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# A Case Study: Safety Glass Regulations under the Hazardous Products Act

## Eighth in a Series of Studies on Government Regulatory Activity

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**Eighth in a Series of Studies on Government Regulatory Activity**

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CONTENTS


FOREWORD v

SUMMARY vii

1. INTRODUCTION 1

2. ANALYSIS OF THE ALLOCATIVE EFFECTS OF THE REGULATIONS 3

Benefits 4
Costs 16
Benefit-Cost Comparisons 17
Sensitivity Analysis 21

3. ANALYSIS OF THE NON-ALLOCATIVE EFFECTS OF THE REGULATIONS 24

Inflation 24
Market Structure and Competition 24
Distribution of Income 25
International Trade 26
Industry Output and Employment 27
Energy Consumption 28

4. CONCLUSIONS 29

NOTES 31

APPENDIX A A Policy Alternative to Direct Government Intervention 40

APPENDIX B An Alternative Derivation of Durability Benefits 43

BIBLIOGRAPHY 45

## FOREWORD

In recent years, increasing concern has been expressed both inside and outside government about the social and economic impact of government regulatory activity. On the one hand, the regulatory process itself has been faulted for being insensitive to public needs and opinions while, on the other hand, doubts have been expressed concerning the efficiency and effectiveness of particular regulations, standards or guidelines. More specifically, with the onslaught of serious inflationary problems, it has been argued that regulations may be unnecessarily adding to costs and prices. In fact, it was in the context of the establishment of the Anti-Inflation Board and the resulting debate on controls and post-controls policies that the Cabinet directed the Department of Consumer and Corporate Affairs and the Treasury Board Secretariat to assess the feasibility of applying benefit-cost and related methods of analysis to government social regulations, and to suggest modifications to the regulatory process which might encourage greater public participation.

In response to this mandate, our predecessors, Dr. Sylvia Ostry and Dr. Maurice LeClair, arranged for the establishment of a Working Group on Social Regulations. A number of studies were initiated in this context, whose results constituted an input to the development of the main features of the Socio-Economic Impact Analysis (SEIA) policy for health, safety and fairness regulations. The SEIA policy guidelines on analytical and consultative process requirements have been incorporated into the Administrative Policy Manual (Treasury Board Canada) as Chapter 490.

The papers in this Series of Studies on Government Regulatory Activity are selected from those which were prepared by the Working Group on Social Regulations, whose major purpose was to study the feasibility and desirability of subjecting health, safety and fairness regulations to more systematic analyses. Two types of background papers were prepared in this context. The first are general studies on the reasons for social regulations, the experience of the United States with regulatory reform, and techniques for the evaluation of regulations (evaluation methodologies for health, safety and fairness regulations are discussed in Chapter 490 of the Administrative Policy Manual). The second group of papers consist of case studies of recent representative regulations in the areas of health, safety and fairness, and provide examples of analytical frameworks likely to be used in the context of the SEIA policy.

Since a major purpose of the SEIA policy is to encourage greater public participation in the regulation-making process, we have decided that selected background papers and case studies prepared by the Working Group should continue to be published in order to increase public awareness of this very important aspect of government activity.

George Post
Deputy Minister
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John L. Manion
Secretary
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## SUMMARY

This case study examines the feasibility of using available methodologies to assess the socio-economic impact of regulatory changes in the area of consumer products safety . The regulations examined, known as the Safety Glass Regulations, were promulgated under the Hazardous Products Act on July 17, 1973, and require that glass used in all storm doors, patio doors and bathtub and shower enclosures advertised in, sold in, or imported into Canada be tempered safety glass rather than ordinary annealed glass.

The impact of the regulations is assessed on both the allocation of resources, or market efficiency, and on non-allocative factors such as the distribution of income, international trade, and energy consumption. The allocative impact of the regulations is assessed in Section 2, using benefit-cost methodology. It was assumed that switching from ordinary annealed glass to tempered safety glass in the three product categories would have the following effects: there would be a reduction in the frequency of injuries caused by broken glass; there would be an increase in the frequency of injuries caused by impact or collision with glass; there would be an increase in the expected useful life of the glass used in the products because of the greater durability of safety glass over ordinary glass; and, there would be an increase in the product costs because of the higher relative cost of safety glass. Therefore, the major benefits expected to result from the regulations were reduced costs associated with cut-by-glass injuries and resource savings attributable to less frequent replacement of the glass in the products. The major costs were increased costs associated with impact injuries and higher product costs resulting from the higher unit cost of safety glass versus ordinary glass. The results of the benefit-cost analysis are expressed in terms of net present values and benefit-cost ratios. A real social discount rate of 10 per cent was assumed and a 30-year time horizon (1973-2002) was selected. The regulations were found to generate net social costs amounting to $5.67 million in 1973 dollars. There was considerable variance in the results when analysed on a product basis. Regulations for storm doors and bath and shower enclosures were

expected to create net benefits of \$14.34 million and \$0.19 million, respectively, while the regulation of patio doors would probably lead to net social costs of \$20.20 million. This suggests that it may be profitable to consider alternatives to regulating the use of safety glass in patio doors.

The non-allocative impact of the regulations is assessed in Section 3. Factors analysed include the impact on inflation; market structure and competition; the distribution of income; international trade; industry output and employment; and energy consumption. The regulations were not expected to have any sustained impact on inflation, although a one-time increase in the retail price of each of the products was anticipated. The average retail price was expected to increase to \$107.50 from \$100 for storm doors, \$295 from \$250 for patio doors, and \$80 from \$65 for bath and shower enclosures. Although no impact on the already heavily concentrated market structure of the glass-manufacturing industry was predicted, it was expected that the regulations might induce slightly more competition in the markets for consumer glazing products. The distribution of income was expected to shift slightly in favour of glass producers and product manufacturers at the expense of consumers of the products because of the high probability that all cost increases would be passed on to consumers in the form of higher retail prices. However, consumers would be compensated (in part, at least) by greater product safety and durability. Little or no impact was anticipated on international trade or on industry output and employment. In the short term, energy consumption was expected to increase slightly but to decrease in the longer term because of a reduction in sales growth resulting from increased glass durability.

Several general conclusions drawn from the study are discussed in Section 4. The study shows that although certain problems should be expected, particularly in the areas of data availability and quality, and in determining the cost of pain and suffering, these are not prohibitive and it is feasible to use existing methodologies to assess the socio-economic impact of similar regulatory changes in the area of consumer products safety.

## 1. INTRODUCTION

On July 1, 1972, the National Building Code of Canada was revised to require that glass used in doors, sidelights, and shower and bathtub enclosures "be safety glass of the laminated or tempered type".[1] The revision was made in an attempt to reduce the estimated 10,000 injuries that Canadians suffered each year in accidents involving architectural glass.[2] The National Building Code must be adhered to for all new construction financed by National Housing Act (NHA) mortgages and changes to the code are frequently incorporated in provincial and municipal laws, by-laws, and standards relating to new building construction.

In May, 1972, the Department of Consumer and Corporate Affairs initiated discussions with industry and government officials to draft regulations covering the replacement and renovation markets as well as new residential construction unaffected by the National Building Code. All markets, including those already governed by the National Building Code, would be covered by including doors and enclosures made with ordinary glass in Part I of the schedule to the Hazardous Products Act and then promulgating regulations prescribing standards for safety glass to be used in such products. The act prohibits the advertisement, sale, and importation of products included in Part I of the schedule.

Meetings were held with representatives from glass producers, product manufacturers, the National Research Council, the Department of Supply and Services, and the Department of Consumer and Corporate Affairs. At that time, an increase in the retail price of the products was anticipated (caused by a higher unit cost of safety glass as compared with ordinary glass) but was considered likely to be offset by a reduction in the hazardous characteristics of the products. On July 20, 1973, the Minister of Consumer and Corporate Affairs "announced new regulations under the Hazardous Products Act requiring safety glass in doors and tub enclosures used in homes".[3]

This paper examines the feasibility of using available methodologies to assess the socio-economic impact of the Safety Glass Regulations. The regulations are evaluated in terms of their probable impact on the allocation of resources in the economy as well as on certain non-allocative factors.[4] Section 2 of the paper concentrates on the allocative impact of the regulations. A benefit-cost analysis is performed comparing expected social benefits and social costs. The results of the analysis are presented for each product category in the form of net present values and benefit-cost ratios, and a sensitivity analysis is performed by showing how the results are affected by a given change in the value of several key parameters. Alternatives that would achieve the same objective as the Safety Glass Regulations are not analysed in this paper, because no data concerning the efficacy of possible alternatives could be found. One alternative was considered and rejected for reasons outlined in Appendix A, page 40. In Section 3, several non-allocative effects of the regulations are analysed. These include the effect on inflation; market structure and competition; the distribution of income; international trade; industry output and employment; and energy consumption. Finally, in Section 4, the experience gained in conducting this case study is applied to reach several general conclusions respecting the feasibility of conducting analyses of similar regulations in area of the consumer products safety.

## 2. ANALYSIS OF THE ALLOCATIVE EFFECTS OF THE REGULATIONS

This section of the paper consists of a benefit-cost analysis of the allocative effects of the Safety Glass Regulations. Expected social benefits and costs are calculated for each of the three product groups over a 30-year time horizon. A common time horizon is used for all the products being analysed, in order to be able to make relative comparisons of the results across product categories. The choice of a 30-year period is somewhat arbitrary, but it was necessary to choose a time horizon at least as long as the expected useful life of ordinary glass in its most durable application (20 years for patio doors). Time horizons of 25 or 35 years, for example, would have been equally suitable. In order to compare benefits and costs occurring in different time periods, a real social rate of discount of 10 per cent per year is used to reduce benefits and costs to their real value in the base year of 1973. This rate is consistent with a Treasury Board Canada recommendation that for benefit-cost analyses, federal departments and agencies should use a real "social discount rate of 10 per cent, and of 5 and 15 per cent for sensitivity analyses."[5] A sensitivity analysis is performed at the end of this section to determine the extent to which the results are influenced by changes in the values of the major underlying parameters.

