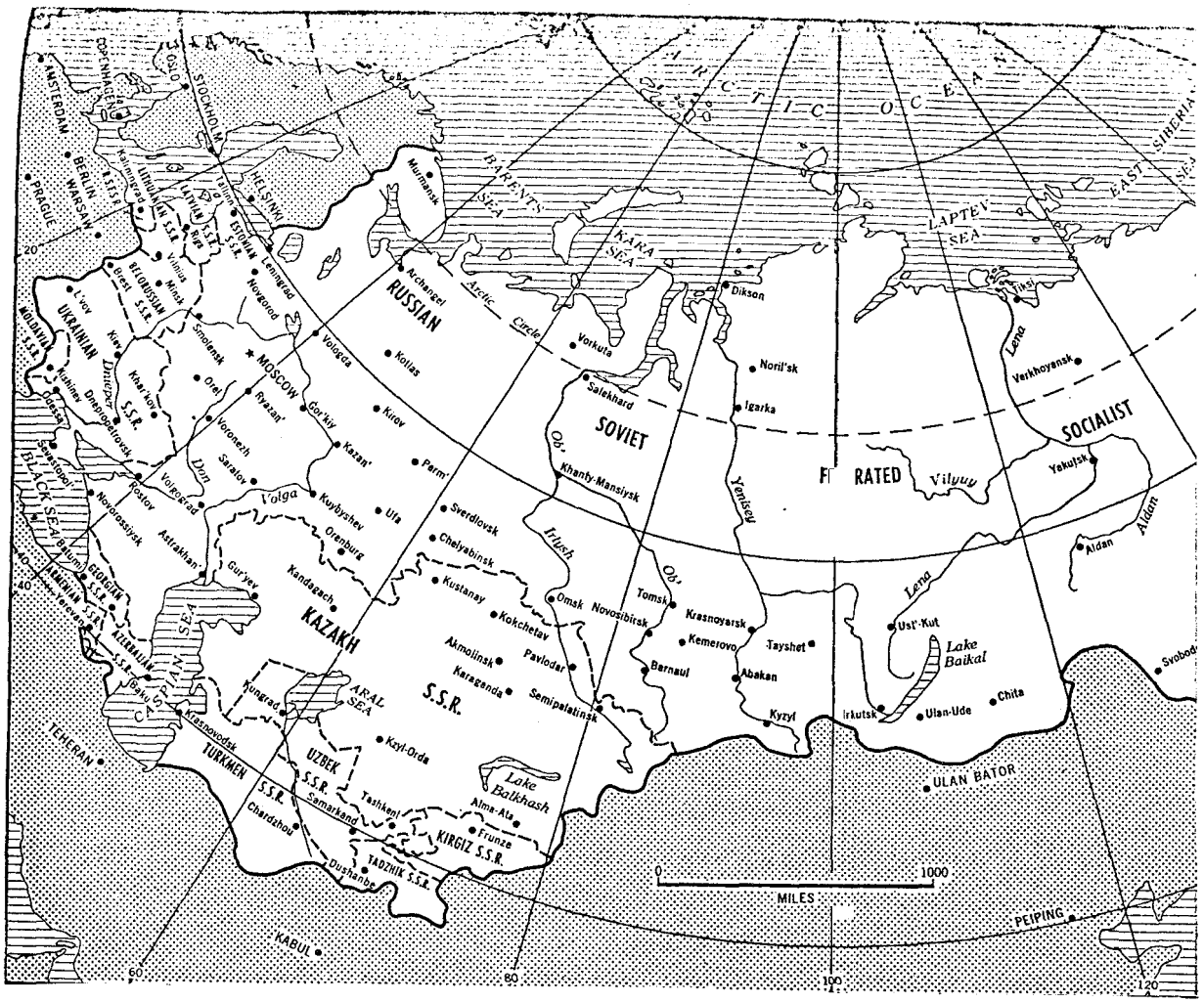

Figure 1: The Union of Soviet Socialist Republics (5, p. 187)

Figure 2: Major Irrigated Areas in Central Asia and Southern Kazakhstan (3, p. 171).

