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Part IV
Measurement and Policy Issues in Consumption Analysis

Risk Measurement and Safety Standards in Consumer Products

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NATIONAL BUREAU OF STANDARDS *

I. INTRODUCTION

STATISTICS of injuries arising in homes and playgrounds are particularly distressing, since those involved are usually either helpless or unaware of the dangers. Few of these injuries are inevitable in any reasonable sense of the term, so that there is also a great sense of waste, both material and emotional. Yet is is obvious that injuries cannot be entirely eliminated. What we wish to do then, and what presumably the new Consumer Product Safety Commission (CPSC) would like to do, is to determine *when* injury statistics, such as those collected by the National Electronic Injury Surveillance System (NEISS), suggest the need for some public action (such as the setting of a physical standard), and *when* they do not.

There are two different but related issues. One is conceptual, namely, formulating a theory of accident occurrence for a specific product. The other is measurement. Clearly, the latter cannot be done independently of the theory. Nonetheless, in this paper, we shall be concerned primarily with the measurement aspect. The reason is a practical one: the CPSC is faced with the gigantic and difficult task of establishing some priority among hundreds of products on the basis of the injury data reported to it through NEISS and other sources. The initial need is for the CPSC to impose a semblance of order out of this mass of data, even though no theory of accident causation has been developed.

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Most safety-related legislation, and certainly the Consumer Product Safety Act (P.L. 92-573), does not aim at eliminating *all* hazards, but only the unreasonable ones. Yet none, so far as I am aware, has attempted to define operationally what an unreasonable hazard is.

In Section 2, a formal criterion for identifying unreasonable hazards is presented. In Section 3, measurement procedures implied by the criterion are discussed with reference to an actual case. The primary intention there is to assess and demonstrate the operationality of the criterion.

2. HAZARDOUS PRODUCTS AND THE MARKET

2.1. Definitions and Preliminaries

We shall give an economic definition of an unreasonable hazard which does not depend on, or presuppose, any particular rule of legal liability. An unreasonable hazard may be defined as the possible occurrence of an undesirable event in the course of normal use or consumption of a good, where the expected cost of the event is greater than the cost of avoiding it. There are three basic elements in the definition: (1) an undesirable event, the occurrence of which gives rise to loss of wealth or income, the enduring of pain or suffering, or death; (2) the probability of occurrence of the event; and (3) an action which may be taken to avoid the loss. The expected cost is defined as the likelihood of occurrence of the event multiplied by the loss sustained if the event should occur. Unless the context indicates otherwise, the definition will relate to society, so that, ordinarily, costs will include all costs of the injury, and avoidance will relate to the set of all possible avoidance actions.

2.1.1. Product Use. The uses to which a product may be put are many, but we have to exclude from our purview those uses which are in some sense illegitimate. Thus, a hunting knife might be used as a nail extractor, or an ashtray to hammer a nail. The injuries that can conceivably result from such activities cannot provide a rationale for social intervention. Since such hazards can be avoided only by banning the product, the cost of avoidance must include all benefits derived from its legitimate uses. The cost of avoidance will then be inflated to the point of exceeding the cost of injury.

The question of what constitutes abnormal use is not merely of academic interest. The courts are continuously called upon to determine whether an injury is the result of misuse of a product, whether the manufacturer should have foreseen the danger which his product posed, or whether a consumer assumed the risk of injury entailed in the use of a product. All of these notions have their analogs in economics. Thus, a court will probably consider the risk of entrapment of a child in an abandoned refrigerator a foreseeable danger. In economics, it would be reasonable to consider such risk as one of the attributes of the product. On the other hand, if a refrigerator is used (criminally) as an entrapment device, then injury resulting from such misuse will neither in law nor in economics be attributed to the product. Finally, some injuries incurred in accidents on the speedway would not in law be attributed to the product, since the driver of the car will be considered to have assumed the risk, just as in economics we would assume that he valued the characteristic of high speed much more than other characteristics of the car. Although the dividing line between legitimate and illegitimate uses is quite blurred, the distinction is nonetheless important.

2.1.2. The Hazard. With any consumer product we may associate a hazard, $H(I)$. It can be viewed as a probability distribution of various types of injuries, denoted by I, arising in the course of normal consumption of the product. It depends upon the type of product, the technology and quality of materials and workmanship embodied in it (all usually summarized by the term "design"), and the information utilized by users.

2.1.3. The Cost of Injury. With the hazard, $H(I)$, we need a weighting function, $J(I)$, which assigns to each type of injury, I_k, a dollar weight J_k representing its severity. $J(I)$ thus stands for the cost of injury. It includes the decrease in wealth, both physical and human, and also pain and suffering. For simplicity, we assume that J is the same for all individuals. Alternatively, J_k may be viewed as the average cost of injury type I_k over all individuals.

For the purpose of our analysis, it does not matter that all injuries have to be monetized. Monetization means that individuals take risks involving bodily harm in return for money. It does *not* mean that individuals would necessarily accept a sum of money in return for submitting to *certain* bodily injury. There is overwhelming evidence to support the former; there is little to support the latter. Thus, the "monetary value of a child's life" does not mean that his parents, or for that matter, society will accept such an amount of money in return for his life. Such a tradeoff is not implied by the term monetization. The tradeoff which is implied is between money and the risk of life, which is hardly unusual.

