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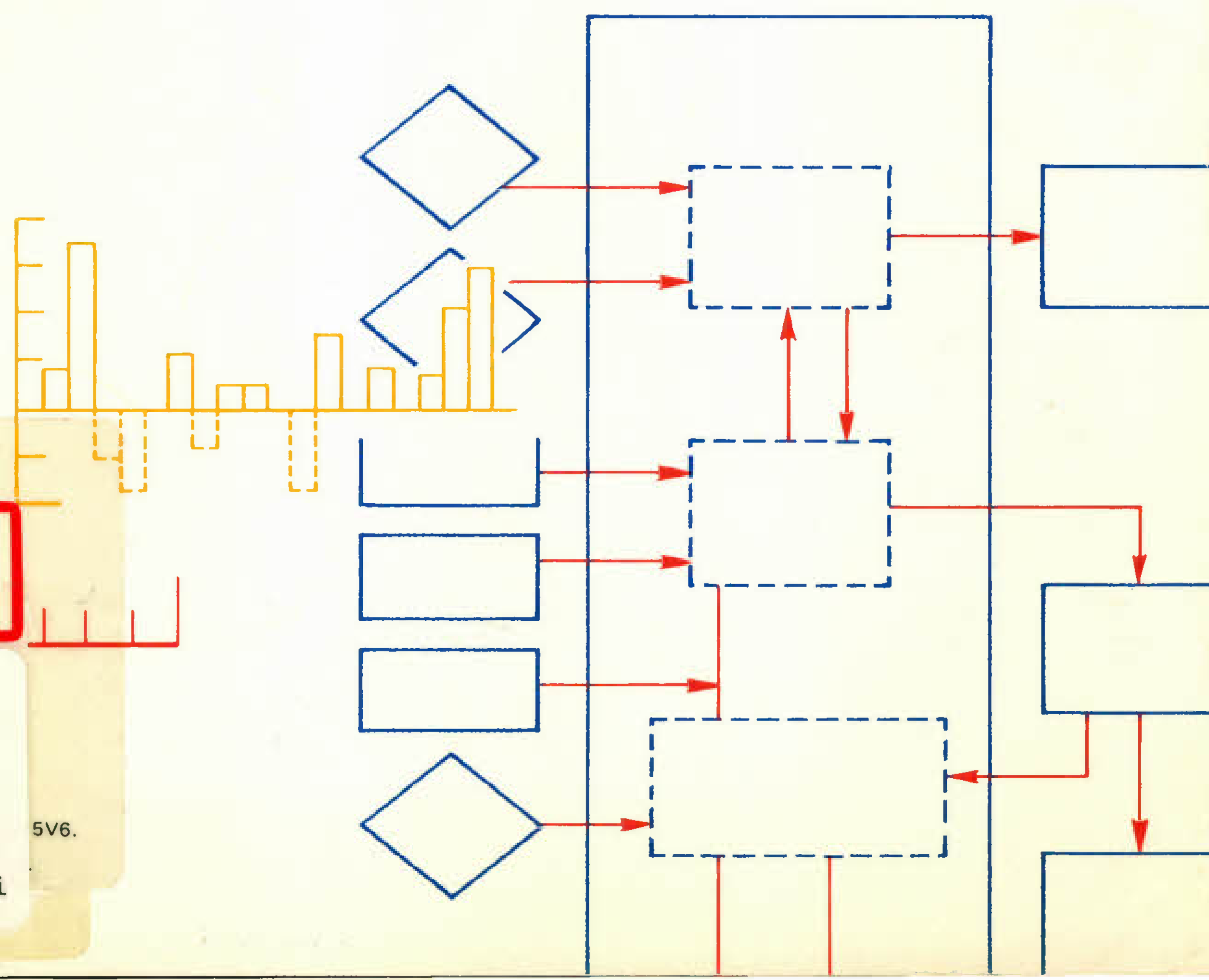

DISCUSSION PAPER NO. 241

The Impact of Environmental Regulation on Productivity Growth

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TABLE OF CONTENTS

RÉSUMÉ

Le présent rapport se propose d'examiner les liens importants qui peuvent exister entre la réglementation de l'environnement et la croissance de la productivité.

Dans la première partie, les auteurs passent en revue les ouvrages déjà publiés sur les effets de la réglementation de l'environnement sur la croissance de la productivité. Ces recherches se fondent sur des données globales provenant des États-Unis. Bien que non concluants, leurs résultats n'en montrent pas moins combien il serait important d'entreprendre une étude à partir de données au niveau de l'entreprise ou de l'usine. Une étude de faisabilité préliminaire a permis de découvrir que, pour l'industrie canadienne des brasseries, nous disposions de données au niveau de l'usine et qu'il était donc possible d'entreprendre une étude microéconomique de l'incidence de la réglementation de l'environnement sur les brasseries canadiennes. En outre, comme plusieurs brasseries sont soumises à certaines redevances sur les effluents, dites surtaxes d'égout, il a été possible d'effectuer une enquête sur ce genre particulier de réglementation de l'environnement. Les auteurs soutiennent que, théoriquement, étant donné que la réaction des entreprises aux stimulants économiques est probablement plus rapide et plus marquée, les effets de ces stimulants sur la productivité seraient plus importants que ceux produits par une application directe des règlements (c'est-à-dire les normes antipollution) qui

ont constitué jusqu'ici le thème central des études relatives aux divers effets sur la productivité.

Dans le reste du rapport, les auteurs passent en revue et décrivent les systèmes de surtaxes d'égout actuellement en usage au Canada et montrent, à l'aide d'estimations, comment les brasseries s'y ajustent. Ils présentent également une estimation de l'incidence de ces taxes sur la croissance de la productivité dans le secteur des brasseries.

L'analyse présentée laisse entendre que la réglementation de l'environnement, du genre dont il est question ici, amène effectivement les entreprises polluantes à lutter contre la pollution, même si elle tend aussi à réduire la croissance de la productivité. Cette conséquence, cependant, n'est pas nécessairement indésirable, car ces coûts sur le plan de la productivité sont compensés par des avantages bien nets découlant d'un environnement plus propre et de meilleure qualité.

ABSTRACT

The purpose of this report is to investigate whether a significant relationship exists between environmental regulation and productivity growth.

The initial section of the study presents a survey of the literature dealing with the impact of environmental regulation on productivity growth. These studies were based upon aggregate data from the United States. While the findings of these studies were not conclusive, they pointed to the importance of undertaking a study using firm or plant level data. In a preliminary feasibility study it was discovered that plant level data for the Canadian brewing industry was available and therefore, that a micro-level study of the impact of environmental regulation in the Canadian brewing industry was possible. In addition, since several brewing plants were subject to a type of effluent charge, known as a sewer surcharge, an investigation of this particular type of environmental regulation could be done. Theoretically, it is suggested that, since the response of firms to economic incentives is probably swifter and more pronounced, the productivity effects would be greater than under the direct regulation enforcement (i.e. the pollution standards) approach which has been the focus of all earlier productivity impact studies.

The remainder of the study presents a description and survey

of sewer surcharge schemes currently in use in Canada and presents estimates of the response of brewing firms to these charges. In addition, the impact of this financial levy on productivity growth in the brewing industry is estimated.

The analysis presented suggests that environmental regulation, of the type investigated here, does induce an abatement response on the part of polluting firms and does tend to reduce productivity growth. This, however, is not necessarily undesirable since accompanying these costs are definite benefits in terms of an improved and cleaner environment.

I. INTRODUCTION

Economic incentive schemes have traditionally been suggested by economists as the appropriate way to deal with environmental problems at stationary sources (Dales, 1968; Baumol and Oates, 1971; Anderson et al, 1977; Tietenberg, 1980). These schemes generally involve a financial penalty imposed on behaviour which is considered undesirable. Two of the more popular examples of these types of proposals are effluent charges and transferable discharge permits (i.e. property rights schemes).

The preference of economists for policies that alter economic incentives follows naturally when one views environmental pollution at a particular source as resulting from the failure of the market to price a scarce input: environmental quality. In essence polluting firms consume this scarce input without having to pay for it. Pollution emissions represent the best observable proxy for this input and thus the pricing of pollution emissions would seem to be a useful way of solving this problem of missing markets. It is argued that if the price imposed per unit of pollution emissions approximates the social damage created by that pollution, then the polluter will be induced to operate efficiently. That is, the polluter will only emit pollution as long as the benefit to him, in terms of foregone abatement costs, exceeds the price of pollution, and hence exceeds the damage created by that pollution. In a partial equilibrium setting, this result is efficient because net social costs including pollution damages plus pollution abatement costs are minimized.

In contrast to the foregoing theoretical approach, environmental protection policy throughout North America has evolved in a direct regulation-enforcement framework. Current policies are based on ambient and effluent standards with, at least in theory, the threat of fines and/or imprisonment available to enforce compliance. This framework often incorporates some form of financial assistance which is meant to defray the cost to the polluter of achieving compliance with environmental regulations.

Typically environmental policies are compared on the basis of their static efficiency implications. It has been suggested that there are also important dynamic consequences of various environmental policies. In particular, it is important to determine the effects of environmental policies on both the rate and direction of technical advance.

In this study we propose to investigate the impact of environmental regulation on productivity growth. While it seems reasonable to assume "...that reductions in pollution per unit of output must be traded off against improvements of productivity..." (McCain, 1978, 546) there has been no empirical attempt to verify this belief or even to determine the magnitude of such impacts. In addition others (Meyers and Nakamura, 1980) have suggested that whether environmental regulation reduces productivity growth or not is an empirical question.

This paper will present an empirical evaluation of the impact of an existing form of a particular environmental incentive on the growth of productivity in the brewing industry. Prior to presenting these results a discussion of the concept of total factor productivity and the current evidence regarding the impact of environmental regulation is presented in Section II. Section III presents a comparison, in static efficiency terms, of various forms of environmental regulation and a discussion of the implications of these forms of regulation for productivity growth. Section IV presents a discussion of various observed applications of an economic incentive scheme which is currently used in certain Canadian jurisdictions: sewer surcharges. A review of the variants of this scheme used in various jurisdictions is provided. Section V presents the model which is used to investigate the impact of these surcharge schemes on productivity growth in the brewing industry.

II. TOTAL FACTOR PRODUCTIVITY

Productivity is typically measured as the ratio of output to inputs. Some of the more commonly used measures of productivity are the single factor productivity indicies (e.g. average productivity of labour) and the total or multi-factor productivity index. The problem with partial measures of productivity growth is that it is often difficult to determine whether they measure technical change, input substitution, etc. As a result the more comprehensive measures, like total factor productivity (TFP) have become popular. The growth of TFP can be defined as the difference between the rate of growth of real output and the rate of growth of real factor inputs (Jorgenson and Griliches, 1967). Thus TFP yields a measure of the growth in output that cannot be explained by the growth in inputs. Conceptually this is sometimes considered to represent a measure of technological advance. As has been pointed out elsewhere, it may also reflect measurement errors (Jorgenson and Griliches, 1967), or a failure to appropriately account for scale economies (Denny, Fuss and Waverman, 1981).

The slowdown of productivity growth since the mid 1970's has been blamed on several factors including energy price increases and increasingly stringent government regulation. With regard to the latter factor, Christainsen and Haveman, (1981a) found that federal regulation in the U.S. was responsible for from 12 to 21% of the slowdown in the growth of labour productivity in manufacturing during the period 1973-77 as compared with the period 1957-65.

Of particular concern here is the impact of environmental regulation on productivity growth. The majority of such studies have been undertaken in the U.S. and with minor exceptions (Kopp and Smith, 1981) they are based on aggregate or macro level data (Christainsen and Haveman, 1981). These studies (Christainsen and Haveman, 1981, 388) suggest that not more than 15% and likely between 8 to 12% of the slowdown in productivity growth can be attributed to environmental regulation in the U.S.

In reality there is a great deal of variation in the estimates of the impact of environmental regulation on productivity growth. This is the result of different methodologies, the use of different time periods and data. One of the more complete analyses can be found in Denison, (1978). Denison's analysis shows that a proportion of the slowdown in productivity growth is due to the diversion of inputs from primary production to pollution abatement. This approach has been criticized on several grounds (Christainsen and Haveman, 1981, 383). One of the primary criticisms is that environmental regulation will affect productivity growth, not only by diverting resources from primary production, but also through its effect on the efficiency of the firms' resource allocation decisions, as well as, through its effect on the allocation of R and D expenditures between primary production and abatement and its impact on the obsolescence of a firm's capital stock.

An alternative approach to estimating the productivity impact of environmental regulations has been used in Crandall, (1981). In this study a cross-section of 36 manufacturing industries were used to regress deviations in productivity growth from the historic trend in industry productivity on pollution control operating costs as a ratio of value added.[1] The results of this analysis proved to be indeterminate.

The problem with many of the studies of the impact of environmental policy on productivity growth is the level of aggregation used. Nadiri (1970) suggests that in general with regard to productivity studies "...the specific results are too sensitive to changes in the types of data and methods of estimation to provide concrete quantitative figures about the contributions of various factors to the growth of output..." (p.1169). This criticism applies particularly to the environmental studies discussed above. It has been suggested that many of the problems inherent in these studies could be overcome if analyses were carried out at the firm or plant level (Kopp and Smith, 1981).

This suggests that empirical analysis of the impact on productivity growth of environmental policy should be undertaken at a disaggregated level in order to avoid the type of aggregation problems discussed by Jorgensen and Griliches, (1967) and that the analysis should be carried out through the estimation of a cost or production function in order to isolate productivity growth from scale effects.

Before presenting evidence regarding the impact on productivity growth in the brewing industry of a particular economic incentive scheme, a comparison of alternate environmental policies is presented in the next section. Productivity is defined in terms of the efficiency with which inputs are transformed into "useful" outputs in the production process. Regulation, by definition, involves an intervention into the market process and hence creates deviations from the usual profit maximizing behaviour. Such alterations will reduce the rate of growth of output per unit of input (i.e. productivity). With regard to environmental regulation, productivity growth will be affected by diverting resources from primary production to abatement, by interfering with the production process and thus reducing the effectiveness of inputs, by channelling R and D expenditures from production to abatement technology, etc. A qualitative analysis of the probable impact of two alternate environmental policies with regard to productivity growth follows.

Before presenting this analysis however an additional point should be made. The analysis thus far suggests that environmental regulation may reduce the growth rate of total factor productivity. This is not necessarily undesirable. Accompanying these costs are definite benefits from cleaner air and water. The analysis which follows ignores these benefits. Any study concerning the overall desirability of environmental regulation must incorporate estimates of these benefits. Thus the purpose of this study is somewhat more limited. In particular, we will attempt to provide some insights into the amount of primary output which is being sacrificed for environmental purposes. In addition, it is possible to compare environmental policies with regard to their costs of achieving predetermined environmental standards and hence to provide some insights regarding the impacts of these policies on productivity growth.

III. A COMPARISON OF EFFLUENT STANDARDS AND CHARGES

A- INTRODUCTION

As has been suggested earlier, there are several ways in which environmental regulation can affect the allocation of resources within and across firms and hence also affect the growth of productivity within firms, as well as, provinces or nations. Part of this effect takes the form of a diversion of inputs from primary production to pollution abatement and may in fact be the result of measurement error. This diversion reflects a movement along the production frontier rather than off the frontier. In reality, increasingly stringent environmental regulation represents an increase in the cost of a socially valuable asset to polluting firms. In response to the increase in the relative price of this environmental asset (i.e. the assimilative capacity of the environment) polluters tend to substitute other inputs (i.e. use labour and capital to abate pollution) for continued use of that asset (i.e. for continued emission of pollution). Thus part of the reduction in productivity growth is the result of a movement along the production frontier induced by the increased cost to firms of using assimilative capacity relative to the cost of other factors of production and resulting from the fact that productivity is defined as the ratio of primary output to conventional inputs (i.e. labour and capital). In fact, the diversion of labour and capital reduces the amount of valuable asset (i.e. environmental quality) consumed by a polluting firm. If the social value of this asset could be determined and if it were included as an input in the calculations, productivity may have in fact risen. Unfortunately it is difficult if not impossible to measure the social value of this asset and thus the traditional approach has been to treat this diversion as a source of productivity slowdown (Denison, 1978). While the traditional approach will be followed here it should be remembered that this diversion merely represents one of the costs of a process which yields definite benefits. The qualitative estimates suggested in this section and the quantitative estimates of latter sections should be interpreted in this light.[2]

In addition to inducing the diversion of conventional inputs, environmental regulation may also effect the efficiency of a production process directly. An example of this would be the impact of environmental regulation on the fuel efficiency of the automobile, ceteris paribus. To the degree that environmental regulations and the resulting abatement equipment interfere with the production process it could have the effect of impeding shifts in the production frontier or actually causing the production frontier to shift in over time.

Effective environmental policies might induce increased research and development into the development of lower cost abatement technologies. This may also have the impact of diverting funds from R and D on primary production technologies and may ultimately slow the rate of productivity growth[3] as conventionally defined.