In assessing the impact of the regulations, it is first necessary to note the physical and cost differences between ordinary annealed glass (window glass) and tempered safety glass. The manufacture of tempered safety glass requires that ordinary annealed glass be subjected to controlled heating and cooling, giving the glass increased resistance to mechanical and thermal stress. Tempered safety glass is four to five times stronger than ordinary glass. In addition, if fracture of the glass does occur, ordinary glass shatters into relatively large hazardous slivers upon impact, whereas tempered safety glass disintegrates into many small, harmless granular pieces. Because of the additional controlled heating and cooling required in the production process, the cost of producing tempered safety glass is higher than ordinary annealed glass.

Given the above characteristics and certain assumptions discussed later in the paper, it is expected that the Safety Glass Regulations would have the following effects in each of the three product categories: there would be a reduction in the number of injuries caused by broken glass involving the products (hereafter referred to as cut-by-glass injuries); there would be an increase in injuries caused by impact with glass that does not break (hereafter referred to as impact injuries); there would be an increase in the expected useful life of the products because of the greater durability of safety glass over ordinary glass; and, there would be an increase in the product costs because of the higher relative cost of safety glass. Therefore, the major benefits expected to result from the regulations are reduced social costs associated with cut-by-glass injuries and resource savings attributable to less frequent replacement of the products. The major costs are increased social costs associated with impact injuries and higher opportunity costs of producing the products, because of the higher resource cost of safety glass versus ordinary glass. The costs of implementing and enforcing the regulations are also relevant, but proved small enough to be ignored for analytical purposes in this particular study.

## Benefits

### (1) Reduced Cut-by-Glass Injuries

The first of the two benefits expected to result from the regulations is a reduction in the number, and therefore the total cost, of cut-by-glass injuries. These benefits are calculated by determining the cost per injury and multiplying it by the number of injuries expected to be prevented. The method of calculating the value of the reduction in cut-by-glass injuries is given by the following formula used separately for each product category (k):

$$PVRI_k = \sum_{t=o}^{n} \left[ \frac{(CI_k)\ (NI_{kt})}{(1+r)^t} \right] \qquad (1)$$

where $PVRI_k$ = present value of benefits from reduced cut-by-glass injuries involving product k

$CI_k$ = cost per cut-by-glass injury in 1973 dollars

$NI_{kt}$ = number of cut-by-glass injuries prevented in year t
= $(NI_k \times GR_t \times IR_k \times RR_{kt})$

$NI_k$ = number of cut-by-glass injuries expected to occur in the absence of the regulations in 1973

$GR_t$ = ratio of projected population in year t over population in 1973

$IR_k$ = rate by which cut-by-glass injuries are expected to be reduced, using product k with safety glass as compared with ordinary glass

$RR_{kt}$ = proportion of total stock of product k that is in compliance with regulations and would otherwise not have been in compliance in year t

$t_o$ = 1973

r = real social rate of discount of 10 per cent

Values for each of the parameters appearing in Equation (1) are given in Tables 1 or 2 and explained briefly below.

Table 1

Cut-by-Glass Injuries

| Parameter | Product Category (k) | | |
|---|---|---|---|
| | Storm Doors | Patio Doors | Bath and Shower Enclosures |
| Cost per Injury ($CI_k$) | \$ 220* | \$ 225* | \$ 335* |
| Number of Injuries ($NI_k$) | 13,324 | 908 | 908 |
| Reduction Rate ($IR_k$) | 0.90 | 1.00 | 0.87 |

*1973 dollars

The cost per injury shown for each product group ($CI_k$) is derived from estimates used in two American studies.[6] There was neither comparable Canadian data nor sufficient alternative information available to construct a proxy with any reasonable degree of confidence. In principle, the average cost per injury should be computed by calculating direct and indirect cost components. The direct cost would be the cost of medical treatment for each injury. This would consist of the cost of medication, the services of a medical doctor, and hospitalization, if necessary.[7] An estimate of this cost would require data on the distribution of cases by degree of severity, e.g. the proportion of cases that required a follow-up visit with a general practitioner or hospitalization.[8] The indirect cost would be the loss of output in the economy resulting from injured persons being absent from work to be treated and to recuperate. The conventional way of estimating such losses is to calculate the loss of gross earnings to the injured as a proxy for value added by labour, i.e. the value of their marginal productivity. Calculation of this indirect cost would require information on the demographic characteristics of the injured, e.g. age, sex, occupation and associated wage rate, participation rate, and employment rate.[9] In some benefit-cost studies involving accidents or diseases, indirect cost also includes an allowance for pain and suffering on the part of victims. Placing a monetary value on human health and lives is controversial, and there are differences of opinion concerning the most appropriate method to be used in particular circumstances. Although these differences tend to be minimized the less serious the illness or accident being analysed and the lower the attendant incidence of death, and although very few accidents of the type analysed here result in serious injuries involving prolonged disability, the issue of whether and how to place a monetary value on human life or on pain and suffering is no less real or less crucial to the final calculations in this particular analysis. Because the regulations are also predicted to lead to an increase in impact injuries, however, the cost associated with the resulting increased pain and suffering would partially offset whatever benefits were attributable to reduced pain and suffering resulting from a reduction in cut-by-glass injuries. Nonetheless, it should be noted that no attempt has been made here to impute any monetary value for pain and suffering.[10] Because of the data limitations outlined above, the cost of foregone output has not been estimated either. Therefore, since only the direct cost of treating injuries is measured, the cost per injury shown in Table 1 should be considered to be a lower limit for the true benefit per injury prevented. It is impossible to determine the relative size of the indirect costs compared to the direct cost of each injury.

The number of injuries prevented is determined by the second bracketed term in the numerator of Equation (1). The number of injuries prevented is simply the number of injuries expected to occur in the absence of the regulations less the number expected under the regulations. In the equation this difference is found by multiplying the expected number of injuries assuming no regulations (given by $NI_k$ X $GR_t$) by the rate by which injuries would be reduced using new regulated products ($IR_k$) and the rate at which old products are replaced by new products ($RR_{kt}$). The origin of these terms is explained briefly below.

The number of injuries expected for each product group ($NI_k$), like the cost per injury, had to be derived from an estimate used in a United States study.[11] As explained in Note 9, it is not possible to determine this number from available Canadian data. Although the National Research Council estimated that a total of 10,000 cut-by-glass and impact injuries occurred in 1973, this number itself was apparently a crude extrapolation from United States data and is almost certainly a gross underestimate. The total of 15,540 estimated in Note 11 is probably the best available estimate for injuries in Canada. It is assumed that the prevalence level of injuries (injuries per capita) would remain constant over the period of analysis in the absence of the <u>Safety Glass Regulations</u>. This implies that over the time horizon of the study, the annual number of injuries would increase by a factor equivalent to the annual rate of population growth. After 1973, the number of injuries for each year t is therefore found by multiplying $NI_k$ by the ratio of projected population in year t over population in 1973. These population growth factors ($GR_t$) are derived from Statistics Canada population projections and are shown in Table 2.[12]

The injury reduction rate ($IR_k$) indicates the proportion of injuries expected to be eliminated if each product used safety glass instead of ordinary glass. An injury reduction rate of 0.95 therefore would indicate that if ordinary glass were replaced by safety glass in all products, 95 per cent of cut-by-glass injuries would be eliminated. The injury reduction rates were also obtained from United States studies.[13] No Canadian studies are known to have been conducted to determine injury reduction rates, but it is reasonable to assume that the United States studies yield rates that are applicable to Canada.

Table 2

Population Growth Factors ($GR_t$) and Replacement Rates ($RR_{kt}$): 1973-2002

| Year | $GR_t$ | $RR_{kt}$ | | |
|---|---|---|---|---|
| | | Storm Doors | Patio Doors | Bath & Shower Enclosures |
| 1973 | 1.000 | 0.050 | 0.023 | 0.028 |
| 1974 | 1.015 | 0.151 | 0.068 | 0.080 |
| 1975 | 1.030 | 0.252 | 0.113 | 0.134 |
| 1976 | 1.043 | 0.353 | 0.158 | 0.189 |
| 1977 | 1.055 | 0.454 | 0.203 | 0.242 |
| 1978 | 1.065 | 0.555 | 0.248 | 0.295 |
| 1979 | 1.079 | 0.656 | 0.293 | 0.349 |
| 1980 | 1.092 | 0.757 | 0.338 | 0.402 |
| 1981 | 1.104 | 0.858 | 0.383 | 0.456 |
| 1982 | 1.117 | 0.959 | 0.428 | 0.510 |
| 1983 | 1.129 | 1.000 | 0.473 | 0.563 |
| 1984 | 1.142 | 1.000 | 0.518 | 0.617 |
| 1985 | 1.154 | 1.000 | 0.563 | 0.670 |
| 1986 | 1.167 | 1.000 | 0.608 | 0.724 |
| 1987 | 1.179 | 1.000 | 0.653 | 0.778 |
| 1988 | 1.191 | 1.000 | 0.698 | 0.800 |
| 1989 | 1.202 | 1.000 | 0.743 | 0.800 |
| 1990 | 1.213 | 1.000 | 0.788 | 0.800 |
| 1991 | 1.224 | 1.000 | 0.833 | 0.800 |
| 1992 | 1.234 | 1.000 | 0.878 | 0.800 |
| 1993 | 1.244 | 1.000 | 0.900 | 0.800 |
| 1994 | 1.253 | 1.000 | 0.900 | 0.800 |
| 1995 | 1.262 | 1.000 | 0.900 | 0.800 |
| 1996 | 1.270 | 1.000 | 0.900 | 0.800 |
| 1997 | 1.278 | 1.000 | 0.900 | 0.800 |
| 1998 | 1.285 | 1.000 | 0.900 | 0.800 |
| 1999 | 1.290 | 1.000 | 0.900 | 0.800 |
| 2000 | 1.305 | 1.000 | 0.900 | 0.800 |
| 2001 | 1.315 | 1.000 | 0.900 | 0.800 |
| 2002 | 1.325 | 1.000 | 0.900 | 0.800 |