In this connection we should note three points: (a) Society's and individuals' risk valuations may differ. (b) Although some people knowingly take risks involving bodily injury, many would probably not take such risks if they knew their real magnitudes. However, the issue here is merely whether risks of injury *can* be monetized, not whether the procedure would always yield the "correct" valuation. (c) Finally, a jury award may also be considered an indication of the money value of injury (or life). So may an out-of-court settlement. Even so, these do not imply that a plaintiff would consider such compensation sufficient for him to submit voluntarily to the same injury. Whatever it means to the plaintiff, it does have the effect of a price to potential defendants—a "controlled" price of injury, so to speak.

The product JH thus represents the expected cost of injury sustained by an individual in consuming a unit of the product. If the total quantity of the product consumed by consumers over an appropriate unit of time is denoted by X, the rate of social cost of accidents is given by XJH.

2.1.4. Avoidance of Injury. Injury avoidance covers a wide range of possible actions, but as a rule one should consider the least costly action first, and then proceed to more expensive ones, including the extremes of nonconsumption and nonproduction. It would include product design changes, the provision of technical information (say through labeling or advertising), and the gaining of experience and knowledge by consumers, all of which may conceivably affect the probability of injury occurrence, H.

An avoidance action has the effect of shifting the probability distribution H such that JH is reduced. If we assume that J is an increasing function of I, then JH will necessarily decrease when H is shifted to the left. Since it was observed earlier that H depended on such factors as product design and use information, any change in these factors which decreased JH would be tantamount to avoidance action. Avoidance actions thus can be taken by both producers and consumers. It is a commonplace observation that many consumers do not read instructions, or often seem not to understand what they read. To make headway with our analysis, however, we assume that consumers will follow instructions faithfully and utilize all the information provided with a product. We also assume that they can and do supply additional information of their own. If they are thereby able to shift the distribution H in the right direction, they would in effect be taking avoidance action. We categorize avoidance actions into two groups: alpha-actions, denoted by α, are those taken by consumers, and beta-actions, denoted by β, are those taken by producers. H is a decreasing function of α and β.[1] $J(\partial H/\partial\beta)$ and $J(\partial H/\partial\alpha)$ represent the costs of injury avoided when β and α avoidance actions, respectively, are taken.

Let $C(X; \beta)$ denote the average cost of a competitively produced quantity, X, of a consumer product of a given safety-related quality. The quantity X is equal to the sum of the consumption of all individuals, n, who consume the product, i.e., $X = \sum_i^n X_i$. As we have indicated, the parameter β refers to the class of safety-related characteristics of the product. We may think of β as a shorthand descriptor of the physical characteristics of a product, such as its flammability, shatter, and thermal qualities. For simplicity of manipulation, we shall treat β as one-dimensional rather than as a vector. The partial $\partial C/\partial\beta$, which will occasionally be written as C_β, is taken to be positive.[2]

The avoidance actions α cause a reduction in the occurrence of injuries (i.e., H) by affecting the behavior of consumers, as, for example, when they acquire or are provided with product information.[3] As with β-action, an α-avoidance action is not costless. Let $V_i(\alpha)$ refer to the cost of α-avoidance actions taken by individual i and assumed to be independent of the amount of consumption of X. The marginal cost $dV_i(\alpha)/d\alpha$ is taken to be positive.

2.1.5. Reasonable and Unreasonable Hazards. A hazard that can arise during the normal use of a product can be said to be unreasonable if it can be reduced through some action by producers or by consumers, or by both, and if the cost of doing so is less than the consequent reduction in its social cost.

This definition can be stated implicitly by the following inequality

$$[X \frac{\partial}{\partial\beta} C(X, \beta) + \sum_i^n \frac{d}{da} V_i(\alpha)] < -[XJ \frac{\partial}{\partial\beta} H + XJ \frac{\partial}{\partial\alpha} H] \quad (1)$$

More conveniently, the above expression can be written in a somewhat different notation, as follows

[1] Note that α and β refer to actions, not financing. A set of instructions, an α-action, may be provided by producers. And a safety device, a β-action, may be purchased separately by a consumer.

[2] For simplicity of representation, we have assumed that only costs of production are significant. However, increased cost of maintenance, diminished efficiency, reduced benefits, etc., have to be added to C_β if they are significant.

[3] To what extent, and why, consumers do not exercise care or utilize all the information provided are matters that perhaps a discipline such as psychology has more valuable things to say about than does economics. Here we assume that the information provided or available is correct and that it will, in fact, be utilized.

$$[XC_\beta + \sum_{i}^{n} (V_i)_\alpha] < -[XJH_\beta + XJH_\alpha] \qquad (1')$$

In (1′), the first term on the left-hand side denotes the cost incurred to provide a β-type avoidance action, such as installing a metal shield in every TV set to intercept harmful radiation. The second term denotes the cost incurred by consumers in taking an α-type avoidance action. An example is the purchase of skid-proof shoes for wearing when using a lawn mower. Note that α may also be in the nature of operating instructions, warnings, or informative labeling, in which case it has some of the characteristics of public goods.

Coming now to the right-hand side of the inequality, the minus sign preceding the expression in the brackets is necessary because H_α and H_β denote *reductions* in the hazard. The term XJH_β represents the savings in accident cost realized from the introduction of the β-type avoidance action. Similarly, XJH_α represents the savings in accident cost realized from the adoption of the α-type avoidance measure. Thus, inequality 1 represents the tradeoff that is possible, in principle, between avoidance cost and injury cost. When no further *net* gains can be realized from accident reduction, i.e., when expression 1 becomes an equality, the hazard still remaining is reasonable.[4]

Since at this stage we are only conceptualizing, the functional forms are to be understood only in their logical, rather than mathematical, connotations. Note that the inequality defining unreasonable hazards depends on each of H, J, and X. An unreasonable hazard may exist because of high probability of injury (e.g., sporting equipment and fireworks), or high cost of the injury (e.g., nuclear contamination and lead poisoning), or the large quantity of the product in use (e.g., processed food and automobiles). The above definition from society's viewpoint may be modified to represent unreasonable hazards from the points of view of consumers or producers by appropriate modification and interpretation of the terms of the inequality.