On the other hand, Meyers and Nakamura, (1980, 463) suggest that increasingly stringent environmental regulation would induce more rapid capital turnover (i.e. modernization) the net effect of which may be an acceleration in productivity growth. Their theoretical analysis is based on a putty-clay model in which substitution of factors is possible prior to investment, but not afterwards. Thus in order to alter factor proportions investment in new vintages must occur. In essence, they argue that, based on their studies of water pollution abatement and factor substitution in manufacturing, this *ex post* assumption of fixed factor proportions is not unreasonable (p.465). As a result environmental regulation raises the unit variable costs of old vintages of equipment more quickly than for new equipment. The result is an added incentive for modernization which would not exist in the absence of this regulation. This suggests that the ultimate impact of environmental regulation is an empirical question depending on which of these effects dominates. As will be seen, however, some *a priori* statements can be made regarding the productivity effect of certain alternate forms of environmental regulation.

In the remainder of this section, a comparison of the current environmental regulation framework, which we will call the direct regulation-enforcement framework[4], and an alternative economic incentive scheme (i.e. effluent charges) will be made on the basis of their likely impact on productivity growth within an individual firm and within a region (i.e. province or nation). In order to determine how these policies would affect productivity growth we must first understand how they effect firm behaviour. In what follows we first define the policies to be discussed, suggest their probable impact on resource allocation and ultimately compare the likely impact of these policies on productivity within a firm and within a region.

B- DIRECT REGULATION - ENFORCEMENT FRAMEWORK

(i) Description

The direct regulation - enforcement framework is the primary form of environmental regulation practised in most provinces and federally in Canada. It generally involves the setting of ambient quality standards which are then used to derive effluent standards at various key point sources. These standards are, at least in theory, enforced by the threat of fines and/or imprisonment. This framework often includes some form of financial assistance which is intended to defray the cost to the polluter of achieving compliance with environmental objectives and regulations. The most popular types of financial assistance in North America include accelerated depreciation allowances on capital expenditures for pollution control, the refund of sales taxes on the purchase of pollution control equipment and direct subsidies on loans for the purchase of pollution control equipment.

Environmental policy, as is necessitated by the federal character of Canada, is a mix of federal and provincial laws. As in other federal jurisdictions, the federal government has the authority to legislate matters of national priority. At the same time, local matters fall within the purview of the province. The division of responsibilities regarding environmental policies between governments is thus blurred.

Historically, the federal government in legislation like the Canada Water Act (1970) and the Clean Air Act (1971) has sought to create national standards and provincial-federal co-operation. As things have evolved, however, the federal government has left much of the initiation and enforcement of environmental programs to the provinces.[5] The Federal Fisheries Act, for example, is enforced in Ontario by the provincial government. The protection of air and water quality in the provinces is therefore generally the responsibility of the provincial government.

Environmental regulation at the provincial levels has been characterized by absolute prohibitions on pollution emissions while elsewhere in the legislation exceptions to the rule are provided. For example, in Ontario's Environmental Protection Act there is a general prohibition against emissions: "...no person shall deposit, add or emit, or discharge a contaminant... into the environment that (a) causes or is likely to cause impairment of the quality of the natural environment for any use that can be made of it..." (Section 13(1)). However, elsewhere in the Act (Section 5) this absolute prohibition is softened: "No person shall deposit in, add to, emit or discharge into the natural environment any contaminant..., in any amount, concentration or level in excess of that prescribed by the Regulations."

These Regulations generally state effluent or discharge standards which may take a variety of forms: total loading (i.e. mass per time period), concentration, technological restrictions, etc. Provisions for financial penalties usually accompany this legislation. For example, penalties under the federal Fisheries Act can be up to $100,000 per day; under the Ontario Water Resources Act and the Environmental Protection Act fines are set as a maximum of $5,000 for the first offence and $10,000 per day for subsequent offences. In practice, however, this route of prosecution is seldom followed and, when it is, the fines usually fall well short of the maximum stated. Estrin and Swaigen, (1978, 148) found that between 1958 and 1972, 11 offenders were fined slightly more than $1,000 each under the Federal Fisheries Act in British Columbia and the Maritimes. In Ontario between 1968 and 1977 there were 17 separate environmentally related prosecutions of pulp and paper mills with fines generally of $2,000 or less (Victor and Burrell, 1981, 145). Dewees, (1980, 14) has concluded that "...while an exhaustive survey has not been undertaken, it is likely that no Canadian jurisdiction has imposed on any industry fines that represent a significant percentage of costs that would be involved in controlling pollution."

In essence the primary source of enforcement is not generated through prosecution and confrontation but rather through a process of bargaining and moral suasion. Given monitoring and legal costs and the limited budget of most environmental agencies a direct confrontation approach involving strict adherence to available standards is likely not a feasible alternative. It has also been suggested that the use of persuasion and bargaining in order to achieve compliance may provide a method of introducing abatement cost considerations into the regulatory process which were ignored when ambient and effluent standards were determined (Dewees, 1980, 12).

This approach to environmental regulation has been described as one of "symbolic actions" (Dewees, 1980, 10). Tough standards which sometimes appear to ignore abatement costs are established in law or in Regulations. The protection of human health is usually an important aspect of these standards. But this is only symbolic. When setting objectives, deadlines and enforcing compliance exceptions are made through bargaining and negotiations. Agreements which may be less restrictive than the letter of the law are made. Implementation deadlines are often deferred. Enforcement through court action and fines is viewed only as a last resort.

(ii) Evaluation

One of the chief criticisms which can be levied against the direct regulation-enforcement framework is that it has not resulted in the timely compliance of major point sources with pollution abatement schedules developed by environmental authorities. It has been argued that this method of regulation instead of providing an incentive to abate has provided an incentive for industries to delay expenditures on pollution abatement (Roberts, 1970, 1528). A firm, in deciding whether to comply with current environmental requirements, will weigh the cost of delay against the rewards of non-compliance. The rewards of non-compliance result from cost savings because research and development may ultimately produce lower cost methods of abatement; more generous financial assistance from governments may become available in the future; and any delay allows a firm to use scarce capital that would have been used to purchase pollution control equipment for profit making investments. In addition, gains also accrue from the savings of operating and maintenance costs which could have been incurred had the appropriate abatement equipment been in place. The costs of non-compliance or delay involve the adverse public reaction and fines which result from prosecution. Given the technical complexity of many modern production processes, however, it is not difficult to give the nominal appearance of co-operation by undertaking successive engineering and cost studies. This will also help high-light technical difficulties which can further aid delaying tactics and help to avoid prosecution. The direct regulation-enforcement approach provides significant rewards for non-compliance and provides insignificant costs from delay.

Thus if a firm does not comply with environmental standards it runs the rather small risk of prosecution and ultimately a fine. But it is unlikely that the magnitude of the fine will exceed the cost savings from delaying compliance. In addition, a firm which exceeds a standard must first be caught, which, if it is one of many firms, is not certain. Even after it is caught, it can probably negotiate if, as in most jurisdictions with finite budgets for environmental litigation, the authority is seeking voluntary compliance. Moreover, where abatement options are costly and uncertain, the firm can be expected to make a good case regarding the unreasonableness and infeasibility of the current requirements. Any delay, whether this delay is the result of litigation or bargaining with the environmental agency has clear and substantial benefits to the polluting firm.

One rationale for financial assistance is that, by reducing the cost of abatement, it tends to reduce the reward to polluters from delaying compliance. But as long as abatement costs remain a substantial net loss item for the firm (as it likely will even with significant tax incentive and subsidy schemes) it is unlikely that financial assistance will have a substantial impact on this tendency to delay compliance.

It is this opportunity for delay which seems to be behind the lack of progress in pollution control at some pulp and paper mills in Ontario.[6] Victor and Burrell, (1981,201) found that while there has been environmental improvement at the industry level, such improvement was achieved at a slower rate than expected and did not reflect a uniform pattern among all mills. The rather slow rate of improvement in this industry can be explained by the ineffectiveness of enforcement activity undertaken by the environmental authorities in Ontario. This is dramatically exemplified by the record of prosecutions and fines brought against mills (outlined earlier), and the history of Control Order Amendments and postponements since 1977, in Ontario.[7]

In 1977, the Ministry in response to the limited success of the regulatory program in use since 1965, put all mills not voluntarily in compliance with agreed upon abatement schedules on

Control Orders. However, since 1977 this approach has been characterized by Control Order Amendments and postponements in response to requests by the mills (Victor and Burell, 1981,144). This evidence is entirely consistent with Roberts' (1970) suggestion that the direct regulation-enforcement framework provides an incentive for industries to delay expenditures on pollution abatement.

As further evidence of the failure of the direct regulation-enforcement framework to induce compliance in the pulp and paper industry in Ontario the following facts have been noted by Victor and Burrell (1981):

(i) Between 1973/74 and 1975/76 the number of mills in Ontario in compliance with federal toxicity requirements rose from one to nine and remained unchanged to 1978. This number represents only about 1/3 of the pulp and paper mills in Ontario (p.28).

(ii) In 1965 the Ontario Water Resources Commission sent a directive to all pulp and paper mills in Ontario requiring that the level of suspended solids in waste emissions be reduced to 50 mg/L by December 31, 1966. By 1978 the average discharge from the industry in Ontario contained nearly 110 mg/L of suspended solids: more than double the level required by 1966. In addition, it should be noted that the industry has progressed more quickly with regards to the abatement of suspended solids than with respect to the control of BOD or toxic elements (p.128).

While the Control Order Amendments and postponements mentioned above may have legitimately resulted from technical difficulties, this does suggest another weakness in the direct regulation-enforcement framework: it does not provide an incentive for technical innovation or advancement. Research and development could result in advancement which would overcome the technical difficulties that have required these amendments and postponements. Unfortunately, it is not in the interest of polluters to overcome these difficulties or at least, to expend resources in attempting to do so. In addition, any advancement which might result from such research might be imposed on the firm when Control Orders are renewed. This is not likely to be desirable from the firm's point of view, since it increases the firm's capital outlay with no corresponding increase in profits. Thus there is little incentive for polluting firms to conduct serious research into pollution abatement techniques under the direct regulation-enforcement approach.

In addition, under the direct regulation-enforcement approach there is a tendency to set stricter quality standards for new sources than for existing sources. For example, the Pulp and Paper Regulations under the federal Fisheries Act sets standards which allow 50% more emissions from existing than new mills. This makes economic sense where new plants can be built to take advantage of economies of scale or install less pollution intensive processes. This differentiated regulation however, provides an incentive for firms to continue to operate obsolete facilities, rather than to replace them with new facilities. In this way firms can delay compliance with the more stringent environmental standards which apply to new facilities. Such a policy can, over time, result in an adverse impact on productivity growth, and in the short-run, could actually result in an increase in pollution emissions (Gruenspecht, 1982). In addition, such a policy would tend to neutralize the tendency, towards modernization induced by environmental regulation suggested by Meyers and Nakamura, (1980).

The direct regulation-enforcement framework is often supplemented with various forms of financial assistance. A major source of financial assistance available to firms in Canada has come from tax provisions intended to encourage expenditures on pollution abatement equipment.[8] From the point of view of efficiency, this type of financial assistance may have some undesirable effects. Because the tax concessions can be applied only to capital expenditures, a firm will have an incentive to adopt abatement techniques which require substantial amounts of abatement equipment, even if this is not the least cost way of achieving pollution reduction. An example of the perverse incentive created by tax provisions, like accelerated depreciation, is presented in Roberts, (1970, 1533):

> "Suppose...a firm has a choice between two methods of abatement. One method involves purchasing significant amounts of land on which to construct treatment ponds. The other method is to buy a set of mechanical devices. Under current tax law, the investment in mechanical devices would be depreciable, while the investment in land would not. Thus, considering tax breaks, the mechanical approach might cost the firm less than the land-use approach, while the real cost to society, i.e. the cost before taxes, of the land purchase method, would have been cheaper."

These tax provisions may also bias abatement choices away from least cost techniques which have high operating costs or which involve process changes if, as is often the case, the tax break applies only to facilities and equipment designed specifically for pollution abatement.

(iii) Conclusions

The direct regulation-enforcement scheme is open to two separate sources of criticism each of which has opposite consequences for productivity:

(a) This approach provides an incentive for firms to delay compliance by using technical and economic arguments. To the extent this is true, environmental regulation would impose few productivity penalties on polluting firms. Firms would tend to spend very little on equipment which could be defined purely as abatement equipment and as a result the diversion of inputs and the interference with the efficiency of the production process would be minimal. In addition, the diversion of R and D expenditures into the development of abatement technology would not be expected nor would any tendency towards increased modernization.

(b) To the degree that this approach does induce compliance, it is not clear that the achievement of environmental quality standards is being achieved in a cost effective way. First, there is no guarantee that any overall environmental standard will be achieved at least cost when this framework is used. A cost effective scheme would require equating the incremental cost of improving environmental quality (with regard to a single pollution parameter, say sulphur dioxide) at all point sources.[9] The fact that abatement costs are not an intricate part of standard-setting ensures that cost effectiveness is not a likely outcome of this process.

In addition, to the extent that the financial assistance schemes offered are effective they also mitigate against the least cost solution. Both of these tendencies will result in larger than required diversions of conventional inputs to abatement and away from primary production. As well, the impact of differentiated regulation between old and new point sources would likely have adverse impacts (as suggested above) on productivity growth.[10]

The available empirical evidence seems to favour the previous type of criticisms. The evidence from the U.S. on the impact of the direct regulation-enforcement framework on productivity growth seems to indicate that it is responsible for from 5-15% of the slowdown in productivity growth (Christainsen and Haveman, 1981, 387). The upper end of this scale comes from the Denison studies (1978;1979). It has been suggested, however, (ibid), 383) that these studies yield overestimates of the impact of environmental regulation in the U.S.. One of the primary criticisms has been that the environmental cost data used were taken from employer surveys and thus would be biased upwards. New equipment which yields fewer residuals would tend to be recorded as primarily abatement equipment.[11] In addition the evidence in Canada with regard to INCO and the pulp and paper mills, discussed above, might lead one to conclude that the current direct regulation-enforcement approach does not and has not provided a significant threat to productivity growth in Canada or the U.S. A similar conclusion is hinted at for the U.S. in Christainsen and Haveman, (1981, 388):

> "...the evidence on the adverse impact of environmental regulations on the capital stock and its productivity appears very weak. Environmental regulations can have major adverse output and productivity impacts on certain sectors or industries. These impacts tend to be localized, however, and because of the small size of these sectors relative to the national economy, they appear to have a rather trivial impact on macroeconomic performance."

Of course if the preceding hypothesis that current enforcement procedures are ineffective is correct this does not imply that the impact of an effective environmental policy on productivity growth would also be trivial. Many economists have suggested the use of economic incentives as a means of overcoming the ineffectiveness of the direct regulation-enforcement framework. Because the impact of these economic incentive schemes on the allocation of resources is generally felt to be substantial relative to the current approach, one might also expect the productivity impacts to be substantial.

C. ECONOMIC INCENTIVE SCHEMES[12]

(i) Introduction

Due to the costly nature of pollution abatement, compliance with environmental standards is not likely to occur unless the failure to control pollution is made still more expensive. While the direct regulation-framework, even when complemented by substantial financial assistance, seems to fail, it is often argued that economic incentives, when properly applied, may induce more timely compliance. It is also argued that these economic incentives can achieve desired levels of abatement at costs that are substantially less than those that would be incurred if compliance were forthcoming under the direct regulation-enforcement framework.

Economic incentive schemes require the legislative authorization of a financial charge on environmentally harmful conduct (Anderson et al, 1977, 1). One of the basic prototypes of this scheme is the effluent charge scheme. Effluent charges involve the imposition of a financial charge on each unit of pollution emissions discharged. A more detailed description and evaluation of this economic incentive scheme follows.

(ii) The Effluent Charge Scheme

(a) Description: The theoretical basis for an effluent charge scheme derives from the failure of the market to place a price on environmental services. The environment is an asset which yields waste assimilative services to users (e.g. pulp and paper mills, municipal sewage treatment plants, smelters, etc.). Problems arise to the extent that the asset is scarce. More services to firms (i.e. more waste emissions by firms) lead to less environmental quality and hence fewer recreational and other services available to other users. The failure of the market to reflect this opportunity cost, or these damages, in a price for these waste assimilative services, induces their overuse by polluters. Efficiency requires that firms internalize the damages which result from their pollution emissions when making their production decisions. Otherwise, the tendency would be for polluting firms to underestimate the costs of production and hence to overproduce. A charge per unit of pollution equal to the social damage of that unit of pollution will thus solve the environmental problem. This is the basis on which effluent charges were initially suggested.

In order to implement such a scheme, important compromises are required. In particular, because pollution damages are almost impossible to compute, another approach to setting effluent charges must be adopted. Despite these compromises many economists argue that a charge scheme still compares favourably with the direct regulation-enforcement framework (Anderson, et al 1977).