The injury reduction rate would complete the formula for calculating the benefits from reduced cut-by-glass injuries in the following circumstances: if all the products in use before the regulations were promulgated had been fitted with ordinary glass; if all these products instantaneously were converted to safety glass following passage of the regulations; and if only safety glass were used in all new products sold. Of these three conditions, only the last is assumed to hold. The first two conditions are taken into account in the formula through the replacement rate for each product type ($RR_{kt}$), defined as the proportion of total product stock that is in compliance with the regulations and that would not otherwise have been in compliance in year t. This rate is a function of the proportion of product stock that would have been fitted with safety glass even if there were no regulations, the expected life of ordinary glass in existing products, and the rate at which new products enter the market. The replacement rate can range in value from zero to one -- the higher the value of the replacement rate, the more effective the regulations in reducing cut-by-glass injuries. The replacement rate would be higher (i) the lower the proportion of product stock that had been fitted with safety glass before the regulations; (ii) the faster ordinary glass is replaced by safety glass after the regulations come into effect; and (iii) the greater the annual growth of new product sales. A value of one, for example, would require no products to have been in compliance before the regulations and all ordinary glass previously in use to have been eliminated. If only 15 per cent of products were fitted with ordinary glass in the absence of regulations, the maximum possible value of the replacement rate would be 0.15. It is assumed that 100 per cent of storm doors, 90 per cent of patio doors, and 80 per cent of bath and shower enclosures were made with ordinary glass before 1973.[14] It is also assumed that only safety glass would be used in replacements (and that the above percentages of products would have been fitted with ordinary glass if there were no regulations) and that there would be no fluctuation in the frequency of replacement purchases. This latter assumption implies that the age of ordinary glass in existing products has a constant relative frequency distribution, so that an equal proportion of the glass in old product stock would be replaced in any given year until it is eliminated.[15]

This distribution is merely the reciprocal of the expected life of ordinary glass in the product. For example, given that ordinary glass has an expected life of 10 years in storm doors (see below), the glass in one-tenth of existing storm doors with ordinary glass would be replaced each year (it follows that, if other variables were held constant, ordinary glass would be completely eliminated in storm doors by 1983).[16] Finally, it is assumed that annual sales of new products are determined by the projected demand for new housing; for renovations to existing housing; and for replacement of worn-out products (this is discussed in more detail later in the paper). All the above information is used to generate the replacement rates shown in Table 2.

Given the values of the various parameters described in the preceding paragraphs, Equation (1) is used to calculate the present value of expected benefits from a reduction in cut-by-glass injuries for each of the product groups. These discounted benefits are found to total $21.83 million for the period 1973 to 2002. For a summary of this and other results of the allocative analysis, see Table 5 on page 18.

(2) Increased Glass Durability

The second type of benefit analysed consists of the resource savings anticipated from the greater durability of safety glass as compared with ordinary glass. It is assumed that safety glass lasts an average of 35 years compared with 10 years for ordinary glass in storm doors; 85 years compared with 20 years in patio doors; and 50 years compared with 15 years in bath and shower enclosures.[17]

For each product, the discounted benefits from increased durability are found by adding over each year the discounted unit cost of ordinary glass multiplied by the difference between the number of units of (ordinary) glass demanded if there were no regulations and the number of units of (safety) glass demanded under the regulations. This is done using Equation (3) on page 14. The rationale for measuring durability benefits in this way becomes clearer if these benefits are examined in conjunction with the resource cost of using safety rather than ordinary glass (calculated in the subsection entitled "Costs"). These two measures are therefore discussed together below.

For each of the products analysed here, annual requirements of glass come from three sources: the market for new products used in new housing construction; the market for new products used for renovations or to replace products that have reached the end of their useful lives; and the market for replacement glass to replace broken glass in otherwise useful products.[18] The net effect of the regulations on all three of these markets can be determined over the period of analysis for each product using the following equation:

$$PVNB_k = \sum_{t=o}^{n} \left[ \frac{(C_kQ_k - C_k'Q_k')_t}{(1+r)^t} \right] \qquad (2)$$

where $PVNB_k$ = present value of net benefits from increased durability for product k

$C_k$ = cost of ordinary glass used per product k

$Q_k$ = total quantity of ordinary glass required for product k without the regulations

$C_k'$ = cost of safety glass used per product k

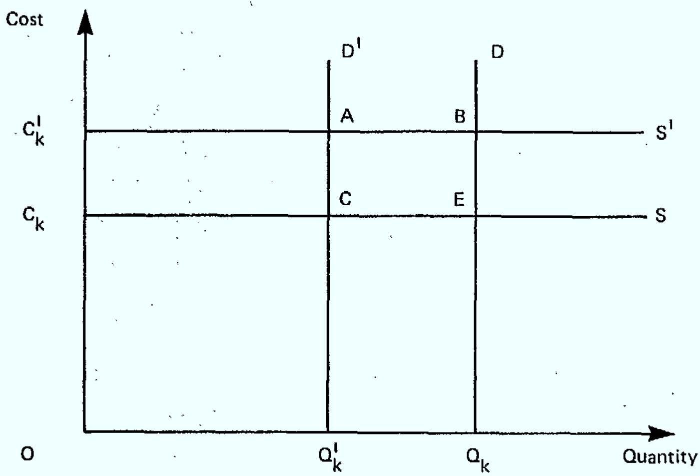
$Q_k'$ = total quantity of safety glass required for product k under the regulations

Equation (2) estimates the net impact of the regulations (ignoring the injury effects measured elsewhere) for the period 1973 to 2002 by subtracting the present value of total expenditures on safety glass if regulations were in effect, $\frac{C_k'Q_k'}{(1+r)^t}$, from the present value of total expenditures on ordinary glass if no regulations were to exist, $\frac{C_kQ_k}{(1+r)^t}$. This amount is equivalent to the net social benefit of the greater durability of safety glass as compared with ordinary glass.

It can be seen that greater durability alone will not necessarily generate net social benefits. The relevant question is: greater durability at what additional cost? Benefits from a reduction in the frequency of replacement purchases will be partially offset by the higher unit cost of safety glass. In addition, the higher unit cost is incurred as soon as a new product or replacement glass is purchased, whereas durability benefits are not realized for a period of 5 to 20 years, depending on the product. Therefore, because of discounting, each dollar of higher unit cost incurred in the present is weighted more heavily than a dollar of increased durability benefits that can only be gained in future periods. The impact of discounting is more pronounced the longer the expected life of ordinary glass, which would have been used in the product if there were no regulations, and of course the higher the discount rate. Increased durability would unequivocally lead to increases in net social welfare only if the discounted expenditure saving, or durability benefits, associated with fewer purchases of replacement glass were greater than the discounted expenditure increase associated with the resulting higher average costs of products. Durability benefits are estimated in this subsection of the paper and increased average glass costs are estimated in the next.

Equation (2) can be broken down in order to identify durability benefits and increased average glass costs, and this may be accomplished most easily with reference to Figure 1, where D and S refer to the demand for and long-run supply of ordinary glass, which would be used in product k without the regulations, whereas D' and S' represent the same variables for safety glass assuming the regulations are in effect. Since glass is an input in the production of each of the products, the demand for glass is derived from the demand for that product itself. The demand for glass is assumed to be completely inelastic, meaning that the quantity demanded is not responsive to changes in its own price. This assumption is based on three facts. First, the products themselves can be considered basic necessities in most new Canadian homes, and so demand for new products is likely to be quite inelastic.[19] This means that it would require a very large increase in product prices to have an appreciable impact on product and hence input (glass) demand. Second, the cost of glass is relatively small in relation to the total production costs for each product, and so it would require a very large increase in glass prices to have any impact on product and hence glass demand. Third, there are very few substitutes that have similar characteristics and that are priced competitively with glass. For these reasons, it is reasonable to assume that the demand for glass would be extremely inelastic over at least the range of price changes considered here. The long-run supply of glass is shown to be perfectly elastic because it is assumed that the glass industry is characterized by constant costs in the long run.

Figure 1



In the absence of regulations, the quantity $OQ_k$ of ordinary glass would be used in the products at unit cost $OC_k$. The value of these resources is equal to area $OC_kEQ_k$ in Figure 1. If regulations were passed, the quantity $OQ'_k$ would be used in the products over the same period at unit cost $OC'_k$ for a total value of $OC'_kAQ'_k$. The value of the resources saved, or benefits from the more durable safety glass, would be area $Q'_kCEQ_k$, or

$$PVID_k = \sum_{t=o}^{n} \left[ \frac{C_k \, (Q_k - Q'_k)_t}{(1+r)^t} \right] \tag{3}$$

The incremental cost of the higher priced safety glass is equal to area $C'_kACC_k$, or

$$PVIC_k = \sum_{t=o}^{n} \left[ \frac{Q'_k \, (C'_k - C_k)_t}{(1+r)^t} \right] \tag{4}$$

Equation (3) measures the social benefit of increased durability in terms of resource savings, whereas Equation (4) measures the social cost in terms of resource costs associated with higher average costs of production. It can easily be shown that Equation (3) minus Equation (4) is equal to Equation (2). This is equivalent to the net social benefit of increased glass durability.[20]

The values for each of the variables used in Equations (3) and (4) are shown in Table 3. The present value of benefits measured by Equation (3) amounts to $17 million for the total of all three product groups. The increased production costs measured by Equation (4) are given in the subsection entitled "Costs".