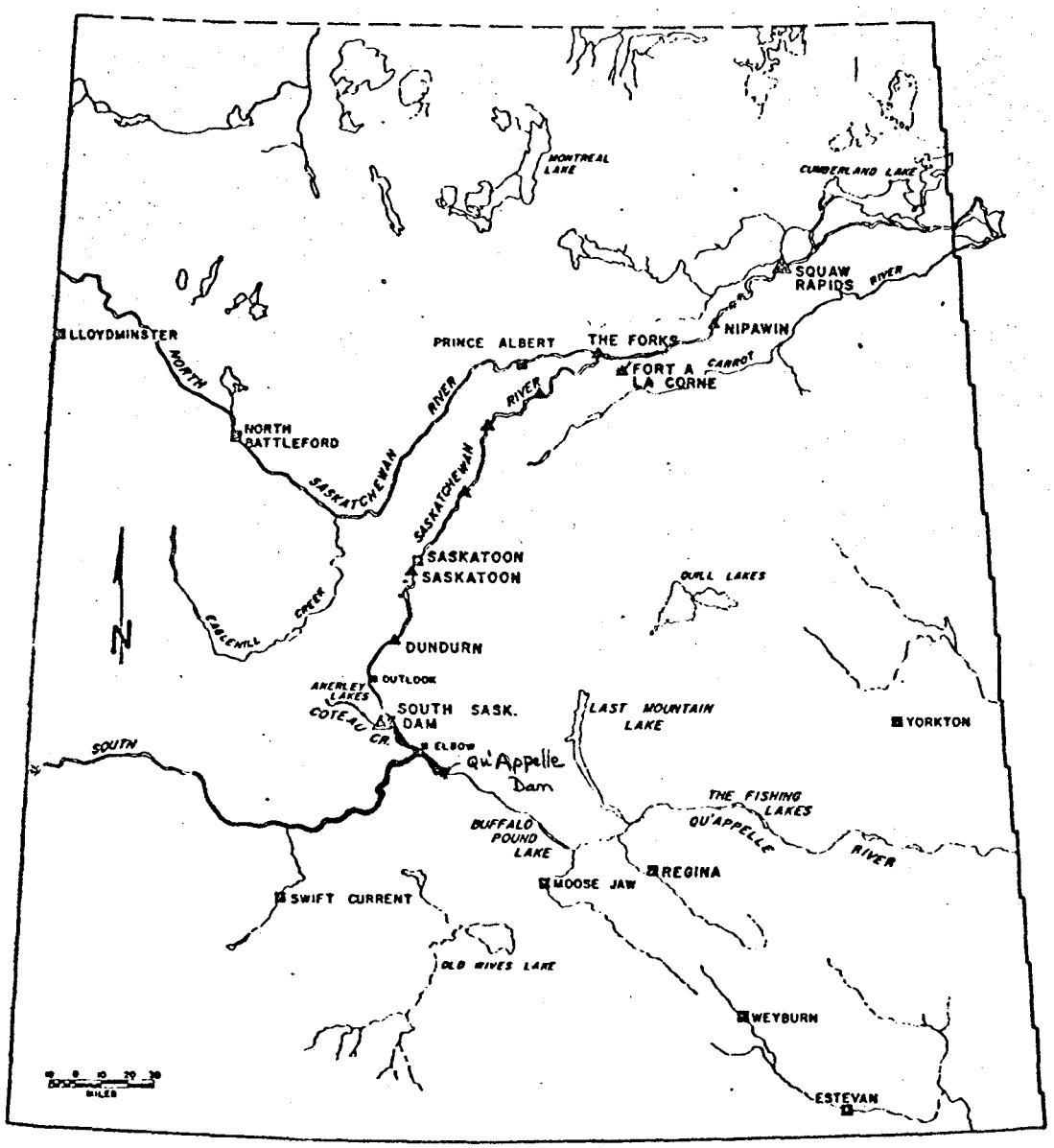

Figure 3: The Saskatchewan River System: The South Saskatchewan Dam and Potential Hydropower Sites (54, p. 35)

▲ Potential Sites

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