2.1.6. The Consumption of Unreasonable Hazards. In a competitive market, the individual consumer takes as given the physical safety features of the goods offered for sale along with their other characteristics. However, α-avoidance actions are a different matter. He must supply these himself or have them provided to him by the seller, such as in the case of a "free" training course or literature which accom-

[4] In principle, it is possible that there are products that are too safe. The inequality in (1) can be, in other words, reversed. Unreasonably safe products, however, do not seem to be a public issue.

panies the product. From his point of view, an unreasonable hazard exists if, by taking some avoidance action, he can reduce the expected cost of the range of possible accidents by more than the cost of avoidance, that is, if $(V_i)_\alpha < X_iJH_\alpha$.

Consumer behavior involves complicated phenomena and, therefore, we do not pretend that the above criterion "explains" very much. The following three observations, however, are relevant: First, though not explicitly accounted for in $V_i(\alpha)$, risk-taking behavior is reflected in it. Second, even were $V_i(\alpha)$ to reflect risk-taking behavior explicitly, $V_i(\alpha)$ is as subjective as any demand function. Thus, we face the same measurement problems in estimating this function as we would encounter in estimating individual demand functions. Third, it should be noted that $\sum^n X_iJ_i(H_i)\alpha$, the total reduction in the cost of injuries directly realized by individuals through their own actions, need not equal XJH_α, the total reductions in costs of injuries experienced by society through the actions of its members. If there is an externality (e.g., if injuries to third parties are likely to occur for which the individual consumer is not made fully responsible), then the two expressions will not be equal. To illustrate, suppose that the rate of accidents involving bystanders increases indirectly due to bad driving habits, then refresher driver education will reduce accident costs more than might be foreseen by individual drivers, since they do not ordinarily perceive the hazards to which they expose bystanders. Also to be noted is the possibility that the overall cost of α-actions when provided by consumers is greater than when they are provided by the seller. For example, if automobile buyers were each to perform a thorough inspection of steering mechanisms to determine whether they are free of defects, the total cost to them of this avoidance action would most probably exceed the cost of an equivalent quality control provided by the manufacturer. The manufacturer is not only probably more adept at such inspection, but he may institute a sampling scheme which would be both effective and substantially cheaper than the inspection performed by the average buyer.

Consideration of what would constitute an unreasonable hazard from the producer's point of view will be discussed in detail below, along with other related topics.

2.2. Competition and Product Hazards

2.2.1. The Optimal Level of Product Hazards. The cause of injury may be a defect in design or manufacture (e.g., shoddy materials or workmanship, concealed sharp objects in toys, radiation or electrical leaks in appliances), lack of maintenance not equivalent to misuse, or normal material failure.

The social cost S of consuming X units of the hazardous product is given by the expression

$$S = XC(X, \beta) + XJH + \sum^{n} V_i(\alpha)$$

where the right-hand members represent production cost, including producer avoidance actions so identified; expected cost of injuries; and cost of consumer avoidance actions so identified.

For any given level of consumption of X, the social cost S is minimized when the following two necessary conditions are satisfied

$$C_\beta = -JH_\beta \tag{2}$$

$$\sum^{n} (V_i)\alpha = -XJH_\alpha \tag{3}$$

Simultaneous solution of (2) and (3), if possible, indicates how unreasonable hazards can be eliminated by joint actions of both producers and consumers. Furthermore, for any given β-action, equation 2 shows that producers should improve product quality so long as the reduction in the cost of injuries exceeds the cost of making the improvements. Correspondingly from (3), for any given α, avoidance actions by the consumer should also be taken as long as the reduction in cost of injuries exceeds the cost of the improvement.[5]

2.2.2. The Competitive Market and Product Hazard. How does the competitive market satisfy the above optimality conditions? Provided that there is voluntary exchange between producers and consumers and that transacting costs between them are negligible, then by the Coase theorem [Coase 1960], as discussed below, the market will bring about the optimal avoidance actions and product quality, regardless of who is made liable for injuries from consumption.[6]

A producer who can introduce a change in the physical characteristics of his product at a unit cost (C_β) that is less than the resulting reduction in expected accident cost to the consumer ($-JH_\beta$) can be "bribed" by the consumer to do so. If safety is a product characteristic which is desired by the consumer (who will be assumed to be able to

[5] The foregoing formulation focuses on the hazard and its elimination. Hence the quantity X produced and consumed in the economy was assumed as given. However, full optimization conditions would ordinarily be expected to affect X.

[6] See also Demsetz (1972).

discriminate between greater or less safety), he would certainly be willing to bear the cost of the improvement via a higher price. If there is competition among producers, it will act as a spur for a producer to introduce the change, whether or not the law holds him liable for the cost of accidental injury, for otherwise he would lose his customer to those of his competitors who do. The process will come to a stop when condition 2 holds.