A workable effluent charge can be designed to achieve a predetermined environmental standard. This scheme involves setting a uniform charge per unit (i.e. pound, ton, etc.) of a particular type of pollutant (e.g. SO_2, particulates, etc.) on all major polluters in order to achieve some overall standard. It is important to the understanding of this and other economic incentive schemes to realize that cost minimizing firms will abate pollution in response to such a charge. A firm will continue to abate additional units of pollution as long as the cost of doing so (i.e. the marginal cost of abatement) is less than the effluent charge. In theory, the individual firm will abate until the marginal cost of abatement (i.e. the cost of removing an additional unit of pollution) equals the charge.[13]

While a uniform charge is set for each point source, a different charge would likely apply to each pollutant included in such a scheme. The overall standard must be determined by the environmental authority and should be stated as the amount (i.e. pounds, tons, etc.) of a particular pollutant (e.g. SO_2) which can be emitted into the environment over a certain period of time. For example, the overall standard might be such that all major SO_2 emitters in a region would be allowed to emit one million tons of SO_2 into the air per year. This "standard", however, would not be translated into a restriction on the emissions of any particular point source. The method of achieving this standard would be to set an effluent charge and to alter this charge each time period,[14] until this overall standard is achieved.

A further implication of this scheme is that over time the charge would have to be adjusted to maintain the overall standard in order to compensate for inflation and growth (Fisher, 1981). Continuing inflation would mean a decline in the real value of the charge, if its nominal value is fixed. This would result, eventually, in emissions in excess of the desired level in particular years. Incorporating an escalator clause that would cause the nominal charge to vary with the annual inflation rate would largely overcome the possibly costly necessity of annually altering the charge by administrative decree, in order to incorporate the effects of inflation.

Growth of output over time, and the resulting increase in the production of polluting by-products requires increasingly stringent abatement, if the overall standard is to be maintained (Magat, 1978). The incentive to increase levels of abatement may require increases in the real value of the charge.[15] Thus the charge might have to be adjusted upwards by administrative decree. The signal for such an adjustment would be given when emissions from the relevant point sources, in aggregate, exceed (or fall short of) the desired standard.[16] The charge would then be adjusted in order to achieve the overall standard.

This system must obviously be supplemented by a monitoring program. The purpose of monitoring in this case is not to detect violations at individual sources but rather to determine the total emissions from each point source per year (i.e. per time period, where the time period in question is the one over which the overall standard has been set). This would likely require taking a number of random samples of emissions from each point source which would then be used to statistically estimate the total emissions from that source during a particular time period. This data would then serve two purposes:

(i) when aggregated for all relevant sources it shows whether the overall standard is being met and hence whether the charge should be altered;

(ii) it is used to determine the payment by individual point sources which can be calculated as the charge times the calculated emissions from the point source.

The revenue generated by this scheme once the optimal charge[17] has been set can be calculated as the product of this charge and the overall standard. Of course, in transitional years, as the charge is being iterated, revenues could be larger or smaller than this amount.[18] These revenues would be used to finance environment programs such as stream re-aeration, altering stream flow, and financing collective abatement facilities, as well as, to finance the administrative and monitoring costs of the governments environmental program. Residual funds could also be used to finance research into abatement technologies.

(b) Evaluation: This variant of the effluent charge scheme compares favourably with the direct regulation-enforcement approach. Unlike the latter approach there is no incentive under an effluent charge to delay the installation of abatement equipment. While failure to install abatement equipment does result in the same type of cost savings described in the previous section, it also results in a larger effluent charge bill. While there is no incentive for bargaining or delay of compliance once the charge has been set, there will likely be bargaining over the imposition of the charge: whether this type of scheme should be imposed and what the initial level of the charge should be.

The effluent charge scheme represents a decentralized method of control. Once the charge is set it is up to the firm to decide how to reduce pollution emissions. There are usually several possibilities: end-of-pipe treatment, process change, output reductions, input substitutions, change in product mix, etc. One reputed advantage of these decentralized economic incentive schemes is that it is the firm which chooses the appropriate abatement methodology and the firm will obviously do so in a manner which will minimize the social cost of achieving a given level of abatement. Under the centralized methods used in the direct regulation-enforcement framework, in which a plant is sometimes ordered to adopt a particular abatement technology, the flexibility the firm enjoys under the effluent charge scheme, with respect to choice of abatement technique is somewhat reduced. As a result abatement cost at a point source will likely be higher under the direct regulation-enforcement framework.[19]

A popular criticism which has often been levied against economic incentives and, in particular effluent charges, is that they provide a licence to pollute. It is often contended by legislators and environmentalists that faced with a charge, firms will merely pay the charge and continue to pollute (Kelman, 1981). The empirical evidence, however, does not support this contention.

Much of the available evidence can be found in studies of a prototype of the effluent charge called sewer surcharges. The particulars of this scheme are discussed in the next section.

In one study of poultry processing plants located in various U.S. cities Ethridge, (1972) found that for every 1% increase in surcharge rates BOD discharges per 1000 birds fell by .5%. Elliott and Seagraves, (1972), in a study of the overall impacts of these sewer surcharges in various U.S. cities, also found that industrial BOD emissions appeared to respond negatively to the level of the surcharge. A 1% increase in the surcharge rate in a typical city was found to result in a .8% decline in industrial BOD emissions. Sims, (1979) found considerable abatement responsiveness to surcharge schemes by breweries located in various Canadian cities. A 1% increase in the surcharge rate on BOD would lead to a .573% decline in BOD emissions from a typical brewery.

Another analogue to the effluent charge scheme is the beverage container deposit scheme currently in use in various North American jurisdictions. This scheme acts like an effluent charge on solid waste. The deposit paid by consumers is refunded when empty bottles or cans are returned. Thus persons who add these containers to the solid waste stream in essence pay a charge, in terms of foregone revenues. Such a plan has been adopted in Oregon, where a deposit of two cents is required on reuseable bottles and five cents on all other containers. Various studies suggest that these rather limited charges have been quite effective in limiting the can and bottle component of the solid waste stream. In particular the returns of refillable beer bottles has increased from 31% to 96% of the market. In addition, bottle and can litter decreased by over 65% in the year after the introduction of this scheme in Oregon (Anderson et al, 1977, 68-71).

These studies all provide evidence of a substantial responsiveness to economic incentives, and in particular to various analogues of the effluent charge. Based on this evidence arguments that effluent charge schemes and economic incentives in general merely provide a license to pollute seem somewhat questionable.

With respect to cost effectiveness[20] and informational requirements, it has long been maintained that market-type schemes and especially effluent charges have advantages over the direct regulation-enforcement framework.[21] The argument that is usually made involves comparing the cost effectiveness a single effluent charge and a uniform effluent standard in achieving a total reduction in the emissions of a particular pollutant. The effluent charge is adjusted until the required quantity of abatement is achieved. With the uniform standard, total abatement is divided equally among all of the point sources. Provided all point sources do not have identical control cost functions the costs of achieving a given level of abatement will always be minimized with the charge.[22]

There are at least two problems with this argument:

(1) an effluent standard which is cost effective could obviously be designed;

(2) the cost-effectiveness of these single price market schemes disappears when firm location and pollution dispersion become important as they undoubtedly are in the real world.

The first problem ((1) above) implies correctly that almost any environmental policy can be cost effective and as a result the relevant question involves the informational requirements for such schemes to be cost effective. If our goal is the reduction of a particular quantity of a pollutant, (i.e. for the moment we ignore problem (2)) then to achieve this with a standard would require knowledge of the abatement cost at each point source. Alternatively one could iterate a single effluent charge until the standard is achieved. While, in theory, this does not require knowledge of the cost curves, in practice it probably does. If a charge is set too high and the polluter is induced to adopt a lasting and incorrect or inefficient method of pollution abatement the iterations will not induce an alteration to the appropriate technology for some time. The costs in the interim could be excessive. Therefore even the pollution charge scheme requires some knowledge of costs.

In most real world pollution situations it is not clear that the appropriate goal is the reduction of a given quantity of pollution. In some circumstances it may be that the appropriate goal is a certain level of ambient air quality at selected points. The difficulty with this is that a pound of emissions from various firms does not have the same impact on air quality at a given receptor point. The impact of the emissions depends on things like firm location and meteorological conditions. As a result cost effectiveness requires spatially differentiated effluent charges.

Where the appropriate environmental goal is an ambient standard, a uniform charge of the type described above will not, in general, be cost effective (i.e. the ambient standard will not be achieved at least cost). There are, however, obvious administrative advantages to a uniform, rather than a spatially differentiated, charge. The empirical evidence on the cost advantage of a spatially differentiated charge over a uniform charge is mixed. Atkinson and Lewis, (1974) found that incorporating spatial and meteorological aspects into an effluent charge scheme resulted in substantial cost savings, on the order of 50%. In a more recent study Eheart, (1980) found that the cost advantage of a differentiated charge scheme over a uniform charge in achieving a uniform standard was minimal and never exceeded 3% at various levels of disolved oxygen at a receptor in the Willamette river.[23] More work is obviously required on the cost advantage of differentiated versus uniform charge schemes.

The available empirical evidence does, however, suggest that an improvement in ambient quality in a region can be achieved more cheaply with a uniform charge than with uniform direct controls (i.e. effluent standards). In a study of the Delaware Estuary (Kneese, 1977) it was found that the cost of achieving an ambient water quality standard of 3-4 ppm of disolved oxygen was $20 million annually with uniform treatment (i.e. the same percentage reduction at all point sources). Whereas with a uniform effluent charge the same ambient water quality level could be achieved at a cost of $12 million per annum.[24] Some of the theoretical complications engendered by incorporating spatial and meteorological or hydrological aspects into the environmental goals are discussed in Tietenberg, (1978;1980).

Effluent charges are also reputed to compare favourably with the direct regulation-enforcement framework with regard to the impetus for technical advancement (Fisher 1981, 191). With the direct regulation-enforcement framework there is no incentive to reduce emissions below that required in the legislation. With an effluent charge, however, that incentive, along with the incentive to adopt innovations which reduce the costs of achieving a given level of abatement, is present. Innovations which allow the achievement of higher degrees of abatement are advantageous to the firm, no matter what the current level of emissions, since it allows the reduction of the total effluent charge payments. The hesitancy towards innovation which exists under the direct regulation-enforcement framework does not appear to be present with the effluent charge scheme.

It is sometimes argued that market schemes like effluent charges are administratively infeasible because they require continuous monitoring (Drayton, 1978). In fact, in actual applications of effluent charge schemes in Europe and in North America (i.e. sewer surcharge schemes) continuous monitoring is not employed. It seems clear that proportional monitoring could be used to determine a reliable estimate of emissions from major point sources. There is always some statistically defined optimal sample size depending on the distribution of emissions, the variance of the distribution and the required degree of accuracy, which when collected will provide a dependable estimate of the total quantity of emissions from a particular point source. One might even argue that if continuous monitoring is ever required it would occur with effluent standards which are set in concentration terms. If, as seems clear, courts levy fines which are no greater than the damages of pollution offences, then in order to induce compliance, a polluter must be caught almost everytime it is in excess of the standard (i.e. the probability of being fined must approach 100%). Because in most economic incentive schemes all that is required is an estimate of the overall quantity of emissions continuous monitoring is not required.

Also for some types of pollutants, determining overall emissions is relatively simple. For example, at a thermal power plant, total SO_2 emissions can be calculated given information on the sulfur content of the fuel burned, the amount of fuel burned and the quantity of SO_2 gathered in pollution control equipment. This type of materials balance approach to monitoring is currently used in Ontario to verify monitoring reports received from various point sources.

There are, however, several practical problems with an effluent charge scheme. As suggested in the previous section, the charge may have to be adjusted at regular intervals to maintain a given effluent standard as growth occurs. If it is administratively difficult or infeasible to alter charges at regular intervals this scheme would, <u>ceteris paribus</u>, lead to a growth in emissions over time (Magat, 1978).

In addition, the revenues generated by effluent charges may reputedly result in various negative local economic impacts. These local economic effects include plant closings, production cutbacks, price increases and layoffs as a result of the effluent charge payments made by polluters and the resulting cost increases. One study by Palmer et al (1980) found that the direct regulation-enforcement framework applied to certain pollutants in a particular region resulted in aggregate abatement costs of $230 million. A system of effluent charges reduced the abatement cost of achieving the same quantity of emissions to $110 million. The amount paid by the firm on remaining emissions was $1400 million, more than enough to wipe out any advantage the effluent charge created in terms of lower abatement costs. This may also explain industrial opposition to charge schemes.

(c) Conclusions: It seems clear that the type of economic incentive scheme (i.e. the effluent charge scheme) discussed above can have a substantial impact on resource allocation and hence on productivity growth in a firm and within a region. Such a scheme not only provides a greater inducement to abatement, thus resulting in a greater diversion of conventional inputs away from primary production but also provides a greater impetus to the diversion of R and D expenditures towards abatement technology. The analysis here suggests the qualitative possibility of such effects.

Our concern in the remainder of this study will be with the impact of a type of effluent charge scheme which is currently imposed in various Canadian jurisdictions on waste emissions, by industrial polluters, to the municipal sewer system. An analysis of brewing firms, some subject to this type of charge, others subject to little or no environmental regulation, should provide important insights as to the likely impact of this type of regulation on productivity growth. A more detailed discussion of the sewer surcharge scheme and the form these charges take in various Canadian jurisdictions follows.

IV. SEWER SURCHARGE SCHEMES IN CANADA

A. INTRODUCTION

An effluent charge is a financial levy which certain firms must pay per unit of pollution emissions. Economists argue that imposing a price on pollution induces a firm to prevent excessive waste emissions (i.e. to abate pollution). They also argue that effluent charges are superior to other administrative techniques such as pollution standards or subsidies. Despite this general acceptance by economists, effluent charges have not historically been a major component of environmental programs in Canada. Recently however, the idea of charging for pollution has been instituted in several jurisdictions. These charges have generally been based on the emissions of industrial polluters into sanitary sewers.

This section describes and compares sewer effluent charge schemes currently in use in Canada. The jurisdictions surveyed include Winnipeg, Manitoba; Edmonton and Calgary, Alberta; and London, Kitchener and Toronto, Ontario. While this does not represent an exhaustive list of jurisdictions, which have instituted sewer effluent charges, it does include those areas, which have had the most experience with them.

The sewer effluent charge schemes currently used in Canadian jurisdictions generally involve two components: a sewer service charge and a sewer surcharge.

The sewer surcharge is a unit charge levied against "extra-strength" emissions by certain industrial polluters. "Extra strength" emissions are those which exceed certain legislated limits on concentration. For example, the allowable or legislated level of biochemical oxygen demand (BOD) in London, Ontario is 300 parts per million (ppm). This means that for every million pounds of sewage emitted a surcharged firm can dump 300 pounds of BOD into the sanitary sewers without any surcharge payment. If a firm's average BOD concentration in its waste emissions was 450 ppm, a surcharge would be paid only on 150 pounds of a total of 450 pounds emitted for every million pounds of sewage discharged. The total surcharge paid by a representative firm is determined by multiplying the surcharge rate times the volume of waste emissions (or some proxy for this volume) emitted into the sanitary sewer system. The surcharge rate is based on the strength of certain pollution parameters, such as BOD, suspended solids (SS), grease and phenols, above the legislated or "normal" concentrations. This is equivalent, as will be shown in section B, to levying a charge per pound of "extra strength" pollution.

The sewer service charge is a charge levied to cover the costs of treating "normal" strength wastes.[25] This charge is normally paid by all users of the sanitary sewer system, including residential households. In most cases these charges comprise either part of the polluter's water bill or part of his property tax rate. At any rate, unlike the surcharge, it does not necessarily vary with the pounds of waste emitted. For example, assume a sewer service charge of $.28 per 1000 gallons of water consumed in a particular jurisdiction, say London, Ontario. If two firms each consumed 20 million gallons of water their sewer service charges would be equal at $5,600 per annum. Yet if the concentration of BOD in waste emissions was 250 ppm for firm 1 and 300 ppm for firm 2, then firm 1 would be emitting 50,000 pounds of BOD while firm 2 would be emitting 60,000 pounds of BOD. Neither firm would pay a surcharge.

In the remainder of this section sewer effluent charge schemes presently being administered in Canada will be described and compared.

B. A SURVEY OF JURISDICTIONS

(i) London, Ontario

The sewer effluent charge scheme in London Ontario was instituted in March 1971 with the passing of by-law W-731-137. This provided for sewer surcharges on industrial waste emissions into the municipal sewerage system. In May 1974 the surcharge formula was amended with the passing of by-law W-731(a)-268.

The London scheme provides only for the payment of a sewer surcharge by certain large industrial polluters, with sewer service or rental charges on normal strength wastes paid with property taxes.

The surcharge in London, Ontario was imposed on the emissions of biochemical oxygen demand (BOD) and suspended solids (SS) by large industrial polluters. In addition,[26] certain standards have been set with respect to fats, oils, grease, temperature, pH, etc. that are discharged in sufficient quantity to interfere with the sewage treatment process. The charges for BOD and SS are imposed for discharges with concentrations in excess of 300 and 350 parts per million (ppm) respectively. As a result of allowing emissions with concentrations below a certain level free, charges like the ones imposed in London are called surcharges. Section 3(g) of by-law W-731-137 for the city of London states:

"If the discharge of wastes are of such unusual strength or character in respect to biochemical oxygen demand (BOD) and/or suspended solids (SS), that compliance with this by-law is not possible, the Corporation of the City of London may agree to supply special treatment, subject to payment therefore as provided in section 7, hereof."