(3) Total Social Benefits

Total discounted benefits from the regulations, found by adding cut-by-glass injury reduction and increased durability benefits, are therefore $21.83 million plus $17 million = $38.83 million.

Table 3

Estimated Sales of Ordinary Glass
and Safety Glass by Product: 1973-2002
(cost per product given in parentheses)

| Year | Storm Doors ($C_k$=\$7.50, $C'_k$=\$10) | | Patio Doors ($C_k$=\$45, $C'_k$=\$60) | | Bath and Shower Enclosures ($C_k$=\$15, $C'_k$=\$20) | |
|---|---|---|---|---|---|---|
| | $Q_k$ | $Q'_k$ | $Q_k$ (in thousands) | $Q'_k$ | $Q_k$ | $Q'_k$ |
| 1973 | 303 | 303 | 90 | 90 | 19 | 19 |
| 1974 | 631 | 631 | 185 | 185 | 39 | 39 |
| 1975 | 595 | 595 | 160 | 160 | 34 | 34 |
| 1976 | 643 | 643 | 171 | 171 | 36 | 36 |
| 1977 | 656 | 656 | 185 | 185 | 38 | 38 |
| 1978 | 635 | 635 | 184 | 184 | 38 | 38 |
| 1979 | 634 | 634 | 186 | 186 | 42 | 42 |
| 1980 | 717 | 717 | 176 | 176 | 44 | 44 |
| 1981 | 666 | 666 | 181 | 181 | 47 | 47 |
| 1982 | 694 | 694 | 176 | 176 | 53 | 53 |
| 1983 | 697 | 534 | 212 | 212 | 56 | 56 |
| 1984 | 719 | 373 | 234 | 234 | 60 | 60 |
| 1985 | 678 | 272 | 239 | 239 | 64 | 64 |
| 1986 | 707 | 364 | 243 | 243 | 70 | 70 |
| 1987 | 708 | 357 | 246 | 246 | 70 | 70 |
| 1988 | 676 | 351 | 250 | 250 | 71 | 52 |
| 1989 | 667 | 345 | 257 | 257 | 71 | 32 |
| 1990 | 642 | 340 | 263 | 263 | 66 | 32 |
| 1991 | 680 | 333 | 279 | 279 | 67 | 31 |
| 1992 | 697 | 323 | 291 | 291 | 69 | 31 |
| 1993 | 687 | 316 | 306 | 216 | 68 | 30 |
| 1994 | 682 | 309 | 308 | 123 | 68 | 30 |
| 1995 | 678 | 306 | 284 | 124 | 66 | 30 |
| 1996 | 664 | 302 | 294 | 123 | 65 | 30 |
| 1997 | 649 | 294 | 310 | 125 | 67 | 30 |
| 1998 | 638 | 291 | 309 | 125 | 65 | 29 |
| 1999 | 628 | 287 | 307 | 125 | 65 | 29 |
| 2000 | 623 | 290 | 295 | 128 | 66 | 30 |
| 2001 | 616 | 291 | 294 | 131 | 66 | 31 |
| 2002 | 605 | 291 | 298 | 131 | 65 | 31 |

Source: See Note 18, page 36. Annual glass sales are determined by adding requirements for new product sales, for renovations and for replacements.

## Costs

(1) Increased Impact Injury Costs

The two major costs expected to result from the regulations are the costs associated with increased impact injuries and the higher unit costs of the products resulting from the higher cost of safety glass as compared with ordinary glass. The cost of the increase in impact injuries is calculated in a manner similar to the benefits from a reduction in cut-by-glass injuries. The present value of such costs by product category (k) is given by:

$$PVII_k = \sum_{t=o}^{n} \left[ \frac{(CI_k^*)\ (NI_{kt}^*)}{(1+r)^t} \right] \qquad (5)$$

where $PVII_k$ = present value of costs from increased impact injuries involving product k

$CI_k^*$ = cost per impact injury in 1973 dollars

$NI_{kt}^*$ = number of increased impact injuries in year t = $(NI_k^* \times GR_t \times II_k \times RR_{kt})$

$NI_k^*$ = number of impact injuries expected to occur in the absence of the regulations in 1973

$GR_t$ = ratio of projected population in year t over population in 1973

$II_k$ = rate by which impact injuries are expected to increase using product k with safety glass as compared with ordinary glass

$RR_{kt}$ = proportion of total stock of product k that is in compliance with regulations and would otherwise not have been in compliance in year t

Values of the parameters $CI_k^*$, $NI_k^*$ and $II_k$ are shown in Table 4. Values of the other variables are identical to those shown in Table 2 for cut-by-glass injuries. The discussion of all the parameters and their sources in the subsection entitled "Benefits" applies equally here.[21]

Table 4

Impact Injuries

| Parameter | Product Category (k) | | |
|---|---|---|---|
| | Storm Doors | Patio Doors | Bath & Shower |
| Cost per Injury ($CI_k^*$) | $120* | $150* | $180* |
| Number of Injuries ($NI_k^*$) | 352 | 24 | 24 |
| Injury Increase Rate ($II_k$) | 2.00 | 2.00 | 2.00 |

*1973 dollars

Equation (5) is used to calculate the present value of expected costs from an increase in impact injuries for each product category. These costs total $0.7 million for the period under analysis.

(2) Increased Unit Production Costs

The second cost involves the higher unit cost of safety glass and this was discussed in the subsection entitled "Benefits". The present value of these costs, calculated for each product category using Equation (4), totals $43.80 million.

(3) Total Social Costs

The total discounted cost of the regulations, given by adding increased impact injury and unit production costs, is therefore $0.7 million plus $43.80 million = $44.50 million.

<u>Benefit-Cost Comparisons</u>

The expected allocative impact of the regulations is summarized in Table 5 using net present values and benefit-cost ratios. The analysis indicates that the <u>Safety Glass Regulations</u> are expected to lead to net social costs (total benefits minus total costs) of $5.67 million ($38.83 million minus $44.50 million) in 1973 dollars over the period 1973-2002.

An interesting conclusion of the analysis is that under the regulations there is considerable variance of net benefits across product categories. Most of the net benefits ($14.34 million) are derived from regulating storm doors. Regulating bath and shower enclosures yields very small social benefits amounting to $0.19 million. The regulation of patio doors is actually shown to incur a large net social cost of $20.20 million. This result can be attributed to three main factors. The most important of these is the relatively long expected life of the product

Table 5

Allocative Impact of the Regulations: Summary of Net Present Values and Benefit-Cost Ratios by Product Category

| | Product Category (k) | | | |
|---|---|---|---|---|
| | Storm Doors | Patio Doors | Bath & Shower | Total |
| | ($ million) | | | |
| Benefits | | | | |
| cut-by-glass-injuries | 19.62 | 0.92 | 1.29 | 21.83 |
| durability | 8.65 | 7.32 | 1.03 | 17.00 |
| Costs | | | | |
| impact injuries | 0.63 | 0.03 | 0.04 | 0.70 |
| unit production costs | 13.30 | 28.41 | 2.09 | 43.80 |
| Net Present Value | 14.34 | -20.20 | 0.19 | -5.67 |
| Benefit-Cost Ratio | 2.03 | 0.29 | 1.09 | 0.87 |

(20 years), because of which it would take many years to capture both the full benefits from reduced cut-by-glass injuries and any benefits from increased glass durability.[22] A second factor is the relatively large glass area per patio door, causing the incremental cost of using safety glass per door to be quite high. These two factors dictate that undiscounted costs are distributed fairly evenly over the time horizon of the

study, whereas undiscounted durability benefits are concentrated entirely in the final five years. Consequently, the present value of such benefits is very small relative to the present value of costs. A third and final factor is the relatively few cut-by-glass injuries estimated to involve patio doors, which, combined with the large glass area, makes the cost per injury prevented very high.

The poor result for patio doors indicates that a regulation requiring safety glass is likely an inefficient instrument with which to reduce the number of cut-by-glass injuries for this product and suggests that alternative measures should be studied. While alternatives are not looked at in the context of this study, one possibility would be a regulation stipulating the use of a metal transom (horizontal crossbeam) on each panel of the door, which would still allow it to slide open and shut, or alternatively the use of a decal strip (or masking tape), which would be far less costly. These would likely be quite effective because most injuries involving sliding glass doors result from the victim's being unaware that the door is closed.[23] Two points of caution are in order here with respect to any consideration to deregulate the use of safety glass in patio doors. The first is that one of the underlying assumptions used in this paper is that the production of both ordinary glass and safety glass is characterized by constant costs in the long run. If this were not true, then a decision to regulate the use of safety glass in storm doors and bath and shower enclosures but not in patio doors would impose benefits and costs different from those calculated here. In particular, if there were increasing returns to scale (or decreasing average costs) in the production of either or both types of glass, then under such a proposal the cost of ordinary glass would increase relative to safety glass. Therefore, the net social cost of including patio doors in the regulations could be less than that calculated here. The second cautionary note concerns the fact that in order to take advantage of a decision to overturn the existing regulation, the glass manufacturing industry would have to undergo a second series of adjustment costs, since it has already adjusted to the existing <u>Safety Glass Regulations</u>. These costs would have to be considered and would outweigh at least part of the potential benefit from any change in the regulations.[24]

It should be pointed out that an evaluation of the allocative impact of the Safety Glass Regulations is not exactly equivalent to an evaluation of the allocative impact of using safety glass as compared with ordinary glass in the three products. This is because safety glass was already in use in at least part of the market for patio doors and bath and shower enclosures before the regulations were passed. However, benefits and costs were recalculated here under the assumption that ordinary glass was used in 100 per cent of the products before the regulations were passed, and the effect on the results was minor.