The producer may also be motivated to provide information and other α-type avoidance measures. He may be able to provide some (but not all) of these more cheaply than the consumer, either because of his superior knowledge of his product, or because of his ability to distribute the cost over all units produced. If transacting costs are negligible, a consumer will be willing to "bribe" the producer to supply these avoidance measures rather than doing so himself. But competition among producers, if present, will independently tend to bring about the same result. The process will come to a stop when condition 3 holds, with producers providing α-type avoidance measures in which they have a comparative advantage, and consumers taking avoidance actions (as explained in 2.1.6) in which they have comparative advantage.

Thus, what is economically efficient will eventually be adopted, regardless of who, by law, is held liable for accidental injuries, provided either competitive conditions obtain or transacting costs are neglible (voluntary exchange being possible).

If third parties suffer accidental injuries (externalities) because neither producers nor consumers consider the costs they impose on third parties in their decisions, and provided that transacting costs are negligible, the three groups can together ensure that the party which can most efficiently reduce these externalities will do so.

In a recent paper "The Economics of Product Safety" (Oi, 1973), Oi shows that in a competitive market where products of the same kind but of different degrees of riskiness are available, a consumer maximizes his utility by buying that product whose "full price" (i.e., market price plus expected loss from injury) is minimum. If the liability for injury is assigned to the consumer, we would expect him to buy insurance or to self-insure, and thereby cover his expected loss. In such a case, the full price of the safe product would consist of its market price plus the insurance premium, the latter depending on the expected damage which the individual will suffer. On the other hand, if liability for the loss were placed on the producer, he too may self-insure or buy product liability insurance. Provided he has full freedom to sell to whomever he pleases at whatever price he pleases (i.e., transacting costs are zero), the full price offered to the consumer will be the same as in the other case. Of course, the producer also has the option of changing the quality of the product, but that decision does not essentially change the conclusion that liability does not affect the level of utility of the consumer under our assumption.[7]

2.3. Unreasonable Hazards in the Economy

The main purpose of the discussion in 2.2 has been to show that voluntary exchange and especially the competitive market, under certain specified conditions, would eliminate unreasonable hazards but allow reasonable ones. We want to address now the conditions under which we might, on the basis of economic theory, expect the economy to tolerate the presence of unreasonable hazards. These conditions are implied in our previous discussion. For convenience of exposition, they are grouped below under five main headings: uninsurable risks, high transacting costs, high litigation costs, consumer sovereignty, and third parties.

2.3.1. Product Liability Insurance and Self-Insurance. If for various reasons, actuarial risk cannot be determined, a product-related accident insurance market is not likely to emerge. Currently, there are only a few types of product-related accident insurance available to the consumer, the most familiar being automobile accident insurance. And though we have home accident insurance, such insurance is not related to specific household products, as, for example, ladders, floor waxes, and ovens. As for product liability insurance for the producer, the current unsettled situation is an indication of the difficulty of forecasting the liability of producers with respect to injuries associated with their products.[8]

The main factors which are inimical to the determination of actuarial risk are lack of valid data and "moral hazard."

[7] Note that avoidance action on the part of the consumer in Oi's model consists of his purchase of a safer product, which is distinguished by an insurance cost that is smaller than that of the less safe product. For this, he pays a higher market price. Likewise, the producer's avoidance action consists in manufacturing a safer product, which is distinguished by a product liability insurance cost which is lower than that of the less safe product. For this, he incurs a higher cost of production. In terms of our model, the insurance cost is JH, whether incurred by the individual consumer or by the producer. Any savings in this cost, $-(\partial(JH)/\partial\beta)$, would be realized by the producer at the cost of $\partial C(X, \beta)/\partial\beta$, which is equivalent to $\partial P/\partial\beta$, the increase in price to the consumer, where P is the market price. assumed equal to $C(X, \beta)$.

[8] See Forrest C. Mercer, "Product Liability Law in the 1960's—The Insurer's View," Paper presented at the Product Liability Prevention Conference, August 22–24, 1973, Newark College of Engineering, Newark, N.J.

Dearth of good data may be due to their cost. The circumstances surrounding a consumer product-related accident may, for obvious reasons, be expensive to investigate and establish *relative* to the cost of the injury. A second reason which tends to keep hazard information from becoming public knowledge is one that is often discussed in a different context, namely, consumer education. Consumers are often alleged to be unable to estimate hazards correctly, or to understand information provided on hazards and to cope with these hazards when they actually occur.[9] Whatever the truth about consumer comprehension and response to hazards, a manufacturer may find that it does not pay to be too explicit about the hazards related to his products, unless such explicitness is likely to reassure an already frightened consumer. For example, if consumer hostility toward nuclear power generation is based upon misinformation concerning the true hazards of nuclear contamination, consumer education will probably increase acceptance of this type of power plant. On the other hand, if the location of an automobile's gas tank is a potential cause of fiery explosion in a collision, a manufacturer who announces that he has reduced this hazard by as much as fifty per cent may succeed only in causing prospective buyers to favor alternative modes of transportation. In such a case, industry will not volunteer such hazard information; nor will it encourage governmental provision of this type of hazard information.[10]

But there is another aspect to consumer comprehension of hazards which is not sufficiently appreciated. It is often stated in terms of consumers' inability to estimate hazards correctly. We should recall, however, that in theory it is not important under the Coase conditions that consumers be able to estimate hazards correctly for the emergence of optimal safety levels for consumer products. They no more need to know about hazard estimation than they need to know about the intricacies of modern production methods. Risk estimation may be an activity that is most efficiently provided by producers, rather than by consumers. And if a question of credibility arises, producers have, theoretically, recourse to independent testing laboratories (Underwriters Laboratories [UL], Consumers Union [CU], and others) to persuade consumers that their safety claims are genuine. But if the measurement of risk depends on properties of a product that are themselves complex (e.g., burn properties of foam plastics), consumers are

[9] Cf. the statement of Corwin Edwards before the National Commission on Product Safety (NCPS), *Hearings*, Vol. 9A, p. 138.