Section 7 outlines the charge (or surcharge) imposed on excess strength waste. The charge attempts to cover the costs of treating these excess strength industrial wastes at the sewage treatment plant. In the legislation, no emphasis was placed on the deterrent aspects of the surcharge with respect to industrial emissions.

The formula outlined in section (7) and in effect prior to 1974 was:

$$SCH_i = (1/2)\{(C/10bq)(10i_b w_i/10^6) + (C/10sq)(10i_s w_i/10^6)\} \qquad (1)$$

where C is the average cost of operating the sewage treatment plant for the previous 3 years in dollars;

b is the weighted average BOD in ppm of influent flows to the sewage treatment plants for the previous year, less 15 ppm;

s is the weighted average of SS in ppm of influent flows to the sewage treatment plants for the previous year, less 15 ppm;

q is the total flow to the sewage treatment plants for the previous year in millions of gallons (m.g.);

w_i is the waste flow in gallons per annum to be used in the levy against firm i;

i_b is the 5 day BOD in ppm at firm i determined from composite samples, minus 300 ppm;

i_s is SS in ppm at firm i determined from composite samples, minus 350 ppm;

and SCH_i is the annual levy against firm i in dollars.

From this formula the charge in dollars per pound of pollutant (BOD for example) is:

$$x = (1/2)(C/10bq) \qquad (2)$$

where 1/2 represents the portion of treatment costs allotted arbitrarily to the treatment of BOD;

10 is the approximate number of pounds in an imperial gallon;

and x represents the estimated cost per pound of BOD treated.

The number of pounds of BOD that firm i must pay the charge on is determined according to:

$$V_b^i = (10 i_b w_i/10^6) = (bod_i - 300)(10 w_i/10^6) \qquad (3)$$

where $i_b = bod_i - 300$, and bod_i is the average concentration of BOD emissions from firm i in ppm;

and V_b^i is the number of pounds of BOD discharged for which firm i must pay a charge.

According to the formula for V_b^i, each firm must pay only for emissions with BOD concentrations in excess of 300 ppm.[27] This is equivalent to allowing firm i to emit z_i pounds of BOD free of charge, where:

$$z_i = 300(10 w_i/10^6) \qquad (4)$$

Thus if firm i discharges 2 million gallons of water per annum it could theoretically emit 6000 pounds of BOD to the sewer system without incurring any sewer surcharge costs.

After 1974 the surcharge formula used in London was changed. le the new surcharge is based on a charge per unit volume of ıge, it can be shown that this new formula is merely a variant :he "old" formula. One can thus still determine a charge per ınd of BOD and per pound of SS.

The new surcharge formula which came into effect in London 974 with by-law no. W-731(a)-268 is:

$$SCH_i = Q_i\{f_b(B_i-B_m)/(B_m)+f_s(S_i-S_m)/(S_m)\}(T_o/100) \quad (5)$$

: Q_i is the quantity of sewage in thousands of imperial gallons discharged by firm i;

f_b is the proportion of costs allocated to the cost of reducing BOD (Note: in London f_b is assumed equal to .5);

f_s is the proportion of costs allocated to the cost of reducing SS (Note: In London f_s is assumed equal to .5);

B_i is BOD in ppm determined from composite samples from firm i;

S_i is SS in ppm determined from composite samples from firm i;

B_m is by-law maximum limit BOD = 300 ppm;

S_m is by-law maximum limit SS = 350 ppm;

T_o is the operating costs of sewage treatment, in cents per thousand imperial gallons of sewage, based on the costs for the year for which the surcharge is being levied;

SCH_i is the annual levy against firm i in dollars.

This is to be compared with the old surcharge formula. In the old formula:

$$Q_i = 10^3 w_i/10^6 \tag{6}$$

Therefore:

$$\begin{aligned} SCH_i &= f_b(B_i - B_m)(T_o/10^2)(10^2/B_m)(w_i/10^6)(10) \\ &+ f_s(S_i - S_m)(T_o/10^2)(10^2/S_m)(w_i/10^6)(10) \end{aligned} \tag{7}$$

In the old formula:

$$10^3 T_o q/10^2 = C \tag{8}$$

Therefore:

$$T_o = C/10q \tag{9}$$

Hence:

$$\begin{aligned} SCH_i &= f_b(C/10B_m q)(10 i_b w_i/10^6) \\ &+ f_s(C/10S_m q)(10 i_b w_i/10^6) \end{aligned} \tag{10}$$

where $f_b = f_s = 1/2$

$i_b = B_i - B_m$

$i_s = S_i - S_m$

Therefore the only difference between the new and old formulae is in the substitution of B_m and S_m for b and s respectively. Since these are variables over which individual firms exhibit no control, it is not expected that the allocative effect of the formulas will be dissimilar.

On the other hand, in years in which $B_m > b$ and $S_m > s$ the implicit charge per pound of BOD and per pound of SS will be lower under the new formula, ceteris paribus.

It may be argued that since B_m and S_m are more stable magnitudes than b and s this change introduces more stability into the charge per pound of pollutant from year to year.

From equations (2) and (9) we can see that:

$$EC_b = f_b(T_o/B_m)$$
$$EC_s = f_s(T_o/S_m) \qquad (11)$$

where EC_b is the implicit charge in dollars per pound of extra-strength BOD;

and EC_s is the implicit charge in dollars per pound of extra-strength SS.

In 1982 the charges in London per pound of BOD and SS were:

$$EC_b = (1/2)(42.0/300) = 7.0¢$$
$$EC_s = (1/2)(42.0/350) = 6.0¢$$

where $f_b = f_s = 1/2$

$T_o = 42.0$

$B_m = 300$

$S_m = 350$

(ii) Winnipeg, Manitoba

The first sewer effluent charge scheme in Canada was instituted in Winnipeg, Manitoba on January 1, 1958. By-law 80 provided effluent charges for industrial waste emissions to sewers or rivers within the district. In addition by-law 65 set the following limits on various pollutants: 300 parts per million (ppm) for BOD, 350 ppm for SS, and 100 ppm for grease. As a result of establishing a metropolitan government these by-laws were incorporated into by-law 12 in 1961. Further changes were made in 1967 with the adoption of by-law 1239.

The Winnipeg scheme provides a sewer service charge based on the annual capital and operating costs of treatment facilities per 1000 gallons of sewage treated. This charge is paid on metered water consumption.

The surcharge scheme is applied only to certain industries in Winnipeg. The surcharge is paid only on extra strength wastes i.e. those emissions with concentrations of BOD, SS and grease in excess of 300 ppm, 350 ppm and 100 ppm, respectively. In order to gain permission to emit these extra strength wastes a firm must first obtain a license, which requires that a firm fulfill certain conditions outlined in the by-laws.

The total surcharge for a representative firm is determined as follows:

$$SCH_i = Q_i R_i \tag{12}$$

where Q_i is 1000's of imperial gallons of sewage emitted into the sanitary sewers by firm i;

R_i is the surcharge in cents per 1000 imperial gallons of emissions by firm i;

and SCH_i is the total surcharge in cents paid by firm i.

The surcharge rate is determined as follows:

$$R_i = \{f_b(B_i-B_m)/(B_m) + f_s(S_i-S_m)/(S_m)\}T_o + (C_i-C_m)T_c/(C_m) + (X_i-X_m)T_x/(X_m) \tag{13}$$

where f_b, f_s, B_i, B_m, S_i, and S_m, are defined as in the London surcharge scheme;

T_o is as defined in the London scheme but also includes some of the sewage treatment plant's capital costs;

C_i is the chlorine demand in ppm in the industrial waste;[28]

C_m is the chlorine requirement in ppm in the sewage serving as base or normal;

X_i is any substance (for example, grease) requiring additional treatment in ppm in the industrial waste;

X_m is the base or normal concentration of X_i in ppm;

T_c is the unit charge based on the cost of required chlorine as set out in the allocation and precepts by-law;

T_x is unit charges based on cost of treating any substance requiring additional treatment.

This formula is similar in structure to that of London, Ontario and thus the surcharge could be stated implicitly as a charge per pound of the various pollutants. In Winnipeg in 1982 these implicit charges per pound of BOD and per pound of SS were:

$$EC_b = f_b(T_o/B_m) = .50(13.1/300) = 2.18¢$$

$$EC_s = f_s(T_o/S_m) = .50(13.1/350) = 1.87¢$$

where $f_b = .50$

$f_s = .50$

$T_o = 13.1$

$B_m = 300$

$S_m = 350$

(iii) Kitchener, Ontario

The city of Kitchener first imposed a sewer effluent charge scheme in 1972 by passing by-law 7439. The scheme is now controlled by the Regional Municipality of Waterloo under by-law 29-73 and is being expanded throughout that region.

The Kitchener-Waterloo scheme is an exact replica of the Winnipeg scheme except that the surcharge is based only on BOD and SS.[29] As with the Winnipeg scheme there is a sewer service charge based on water consumption and paid with the utility bill. The sewer service rate in Kitchener in 1975 varied from 34.9¢ to 50.6¢ per 1000 gallons of water consumed,[30] but now is calculated as 100% of a firm's water bill.

The authorities in the Waterloo region monitor each surchargeable firm's waste emissions twice each quarter.

In 1982 the implicit charges per pound of BOD and per pound of SS were:

$$EC_b = (1/2)(36.07/300) = 6.01¢$$

$$EC_s = (1/2)(36.07/350) = 5.15¢$$

(iv) Edmonton, Alberta

The sewer effluent charge scheme in Edmonton consists of both a sewer service charge and a sewer surcharge. The sewer service charge is levied per 100 cubic feet of water consumed and is levied monthly with the water bill. The sewer surcharge affects only certain industrial polluters. It was introduced in December 1959 in by-law 1978. The charge was levied only if concentrations exceeded limits set out in section 506 of this by-law. Initially these limits were 1000 ppm for BOD, 750 ppm for SS and 300 ppm for grease and oil.

If any of these limits were exceeded the polluter was charged N x 6¢ per 100 cubic feet of water consumed where N is determined as follows:

$$N = 1 + (x/3000) + (y/2250) + (z/900) \qquad (14)$$

where N is the multiplier of the standard 6¢ rate for water;

x is the difference between the actual BOD in ppm and the allowable BOD in ppm;

y is the difference between the actual suspended solids in ppm and the allowable suspended solids in ppm;

and z is the difference between the actual grease in parts per million and the allowable grease in ppm.

Note that the addition of one to the right-hand side of the equation indicates only that surcharged firms also pay the sewer service charge.

In 1960 the allowable concentrations of pollution fell to 700 ppm for BOD, 400 ppm for SS and 200 ppm for grease. In 1975 these were again amended to 500 ppm, 350 ppm and 150 ppm respectively. Currently the allowable concentrations are 300 ppm, 300 ppm and

100 ppm, respectively.

In 1974 the form of surcharge formula was changed with the passing of by-law 4264. For every pound of BOD beyond the limit outlined a charge of 1.4¢ was to be levied. Similarly for SS and grease the charge was 0.45¢ and 0.60¢ per pound respectively.[31] The current rates for BOD, SS and grease respectively are 1.77¢, .57¢ and .76¢. The poundage to which these rates are applied are calculated for each component as follows:

$$(\text{component tested} - \text{component allowed}) \times \text{water consumption} \times 62.29/10^6 \qquad (15)$$

where component tested is the result of sewage sample tests in ppm;

component allowed is allowable limits in ppm;

and water consumption is the total amount of water consumed in cubic feet.

Note that $62.29/10^6$ converts water consumption from cubic feet to millions of pounds.

Monitoring of an industrial point source in Edmonton takes place approximately four times per month. These are either 24 or 16 hour composite samples.

(v) Calgary, Alberta

Calgary has had a sewer effluent charge, made up of a sewer service charge (72% of the water bill in 1982) and a sewer surcharge, since 1958. By-law 8718 passed in January 1974 defined the current surcharge scheme.

According to section 16 of this by-law the limits on BOD, SS and grease are 300 ppm, 300 pp, and 100 ppm respectively. The surcharge is determined as follows:

$$R_i = .123B + .136S + .143G \qquad (16)$$

where R_i is the surcharge rate in ¢ per 1000 gallons;

B is the actual concentration of BOD emissions in ppm minus 300;

S is the actual concentration of SS in ppm minus 300;

and G is the actual concentration of grease in ppm minus 100.

R_i is multiplied by the monthly gallonage of water consumed by the particular firm and is paid with the utility bill.

These charges can be stated per pound of BOD. In order to facilitate this one must first express equation (16) in a form similar to the London or Winnipeg surcharge schemes. Now:

$$\begin{aligned} SCH_i &= R_i W_i (62.29)/10^6 \\ &= \frac{W_i(62.29)}{10^6}\{.123(B_i-B_m) + .136(S_i-S_m) + .143(G_i-G_m)\} \end{aligned} \tag{17}$$

where SCH_i, Q_i, B_i, S_i, S_m and T_o are as defined in the London surcharge scheme;

G_i is grease emissions in ppm by firm i;

and G_m is the legislated limit on grease (100 ppm).

Under a London-type scheme in which BOD, SS and grease are surcharged:

$$\begin{aligned} R_i = T_o\{f_b(B_i-B_m)/(B_m) &+ f_s(S_i-S_m)/(S_m) \\ &+ f_g(G_i-G_m)/(G_m)\} \end{aligned} \tag{18}$$

where f_s, f_b and f_g are the proportion of sewage treatment costs attributable to SS, BOD and grease respectively.

Therefore from (17) and (18):

$$\begin{aligned} .123 &= f_b T_o/B_m \\ .136 &= f_s T_o/S_m \\ .143 &= f_g T_o/G_m \end{aligned} \tag{19}$$

From equation (11) these are shown to represent implicit charges in dollars per pound of BOD, SS and grease emitted.

In addition, we know that:

$$f_g = 1 - f_s - f_b$$

$$B_m = S_m = 300$$

$$\text{and } G_m = 100$$

It can thus be shown with the aid of (19) that:

$$f_s = .4435$$

$$f_b = .4011$$

$$f_g = .1554$$

$$\text{and} \quad T_o = 92.0¢$$

Hence from equation (11) the charge per surchargeable pounds of BOD, SS and grease is:

$$EC_b = 12.3¢$$

$$EC_s = 13.6¢$$

$$EC_g = 14.3¢$$

The Calgary scheme does diverge from the previous schemes in at lease two ways. Section 18 subsection 2 of the by-law states that if a firm installs pollution abatement equipment the city may refund up to 50% of the sewer surcharges paid over the previous three years. The amount of this refund is limited however, to the amount of the capital costs of the new facilities installed. While this is meant to be an additional incentive for abatement its probable effect is to induce capital intensive abatement techniques which may indeed be inefficient.

In addition, with respect to monitoring, samples are taken on a quarterly basis, but a great deal of reliance is placed on sampling done by the firms on their own wastes.

(vi) Toronto, Ontario

The sewer effluent charge in Toronto is based primarily on a sewer surcharge with payments for treatment of normal waste concentrations being levied in property taxes. Municipalities in the Metro area have had experience with surcharges since 1967. The 1977 limits on the emissions of waste in Toronto as stated in by-law 2520 were 500ppm for BOD, 600 ppm for SS, 150 ppm for grease and 1 ppm for phenols. The current surcharge formula is:

$$\text{Annual Surcharge} = V \times F \times G \times C$$

where V is the volume of annual plant discharge in gallons;

F is a factor converting ppm into pounds per gallon = $1/10^5$;

G is the excessive concentration of SS (S), grease (G), BOD (B), or phenols (P) in ppm whichever is greatest in excess of their respective by-law limit;

C is the cost in dollars for treating excessive strength wastes, G ($.039 per pound in 1980).

As is obvious this scheme diverges from the other Canadian schemes in that it imputes a charge based only on that component which is greatest in excess of its legislated limit. The effect of this is to exaggerate any inequities inherent in the other surcharge schemes. For example assume two firms in the Toronto jurisdiction emit the same volume of waste but that the concentration can be represented as follows:

FIRM	SS (S_i) (ppm)	BOD (B_i) (ppm)	GREASE (G_i) (ppm)	PHENOLS (P_i) (ppm)
1	1000	600	0	0
2	1000	890	500	250

In this case both firm 1 and 2 would pay charges on 400 ppm of SS, since this component exceeds the by-law limit by the largest amount (400 ppm). Both firms therefore pay identical surcharge bills yet it is obvious that firm 2 is receiving far more waste disposal services than is firm 1.

Monitoring of wastes in Toronto takes place about six times per year.

C. AN EXAMPLE

Table I summarizes various similarities and differences in the sewer effluent charge schemes of the six jurisdictions. All of the variables in this Table are defined in the relevant sub-sections above.