Finally, it might be noted that, in principle, it would be possible using benefit-cost methodology to determine optimal glass strength standards that could be specified as part of the Safety Glass Regulations. Strength would be measured by the ability to withstand an impact of some given force and could be achieved through increased glass thickness, tempering, or any other means. From an allocative standpoint, standards for optimal strength would be those which maximize the present value of net benefits arising from the regulations. Net benefits would be at a maximum at that level of strength where marginal benefits equal marginal costs. In practice, this cannot be done because there are insufficient data to do the necessary calculations. What is needed for each product is an estimate of the production and cost functions for glass of various strengths, injury reduction and increase rates as a function of glass strength, and glass durability as a function of glass strength. With this information, the optimal strength of glass could be determined for each product by equating the marginal benefits from a reduction in cut-by-glass injuries and glass breakage with the marginal costs from an increase in impact injuries and production costs.

A more immediate concern than the lack of sufficient data to determine optimal glass standards, however, is the uncertainty concerning the accuracy of available data used in the study to calculate net present values and benefit-cost ratios. It is because of this uncertainty that a sensitivity analysis is performed in the following subsection.

## Sensitivity Analysis

In circumstances where the results of a socio-economic impact analysis are suspected to be quite sensitive to changes in the values of key parameters, and where these values are subject to some degree of uncertainty, it is advisable to perform some type of sensitivity analysis to determine the extent to which the results are dependent upon the assumptions used concerning such values. A sensitivity analysis, therefore, is performed here using various alternative assumptions concerning the parameters $CI_k$, $CI_k^*$, $IR_k$, $II_k$, and r. Certain extreme assumptions were chosen to yield lowest and highest plausible values for each of the parameters. These values are shown in Table 6. Rather than showing the marginal impact that a series of iterative changes in the values of each parameter would have on the final results, only two outcomes are presented: for that combination of values which yields the lowest net present value and benefit-cost ratio for the products taken as a whole, and for that which yields the highest (the results reported in "Benefit-Cost Comparisons" are for the most likely outcome). In the first instance, conditions that yield a lower-bound estimate for the final results are assumed to prevail simultaneously for all parameters; then, conditions that yield an upper-bound estimate are assumed.

For the lower-bound outcome the values of the parameters used are as follows: $CI_k$ = \$165 (storm), \$170 (patio), and \$250 (bath); $CI_k^*$ = \$160 (storm), \$200 (patio), and \$240 (bath); $IR_k$ = 0.85 (storm), 0.90 (patio), and 0.80 (bath); $II_k$ = 2.50 and r = 0.15. For the upper-bound outcome the values are assumed to be: $CI_k$ = \$295 (storm), \$300 (patio), and \$445 (bath); $CI_k^*$ = \$90 (storm), \$110 (patio), and \$135 (bath); $IR_k$ = 1.00, $II_k$ = 1.50 and r = 0.05.

Table 6

Sensitivity Analysis: Lowest and Highest Plausible Values of Selected Parameters

| Parameter | | Lowest | Most Likely | Highest |
|---|---|---|---|---|
| $CI_k$ | Storm Doors | $165 | $220 | $295 |
| | Patio Doors | $170 | $225 | $300 |
| | Bath and Shower | $250 | $335 | $445 |
| $CI^*_k$ | Storm Doors | $ 90 | $120 | $160 |
| | Patio Doors | $110 | $150 | $200 |
| | Bath and Shower | $135 | $180 | $240 |
| $IR_k$ | Storm Doors | 0.85 | 0.90 | 1.00 |
| | Patio Doors | 0.90 | 1.00 | 1.00 |
| | Bath and Shower | 0.80 | 0.87 | 1.00 |
| $II_k$ | | 1.50 | 2.00 | 2.50 |
| $r$ | | 0.05 | 0.10 | 0.15 |

Table 7

Sensitivity Analysis: Summary of Net Present Values and Benefit-Cost Ratios by Product Category

| Product | Net Present Value ($ million): lower-bound outcome | Net Present Value ($ million): upper-bound outcome | Benefit-Cost Ratio: lower-bound outcome | Benefit-Cost Ratio: upper-bound outcome |
|---|---|---|---|---|
| All Products | -15.80 | 37.13 | 0.51 | 1.54 |
| Storm Doors | 1.94 | 54.03 | 1.18 | 3.71 |
| Patio Doors | -17.15 | -20.17 | 0.14 | 0.55 |
| Bath and Shower | - 0.59 | 3.27 | 0.61 | 1.98 |

The results of the sensitivity analysis are presented in Table 7. The analysis shows that the regulations would incur net social costs of $15.80 million for the lower-bound outcome and yield net social benefits of $37.13 million for the upper-bound outcome. The probability that either of these outcomes will occur is very small. It is interesting to note that the regulation of storm doors would be efficient even under the most unfavourable conditions, whereas the regulation of patio doors would be inefficient even under the most favourable conditions.[25] As stated in the previous subsection, the most likely impact of the regulations would be to yield net social costs of $5.76 million.

## 3. ANALYSIS OF THE NON-ALLOCATIVE EFFECTS OF THE REGULATIONS

The previous section evaluated the Safety Glass Regulations purely in terms of their impact on the allocation of resources. In addition to market efficiency, however, there are many non-allocative social and economic factors that may be affected by government regulatory intervention. Any analysis of the impact of proposed regulations should consider these effects. In this section, the question of the non-allocative impact of the regulations is addressed. Of necessity, this analysis is more descriptive than the preceding one. Factors considered include the impact on inflation, market structure and competition, the distribution of income, international trade, industry output and employment, and energy consumption.

### Inflation

It is important to distinguish between the impact that the regulations have on the level of prices of the products in question and on the rate of change of such prices. In order for them to have a sustained impact on inflation (the rate of change of prices), the regulations would have to be made more and more stringent over time or their coverage would have to be extended over more and more products. Neither of these events is anticipated to occur. The regulations are only expected to cause a modest one-time increase in product costs amounting to $2.50 for a storm door, $15 for a patio door and $5 for a bath and shower enclosure. If a 300-per-cent mark-up between manufacturers' costs and retail prices is assumed,[26] retail prices would rise by $7.50, $45, and $15 respectively. Given the assumptions used in the paper (see Note 18), the average price of a detached single family dwelling would be expected to increase only by about $45.

### Market Structure and Competition

There are two industries directly affected by the regulations -- glass producers and manufacturers of consumer glazing products. In the patio door market the safety glass manufacturer is the supplier of a final product, since these doors are generally assembled by a building contractor or local distributor near the construction site.

At the time the regulations were developed, about 80 per cent of glass requirements were produced by the three largest firms in the industry -- Canadian Pittsburgh Industries, Tempglass, and Pilkington Brothers. Small-volume producers accounted for an additional 10 per cent, and the remaining 10 per cent was imported from United States producers by their Canadian glazing-product subsidiaries.[27] It is not expected that the regulations would have any impact on the already heavily concentrated structure of this industry.

The regulations should lead to increased standardization of consumer glazing products, since safety glass cannot be cut and only a limited number of sizes can be produced profitably. This increases the possibility of product substitution for buyers and may increase competition in consumer glazing markets.

Distribution of Income

Given the elasticities of demand and supply assumed in Section 2, it is expected that all increased costs of the glazing products would be passed on to consumers in the form of higher product prices. However, almost all the redistribution of income from consumers to producers should represent real increases in costs of production, and consumers would be compensated by greater product safety and durability. To the extent that industry mark-ups might be based on a percentage of cost, however, there would be a small increase in producer profits at the expense of consumers.

The regulations probably would be mildly progressive in their effect on the general distribution of income in society because most of the burden of the regulations would fall on homeowners, and most homeowners have higher than average incomes. Tenants would also be affected but only to the extent that increased costs could be passed on in the form of higher rents.

Concerning the distribution of income in future years, it was implicitly assumed in the allocative section of the paper (when forecasting annual product sales (see Note 18, page 36) that the income elasticity of demand for each product would be zero. If this were true, then as average incomes rise in future years, the burden of the regulations would not shift to higher (or lower) relative income classes. However, if the income elasticity is greater than (less than) zero, the regulations would become more (less) progressive through time.

Finally, the regulations have an impact on the intertemporal distribution of income between present and future generations. As indicated in the section on allocative effects, the increased product costs are incurred at the time a product is purchased, whereas the benefits from increased durability take place in future periods. For a given consumer, this merely could represent a transfer of income from himself today to himself in future periods, or alternatively (if he dies or sells his house and the durability benefits are not capitalized in the selling price), from himself to someone else in the future. In either case, assuming that average real incomes will continue to rise, the regulations may be considered to cause a regressive transfer of income from present to future periods.

<u>International Trade</u>

Imports of tempered glass from the United States amount to about 10 per cent of the market. These imports are received by subsidiary firms engaged in manufacturing consumer glazing products. This situation is not expected to change significantly as a result of the <u>Safety Glass Regulations</u>. Even though the standardized product sizes are identical in the United States and Canada, there is no significant trade in the final goods, primarily because of tariffs in force, which though small are effective because of almost identical production costs.