[10] This of course does not imply that manufacturers of substitutes, e.g. battery-driven cars, will not point out this hazard to consumers.

not likely to be able to estimate expected losses. Without this information, the consumer cannot make a rational decision. If *caveat emptor* prevails, the consumer obviously cannot self-insure, and if *caveat venditor* prevails, the consumer would still not be in a position to choose intelligently between two products that included, in their prices, estimates (by the producer) of expected damage claims.[11]

The second main reason which inhibits the emergence of a product-related insurance market is "moral hazard," that is, the impact of insurance on consumer behavior or producer behavior resulting in an increase in demand for compensation and even in higher injury rates.[12] If consumers are insured against costs of injuries, total claims are likely to increase, even if injuries did not, because small claims which formerly would not have been presented are now pressed, and because consumers will be inclined to be less concerned with the costs incurred, such as for medical care. Similar type problems arise in products liability insurance sold to producers.[13] Furthermore, the presence of insurance may induce more risk taking, however slightly; that is, it will affect α-type and β-type avoidance actions, including the purchase and sale of lower-quality products. In the aggregate, these may result in higher injury rates. As premiums are increased to cover these higher costs, better-than-average-risk consumers will forgo insurance, driving premiums still higher. Under these circumstances, insurance ceases to be a profitable business, unless discriminatory pricing policies are practiced, a procedure which is likely to run afoul of public regulatory agencies. If, for the reasons cited, no adequate product-related accident insurance is available (and self-insurance cannot be effectively practiced), then the consumer is not in a position to treat risk as an objective datum but rather as something entering directly into his preference function. The risk-averse consumer in such a situation may reduce his consumption below what might be socially justifiable. That is, he may consider unreasonable what from society's point of view would be a reasonable hazard.[14]

[11] It does not help much here to have government or industry assure uniformity in the measurement of risk or in test procedures. Uniformity per se is more likely to help manufacturers cut costs than help consumers make better decisions. The problem is that "safety," though a desirable good, is often conceptually difficult to measure. To say that consumers prefer more safety to less begs the question of whether they would recognize an increase in safety. Indexes of risk are not easy to interpret.

[12] On "moral hazard," see Arrow (1963, 1968), Grubel (1967), Pauly (1968), and Ehrlich and Becker (1973).

[13] Mercer, "Product Liability Law . . . ."

[14] The foregoing discussion does not provide a rationale for a standards-setting role by government. If the unintended effect of a standard in connection with a highly com-

2.3.2. High Transacting Cost. A critical assumption which is fundamental to the Coase theorem is that transacting costs are negligible. Most consumption occurs over a period of time, whereas the buyer-seller relationship usually ends with the completion of the act of sale-purchase. The consumer is in a better position to monitor his consumption, while the seller is in a better position to appraise the qualities of his merchandise. The efficient method of ensuring safe consumption is to make the consumer responsible for the *manner* of his consumption. At the same time, competition among sellers acts to reduce the consumer's lack of knowledge about product characteristics. It would be inefficient to assign responsibility to sellers inasmuch as sellers will find it difficult (though not impossible) to influence the way purchasers will consume products. Firearm dealers, for example, might require annual psychiatric and police reports from purchasers of firearms, or appliance dealers might require customers to buy inspection and maintenance contracts. Such requirements might even be tailored for specific customers, the cost varying on the basis of use and the customer's educational background and income level. Though the cost of thus monitoring the activities of consumers would be included in the price, it is likely to be greater than if consumers acted on their own responsibility.

It is unlikely, of course, that producers would be allowed to resort to these cost-reducing devices designed to minimize their total liability for accidents sustained by their customers.[15] These prohibitions can be viewed as further escalation of transacting costs. Oi (1973) has shown that where producers are required to charge uniform prices, the full price of the product will include its production cost plus a premium representing the average expected claim for damages arising from accidents sustained by consumers in general during consump-

plex product is the creation of a sense of security for the consumer which is not justified by the necessarily limited class of risks on which the standard is based, he would continue to make his decisions in an uninformed way. The result is that: (a) even though products will tend to become more homogeneous with respect to safety, they may be no safer on the average than before; and (b) if more consumption is induced, the cost of accidents may rise. To the extent that the government standard may not be significantly more stringent than the lower end of the previous product spectrum (i.e., it is a minimum standard), the social cost of accidents may increase. It thus follows that consumer education, one way or another, cannot be ignored as a practical matter in favor of physical standards, as the National Commission on Product Safety (NCPS) seemed to imply in its *Report* (1970).

[15] Mortgage institutions which might require some of their mortgagors to practice family planning would similarly find that such a cost-cutting device is "socially" unacceptable.

tion.[16] The result of this uniform pricing policy is that those consumers whose expected cost of injury is greater than average (usually the more well-to-do) will realize a gain and those whose expected cost of injury is less (usually the less well-to-do) will experience a loss, compared to the alternative of full discrimination among customers. In other words, some wealth redistribution, most probably from the poor to the wealthy, will take place.