In many jurisdictions there are differences in surcharge rates and in the free base level of emissions allowed. In order to emphasize these differences an identical "representative" firm was assumed in each of the six jurisdictions. It is assumed that the emissions of this firm contains 1200 ppm of BOD and 700 ppm of SS. In addition the "representative" firm's water usage or demand is 50 million imperial gallons per annum and it emits 45 million imperial gallons of waste to the sanitary sewer[32] per annum. The differences in the total surcharge this firm would pay as well as the different amounts of pollution it would be allowed to emit free of charge in the various jurisdictions are summarized in columns 6 and 7, respectively of Table I.

D. CONCLUSIONS

This section has provided a survey of sewer effluent charge schemes in various Canadian jurisdictions. While the schemes seem to vary widely in form it has been shown that in content they are very similar.

The characteristics of these schemes which are common to all six jurisdictions include the following:

1- All sewer effluent charge schemes involve charges on wastes of normal concentrations called sewer service or rental charges, which are paid by all users of the sanitary sewers. In addition, sewer effluent charges consist of sewer surcharges,

TABLE I

A SUMMARY OF SEWER EFFLUENT CHARGE SCHEMES IN CANADA

(1) Area	(2) Sewer Service Charge Per 1000 Gal. of Water Used	(3) Sewer Surcharge Formula	(4) Legislated Limits on Surcharged Pollutants (ppm)	(5) Charges Per Pound of Excess Strength Pollutant (¢/lb.)	(6) Total Surcharge Payments by a Representative Firm ($)	"Free" Base Emissions by the Representative Firm (1000's of lbs.)
LONDON, ONTARIO	Paid in Property Taxes	$SCH_i = a_i\{f_b(\frac{B_i-B_m}{B_m}) + f_s(\frac{S_i-S_m}{S_m})\}\frac{T_o}{100}$	$B_m = 300$ $S_m = 350$	$EC_b = 7.0$ $EC_s = 6.0$	$37,800	$BOD_f = 135.0$ $SS_f = 157.5$
WINNIPEG, MANITOBA	$1.04	$SCH_i = a_i\{(f_b(\frac{B_i-B_m}{B_m}) + f_s(\frac{S_i-S_m}{S_m}))T_o + (\frac{C_i-C_m}{C_m})T_c + (\frac{X_i-X_m}{X_m})T_x)\}\frac{1}{10^2}$	$B_m = 300$ $S_m = 350$ $G_m = 100$	$EC_b = 2.18$ $EC_s = 1.87$	$11,790	$BOD_f = 135.0$ $SS_f = 157.5$
KITCHENER, ONTARIO	100% of Water Price	Same as for London, Ontario	$B_m = 300$ $S_m = 350$	$EC_b = 6.01$ $EC_s = 5.15$	$32,463	$BOD_f = 135.0$ $SS_f = 157.5$
EDMONTON, ALBERTA	90.7¢	$SCH_i^* = \{.0177(B_i-B_m) + .0057(S_i-S_m) + .0076(G_i-G_m)\}\frac{W_i(62.29)}{10^6}$	$B_m = 300$ $S_m = 300$ $G_m = 100$	$EC_b = 1.77$ $EC_s = 0.57$	$ 9,105	$BOD_f = 150.0$ $SS_f = 150.0$

TABLE I (CONTINUED)

A SUMMARY OF SEWER EFFLUENT CHARGE SCHEMES IN CANADA

(1) Area	(2) Sewer Service Charge Per 1000 Gal. of Water Used	(3) Sewer Surcharge Formula	(4) Legislated Limits on Surcharged Pollutants (ppm)	(5) Charges Per Pound of Excess Strength Pollutant (¢/lb.)	(6) Total Surcharge Payments by a Representative Firm ($)	"Free" Base Emissions by the Representative Firm (1000's of lbs.)
CALGARY, ALBERTA	72% of Water Bill	$SCH_i^{*}=\{.123(B_i-B_m)+.136(S_i-S_m)+.143(G_i-G_m)\}\frac{W_i(62.29)}{10^6}$	$B_m = 300$ $S_m = 300$ $G_m = 100$	$EC_b = 12.3$ $EC_s = 13.6$	$82,550	$BOD_f = 150.0$ $SS_f = 150.0$
TORONTO, ONTARIO	Paid in Property Taxes	$SCH_i = Q_i(10^3)xFxGxC$	$B_m = 500$ $S_m = 600$ $G_m = 150$ $P_m = 1$	$EC^{**} = 3.90$	$12,285	$BOD_f = 225.0$ $SS_f = 270.0$

* W_i in this formula is water consumed in cubic feet.

** In Toronto a charge is levied only on that pollutant which exceeds its legal limit by the most. The charge of 39¢ is then applied to that pollutant.

which are paid only by those industrial polluters that emit extra-strength wastes.

2- Sewer surcharges are imposed only on wastes that exceed certain legislated limits or normal waste concentrations for various pollutants. For waste emissions with concentrations below the legislated limit no surcharge is imposed.

3- All surcharge schemes can be defined in terms of implicit charges per pound of surcharged pollutants, even though most current schemes are based on charges per unit volume of sewage discharged.

Also certain dissimilarities in these schemes can be identified:

a) The Toronto surcharge scheme unlike the other schemes bases its charge on the maximum of (B_i-B_m) or (S_i-S_m) or (G_i-G_m) or (P_i-P_m) where the bracketed expressions represents the difference between actual and legislated concentrations of BOD, SS, grease and phenols, respectively.

b) In Edmonton and Calgary the surcharge rate per 1000 gallons is determined in a manner similar to that of other Canadian Jurisdictions. Unlike the other Jurisdictions, however, these rates are applied to total water use rather than to the total volume of emissions to the sanitary sewer. For some industries these two magnitudes will diverge.

c) In Calgary, Alberta there is a rebate scheme by which up to 50% of the sewer surchargepayments made over the previous three years may be refunded depending on improvements in abatement efficiency. This is limited to the amount of the capital costs for new treatment facilities installed.

d) In many jurisdictions there are dissimilarities in surcharge rates and in the free base level of emissions allowed (see Table I).

V. DATA REQUIREMENTS, SOURCES, DEFINITIONS AND SAMPLE CHARACTERISTICS

A. INTRODUCTION

In this section we outline the requirements, sources, definitions and sample characteristics of the data used in the empirical portion of this report. The data collected are quite comprehensive and are certainly sufficient to provide many useful insights into productivity and regulation within the brewing industry. We begin with a discussion of the data requirement for modelling brewing in regulated and unregulated municipalities.

B. DATA REQUIREMENTS FOR MODELLING BREWING IN THE PRESENCE OF REGULATION

As was pointed out in section IV most if not all sewer surcharges in Canada can be modelled as prototypes of the Winnipeg or London schemes. Using the London variable definitions (see section IV.B(i)) a surcharged brewing plant's total costs (TC) could be written as follows:

$$TC = Z + P_W W + SCH \tag{20}$$

where, Z represents labour, capital, energy and raw materials costs of a brewery;

P_W is the price of water per million pounds;

W is the water purchased by the brewery in millions of pounds; and

SCH is the surcharge on waste emissions by the brewery.

In addition,

$W = V + W_0$

and

$SCH = RQ$

where, V is the amount of wastewater emitted to the sanitary sewers, in millions of pounds by the brewery;

W_o is the remainder of W which can reasonably be considered as entering the brewery process as a material input;

$R = \{f_b(B_i - B_m)/(B_m) + f_s(S_i - S_m)/(S_m)\}(T_o/100)$ is the surcharge in dollars per 1000 gallons; and,

Q is 1000's of imperial gallons of sewage emitted to the sanitary sewers by the brewery $[(Q/100) = V]$.

Thus we can rewrite equation (20) as:

$$\begin{aligned} TC - Z' &= P_w V + (Q/100)\{(f_b T_o)/(B_m)[B_i - B_m] + (f_s T_o)/(S_m)[S_i - S_m]\} \\ &= P_w V + V\{EC_b(B_i - B_m) + EC_s(S_i - S_m)\} \qquad (21) \end{aligned}$$

where Z' represents the cost of the water augmented (W_o) materials aggregate; and

EC_b and EC_s are as defined in section IV(b).

For simplicity we can rewrite the total cost function as:

$$TC = Z' + P_s V \qquad (22)$$

where P_s is the quality adjusted price of sewage containing BOD and SS from the brewery.

Thus,

$$P_s = P_w + EC_b(B_i - B_m) + EC_s(S_i - S_m)$$

and,

$$\begin{aligned} P_s V &= (P_w - EC_b B_m - EC_s S_m)V + EC_b \cdot BOD + EC_s \cdot SS \\ &= P_v V + EC_b \cdot BOD + EC_s \cdot SS \end{aligned}$$

where, BOD is the total emissions of BOD in pounds to the sanitary sewer by the brewery;

SS is the total emissions of SS in pounds to the sanitary sewer by the brewery;

$P_v = (P_w - EC_b B_m - EC_s S_m)$ is the implicit non-quality-adjusted price of V to the brewery.

P_v represents the price the brewing firm pays to purchase an additional million pounds of water for use in washing a given amount of BOD and SS to the sewer system. It includes the price of water, P_w, minus the reduction in surcharge costs which result from lowering the concentration of waste emissions. For example, with respect to BOD, if in a given jurisdiction emissions with a concentration of 300 ppm are not surcharged (i.e. $B_m = 300$) then for each additional one million pounds of water used to wash away wastes with a given waste load (i.e. pounds of BOD) to the sanitary sewers, 300 additional pounds of BOD will not be surcharged. This represents in essence a bonus for water use of 300 EC_b or $B_m EC_b$. The same argument applies to SS.

The price of a unit V (i.e. one million pounds) emitted to the sanitary sewer system in surcharged jurisdictions is, however, higher than P_v, since it also depends on the strength of wastes (i.e. BOD and SS) in emissions. That is, the price must be adjusted[33] based on the quality of V. This is precisely the price P_s. It should be noted that in an unregulated jurisdiction $P_s = P_w$.

Thus in the procedure adopted for modelling the brewing industry the pollution charges enter indirectly through P_s and firms are expected to respond to changes in effluent charges and hence in P_s, by reducing their emissions to sanitary sewers.[34] P_s is smaller, ceteris paribus, in unregulated jurisdictions.

In summary, a considerable amount of data is required in order to successfully study the brewing production process within a market setting (where market information on prices is incorporated to improve the efficiency of estimated production characteristics). In what follows we will describe the sources and types of information used to construct the data set which we used to estimate characteristics in the brewing production process.

C. SOURCES

The data were collected from three major sources. With the permission of two brewing companies we obtained copies of the confidential plant level data collected by Statistics Canada in the yearly Census of Manufacturers of breweries. A second set of plant level data was obtained by circulating a questionnaire to the breweries. Supplementary production and financial information as well as insights into the major characteristics of the brewing process were obtained in follow-up conversations with the breweries officials. The production and financial data were complete for four plants for a period of ten years (1971-1980). The last set of data was obtained from municipal authorities with the permission of the breweries. The municipal data included, by plant: water use, quantities of emitted pollutants and the respective water and sewer surcharge rates.

(i) Census Data

Each year brewing plants in Canada are required to complete a form summarizing aspects of their economic activity. An example of this form for 1975 can be found in the Appendix at the end of the report. Information from this form has been used to construct time series of economic measures of several inputs and output for the sampled plants. Over time the Statistics Canada questionnaire has changed. One example of this is the introduction of the metric system in 1979. Considerable effort has been devoted to correcting for all changes in reporting requirements. In what follows we summarize the constructed variables in reference to the attached census form for 1975.

(a) Output

Two measures of output were obtained from the census data The first is given in section 6.10.2 as the total number of gallons brewed during the year. However, not all brewed beer is shipped and it is therefore useful to consider section 6.10.6 which provides information on the shipments of brewed products produced by a given plant. Some brewed products evaporate or are otherwise lost and some go into inventories. Since our labour data is not disaggregated between brewing and packaging operations, the choice of the appropriate output measure is potentially important. Fortunately, there is a strict proportionate relationship between the output measures where shipments are invariably 99% of total brewed products. A simple regression of shipments on a constant and brewed output confirms that up to this known factor or proportionality, the choice of an output measure between shipments and total brewed products is not an important issue. We chose to work with shipments.

(b) Labour

Section 14 of the census form provides detail on labour services. In particular, section 14.1.2 provides total manufacturing labour salaries, hours worked and number of employees. In this study we are interested in manufacturing labour only and ignore the input of administrative staff. Our initial thought was to measure labour input by total hours worked thereby including intensity adjustments. Unfortunately, there were several reporting errors and inconsistencies in these data which could not be corrected. Fortunately, an accurate time series on total employees could be constructed for each plant.

In the empirical work total labour is therefore given by the total number of employees and the price of labour is given by the ratio of total wages to total labour.

(c) Energy

The sampled brewing plants meet their energy requirements using a variety of fuel sources (natural gas, light and heavy fuel oils, diesel fuel and liquid propane) and electricity. Section 5 of the census form provides quantity and cost information on these sources. An aggregate index of energy input was computed by first converting the fuel quantities and electricity into their BTU use energy equivalents and then adding these BTU quantities together. The aggregate energy price index follows by dividing total energy costs by the input index. The BTU use energy equivalents for the various fuels and electricity were supplied by Energy, Mines and Resources, Canada.

(d) Materials

Section 6 of the census form provides a detailed breakdown of quantities and cost of raw materials, packaging and sundry materials used in the production process. Over ninety percent of the raw materials costs arise from the purchase of barley, malt, corn and hops. The remainder are generated by the purchase of various chemicals. The quantities of these raw materials were found to follow essentially constant proportionate relationships and it was therefore possible to construct an accurate index of total raw materials quantities. Unfortunately, quantity information could not be obtained for packaging and sundry materials. Thus only raw materials were used. The price of materials was obtained as the ratio of total raw materials costs to the quantity index. As will be discussed later, the raw materials price and quantity indices are subsequently combined with brewing retained water to provide a more composite materials index.

(ii) Questionnaire Data

The circulated questionnaires provided many important pieces of information for characterizing the production process. Perhaps the most important information was that which allowed us to construct the capital series for the plants.

(e) Capital

Although the economic and financial concepts of capital are not completely reconcilable, the breweries were able to supply us with enough financial and engineering-study information to allow the construction of a capital stock time series for each plant. The constructed capital index measures the plant and equipment replacement costs in constant 1971 prices. The opportunity (user) cost of capital taken as the yearly factor price of capital was obtained from the Economic Council of Canada's Candide Model. This series was constructed using the Jorgenson-Hall methodology whereby real after tax interest rates, depreciation rates, tax incentives and the capital goods price index are combined to estimate the opportunity cost associated with employing another unit of capital.

(iii) Municipal Data

In what follows the data supplied by the municipal authorities and used in the regulation modelling is described.

(f) Water

From all municipalities we obtained data on water inflow and total cost for the water. Water prices were calculated as the ratio of the total cost to volume. This data was generally consistent with the water information available in section 6.1.33 of the Census of Manufacturers questionnaire but was more complete (Census data on quantities were not collected after 1978) and, we felt, probably more accurate. Some plants supplement their municipal water with well water. This however was found to be negligible and was not included in the analysis.

(g) Emissions

From those municipalities with regulation schemes in place we were able to obtain the monitored volume of waste-water emissions. The municipalities sample these emissions regularly and on the basis of estimated concentration of BOD and SS and the legislated surcharge schemes described earlier, they bill the breweries. For the period 1971 to 1980 we obtained sufficient information to calculate BOD and SS quantities, their associated unit charges and the per base (un-charged) discharge amounts. With this and the water information we were able to construct an index of emissions and, the quantity adjusted, price index of these emissions described above.

The volume of emissions falls short of the volume of water intake. This shortfall represents water which is used as a material input into brewing. Relative to emission and, thus to intake, this quantity is very small. Nonetheless, it was combined with the raw material index described above to provide a composite Divisia materials' index. For some plants the difference in water intake and outflow was not available. However, it was found that, for those plants where the information was available, the difference was almost always 3% of output. Thus, these differences were estimated on the basis of this relationship.

D. SAMPLE CHARACTERISTICS

(i) Composition

Originally we had hoped to have complete data on a total of nine plants from three breweries. Unfortunately, one brewery decided it could not meet the time constraints of the study and decided not to provide any data. The other breweries were most helpful in supplying the requested data on their plants. One plant however reported the consolidated activity of two plants and since we were unable to disentangle the information, this plant had to be dropped from the sample. Also, one plant had data for only 4 years in the sample. Given the estimation restrictions imposed by the computer package (TSP) it was not possible to incorporate this partial information. In addition, there was no surcharge scheme in this municipality.

In summary, our sample consisted of ten years of data for each of four plants. Of these four plants, two were located in municipalities with surcharge schemes and two were unregulated. The annual outputs of the plants ranged from one to fifty million gallons.