Industry Output and Employment

The production of safety glass requires that annealed glass be subjected to controlled heating and cooling. This change involves "add-on" technology rather than a change in the basic process. Consequently, the impact of the regulations would be to shift the industry supply curves (for both glass and products) upward at any given level of output. Because of the low elasticity of demand for the products, price increases of the magnitude indicated earlier could be expected to have little effect on industry output. In addition, efficiency should increase because tempered glass is easier to work with than annealed glass, there is less breakage, and there are fewer industrial accidents. Short-run output adjustments in the glass industry should therefore consist primarily of substituting safety glass for annealed glass, with little change in volume but with some increase in the value of output.

This "add-on" technological change requires only minor capital equipment adjustments because the existing capital stock can be used to produce either annealed or safety glass. Although the regulations cause the capital-intensity of the production process to increase, there would be some absolute increase in labour input as well. Discussions with industry officials indicate that employment effects should be small. It is not possible to make more precise estimates of the impact on industry employment without more detailed information than is currently available about the production processes of individual firms within each industry.

The long-term impact of improved product quality and longer product life will have some negative effects on the growth of industry output and employment. However, the shift in demand resulting from improved product quality should take place gradually over a period of many years, and so there should be no short-term disruptive effects on output or employment in either the glass or product industries.

## Energy Consumption

Safety glass requires somewhat more energy to produce because of the controlled heating and cooling phase added to the process. Industry officials have estimated that energy costs constitute seven to eight per cent of total costs, and, though they are unable to identify precisely what portion of that figure is attributable to the tempering process, they feel confident that it is not major. Energy costs will vary with the type of tempering furnace (gas fired or electric), length of production run, and thickness of glass being tempered. Nonetheless, it seems that a major increase in energy consumption would not result from a change to tempered safety glass from annealed glass. Therefore, in the future, the net effect of the regulations should be to reduce the total energy requirements for manufacturing the products because of the reduction in sales growth resulting from increased glass durability.

## 4. CONCLUSIONS

This study was conducted to examine the feasibility of using existing methodologies to assess the allocative and non-allocative impact of regulatory changes in the area of consumer products safety.

The allocative analysis of the Safety Glass Regulations indicated the importance of looking at each of the component parts of proposed regulations in addition to the total regulatory package. In cases where an *ex-ante* analysis is performed, a package of regulations might be improved considerably by removing or making modifications to those regulations which are shown to incur net costs to society. This portion of the study thus confirmed the need to consider (and perform *ex-ante* analyses of) alternatives as an integral part of the regulatory process.

The sensitivity analysis showed that the results of a study can be quite sensitive to the underlying assumptions and data used in it. For this reason the assumptions used should be made as explicit as possible, and the impact that various changes in assumptions and data have on the final results should be measured and reported.

In conclusion, the study showed that although certain problems exist, particularly in data availability and quality, and in the valuation of pain and suffering, it is possible using existing methodologies to perform socio-economic impact analyses of regulatory changes in the area of consumer products safety. Although a benefit-cost analysis was selected for this particular study, cost-effectiveness analyses are recommended for studies concerning regulatory changes affecting serious accidents or illnesses, and especially those involving any risk of death.

## NOTES

1. National Research Council of Canada, Associate Committee on the National Building Code, Errata and Revisions to the National Building Code of Canada 1970, Change Series no. 2, July 1, 1972, Articles 9.6.5.2, 9.6.5.3, and 9.6.5.5, pp. 27-28.

2. National Research Council estimate quoted in News Release (Note 3).

3. Department of Consumer and Corporate Affairs, News Release (Ottawa: July 20, 1973).

4. The evaluation is of the impact of the Safety Glass Regulations (SGR) on the total market for the affected products. It could be argued that what is actually evaluated is the cumulative impact of the SGR and the provisions under the National Building Code (NBC). This is because the NBC provisions were already in effect before the SGR were promulgated. Therefore, the true impact of the SGR is incremental, being only on that portion of the product markets not already governed by the NBC. In fact, this would be the proper scope for an ex-ante analysis to determine the (marginal) impact of the SGR. This approach is not used for the purposes of this study because an analysis of the total market, requiring only aggregated data, is simpler to conduct and is probably of more interest to the general reader. It might be noted that in one sense the SGR make the NBC provisions redundant in that they cover the sale and import, and thus the availability, of all products, not just the use of the products in non-NBC markets.

5. Treasury Board Secretariat, Planning Branch, Benefit-Cost Analysis Guide (Ottawa: Supply and Services Canada, March, 1976), p. 26. See also Glenn P. Jenkins, Capital in Canada: Its Social and Private Performance 1965-1974, Economic Council of Canada, Discussion Paper no. 98, October, 1977. Jenkins estimates that the real social rate of discount in Canada during this period was 10.02 per cent.

6. Consumer Safety Glazing Committee, Architectural Glass Project, Final Report, Economic and Environmental Subcommittee, February 7, 1975. The cost per injury in 1973 was estimated to average $244, $242, and $311 U.S. for storm doors, patio doors, and bath and shower enclosures. These costs do not distinguish between cut-by-glass and impact injuries. See also Garry S. Stacey and Benjamin B. Gordon, Analysis of Product Costs and Injury Costs For Architectural Glazing Standards, Battelle Columbus Laboratories, Columbus, Ohio, October 21, 1976, pp. 14-16. Both these studies included only the cost of medical treatment for each case. The estimates that appear in this study have been adjusted to account for the 1973 rate of exchange between American and Canadian dollars. The CSGC is an ad hoc group of industry, labour, and general-interest groups initially formed in 1968 to draft, and to lobby for the passage of, a model safety glazing bill in several states in

the United States. The committee worked closely with the United States Consumer Product Safety Commission in developing standards that the commission eventually established pursuant to the provisions of the Consumer Product Safety Act on July 6, 1977. In the course of its investigation of architectural glass, the commission contracted the services of Battelle Columbus Laboratories to analyse the potential economic impact of the proposed standards.

7. All costs in this paper are expressed in constant (1973) dollars. During the decade prior to 1973, the cost of medical treatment was rising relative to the general level of costs in the economy. If this were to continue, the real value of benefits per case averted would increase over the period of analysis. Not adjusting for this change in relative costs would mean that the benefits calculated here would understate the true benefits of injury reduction. Of course, this would be compensated for in part by the fact that the costs associated with increased impact injuries, calculated in the next section, would similarly be understated.

8. United States data for 1973 indicated that most of the injuries involving the products were relatively minor. Eighty-five per cent of accidents involved lacerations, primarily to the hand or finger. Only about two per cent of the injuries required hospitalization. See United States, Consumer Product Safety Commission, Directorate for Hazard Identification and Analysis, Hazard Analysis - Injuries Involving Architectural Glass, November, 1974. These estimates were obtained from the CPSC's National Electronic Injury Surveillance System, a survey of hospital emergency rooms.

9. Although Statistics Canada collects data from the provinces on hospital cases by type of injury or illness and provides a distribution by age and sex, it does not specify the distribution by occupation. See Statistics Canada, Hospital Morbidity, Catalogue no. 82-206, annual. In addition, cause of injury is reported by only a few provinces, and even in these, not specifically enough to determine the number of cases by product category. It is possible, in other words, to isolate the number of cases hospitalized for lacerations to various parts of the body involving glass and certain other sharp objects, but it is impossible to tell whether the glass came from windows, bottles, mirrors, or the three products analysed here.

10. This has been attempted in other benefit-cost analyses. Some analysts, for example, multiply the medical treatment costs of a given accident by a factor designed to approximate the value of pain and suffering experienced by victims. This procedure is very arbitrary and open to criticism. It actually implies, for instance, that the degree of pain and suffering of the injured changes in proportion to changes in the price index of health care costs. If the real cost of medical treatment fell by one-half, would the pain and suffering of the injured be half as great? Another more

acceptable solution to the problem of placing a value on human health is through the use of the cost-effectiveness methodology. This methodology is used in those instances where the benefits of a particular regulation or program cannot easily be quantified in monetary terms. Instead, benefits are quantified in physical terms (e.g. number of accidents or deaths prevented) and the regulation or program is judged in terms of the costs entailed to achieve a physical goal (e.g. cost per injury or death prevented). However, this methodology has certain well-recognized limitations relative to the benefit-cost methodology.

11. See United States, Consumer Product Safety Commission, op. cit. (Note 8). A total of 45,700 injuries involving the products were estimated to have been treated in hospital emergency rooms in 1973 (no estimates of injuries treated outside emergency rooms is available). The distribution was storm doors (37,900), patio doors (4,400), and bathtub and shower enclosures (3,400). Eight-five per cent of total injuries involved cuts and lacerations. It is assumed that the remaining 15 per cent can be classed as impact injuries. The resulting distribution by type of injury is shown in the table below:

Estimated Injuries in the United States, 1973

| | Cut-by-Glass | Impact | Total |
|---|---|---|---|
| By Product | | | |
| Storm Doors | 32,215 | 5,685 | 37,900 |
| Patio Doors | 3,740 | 660 | 4,400 |
| Bath & Shower | 2,890 | 510 | 3,400 |
| Total | 38,845 | 6,855 | 45,700 |

In the United States, all but 18 states already were covered by safety glass regulations in 1973. It is probable that per capita injuries in Canada in the absence of regulations would have been roughly equivalent to that of these 18 unregulated states. In order to determine the distribution of injuries between unregulated and regulated states, it is necessary to know the ratio of population in unregulated states compared with regulated states, and the expected ratios of cut-by-glass and impact injuries using ordinary glass compared with safety glass. The ratio of population in unregulated states compared with regulated states was 1:4 in 1973. Estimates of the ratio of injuries using ordinary glass compared with safety glass are given elsewhere in this paper (see "injury reduction rates" and "injury increase rates" defined on pages 5 and 16, respectively).