To what extent does high transacting cost allow unreasonable hazards to remain in the market? The answer, one would suspect, is "very little." Competition in the market is a far more important factor for safety than low transacting costs. Suppose that the prevailing rule is *caveat emptor,* and that a manufacturer markets a commodity (say, a play tent) which poses an unreasonable hazard to children because (a) the material of which the tent is made is flammable, (b) the very shape of a tent favors sudden conflagration, and (c) children like to light candles inside a tent. Assume that treating the material with flame retardant or changing its shape reduces the hazard far more cheaply than constant vigil by parents, and assume further that the manufacturer's avoidance cost is less than the expected cost of injuries. How is the manufacturer to be induced to introduce the safety feature?

If consumers could band together, it would surely be economical for them to "bribe" the manufacturer to use nonflammable material, since the amount of the bribe is less than the alternative avoidance cost (by assumption) and is also less than the avoided injury cost. But the total costs of identifying parents who are potential buyers of the tent, of organizing and representing them, of undertaking investigative studies, public relations, negotiations, etc.—all covered by the term "transacting cost"—would probably exceed the benefits that such a group of concerned parents might derive. Therefore, this course of action is not likely to be taken.

Most of these burdensome activities would, however, be unnecessary if there were competition among manufacturers of tents, *and* if parents indeed wanted safer tents and were willing to pay the extra price for them. Some producers would discover this latent demand and attempt to satisfy it. Expressing this result in a different way, competition among producers will reduce transacting costs so drastically that little overt action by consumers will be necessary, other than their acts of purchase.

By way of contrast, consider the case of a public utility supplying a

[16] In the terminology of our model, this premium is *JH*.

residential community with natural gas. Suppose that its installation practices occasionally resulted in gas explosions involving personal and property losses. Because the public utility is a monopoly, considerable time may elapse before it decides that an increase in gas rates to finance improved installation practices, greater supervision, and better materials can be justified to the general public and to the cognizant regulatory agency. The process would have to be impelled by periodic newspaper accounts of such tragedies, an aroused public, letter-writing campaigns, public hearings, and so on.

High transacting costs are thus akin to "noise" in a system, but they are not as serious as absence of competition or lack of information.

2.3.3. High Litigation Costs. Claims against producers or sellers are not costless. The NCPS considered the cost of litigation to be a principal reason for the ineffectiveness of products liability law in eliminating unreasonable hazards, especially where the cost of litigation exceeds the cost of injury.

Although an injured consumer may receive less than he deserves, the award, or the possibility of it, will act as an incentive for the manufacturer to improve the safety of his product. While it is true that the manufacturer is likely to be wealthier than the injured consumer, he will nonetheless consider the settlement option if he is an income maximizer. Moreover, on the basis of financial consequences of adverse publicity, a settlement is preferable to possible loss of suit.[17] The cost of defending a suit is no less onerous to a manufacturer than to the consumer. And though a lost suit may not by itself cripple a manufacturer, considerable pressure can be exercised on him to the benefit of the consumer by retailers, wholesalers, and distributors who are also vulnerable to suits.

Where the cost of litigation (including attorney's fees) exceeds the cost of the injury, the consumer will not exercise his right to sue. The situation is essentially equivalent to transacting costs being significant. However, in addition to legal devices designed to reduce litigation costs, such as small claims courts and class action suits, the market influences described earlier (namely, good reputation and business pressures of intermediaries) are still operative. In other words, the problem is not as bleak as it is usually described. We should realize that a court of law is not a liability-dispensing machine which is activated whenever rights and liabilities are to be assigned. It is rather a

[17] Scares resulting from isolated instances of food poisoning have been known to result in millions of dollars of losses and even in bankruptcies. See *Forbes*, April 15, 1972. pp. 55–57.

settler of *doubtful* claims, at a price. If the rules of liability are clear and the facts admit of no uncertain interpretation, the law is obviously quite effective. The role of the courts can easily be exaggerated.

Nevertheless, the high transacting cost represented by litigation leads to some market imperfection, and to that extent some unreasonable hazards will not be "filtered" by the market. Fortunately, these are not likely to include major hazards which are uppermost on the agenda of public agencies. Since the high costs of litigation are themselves the object of concern, we can expect eventual adoption of innovative measures directed to the heart of this problem.

2.3.4. Consumer Sovereignty. Suppose that a particular product is banned because, say, in the opinion of the new Consumer Product Safety Commission, it represents an unreasonable hazard, and another product which is less hazardous but more expensive is favored. Assuming that the marginal cost of the safer product does not change as a result of the shift toward it, then the decline in the social (or aggregate) cost of accidents should exceed the decline in the consumer utility (due to the additional cost of safety). This follows from the fact that the banned product is *unreasonably* hazardous. However, some consumers must have believed otherwise, since before the ban was imposed they had the option of consuming the safer product but preferred to consume the other. Therefore, they were either systematically wrong in their assessment of the hazard—a possibility which we have already considered—or they are not the best judges of their own welfare. Although this latter inference is contrary to the fundamental ethical principle of consumer sovereignty, many statements by consumer advocates unfortunately imply this view of the consumer. Granted that such views often result from honest misreading of the facts, and granted that often they are reinforced by particular instances where consumers did not seem to have a good rationale for their choices, nevertheless in large part they are expressions of basic values. Since this is not a political or ethical investigation, no more will be said here on the subject.