(ii) Behavior of Factor Shares in Total Cost

As noted above, the major imputs into brewing and those for which we have collected data include: labour, capital, energy, materials and emissions. The prices of these factors were constructed as indicated above and a total cost variable was constructed as the sum of the individual factor costs. The sample averages for the cost share of labour, capital, energy, materials and emissions were respectively: .193, .616, .023, .162, .006. The energy share doubled for almost all plants in the ten sample years with major increases coinciding with energy price increases in the early 1970's. Finally, the materials and capital shares displayed a very interesting inverse pattern of behavior. In particular, the materials share was much higher and the capital share much lower for plants producing large quantities of beer. A reasonable explanation for this behavior might be that materials are extremely price inelastic. This would not be inconsitent with the materials balance restriction whith the data should satisfy, - namely that the output mass cannot exceed the mass of materials input. Similarly, the decline in the capital cost share would not be inconsistent with significant scale economies arising largely through the capital input.

VI. MODEL SPECIFICATION AND ESTIMATION

A. INTRODUCTION

In this section we specify and estimate a model of the brewing production technology. Our goal is to determine what, if any, effect regulation has upon sewage discharges (V) and upon the rate of productivity growth. We begin with a brief description of the brewing process and then proceed to specify the econometric cost model which will be used to study the characteristics of the underlying production process. We then present the estimated results.

B. AN OVERVIEW OF BREWING

(i) The Brewing Process

Brewing is essentially an assisted natural process which combines five ingredients: barley malt, adjunct material (such as corn, rice or wheat), water, hops and yeast, to produce the final output: beer. The primary ingredient is barley malt which is barley that has been allowed to germinate and grow to a limited extent. Kiln drying is used to prevent growth beyond the desirable level.

The barley malt is screened and crushed before being mashed with water. This mashing process takes place in a mash mixer or mash tun. During this process the malt enzymes break down the malt starches[35] to sugars and the complex proteins of the malt to simpler nitrogen compounds. After this stage is complete the mash is transferred to a straining or "lautering" vessel. The liquid extract or "wort" drains through the bottom of the lauter tub into the brewing kettle where it is boiled for abour two hours after the addition of hops.[36] This boiling serves several purposes:

(a) to concentrate the wort to the desired specific gravity;

(b) to sterilize the wort;

(c) to obtain the desired extract from the hops;

(d) to destroy undesirable protein substances which have come from the mash tun.

After this procedure the hops are removed by passing the wort through a "hop jack" or separator to remove the hops and the "trub" or protein which has precipitated during the boiling. The wort then proceeds to the hot wort tank, where any remaining trub is removed by settling.

The wort is then cooled and moved to the fermenation vessels where yeast is added.[37] The fermentation lasts about seven days after which the yeast is removed - by skimming for top fermentation or by pumping off the beer for bottom fermentation - and for the first time the liquid is called beer. It is during fermentation that the yeast converts the sugar in the wort to carbon dioxide and alcohol.

After fermentation the beer is cooled, filtered, polished and aged for 3-5 weeks. The beer is then finally either bottled and pasteurized or placed into kegs. Pasteurizing increases the shelf life of beer. Since draught beer is sold within a few days, the keg beer is not pasteurized.

(ii) Brewing and Pollution Abatement

The major forms of pollutants emitted to the sewer system are BOD, SS and caustic materials.[38] Caustic materials generally show up in terms of high pH readings in sewage discharges. These types of emissions are of some concern to waste treatment authorities in most jurisdictions because they interfere with the working of the sewage treatment plant. Such emissions are the result of cleaning agents generally used in the bottle washing process. Despite the concern with regard to pH most sewer surcharge schemes do not levy a charge on these caustic emissions and instead have set emission standards.

The main elements of the sewer surcharges imposed in most Canadian jurisdictions are BOD and SS. With respect to brewing the major BOD sources are the yeast left after fermentation, the liquor from spent grains left after mashing the malt and straining the wort, the trub and beer spills. The major sources of SS are spent grain husks from mashing and straining, and the diatomaceous earth used in the filtering and polishing processes.[39]

The sewer surcharge schemes currently in effect in Canada result in surcharge payments by regulated brewing firms of from 1% to 3% of total costs. As such the response of most brewing firms with respect to these charges based on the volume of emissions and the strength of emissions will probably lead to improvements in housekeeping procedures. These procedures would involve better cleaning of tubs and kettles to reduce the level of emissions of spent grains, yeast, trub, and diatomaceous earth. Thus it might be expected that some response to pollution surcharges would come in the form of an increased allocation of labour towards such additional housekeeping procedures.

In addition, although pH is not generally surcharged, one might suspect that actions by municipal authorities would be swifter in jurisdictions with surcharge schemes. If, as might be expected, more frequent waste monitoring is carried out in surcharge regulated jurisdictions and, as a result, more information with regard to the pH of emissions were available, these jurisdictions might prove to be more insistent with regard to maintaining pH levels in brewing emissions. Thus greater pH control might result in these jurisdictions.

pH control generally involves the recycling of in-plant waste streams. Therefore relatively more capital may also be allocated to pollution abatement at surcharged than non-surcharged locations.

C. SPECIFICATION

(i) Background

We assume that brewing operations are consistent with the neo-classical concept of production whereby inputs are combined to form output in a fashion which can be represented by a production function. We further assume that brewing operations are cost efficient in that firms react to market input prices and produce desired output levels at the minimum cost possible to themselves.

Formally, we define the production function as:

$$q = f(X, t) \tag{23}$$

where q is output, X is the set of factor inputs, t is a time variable (indicating that the production function may shift out over time due to productivity advances). The function f is assumed quasi-concave in factor inputs (X). Cost efficiency enters through the assumption that the behavior of the plants is consistent with the constrained minimization problem:

$$\underset{\{X_i\}}{\text{minimize}}\ \Sigma P_i X_i \qquad \text{subject to (23)} \tag{24}$$

where P_i are the market determined prices corresponding to the individual input X_i.

The solution to the problem given in (24) is a cost function of the form:

$$C = C(P, q, t)$$

where C represents the minimum of producing q units of output given a set of factor prices P. The optimal levels of the inputs

($X_i^*(P,q)$) to be used to produce q units of output when the factor prices are given by P can be found by differentiating the cost function with respect to the factor prices to obtain:

$$X_i^*(P,q,t) = \frac{\partial C}{\partial P_i} \tag{25}$$

Thus, all of the characteristics of the production technology can be obtained from the cost function. The logarithmic derivative of the cost function with respect to output yields the cost elasticity which will be the inverse of the scale elasticity of the production function along the input expansion path of the firm.

(ii) The Translog Cost Function

For this report we have chosen to approximate the cost function to the second order in logarithms with a "translog" flexible functional form. In addition to estimating parameters of this cost function we will also include the factor demand information given by (25). Our parameter estimates will therefore be more efficient.

There are several reasons for choosing the translog approximation. Besides the fact that the translog function provides a second order Taylor series approximation to any cost function, the translog function and associated factor demands written in share form are linear in the parameter. This is an increasingly important feature as the number of inputs and data points increase. Finally, the translog function is not restrictive with respect to homogeneity or homotheticity and does not constrain factor elasticities of substitution to be constant and/or equal.

The translog cost function is written:

$$\begin{aligned} \ell n\ C = {} & A_0 + \Sigma A_i\ \ell n\ P_i + .5\ \Sigma\Sigma A_{ij}\ \ell n\ P_i\ \ell n\ P_j + \Sigma A_{iq}\ \ell n\ P_i\ \ell n\ q \\ & + A_q\ \ell n\ q + .5\ A_{qq}(\ell n\ q)^2 + A_t\ \ell n\ t + .5\ A_{tt}(\ell n\ t)^2 + \\ & + A_{tq}\ \ell n\ t\ \ell n\ q. \end{aligned} \tag{26}$$

Logarithmic differentiation of the cost function with respect to the factor prices yields the factor shares as:

$$S_i = A_i + \Sigma A_{ij} \ \ln P_j + A_{iq} \ \ln q \qquad (27)$$

In the above expression the indices (i,j) refer to the inputs labour (L), capital (K), materials (M), energy (E) and sewage emission (V). Since the cost function must be homogeneous of degree one in factor prices, the following parameter restrictions must be imposed:

$$\begin{aligned} A_{ji} &= A_{ij} \qquad \text{(symmetry)} \\ \Sigma A_i &= 1 \\ \Sigma A_{ij} &= 0 \qquad \forall j \\ \Sigma A_{iq} &= 0 \end{aligned} \qquad (28)$$

In addition, the cost function should be concave (weakly) in factor prices. This restriction cannot be imposed ex ante without seriously reducing the 'flexibility' of the cost function. It is therefore verified for the estimated function.

It will be recalled from the earlier discussion that regulated firms have emission prices (P_s) which differ from the price of water by the amount of the unit surcharge. The cost model therefore incorporates these differences. With respect to differences in productivity which may arise due to regulation we allowed the technology parameters to differ between regulated and unregulated plants. In particular:

$$\begin{aligned} A_t &= A_{tu} + A_{tR} \cdot REG \\ A_{tt} &= A_{ttu} + A_{ttR} \cdot REG \\ A_{tq} &= A_{tqu} + A_{tqR} \cdot REG \end{aligned} \qquad (29)$$

where the subscripts u and R respectively indicate unregulated and regulated firms and REG is a dummy variable taking the value 1 if the plant is regulated. A_t, A_{tt} and A_{tq} are therefore the appropriate total coefficients for regulated firms. If these technological change coefficients are found to be significantly different from zero that would indicate a significant change in cost unexplained by factor prices and output. This will be called a productivity change. Clearly the specification in (29) allows for the possibility of different productivity growth in regulated and unregulated plants.

(iii) Estimation Technique

There will be some stochastic variation associated with the cost (26) and share equations (27) arising from the cost function approximation, optimization errors and other small uncorrelated errors involved in the definition and measurement of variables. For estimation purposes we treat the cost and share equations as a simultaneous system of stochastic equations and recognize the cross-equation parameter constraints. To allow for possible contemporaneous correlations of errors across equations we chose to estimate the parameters using Zellner's seemingly unrelated regression equation estimation. During estimation only four of the possible five factor share equations were combined with the cost function. We did this because the dependent variables of the share equations by definition sum to unity and the errors of the fifth equation are not independent and, in fact, are completely determined by those of the other four. The parameter estimates obtained will be independent of the excluded share equation as long as the final parameters represent the limit of a sequence of convergent iterations. In our estimation procedure we dropped the energy share equation and then recuperated the parameter estimates using the constraints given in (28). All estimation was undertaken using the TSP package available on the Concordia University CDC computer.

D. ESTIMATION RESULTS

(i) Preliminary Estimation Results

The first round estimation results pointed to a problem with the materials share equation. As we noted in the previous data section, the materials share in total cost increased significantly as output increased in the sample. When we calculated the factor demand and elasticity for materials at the sample points using the first round parameter estimates we found that point estimates fluctuated in a band around zero. The elasticity at the sample mean was found to be .102 with a standard error of .083 implying that the hypothesis that the material input was perfectly inelastically demanded could not be rejected. Further, the cross-elasticities of factor demand with the other inputs was negligible. Finally, the other factor demands were found to be downward sloping with reasonable magnitudes for the estimated elasticities. This led us to the conclusion that the appropriate way to specify the production function (23) is as follows:

$$q = f(X,t) = \min[g(\bar{X},t),\ h(M,t)] \qquad (30)$$

Such a specification when combined with the minimization problem given in (24) is consistent with a zero factor price elasticity of materials, independent of materials and other factors (prices) and a full range of possible factor elasticity for the other factors ($\bar{X}$). Efficient factor use for (30) implies the following joint technological relationships must hold:

$$q = g(\bar{X},t) \qquad (31)(a)$$

$$q = h(M,t) \qquad (31)(b)$$

In the second round of estimation we therefore estimated the translog cost function and factor share equations for labour, capital, emissions and energy which approximate the solution to the optimization problem (24) subject to the production constraint (31)(a). A second purely technological relationship linking materials and output are estimated by approximating (31)(b) by:

$$\ell n\ q = A_M + A_{Mt} \cdot t + A_{MM}\ \ell n\ M \qquad (32)$$

where A_{Mt} was allowed to differ between regulated and unregulated firms. It is worthwhile noting at this point that the factor price elasticities at the sample mean calculated from the second round model specification were not significantly different from those calculated initially. At the same time however the cost function of the second round was verified to be weakly concave: a property which the initial cost function did not exhibit.

In addition, it should be noted that Pratten (1975) in a study of scale economies in the brewing industry in England also found that materials used per unit of output in beer production are unaffected by plant size. This fixed relationship between materials and output was also suggested in discussions with brewing firm officials.

(ii) Final Estimation Results

The Tables 2, 3 and 4 respectively display: the parameter estimates from the cost model, equation by equation summary statistics of the cost model and parameter estimates of the materials model. In the section which follows we discuss the implication of estimation results in terms of implied properties of the production process as reflected by the cost model. At this point it is worth noting however that the model provides an excellent fit of the data. Further, since the estimated cost function is (weakly) concave in factor prices, we can have some confidence in the results generated by the model.

With regard to the materials model estimates presented in Table 4 it is worth noting that there is strong evidence of a strictly proportionate relationship (independent of scale) between materials and output since A_{MM} is not significantly different from 1. In addition, technological change is not evident in the relationship.

TABLE 2

PARAMETER ESTIMATES OF THE COST MODEL

PARAMETER	ESTIMATE	ASYMPTOTIC t-RATIO
A_0	6.506	3.889
A_L	-.268	-2.562
A_K	1.316	12.228
A_V	.0004	.078
A_{LL}	.054	1.818
A_{KK}	.067	2.121
A_{VV}	.0038	9.471
A_{LK}	-.0515	-1.682
A_{LV}	.0002	.162
A_{KV}	-.0029	-2.172
A_q	.314	.841
A_{qq}	.0119	.291
A_{tu}	1.900	6.434
A_{tR}	-1.932	-4.887
A_{tqu}	-.263	-7.134
A_{tqR}	.268	5.745
A_{ttu}	.207	4.949
A_{ttR}	-.215	-3.735
A_{Lq}	.034	7.407
A_{Kq}	-.042	-8.857
A_{Vq}	.0017	7.102
A_E	-.048	-4.624
A_{LE}	-.0031	-.931
A_{KE}	-.0129	-4.304
A_{VE}	-.0011	-1.840
A_{EE}	.0172	10.525
A_{Eq}	.0059	10.729

TABLE 3

EQUATION BY EQUATION SUMMARY STATISTICS

EQUATION	STANDARD DEVIATION OF THE DEPENDENT VARIABLE	SUM OF SQUARED RESIDUALS	R^2
Cost	.792	.159	.994
Labour Share	.059	.038	.714
Capital Share	.065	.040	.758
Emission Share	.005	.00006	.938

Log of likelihood function (entire system) 544.472.

TABLE 4

MATERIALS PARAMETER ESTIMATES AND EQUATION STATISTICS

PARAMETER	ESTIMATE	t-RATIO
A_M	2.129	25.391
A_{Mtu}	.0C47	1.05
M_{MtR}	.0059	1.025
A_{MM}	.989	80.974

Standard derivation of dependent variable	1.224
Sum of squared residuals	.180
R^2	.997
Log of likelihood function	51.365

VII. ANALYSIS OF THE EMPIRICAL RESULTS

A. INTRODUCTION

In this section we summarize and explain our major findings. The results are presented in three parts: factor elasticity estimates and the implications for municipal waste management, productivity growth estimates and implications for regulation policy and economies of scale estimates. The results are integrated with the analysis presented in earlier sections of this report. In addition, where possible, the results are compared with other published findings.

B. ELASTICITY RESULTS

The factor price elasticities (holding output constant) can be conveniently calculated from the parameters of the estimated cost function and factor shares using the following formulas:

$$\begin{aligned} \varepsilon_{ii} &= S_i - 1 + A_{ii}/S_i \\ \varepsilon_{ij} &= S_j + A_{ij}/S_i \end{aligned} \qquad i,j = [L,K,E,V] \qquad (33)$$

These elasticities calculated at the sample mean are presented in Table 5.

It will be noted that all of the 'own price' elasticities are significantly negative and less than unity in absolute value implying that the factors are all inelastically demanded. Our estimate of the price elasticity of emissions is -.48. This estimate is somewhat smaller than the corresponding value of -.945 reported by Sims (1979). It should be noted however that the estimate presented here is based upon a more complete cost model specification. For example, Sims did not have complete factor quantity data and his total cost variable may be more reflective of total revenue than of total cost.

The cross-price elasticities between capital, labour and emissions

TABLE 5

FACTOR DEMAND ELASTICITIES AT THE SAMPLE MEAN

	LABOUR	CAPITAL	ENERGY	EMISSIONS
Labour	-.535	.511*	.0144	.0083
	(4.19)**	(3.86)	(1.2)	(1.4)
Capital		-.177	.0097	.0034
		(4.08)	(2.36)	(1.88)
Energy			-.354	-.0324
			(6.01)	(1.48)
Emissions				-.48
				(8.76)

* Off-diagonal elements represent the elasticity of the row factor with respect to the column factor price.

** t-statistics are presented in parentheses .

provide information which is not inconsistent with what one would reasonably expect, ex ante, and with information supplied by the breweries. In particular, the elasticities are positive and therefore imply that, ceteris paribus , an increase in the price of emissions will lead to some substitution towards capital and labour. At the same time, however, these elasticities are small and suggest that the substitution response will not be large. In fact, the cross-elasticity with respect to labour is not strongly significant. In conversations with the breweries we have been told that, while they devote resources to keep their emissions 'clean', it has not been necessary to redirect major quantities of capital and labour expenditures to this end in the municipalities in our sample. Further, these results are not inconsistent with the general production description presented in section VI.B(ii).