For storm doors, for example, the ratio for cut-by-glass injuries is 9:1 and for impact injuries it is 1:2. Let the number of cut-by-glass injuries in unregulated states be X and in regulated states be Y. Therefore, X = (1/4) (9/1) (Y). But Y = (32,215 - X). Thus, by substitution, X = (9/4) (32,215 - X) = 22,303. Similarly, Y = (4/9) (32,215 - Y) = 9,912. The distribution of injuries between unregulated and regulated states is given in the following table.

Estimated Distribution of Injuries in the United States: Unregulated States Compared with Regulated States (in parentheses)

| | Cut-by-Glass | Impact | Total |
|---|---|---|---|
| By Product | | | |
| Storm Doors | 22,303 (9,912) | 632 (5,053) | 22,935 (14,965) |
| Patio Doors | 3,740 (0) | 73 (587) | 3,813 (587) |
| Bath and Shower | 2,786 (104) | 57 (453) | 2,843 (557) |
| Total | 28,829 (10,016) | 762 (6,093) | 29,591 (16,109) |

Extrapolating for Canada involves calculating the assumed per capita incidence of injuries in the unregulated states and multiplying by the 1973 Canadian population. The resulting injury profiles are then adjusted to reflect the fact that there are proportionately more storm doors and fewer patio doors per capita in Canada than in the unregulated states (the National Research Council estimates that the share of total injuries for storm doors, patio doors, and bath and shower enclosures is 88 per cent, 6 per cent, and 6 per cent respectively, compared with 83 per cent, 10 per cent, and 7 per cent in the United States.)

This yields estimates for the number of injuries that would have occurred in Canada in 1973 in the absence of regulations. These estimates are shown below:

Estimated Injuries in Canada, 1973

| | Cut-by-Glass | Impact | Total |
|---|---|---|---|
| By Product | | | |
| Storm Doors | 13,324 | 352 | 13,676 |
| Patio Doors | 908 | 24 | 932 |
| Bath and Shower | 908 | 24 | 932 |
| Total | 15,140 | 400 | 15,540 |

The estimates of injury distribution in the United States are based on the implicit assumption that products in unregulated states contain only ordinary glass and products in regulated states contain only safety glass. An unknown proportion of products in each jurisdiction probably does not conform to this assumption. Therefore, for unregulated states (and Canada) the number of cut-by-glass injuries probably is overestimated and the number of impact injuries probably is underestimated.

12. Statistics Canada, Population Projections for Canada and the Provinces 1976-2001, Catalogue no. 91-520, occasional.

13. Consumer Safety Glazing Committee, Architectural Glass Project, Risk of Injury Subcommittee Report, February 7, 1975; and Garry S. Stacey and Benjamin B. Gordon, op. cit. (Note 6).

14. Based on industry estimates.

15. Either the whole product or simply the glass could be replaced; for this portion of the analysis it does not matter which, although this is obviously relevant in the sections of the paper dealing with durability benefits and production costs. There, it is assumed that only the glass is replaced.

16. This view is probably somewhat optimistic, as it is assumed that when ordinary glass is broken, it always will be replaced with safety glass or a substitute of similar tolerance, such as acrylic. In fact, since the regulations do not cover the replacement market, it is probable that ordinary glass will still be used in some replacements. For example, tempered safety glass cannot be cut and a limited number of standard sizes are manufactured. Ordinary glass would therefore be used to replace broken glass in old products that are not of standard size. This means that a proportion of products will continue to contain ordinary glass, although this proportion will decline considerably through time.

17. Based on certain estimates used in Stacey and Gordon, op. cit. (Note 6), as well as on discussions with industry officials. It is assumed that ordinary glass used in storm doors has a considerably shorter expected life in Canada than in the United States because storm doors are used more extensively and for a longer part of the year in Canada. The expected life for patio doors is assumed to be marginally shorter. In order to simplify the specification of the replacement rate in the previous subsection and the estimation of replacement demand in this subsection, it is assumed that the average life of glass in each product has zero variance -- that is, for example, all ordinary glass used in storm doors lasts exactly 10 years. This assumption is obviously unrealistic but probably has an insignificant influence on the results of the analysis. The order and direction of bias, if any, would depend on the discount rate used and the true probability distribution of the life of glass for each product.

18. The demand for glass used in new products in new housing construction is a function of new housing completions over the period 1973 to 1979 and a projection for housing demand over the period 1980 to 2002 (see table, p. 37). The demand for products in this market is based on the following assumptions: there are 2.0 storm doors per single detached dwelling, 1.7 per multiple family dwelling, and 0.1 per apartment unit; 0.65 patio doors per single and multiple family dwelling and 0.9 per apartment unit; and 0.15 bath and shower enclosures per each type of dwelling. These assumptions are similar to those used in a United States study (see Consumer Safety Glazing Committee, op. cit., Note 6) and yield estimates of product sales for the period 1973 to 1979 that conform closely with industry estimates of actual sales. The demand for new products used for renovations and replacements is assumed to be a simple function of the size of the existing stock of housing (although it is obviously a function of prices and real disposable income as well). Finally, the market for replacement of broken glass is determined for each product type by the expected life of ordinary glass in each product. Ordinary glass is assumed to have a failure rate of 0.10 in storm doors, for example, which implies an expected life of 10 years. Therefore, replacement glass requirements in year t are equal to requirements for new product sales plus renovation and replacement product sales in year t-10. Glass replacement sales in year t-10 are not used to determine glass replacement requirements in year t because it is assumed that the storm door (or other product) itself will reach the end of its useful life before a second glass replacement is needed. Annual glass requirements are determined by adding requirements in the markets for new products, for renovations and product replacements, and for glass replacements.

Housing Completions: 1973-1979
Forecast Housing Demand: 1980-2002

| | Type of Dwelling | | | |
| --- | --- | --- | --- | --- |
| Year | Single Detached | Single or Multiple Attached | Apartment | Total |
| 1973 | 122.7 | 28.3 | 95.6 | 246.6 |
| 1974 | 129.7 | 31.7 | 95.8 | 257.2 |
| 1975 | 113.4 | 28.3 | 75.2 | 216.9 |
| 1976 | 128.6 | 36.3 | 71.3 | 236.2 |
| 1977 | 117.8 | 48.8 | 85.2 | 251.8 |
| 1978 | 106.2 | 45.8 | 94.5 | 246.5 |
| 1979 | 110.5 | 38.9 | 94.5 | 243.9 |
| 1980 | 124.0 | 35.7 | 67.1 | 226.8 |
| 1981 | 127.9 | 34.9 | 60.3 | 223.1 |
| 1982 | 140.7 | 34.5 | 56.8 | 232.0 |
| 1983 | 142.0 | 32.4 | 54.4 | 228.2 |
| 1984 | 143.6 | 30.4 | 52.2 | 226.2 |
| 1985 | 144.9 | 28.7 | 49.2 | 222.9 |
| 1986 | 143.2 | 26.7 | 43.3 | 213.2 |
| 1987 | 141.9 | 24.5 | 37.7 | 204.2 |
| 1988 | 140.3 | 22.6 | 32.8 | 195.7 |
| 1989 | 138.1 | 21.2 | 29.5 | 188.8 |
| 1990 | 136.2 | 20.3 | 21.5 | 184.7 |
| 1991 | 132.6 | 19.0 | 26.2 | 177.8 |
| 1992 | 129.0 | 17.6 | 23.9 | 170.5 |
| 1993 | 126.0 | 16.2 | 22.5 | 164.4 |
| 1994 | 123.0 | 15.4 | 22.1 | 160.4 |
| 1995 | 121.3 | 15.2 | 23.1 | 159.6 |
| 1996 | 118.3 | 15.1 | 25.8 | 159.1 |
| 1997 | 114.9 | 15.0 | 27.5 | 157.4 |
| 1998 | 112.4 | 14.7 | 29.2 | 156.2 |
| 1999 | 110.2 | 14.7 | 30.6 | 155.5 |
| 2000 | 110.2 | 15.4 | 34.0 | 159.6 |
| 2001 | 109.7 | 15.9 | 36.0 | 161.7 |
| 2002 | 109.0 | 16.0 | 37.0 | 162.0 |

Source: Statistics Canada, Housing Starts and Completions, Catalogue no. 64-002, monthly; and Market Analysis and Forecast Division, Canada Mortgage and Housing Corporation.

19. This would be equally true of demand in the product replacement market.

20. For an alternative derivation of the net social benefits of increased glass durability, see Appendix B.

21. The discussion relevant to $CI_k^*$ appears on page 6, $NI_k^*$ on page 7 and Note 9, $II_k$ on page 8, $GR_t$ on page 7, and $RR_{kt}$ on page 9.

22. It would have been more realistic and, for that reason, preferable to determine the probability distribution for the expected life of glass in each product instead of using a simple point estimate of average expected life. If this were done, the flow of expected benefits from increased durability would be spread somewhat more evenly over the time horizon of the study rather than concentrated entirely in later years because, based on the distribution of expected life, some proportion of glass would be assumed to break before the average expected life was reached, and some would be assumed to last longer. However, sufficient information was not available with which to construct a statistically valid probability distribution for the expected life of glass in each product, and as mentioned in Note 17, assuming zero variance simplified the calculations.

23. See United States, Consumer Product Safety Commission, op. cit. (Note 8), p. 26. The use of a decal was recommended as an additional precautionary measure in the news release announcing the regulations (see Note 3). It was also suggested as an alternative in the United States by the Council on Wage and Price Stability in commenting on the CPSC's proposed regulations (see United States, Council on Wage and Price Stability, Comments on Architectural Glazing Materials before the Consumer Product Safety Commission, Washington: March 15, 1976).