2.3.5. Third Parties. A special case of high transacting costs occurs where the victim is not a party to the transaction which has led to the injury. Such an individual is commonly referred to as a "third party" or innocent bystander, and the injury as a disutility or negative externality. Third parties exert little influence on the transaction; it is too costly for them to do so, since they would have to identify the parties to a transaction and anticipate its nature. By the same token, parties to a voluntary transaction would not, in the process of arriving at their bargains (say, to produce, sell, buy, or consume), consider the costs they are likely to impose on others.

An example of a third party is a pedestrian who is injured in a highway accident due to a defect in a passing car.[18] Another example is an accident where the automobile driver is under the influence of alcohol. The public has little chance to ensure that a habitual drinker will demand, or that the manufacturer will install, a device to prevent operation of the car when the driver is intoxicated. A third example where different basic values could lead to different conclusions is the purchase by parents of hazardous toys for their children. While parents act in the interest of their children in various degrees, children have no independent influence on the safety of toys made and purchased for them.

If a transaction between a producer and a consumer, or seller and buyer, creates an externality in the form of a hazard imposed upon a third party, the terms corresponding to $X_i J(\partial(H)/\partial\beta)$ and $X_i J(\partial(H)/\partial\alpha)$ inequality 1 will appear to the transactors to be less than their true social value by the value of the externality. It is therefore possible for the inequality to hold from *society's* point of view, signifying the existence of an unreasonable hazard, while simultaneously conditions 2 and 3 hold.

To recapitulate, five major conditions were reviewed which gave rise to market failure. Most of them turned out to be special cases of high transacting costs. Technological reasons seemed to give rise to case 1 (excepting complexity of hazard), and cases 2 and 5. Legal and social considerations gave rise to case 3 and partially to case 2. Even where consumers were allegedly irrational (case 4), it was a case where those who knew better found it costlier to reason than to legislate. Yet, as was implied in the discussion, in the perspective of market performance, competition was the single most dominant force in reducing transacting costs.[19]

3. IMPLICATIONS FOR MEASUREMENT

3.1. Introduction

Since injury data are collected in order to help decide whether public action is indicated and, if so, whether a physical standard would be

[18] The manufacturer's liability is primarily to the car owner, not to the pedestrian.

[19] In an unpublished paper entitled "Reasonable and Unreasonable Hazards in Law and Economics," presented at the Western Economic Association Conference (August 15–17, 1973), I have argued that legal rules of products liability are quite consistent with principles of economic efficiency, as discussed in this section.

justified, it is necessary that measurement procedures be appropriate for the task of discovering the presence of an unreasonable hazard.

Assuming that obtaining adequate data about a certain hazard presents no problem, the question I wish to address is, What sort of data do we need? In answering this question, I make use of the theoretical apparatus of Section 2. In order to prevent the following discussion from moving at an abstract level. I shall draw most of my illustrative material from one particular hazard for which a physical safety standard has actually been set. This is the hazard of death by entrapment in a household refrigerator. It is not, however, my intention to evaluate the standard here. I start with a brief history of the present refrigerator magnetic-door standard, which is to serve as our illustrative case. A short description of a potentially major source of hazard data on household products, namely NEISS, will also be given.

3.2. Refrigerator Hazards and Magnetic Doors

Between 1946 and 1955 inclusive, 114 cases of deaths of young children trapped in household refrigerators, iceboxes, and freezers were reported. These children had apparently entered the enclosures during play, and subsequently the doors were somehow closed. Because entrapment was in an airtight compartment, asphyxiation resulted within the first hour [20] (Table 1).

The tragic nature of these deaths, prompted the Congress of the United States to pass a law (P.L. 84-930) on August 2, 1956, requiring safety devices to be installed on household refrigerators shipped in interstate commerce.[21] These devices were to allow the doors of refrigerators to be opened easily from the inside. The task of prescribing such a device, called also a safety standard, was entrusted to the Department of Commerce, which in turn assigned the National Bureau of Standards the task of developing it.

One year later, on August 1, 1957, the National Bureau of Standards published specifications for two alternative safety devices, to take

[20] This view has been disputed. A research team at the University of Louisville School of Medicine claimed that it had "proved conclusively" that deaths in refrigerators were the result of heat stroke rather than lack of oxygen. (See the *Courier-Journal*, February 21, 1970.) This theory may explain some puzzling but largely ignored observations scattered in police reports to the effect that the victims were warm, soaking wet, or dehydrated at the time they were discovered.

[21] The Senate Committee on Interstate and Foreign Commerce stated in its report on H.R. 11969, which bill later was enacted into law, that neither publicity nor state laws and local ordinances forbidding the abandonment of refrigerators were adequate to ensure safety.

Table 1

Recorded Deaths in Refrigerators [a]

Year	Deaths	Incidents	Year	Deaths	Incidents
1946–55	114	N.A.	1964	44	30
1956	11	8	1965 [b]	22	13
1957	14	8	1966	31	19
1958	17	11	1967	31	19
1959	15	10	1968	26	14
1960	6	4	1969	20	11
1961	25	16	1970	17	11
1962	35	22	1971	10	10
1963	21	12	1972	10	6
			1973 [c]	10	N.A.