As a final point it is worth noting that, under the assumption of our regulation model, some scope exists for the municipalities in our sample to simultaneously increase revenue (by raising water prices and pollution surcharges) and cause emissions to be reduced.

C. PRODUCTIVITY RESULTS

It will be recalled that a time variable was introduced into the cost model to measure any systematic cost charges unrelated to factor prices and output. This technical change or productivity variable was specified such that regulated and unregulated firms in the sample could potentially exhibit different rates of productivity growth (or, equivalently, cost reduction).

The productivity growth rates are obtained from differentiating the logarithmic cost function with respect to the time variable and then multiplying by minus unity to convert the rate of cost reduction into productivity increase. At the mean of the sample the growth rates in productivity were calculated as 1.6% per annum in unregulated firms and -.008% in regulated plants. The coefficient for the unregulated plants is significant with a t-statistic of 2.67. Alternatively, the coefficient for the regulated plants was insignificant ($t = .016$). As such the results suggest that the productivity growth in unregulated plants significantly exceeds that in regulated plants. Indeed, there is no evidence of productivity growth in regulated plants.

These results do not appear to be inconsistent with the results presented by other researchers. For example, Denison (1979) reports an annual productivity growth rate of 2% for US manufacturing and estimates that there has been a 10% reduction in productivity growth due to pollution abatement programmes. In Canada, Denny, Fuss and May (1981) report provincial productivity growth rates of (.96%, .96% and .72%) for the Food and Beverage industries of Atlantic, Ontario and Prairies regions respectively. It is interesting to note that their estimates are bracketed by those arising in this study. At the same time, however, it must be noted that brewing shipments comprised only 4% of total Food and Beverage sector shipments in 1978 and therefore it may be unwise to stress the importance of this comparison.

Given that the magnitude of our estimates of productivity growth is not unreasonable, it remains to discuss the nature of the conclusions which can be drawn from these results.

From the specification of the model, we cannot reject the hypothesis that regulation significantly reduces productivity growth. Indeed it would appear that this effect is larger than other researchers have reported. At the same time, however, this finding is not inconsistent with our earlier arguments that regulation by means of prices is likely to have a larger effect upon firms than regulation by means of standards.

A final word of caution is in order. It must be kept in mind that productivity growth is measured as a systematic residual component and that, to some extent, it could also reflect other systematic differences between regulated and unregulated firms. In addition, as pointed out earlier in this report, even if regulation has in fact been responsible for the measured productivity differential, this does not represent a net cost to society. It must be balanced against the social benefits of cleaner air and water.

D. SCALE ECONOMIES

The largest plant in our sample provided 11% of total Canadian shipments in 1978. Despite the size of this plant it is evident from the cost equation estimated that it had still not exhausted all plant scale economies. The scale elasticity for this plant in 1980 was 1.14. This is not inconsistent with a statement by Scherer et al (1975, 1979) that in brewing "...unit costs...(are)...believed to continue falling beyond the size of the largest modern plant...". In addition, Scherer argues that a plant of minimum efficient scale in the brewing industry would supply approximately 34.5% of Canadian domestic consumption (p. 94). In fact in 1978 there were 41 plants in Canada.[40] This suggests that all plant scale economies are not being exploited.[41] Indeed our estimates suggest that the smaller plants in our sample have scale elasticities in excess of 2. Thus our results do not seem to be inconsistent with previous studies of plant scale economies in the brewing industry (Pratten, 1975; Scherer, 1975).

In addition, the existence of potentially large scale economies in brewing casts doubt on alternative methodologies for measuring productivity growth, which incorporate the assumptions of constant returns to scale. It is quite likely that such methodologies (Denny, Fuss and May, 1981; Denison, 1979) could confuse the separate effects of productivity growth and scale economies. To the extent that these scale economies are a pervasive characteristic of Canadian manufacturing, approaches similar to the one adopted in this report should be pursued in studies of productivity growth.

VIII. SUMMARY AND CONCLUSIONS

The purpose of this report was to investigate whether a significant relationship exists between environmental regulation and productivity growth.

The initial section of the study presents a survey of the literature dealing with the impact of environmental regulation on productivity growth. These studies were based upon aggregate data from the United States. While the findings of these studies were not conclusive, they pointed to the importance of undertaking a study using firm or plant level data. In a preliminary feasibility study it was discovered that plant level data for the Canadian brewing industry was available and therefore, that a micro-level study of the impact of environmental regulation in the Canadian brewing industry was possible. In addition, since several brewing plants were subject to a type of effluent charge, known as a sewer surcharge, an investigation of this particular type of environmental regulation could be done. Theoretically, it was suggested that, since the response of firms to economic incentives is probably swifter and more pronounced, the productivity effects would be greater than under the direct regulation enforcement approach which has been the focus of all the productivity impact studies discussed earlier in this report.

Prior to estimating the actual impact on the productivity growth and the pollution abatement of brewing plants, a description and survey of sewer surcharge schemes currently in use in Canada was presented. It was found that while several of these schemes varied in form, in substance they were essentially identical. Each could be interpreted as imposing a price per pound of BOD and/or SS emissions or as imposing a charge per unit of aggregate sewage emissions, where the charge varied based on the quality of emissions. Because it was expected that the ability to substitute between elements (i.e. quality characteristics) of the sewage aggregate (V) is limited, the latter approach was adopted.

The conclusions of the empirical sections of this study may be summarized as follows:

a) Sewer surcharges induce a statistically significant reduction of emissions to the sewer system by brewing plants;

b) The rate of productivity growth is significantly lower in regulated, (i.e. surcharged) than non-regulated (i.e. non-surcharged) brewing plants;

c) Plant scale economies are significant in the brewing industry. Thus any investigation of productivity growth in this industry, or other industries in which scale economies may be a factor, should adopt a methodology which allows for their existence. This would minimize the possibility of confusing productivity growth and scale economies.

Finally one last point must be emphasized. The analysis presented suggests that environmental regulation tends to reduce the growth rate of total factor productivity. This is <u>not</u> necessarily undesirable. For accompanying these costs are definite benefits in terms of an improved environment. This study ignores these benefits by design. Informed public policy must, however, take such benefits into account when judging the desirability of alternate forms and degrees of environmental regulation.

FOOTNOTES

1. Other variables were included in the equation to correct for cyclical swings in output and energy price changes.

2. A failure to recognize this might lead one to conclude that an ineffective form of environmental regulation is superior to a policy which is effective and hence affects the allocation of resources. Such a conclusion could only be justified if the value of additional environmental quality were zero.

3. It should be emphasized once again that these costs may be accompanied by substantial benefits. It is even possible that some diversion of R and D towards abatement technology, relative to the situation which would exist with minimal environmental regulation, would be desirable.

4. This approach is sometimes referred to, in general, as the standards approach.

5. This is in stark contrast to U.S. experience, where the federal authorities play an active part in environmental regulation.

6. The short history of INCO found in Dewees (1980,12) also seems to provide evidence of behavior consistent with this tendency to delay compliance. Felske (1981,192) also notes a tendency for INCO to use technical and economic arguments to facilitate delaying tactics.

7. Control Orders are issued by the Ministry of the Environment in Ontario to polluters and specify various abatement requirements including such things as the desired quantity and concentration of emissions, the type of abatement activity, the timing of such actions, etc.

8. Since 1979 a joint federal-provincial grant has also been available to pulp and paper mills for modernization and pollution abatement. Some parties have expressed skepticism regarding the possible effectiveness of this scheme (Victor and Burrell, 1981,203).

9. The cost effectiveness of standards and charges is discussed in more detail in the section concerning economic incentive schemes.

10. It is assumed that the differentiated regulation discussed earlier, which is usually characteristic of the direct regulation-enforcement framework, would neutralize any tendency towards modernization which might otherwise have been induced.

11. The difficulty in defining equipment as primarily abatement or production oriented has been the source of some skepticism regarding the joint federal-provincial financial assistance program available to pulp and paper mills for modernization and pollution abatement, (Victor and Burrell, 1981,203).

12. Several different economic incentive schemes which are designed to induce compliance with environmental regulation have been suggested. Two of the more prominant ones are the effluent charge and transferable discharge permit (TDP) schemes. The discussion here will concentrate on the former. For more information on TDP schemes see Dales (1968), and Tietenberg (1974;1980).

13. A simple example can help to explain this idea. If the uniform charge were $5 and the extra "marginal" cost to the firm, at current levels of abatement, of abating one more unit of pollution is $2, a cost minimizing firm would abate because

this is cheaper than paying the charge. Additional abatement would cost $2 per unit but would save the firm $5 in effluent charge payments, a net gain to the firm of $3. Obviously abatement will be expanded as long as the charge exceeds the incremental or "marginal" cost of abatement.

14. In this case because the overall standard is set per annum the charge would be adjusted each year, if it were determined that aggregate emissions of SO_2 were not exactly one million tons.

15. The effect of growth in requiring an increasing charge over time could be offset, at least in theory, by technological progress in pollution abatement.

16. It is also possible that the desired standard could vary from year to year. This would also require varying the effluent charge.

17. The optimal or equilibrium charge is the one which, at a point in time, ensures aggregate emissions of one million tons of SO_2.

18. The charge is assumed to be altered in this scheme once per year given that the overall standard is defined per annum.

19. It is assumed here that the direct regulation-enforcement scheme is effective at inducing compliance.

20. A cost effective scheme achieves the overall standard at least cost.

21. Usually the argument is couched in terms of a uniform standard. In reality standards often vary over groups of firms often for equity reasons, but are generally uniform within each group of firms. It is doubtful that this complication affects the argument presented in any significant way. If the variation in standards across groups was based purely on abatement costs

then this scheme would also be more cost effective than a uniform standard.

22. This is because the extra or marginal cost of abatement at all point sources will be equated. If this were not true abatement could be shifted from high to low cost sources with a resulting decline in costs. There is empirical evidence provided by Pittman (1981) that under the current direct regulation-enforcement framework in the U.S., pulp and paper mills exhibit systematic differences in the marginal cost of abatement at current loading levels. Thus there is evidence of serious inefficiencies resulting from the current system of pollution control regulation.

23. This study actually compared spatially differentiated and undifferentiated transferable discharge permits, but these results have definite implications for effluent charge scheme.

24. A tax which varied with the location of firms (i.e. a zone effluent charge) was found to produce abatement costs of only $8.6 million per annum. These findings are of course consistent with the theoretical discussion above.

25. Normal strength wastes are usually defined in each jurisdiction in a by-law. In theory these are wastes of the same concentration as "average" residential waste emissions.

26. It is common practice in all the jurisdictions discussed to place limits on the strength of pollutants which do not enter the surcharge formula.

27. Note that similar statements could be made with respect to suspended solids. In order to conserve space the analysis is carried out only in terms of BOD.

28. Chlorine demand has yet to be charged for.

29. The Waterloo-Kitchener surcharge formula is identical to equations (12) and (13) with $T_c = T_x = 0$.

30. There is a sewer service charge rebate for water purchased but not emitted into the sanitary sewers.

31. The "old" formula given by equation (14) could be converted to a form identical to the London or Winnipeg surcharge schemes. Hence one could determine charges per pound of pollution emitted. Thus differences between the old and new formula are in appearances only. Note however, that one difference between the London or Winnipeg surcharge and the Edmonton surcharge is that the former are based on volume of waste emissions whereas the latter is based on volume of water consumer.

32. The volume of waste emissions by the "representative" firm can be put into perspective by comparing them with the volume of emissions from a "typical" poultry processing plant: 210,370,000 U.S. gallons or 175,300,000 imperial gallons. (Ethridge, 1970,48-9). Similarily a "typical" beet sugar processing plant emits approximately 590 million imperial gallons per annum. (ibid, 41).

33. P_s beside depending on the concentration of BOD and SS in waste emissions also depends on the level of EC_b and EC_s set by the pollution control authority.

34. It is expected that the brewery's do not attempt to alter the quality of sewage being emitted. They view a change in EC_s or EC_b as a change in P_s and attempt only to reduce the quantity of emissions. This would of course entail proportionate reductions

of pollution. This relationship was suggested in conversation with brewery officials and was confirmed with data supplied by municipal pollution control authorities.

35. Sometimes the malt is supplemented at this stage by starch from other adjunct material.

36. The spent grains left in the lauter tub are collected and sold as cattle feed.

37. The brew-master uses two types of yeast depending on whether he is brewing ale or lager. If he is brewing ale or stout he uses a yeast which rises to the top of the liquid when fermentation is complete (Saccharomyces cerevisiae). With lager the yeast drops to the bottom of the brewing vessel (Saccharomyces carlsbergensis).

38. There has also been some concern about air (especially from grain drying) and land (i.e. litter) pollution. These forms of pollution are, however, beyond the scope of the current paper.

39. It is sometimes difficult to separate the sources of BOD and SS. It is undoubtedly true that any process designed to remove one will remove the other. For example, while trub and beer spills have been listed as sources of BOD (one expert estimated that they contained 3000 to 4000 ppm of BOD) they are undoubtedly also sources of SS. These statements are consistent with our approach of modelling the brewing firms' responses to P_s rather than EC_b and EC_s.

40. The largest 4 brewing firms in Canada controlled 99% of the market in 1978.

41. This may of course be explained by regional markets and high transportation costs.

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Statistics Canada Statistique Canada

Manufacturing and Primary Industries Division

ANNUAL CENSUS OF MANUFACTURES

In all correspondence concerning this questionnaire please refer to the first seven digits in the top line of the mailing address below.

BREWERIES

1975

Pour un questionnaire dans l'autre langue officielle veuillez communiquer avec la Division des industries manufacturières et primaires, Statistique Canada, Ottawa, K1A 0V6

Mailing Address (Please correct if necessary)

Physical Location of Establishment (Please correct if necessary)

S.I.C. 1093 Form CM 5-3305-18.1

1.1 **AUTHORITY**
The Annual Census of Manufactures is collected under the authority of the Statistics Act, Chapter 15, Statutes of Canada, 1970-71-72. For further details see item 1.1 in the enclosed Reporting Guide.

1.2 **REPORTING INSTRUCTIONS**

The enclosed Reporting Guide is designed to assist in the completion of this report. The instructions are numbered to correspond to the items to which they refer.

Report for your fiscal year ending between April 1, 1975 and March 31, 1976. Completed questionnaires must be returned within 60 days of receipt. Please keep one copy for future reference.

1.2.2 SINGLE ESTABLISHMENT FIRMS (as defined under 1.2.2 of the Reporting Guide): Please include in this report all of your operations, including any head office or ancillary units such as administrative offices, sales offices, warehouses, laboratories, etc., regardless of their location.

1.2.3 MULTI-ESTABLISHMENT FIRMS (as defined under 1.2.3 of the Reporting Guide): Please include in this report all of the operations pertaining to this establishment, including any ancillary units (administrative offices, sales offices, warehouses, laboratories, etc.) that serve this establishment only, regardless of their location. (Operations of ancillary units that serve more than this establishment and operations of head offices are to be reported on head office forms which will be mailed separately to the appropriate address.)

1.3 **OPERATIONS** Yes No

1.3.1 Did this establishment operate in the reporting year as defined in 1.2 above? .... 1 ☐ 2 ☐
If "No" sign in question 1.9 below and return.

1.3.2 Did this establishment go out of business during the reporting year? .... 1 ☐ 2 ☐

If "Yes", give date ____________
and complete this form for the period operated.

1.3.3 Did any change in ownership occur during the reporting year? .... 1 ☐ 2 ☐

If "Yes", give date ____________
and provide information for the full reporting year. If this is not possible provide information for the period operated and give name and address of respondent to contact for balance of information.

____
(name)

____
(address)

1.4 **FEDERAL PROVINCIAL AGREEMENTS**

In order to avoid duplication of enquiry and to provide consistent statistics, agreements have been made:

- With the provincial statistical agencies of Quebec, Manitoba and Saskatchewan under Section 10 of the Canada Statistics Act for the exchange of information collected in this survey for establishments located in Quebec, Manitoba and Saskatchewan, respectively. The Statistics Acts of these Provinces include the same provisions for confidentiality and penalties for disclosure of information as the Federal Statistics Act.
- With all other Provinces under Section 11 of the Act for the exchange of information relating to establishments located in their respective Provinces. The Section 11 agreement to share information relating to this establishment shall not apply if you object in writing and mail your letter, together with the completed questionnaire, to Statistics Canada.

For further details on these agreements see item 1.4 in the enclosed Reporting Guide.