24. A closer examination of Table 5 reveals another interesting finding of the allocative analysis. That is, although the regulations are very effective at reducing the net cost of injuries involving each product (benefits from reduced cut-by-glass injuries minus costs from increased impact injuries), the increase in unit production costs is so high relative to these net benefits and to durability benefits that the regulations taken as a whole incur net costs to society. The implication is that all potential benefits and costs are important in the determination of the net impact on the allocation of resources and should be taken into account when selecting an appropriate policy instrument.

25. The benefit-cost ratio for each product is higher for the upper-bound outcome than for the lower-bound outcome. However, the net present value for patio doors is actually lower for the upper-bound than for the lower-bound outcome. This apparent inconsistency is unusual and calls for a brief explanation. Normally, net present value is a strictly increasing or decreasing function of the social rate of discount. That is, as the discount rate is increased with all

other variables held constant, net present value will either continuously increase or decrease depending on the time stream of net benefits. Net present value for both storm doors and bath and shower enclosures decreases continuously as the discount rate is increased. In some cases, however, net present value will decrease, reach a minimum and then increase (or vice-versa) as the discount rate is increased. This would happen, for example, if there were two or more sign changes in the value of annual net benefits over the time horizon of a study, indicating in mathematical terms that net present value was a quadratic or higher-order polynomial function of the discount rate. For an example of the quadratic case see E.J. Mishan, Cost-Benefit Analysis, 2nd ed. (London: George Allen and Unwin, 1975, p. 192). In the case of patio doors, net present value is at a local maximum of minus $4.62 million when the discount rate is zero, decreases and reaches a global minimum of minus $21.35 million when it is approximately eight, and thereafter increases asymptotically approaching the value minus $1.34 million (the value of net benefits in the base year) as the discount rate approaches infinity.

26. This mark-up is considered to be typical for the industry in the United States. See United States, Consumer Safety Glazing Committee, op. cit. (Note 6). There is no empirical evidence concerning price margins or the existence of a mark-up pricing policy in Canadian industry. Because of the similarities between American and Canadian markets, however, and high Canadian concentration levels, it would not be unreasonable to assume that at least an equivalent mark-up is typical in Canada.

27. Based on industry estimates.

## APPENDIX A
## A POLICY ALTERNATIVE TO DIRECT GOVERNMENT INTERVENTION

An alternative to direct government intervention through the regulatory process would be for the government simply to provide consumers with information regarding the hazardous characteristics and probabilities of injuries using each type of glass. Given their preferences regarding risk-taking, consumers would then have the freedom to choose products containing whichever type of glass they judged appropriate for them. The demand for each product would be a function of the income of each consumer and the price of the product which, in this case, would include the cost of purchasing the product plus the expected cost of having an accident (average cost per accident multiplied by the probability of having an accident). In theory, each consumer would maximize his utility subject to a budget constraint, and the outcome would be an optimal allocation of resources and an "optimal" number of injuries. However, such a solution is dependent upon a number of preconditions, all of which cannot easily be assumed to hold in the context of this particular study.

First, the objective probability of injuries provided by the government to consumers must be accepted by them and actually incorporated in their purchasing decisions. In other words, the government advertising campaign must be effective. In addition, the resulting revised subjective probabilities of individual consumers must in total be equivalent to the true objective probability provided by the government. Even if consumers have perfect information, this might not occur if, for example, they systematically underestimate risks because they believe accidents "always happen to the other guy".

Second, the social cost of injuries must be equal to the private cost of injuries. This means that there must be no externalities (third-party effects) in the consumption of any of the products. More specifically, injuries must be suffered only by the owner-purchaser of the product, not by others, and the costs of injuries must be borne entirely by the injured, not for example, by the government through subsidized medical insurance (although in practice the former requirement could be relaxed if a system of liability rules were in force which ensured that buyers or sellers would be liable for expenses incurred in the injury of others, thus internalizing the externality).

Finally, there must not be a failure on the supply side of any market. That is, when consumers express their demand for either type of glass in the products, the market mechanism must function properly to provide products containing the type preferred. There are many circumstances where this would not be the case. For example, the glass and product markets in Canada are relatively small and concentrated. Under such circumstances, the speed and extent to which manufacturers would be willing or able to respond to changes in consumer tastes is subject to more uncertainty than if there were a larger market with larger numbers of competitors (in fact, this may explain why there was very little safety glass in use prior to the regulations). In addition, the products in question are often bought by consumers as part of a much larger package -- the purchase of a house. For a previously occupied house, a consumer may not know the type of glass used. Even for a new house, there usually are intermediate purchasers in the form of contractors and subcontractors, and so the final consumer might find his choice constrained.

All these conditions relate to the attainment of an "optimal" level of injuries defined from a strictly economic perspective given an individual's income and preference regarding risk (of course, from a moral or political standpoint, the optimal number of injuries may be much lower, and perhaps equal to zero). Even if some of the above conditions were violated in practice, so that government provision of information did not yield an "optimal" number of injuries, such an instrument might still be quite effective in simply reducing injuries, and this is the stated goal of the Safety Glass Regulations. As such, it might be an appropriate alternative to evaluate in this paper. It is not evaluated here, however, for the following reasons: (i) for the provision of information to be effective in reducing injuries, it must be possible for a consumer to reduce the risk of being injured by exercising more care in the use of the product, and for the products in question, accidents are more a function of the inherent dangerous characteristics of ordinary glass than the lack of proper care taken by consumers; (ii) it is probable that, following the provision of information, the time path of adjustment towards a new equilibrium would be very long relative to that for regulatory intervention; and, (iii) no data are available to estimate the rate by which injuries might be reduced if consumers were provided with additional information by the government. It should be stressed, however, that there are other cases of market distortions where this policy instrument could be applied quite successfully. One such example is the subject of another case study in this series (see Ronald Hirshhorn, A Case Study: Energy Consumption Labelling Requirements for Refrigerators).

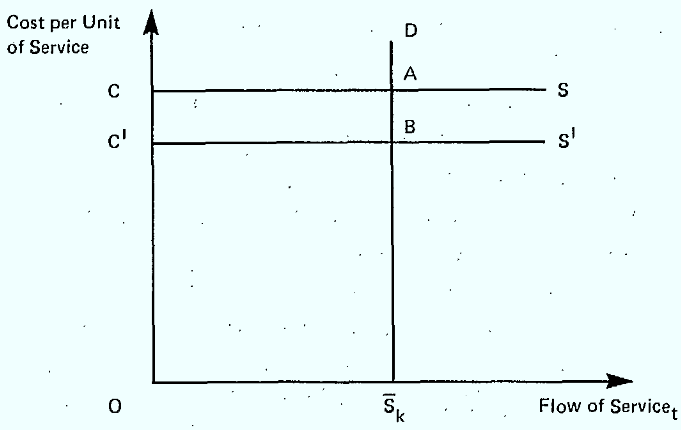
## APPENDIX B

## AN ALTERNATIVE DERIVATION OF DURABILITY BENEFITS

Normally, changes in social welfare (such as those shown in Figure 1) resulting from shifts in demand and supply can be measured by calculating net changes in consumers' and producers' surplus, which result from moving to a new equilibrium price and output (point A) from old equilibrium levels (point E). Here, however, the demand and supply schedules actually refer to two different products (ordinary glass and safety glass) with different characteristics. This is not a problem on the supply side, since the technology for producing tempered safety glass involves simply subjecting ordinary glass to additional controlled heating and cooling. The true unit opportunity cost of safety glass versus ordinary glass is therefore reflected by an upward shift in supply, or average (which equal marginal) costs, from $C_kS$ to $C_k'S'$. On the demand side, however, a shift in demand does not correspond to a change in utility because of the superior characteristics of safety glass. Purely in terms of service provided (i.e. ignoring the benefits of increased safety) the equilibrium quantity of safety glass demanded ($Q_k'$) yields the same flow of utility over the time horizon as the larger quantity of ordinary glass that would otherwise be demanded ($Q_k$). Calculating a net change in social welfare (utility) therefore becomes a matter of measuring changes in the resource cost of providing a given level of service. Maximizing welfare would involve minimizing such resource costs. More generally, for any given level of service, welfare would increase only if resource costs were reduced.

A change in social welfare may be illustrated through reference to Figure 2, where flow of service rather than quantity of safety glass is measured on the X axis. The Y axis measures cost per unit of service. Demand for service is a derived demand and is shown to be perfectly inelastic, since it is a function of the fixed physical area that requires glazing material (either ordinary or safety glass). Demand is totally satiated at this level of service. The line CS represents the cost of supplying service with ordinary glass, while C'S' represents such cost using safety glass. The cost per unit of service is defined as the cost per unit of glazing material multiplied by the number of units required to provide one unit of service for a given period of time, t. A unit of service could be defined as continuous coverage of one square foot of area for one year. The supply curves are perfectly elastic because of the assumption of constant costs of glass production and because of the fact that the relationship between a unit of service and the number of units of glazing material required to provide it is fixed. The vertical distance between the curves is determined by two factors: the difference in cost per physical unit and the difference in the number of physical units required to provide one unit of service. Although the cost of a physical unit of safety glass is higher than that of ordinary glass, the greater durability of safety glass is shown to more than compensate for this extra cost, so that the cost per unit of service using safety glass is actually lower (although in practice the analysis shows that this is not likely to be the case except for storm doors, given very optimistic assumptions). The introduction of the regulations would therefore increase consumers' surplus (defined here as the excess of what consumers would otherwise have to pay for service compared with what they actually pay) by an amount equal to area CABC' in Figure 2. This area is equivalent to area ($Q_k'CEQ_k - C_k'ACC_k$) in Figure 1.

Figure 2



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