1.5 **LOCATION OF THIS ESTABLISHMENT**

1.5.1 Has the location of this establishment changed from last year? .... Yes 1 ☐ No 2 ☐

1.6 **TYPE OF ORGANIZATION** (Check one)

1.6.1 Individual Ownership 1 ☐ Partnership 2 ☐ Incorporated Company 3 ☐ Co-operative 4 ☐

1.6.2 Does this represent a change in organization from your last report? .... Yes 1 ☐ No 2 ☐

Date of change ____________ 19 ______

1.7 **NATURE OF BUSINESS** (describe briefly)

1.7.1 ____________

1.7.2 Is this a change from last year? .... Yes 1 ☐ No 2 ☐

1.8 **HEAD OFFICES AND ANCILLARY UNITS OF MULTI-ESTABLISHMENT FIRMS**

1.8.1 Does this establishment have a Canadian Head or Executive Office whose operations can be reported separately?* Yes 1 ☐ No 2 ☐

1.8.2 If "Yes", please give its:

1.8.3 Name ____________

1.8.4 Address ____________

1.8.5 Is this establishment served by any ancillary units that also serve (an) other establishment(s) of your firm (see 1.2.3)?* Yes 1 ☐ No 2 ☐

* Data for such units should not be included in this report.

1.9 **CERTIFICATION**

I certify that the information contained herein is complete and correct to the best of my knowledge and belief and covers the fiscal year or period

from |_|_|_|_|1|9|7|_| to |_|_|_|_|1|9|7|_|
Day Month Year — Day Month Year

Signature of authorized person	Title	Date

Name of person to contact regarding this report	Address including postal code (if different from mailing address above)	Telephone: Area code	Telephone: Number	Telephone: Ext.	Telex

STANDARD

		Inventory for period covered by this report	
2.	**INVENTORIES** at book value, including those in transit and those on consignment in Canada (refer to Instruction 2 in the Reporting Guide)	Opening Canadian dollars (omit cents)	Closing Canadian dollars (omit cents)
2.1	Manufacturing Inventory		
2.1.1	Do these figures include inventory held but not owned? Yes 1 ☐ No 2 ☐		
2.1.2	Inventory of fuel		
2.1.3	Inventory of raw materials, purchased components and supplies		
2.1.4	Total inventory of fuel, raw materials, etc. (2.1.2+2.1.3)		
2.1.5	Inventory of goods in process (less federal excise duty)		
2.1.6	Inventory of finished products (less federal excise duty)		
2.2	Inventory of goods purchased for resale in same condition as purchased		
2.3	Other non-manufacturing inventory (specify)		
2.5	Total inventory of this establishment		

3. **UNFILLED ORDERS** (refer to Instruction 3 in the Reporting Guide)

3.1 Report value (or give your best estimate) as of December 31, 1975 ....

3.2 Do you normally have a backlog (not shipping backlog) of unfilled orders? .... Yes 1 ☐ No 2 ☐

4. **BASIS OF VALUATION** (refer to Instruction 4 in the Reporting Guide)

4.1 Fuel, raw materials, containers, supplies, etc. (as reported in question 5 and 6)

4.1.1 Are you reporting consumption as requested? .... 1 ☐
OR
Are you reporting purchases of these items? .... 2 ☐

4.2 Products (as reported in question 8)

4.2.1 Are you reporting value of shipments as requested? .... 1 ☐
OR
Are you reporting value of production? .... 2 ☐

4.2.2 Are the reported values at: (Check "other" if more than one is applicable)
- Cost? .... 1 ☐
- Book transfer value? .... 2 ☐
- Final selling price? .... 3 ☐
- Other (specify) .... 4 ☐

5. **CONSUMPTION OF PURCHASED FUEL AND ELECTRICITY** (refer to Instruction 5 in the Reporting Guide)

	Kind	Commodity code for Statistics Canada use	Unit of measure	Quantity used	Cost at this establishment Canadian dollars (omit cents)
5.1	Coal and coke	261	ton		
5.2	Natural gas	263 1	1000 cu. ft.		
5.3	Gasoline	431	Cdn. gal.		
5.4	Kerosene, stove oil (No. 1 fuel oil)	432 2	"		
5.5	Diesel oil	432 3	"		
5.6	Light fuel oil (Nos. 2 and 3)	432 4	"		
5.7	Heavy fuel oil (Nos. 4, 5 and 6)	432 5	"		
5.8	Liquefied petroleum gases (propane, butane, etc.)	436 1	"		
5.9	Electricity purchased (include service charge)	497 1	1000 kwh.		
5.10	Other fuel (include steam purchased) (specify)				
5.11	Total fuel and electricity				

5.12 **ELECTRIC GENERATING FACILITIES**
Did this establishment during the reporting period operate generating facilities with nameplate rating of more than 500 kw? .... Yes 1 ☐ No 2 ☐

SELECTED MANUFACTURING INPUTS

6. Raw materials, components, containers, supplies, etc., purchased and used in manufacturing operations (refer to Instruction 6 in the Reporting Guide) – Do not include materials, etc. produced by this establishment for its own use.

Description	Commodity code for Statistics Canada use	Unit of measure	Quantity used	Total cost at this establishment Canadian dollars (omit cents)
6.1 Raw materials and components purchased and used in manufacturing operations				
6.1.1 Malt, barley, Canadian	062 32	lb.		
6.1.2 Malt, barley, imported	062 32	"		
6.1.3 Malt, other than barley malt	062 33	"		
Cereal flakes, grits and meals –				
6.1.4 Corn, Canadian	062 52	"		
6.1.5 Corn, imported	062 52	"		
6.1.6 Rice	062 53	"		
6.1.7 Soybean	069 41	"		
6.1.8 Wheat	062 55	"		
6.1.9 Other cereal flakes, grits and meals	062 5	"		
6.1.10 Hops, Canadian	144 3	"		
6.1.11 Hops, imported (include excise duties in cost)	144 3	"		
6.1.12 Hop, extract	144 32	"		
Miscellaneous brewing ingredients –				
6.1.13 Acid – lactic	414 33	"		
6.1.14 phosphoric	401 51	"		
6.1.15 Muriatic	401 12	"		
6.1.16 Carbon dioxide for brewing	401 8	"		
6.1.17 Chemicals for refrigeration (ammonia)	402 1	XXX	XXXXX	
6.1.18 Clarifying agents	429 41	XXX	XXXXX	
6.1.19 Foam retaining agents	429 46	XXX	XXXXX	
6.1.20 Defoaming agents	429 45	XXX	XXXXX	
6.1.21 Filtering agents	429 22	XXX	XXXXX	
6.1.22 Gypsum	279 33	lb.		
6.1.23 Salt – sodium chloride	279 712	"		
6.1.24 potassium (KMS,etc.)	404 96	"		
6.1.25 other salts (Burton, etc.)	404	"		
6.1.26 Yeast (if purchased)	144 7	"		
6.1.27 Sugar, granulated, cane and beet	101 31	"		
6.1.28 Sugar, invert and similar liquids (sugar solid basis)	101 33	"		
6.1.29 Glucose (including industrial corn syrup)	101 612	"		
6.1.30 Caramel	146 321	"		
6.1.31 Food colourants	146 32	"		
6.1.32 Other brewing adjuncts, specify		XXX	XXXXX	
.....		XXX	XXXXX	
6.1.33 Water purchased	278 1	M gal.		
6.1.34 Water treatment chemicals	429 93	XXX	XXXXX	
6.1.36 Other ingredients, specify				
.....				
.....				
6.2 Sub-total of items in 6.1				

5-3305-18.1

SELECTED MANUFACTURING INPUTS – concluded

6. Raw materials, components, containers, supplies, etc., purchased and used in manufacturing operations (refer to Instruction 6 in the Reporting Guide) – Do not include materials, etc. produced by this establishment for its own use.

Description	Commodity code for Statistics Canada use	Unit of measure	Quantity used	Total cost at this establishment Canadian dollars (omit cents)
NON-RETURNABLE (see also section 7.8)				
6.3 Non-returnable containers and other shipping and packaging materials purchased and used for goods of own manufacture				
6.3.1 Bottle expenses { Include: breakages, loss on refunds, write-offs, inventory shortages, etc. Exclude: actual cost of new bottles }	XXX	XXX	XXXXX	
6.3.2 Cans	951 123 2	doz.		
6.3.3 Other non-returnable containers (plastic bottles, etc.)	951	"		
6.3.4 Metal closures (caps and crowns)	951 911 1	XXX	XXXXX	
6.3.5 Folding and set-up boxes and cartons	951 312	XXX	XXXXX	
6.3.6 Corrugated boxes and cartons	951 311	XXX	XXXXX	
6.3.7 Labels, body and neck	899 3	XXX	XXXXX	
6.3.8 Keg expenses	XXX	XXX	XXXXX	
6.3.9 All other packaging materials and supplies		XXX	XXXXX	
6.4 Sub-total of items in 6.3				
6.6 Total value of operating, maintenance and repair supplies purchased and used in manufacturing operations, excluding fuel				
6.7 Total of raw materials, components, containers, supplies, etc. (6.2 + 6.4 + 6.6)				
6.8 Amount paid out to other establishments for work done on materials owned by this establishment (refer to Instruction 6.8 in the Reporting Guide)				
6.9 Total of raw materials, containers, supplies and amount paid for work done (6.7 + 6.8)				

6.10 SUMMARY STATEMENT ON BREWED PRODUCTS Include quantities in fermenters, storage tanks, etc.	Number of gallons
6.10.1 On hand at beginning of year	
6.10.2 Brewed during the year (measure at second dip – as used for excise duty)	
6.10.4 Brewed products purchased for resale	
6.10.5 Total available	
6.10.6 Shipments of brewed products produced by this plant (pg. 6 item 8.1.6 refers)	
6.10.7 Shipments of brewed products purchased and resold (item 6.10.4 refers)	
6.10.8 Shrinkage, wastage, etc.	
6.10.9 On hand at end of year	
6.10.10 Total accounted for	

SELECTED NON-MANUFACTURING INPUTS	Total cost at this establishment Canadian dollars (omit cents)
7. Merchandising and construction activities, etc. (refer to Instruction 7 in the Reporting Guide)	
7.1 Purchases of goods from other establishments for resale in same condition as purchased (include transfers of such goods from other establishments of your company) (report sales of such goods in question 9.1)	
7.2 Purchased materials and supplies used in new construction produced by own labour force for own use (only those items charged to Fixed Assets Accounts which are reported in question 9.2)	
7.3 Purchased materials and supplies used in production of any machinery and equipment for own use by own labour force (only those items charged to Fixed Assets Accounts which are reported in question 9.3)	
7.4 Office supplies purchased and used	
7.5 All other purchased materials and supplies used by this establishment	
7.6 Sub-total of items in 7	
7.7 Grand total of selected manufacturing and non-manufacturing inputs (6.9 + 7.6)	

SUPPLEMENTARY

	Unit of measure	Quantity	Cost value at the plant
7.8 Returnable containers purchased during the year: – Original price			Canadian $
7.8.1 NEW bottles – Small	dozen		
7.8.2 Large	"		
7.8.3 NEW cases (for beer) Corrugated paper (re-trippers)	number		
7.8.4 Barrels and kegs – metal	"		
7.8.5 Other returnable containers, specify			

7.9

SUPPLEMENTARY – MANUFACTURED OUTPUTS

DUTIES, TAXES, FEES, LICENSES, ETC., PAID ON PRODUCTS SHIPPED Please ensure that these payments are excluded from commodities reported in Section 8.1	Canadian dollars (omit cents)
7.9.1 Federal excise duties	
7.9.2 Federal sales taxes	
7.9.3 Provincial sales taxes	
7.9.4 Provincial gallonage tax, if applicable	
7.9.5 Brewers' license fees (Fed. and Prov.)	
7.9.6 Other taxes, specify	
7.10 Total of items 7.9.1 to 7.9.6 inclusive	

SELECTED MANUFACTURING OUTPUTS

8. Shipments of goods of own manufacture (refer to Instruction 8 in the Reporting Guide)

Description	Commodity code for Statistics Canada use	Unit of measure	Quantity shipped	Net value of shipments, excluding sales taxes, excise duties and excise taxes, shipping charges by common or contract carriers and net of any sales discounts, allowances, etc. Canadian dollars (omit cents)
8.1 Products shipped				
Brewed Products –				
8.1.1 Small bottles	172 111	gal.		
8.1.2 Large bottles	172 112	"		
8.1.3 Canned	172 12	"		
8.1.4 Draught	172 13	"		
8.1.5 Brewed products shipped in bulk (bottled by other plants)	172 19	"		
8.1.6 Total (8.1.1 to 8.1.5 inclusive)	x x x	"		
Other products:				
8.1.7 Brewers' grains – dried	155 311	ton		
8.1.8 Brewers' grains – wet	155 312	"		
8.1.9 Brewers' yeast – dried	144 712	"		
8.1.10 Brewers' yeast – wet	144 711	"		
8.1.11 Carbon dioxide gas, produced for sale	401 81	lb.		
8.1.12 Distilled water	409 8	gal.		
8.1.13 Yeast (lab. produced) made for own use	144 7	lb.		x x x x x
8.1.14 Yeast (lab. produced) made and sold	144 7	"		
8.1.15 Scrap cartons	291 22	x x x	x x x x x	
8.1.16 Scrap glass, cullet	291 8	x x x	x x x x x	
8.1.17 All other products shipped (specify main items separately)				

8.2 Total value of shipments of goods of own manufacture (total of items in 8.1)

8.3 Less adjustments for the following items if you were not able to exclude them from the value of the individual products in section 8.1

8.3.1 Total payments for shipping charges by common or contract carriers

8.3.2 Total payments of sales taxes, excise duties and excise taxes

8.3.3 Total amounts of discounts, sales allowances and returned sales

8.4 Total adjustments (sum of items in 8.3)

If the amounts reported above include any incurred in connection with goods purchased for resale (see 9.1) please check here ☐

8.5 Adjusted value of shipments of goods of own manufacture (8.2 less 8.4 or 8.2 if 8.4 is zero)

8.6 Amount received in payment for work done on materials and products owned by other establishments (including those from any other establishment of your own company)

8.7 Total value of shipments of goods of own manufacture and amount received for work done (8.5 + 8.6)

9. **SELECTED NON-MANUFACTURING RECEIPTS** (refer to Instruction 9 in the Reporting Guide)

	Canadian dollars (omit cents)
Value of shipments of goods purchased and sold in same condition as purchased (purchases of such goods should be reported in question 7.1)	
9.1 Total value	
Specify below the major products included in this value and give estimate of percentage which each represents of this value Name of product ________ Estimated % ________	
9.2 Book value of new construction by own labour force for own use (only that amount charged to the Fixed Assets Accounts – this should at least include material costs reported in question 7.2 and labour included in 14.1.4)	
9.3 Book value of machinery and equipment manufactured by own labour force for own use (only that amount charged to the Fixed Assets Accounts – this should at least include material costs reported in question 7.3 and labour included in 14.1.4)	
9.4 Revenue from sale of electricity	
9.5 Revenue from lease or rental of machinery and equipment manufactured by this establishment	
9.6 All other revenue from products and services (exclude non-operating revenues such as interest, dividends, etc.)	
9.7 Total of items in 9	
10. Grand total of manufacturing and selected non-manufacturing outputs (8.7 + 9.7)	
SUPPLEMENTARY	
11. Revenue from lease or rental of property; lands, buildings, offices, etc.	
12. Revenue from lease or rental of machinery and equipment other than that included in 9.5 above (i.e. from machinery of all kinds, engines, trucks of all types, trailers, tractors, other equipment, etc.)	

STANDARD

14. **EMPLOYEES OF THIS ESTABLISHMENT** (refer to section 14 in the Reporting Guide)

See reporting instructions 1.2.2 and 1.2.3 on page 1 of this form	Gross salaries, wages, commissions, bonuses, etc. (omit cents)	Average number employed during reporting period		Number of man-hours (please provide reasonable estimate where records are not maintained)	
		Male	Female	Worked	Paid
14.1 Employees at this location					
14.1.1 Executive, administrative and sales staff				XXXX	XXXX
14.1.2 Employees in manufacturing operations					
14.1.3 Outside pieceworkers. Please include amounts paid to outside pieceworkers in section 6.8	XXXX	XXX	XXX	XXXXX	XXXXX
14.1.4 Other production and related workers, including employees engaged in construction and production of machinery and equipment for own use (see 9.2 and 9.3)				XXXXX	XXXXX
14.2 Employees at other locations					
14.2.1 Employees in manufacturing operations					
14.2.2 All other employees				XXXXX	XXXXX
14.3 Total employees at other locations				XXXXX	XXXXX

14.4 Supplementary information	Employees in administration, sales, etc. at this location (see 14.1.1)	Employees in manufacturing operations at this location (see 14.1.2)
14.4.1 Average hourly rate of pay in dollars and cents	XXXXXX	
14.4.2 Number of hours in standard work week		
14.4.3 Average paid vacation in number of weeks per year OR		
14.4.4 Vacation pay as % of earnings		
14.4.5 Number of paid statutory holidays per year		

15. Employees at other locations included in this return (attach separate sheet if necessary)

Location (street and number, municipality name, province)	Major activity carried on	Statistics Canada use	Gross salaries, wages, commissions, bonuses, etc. (omit cents)	Average number employed during reporting period	
				Male	Female
Total (should agree with 14.3 above)					

	Number
16. Working owners and partners	

5-3305-18.1