NOTE: Difference between incidents and deaths is due to multiple deaths. N.A. indicates not available.
SOURCE: Refrigerator Service Engineers Society, Des Plaines, Ill.
[a] Includes freezers and iceboxes, United States and Canada.
[b] Adjusted for 2 deaths and 1 incident of homicide.
[c] First nine months.

effect on October 30, 1958, as required by the Act. The devicę which was eventually adopted universally by the industry required that a force of not more than 15 lbs.[22] be sufficient to open the door when applied from within the refrigerator. Present day magnetic-closure devices on refrigerators and freezers are supposed to be in conformity with this standard.[23]

3.3. The National Electronics Injury Surveillance System (NEISS)

NEISS, operated now by the Consumer Product Safety Commission, came about through the merger of two separate data-collection programs: the Hospital Emergency Room Injury Reporting System (HERIRS) set up by the former National Commission on Product Safety, and the National Injury Surveillance System (NISS) set up by the Food and Drug Administration (FDA) in 1969. NEISS be-

[22] Supposedly, a child can comfortably exert this much force against the door of a refrigerator.

[23] It is interesting to note that, perhaps in anticipation of the mandatory standard, industry and the Department of Commerce had worked out, prior to the legislation, such a device which could have been adopted on a voluntary basis.

came fully operational on July 1, 1972, when the last hospital of a statistically selected sample of 119 (out of 4,906 hospitals across the United States) began reporting. Participating hospitals report daily on injuries treated in their emergency rooms. Not included in NEISS are, therefore, injuries treated in doctors' offices (estimated by CPSC at 41 per cent of the total), at home (18 per cent of the total), and by direct hospital admissions (3 per cent).

NEISS groups products into 19 general categories. Injuries are summarized and tabulated monthly showing, for closely related products within each category (e.g., electric dryers), total incidents classified by age and sex of victim. A mean severity index is calculated for each product group, based upon a system of weighting applied to 9 categories of injuries.[24]

The Bureau of Epidemiology, which has management responsibility for NEISS, also conducts in-depth investigations of some injuries, selected on the basis of their severity and frequency. *All* cases of death, as well as injuries related to flammable fabrics, are investigated.

On September 30, 1973, the CPSC issued a ranked listing of product categories based on an index of severity and frequency of injuries associated with them, as reported through NEISS.[25] The topmost ten included, in descending order, bicycles, stairs, doors, cleaning agents, tables, beds, football-related products, playground equipment, liquid fuels, and architectural glass. Refrigerators and freezers ranked seventy-third on the list. However, victims of refrigerators and freezers are not ordinarily routed through hospital emergency rooms, since they would already be dead on arrival. Since we know that during the first nine months of 1973 ten children were victims of refrigerators, the ranking of this product category should shift at least to somewhere within the thirty to forty rank class.[26]

3.4. Market Failure

At a fundamental level, an empirical issue to be settled is whether there is evidence of market failure. The five aspects of market failure discussed in Section 2 should be examined.

Investigation of market failure requires some evidence of a kind not directly related to hazard data. In other words, the problem is not

[24] CPSC, *NEISS NEWS*, Vol. 1, No. 6, August 1973.

[25] Ibid., Vol. 2, No. 4, December 1973.

[26] Bearing in mind that the same rate of accidents was considered intolerable by Congress in 1955, it is rather astonishing that there are so many products today that appear to be even more hazardous.

so much one of hazard measurement as of the theory of accident occurrence. Nonetheless, data on hazards should, as far as possible, shed light on the presence of market failure.

3.4.1. Third Parties. The data collected should indicate separately injuries to third parties, including children. In terms of our basic illustration, the victims of refrigerator hazards are children. Since the majority of these children belong to the households owning the hazardous appliances, and as we shall see presently, the hazard can easily be comprehended by consumers, the transaction between the principal parties may be considered to give rise to no externality (see Section 3.4.5 below).

3.4.2. Complexity of the Hazard. Injury data should distinguish between hazards which are easy to comprehend and those which are complex. As far as potential hazards from refrigerators are concerned, there is a single major hazard of interest, namely, death by entrapment. On one hand, the victim most likely does not comprehend it; on the other, the consumer is certainly able to understand it easily but may have to be reminded of it. (See 3.5.3)

3.4.3. High Transacting Costs. Whether transacting costs are high is not a question into which data on hazards can offer any insight. Nonetheless, we shall consider this issue, and the following two which are similar in this respect, because they provide an opportunity to evaluate the practical utility of the theory developed in Section 2.

Are transacting costs between manufacturers of refrigerators and consumers so high as to permit an unreasonable hazard to exist? Considering that competition among manufacturers of refrigerators has always been quite keen and that the hazard faced by owners' children is not less than that faced by nonowners' children, the market should have no difficulty transmitting, or revealing, latent demand for safety, if it exists, to the manufacturers.

As between those who might abandon refrigerators and those whose children might be endangered as a result, negotiations are quite costly. However, criminal liabilities [27] are imposed on the former group in most states; [28] many counties have similar ordinances.

3.4.4. Cost of Litigation. We consider next the effect of the high cost of litigation on the level of the hazard. By and large, the available socioeconomic evidence indicates that the majority of those responsible for abandoning the refrigerators which caused death to children

[27] Possibly civil as well.

[28] See for example, Section 334 of the *Annotated Code of Maryland,* entitled "Iceboxes: Abandoned and Discarded."

came from relatively low-income classes. Therefore, an action in tort for negligence is not likely to net significant damages to the plaintiff after litigation costs are defrayed. The disincentive effect of civil liability is thus attenuated, and the degree of hazard from abandoned refrigerators is to that extent higher than otherwise. However, deaths in *abandoned* refrigerators constitute a small proportion of total deaths in refrigerators. A survey of 146 such deaths between 1959 and 1969 shows that only about 30 per cent (45 deaths) occurred in *abandoned* refrigerators, freezers, and iceboxes.[29]

3.4.5. Consumer Sovereignty. It is conceivable that the underlying assumption of Public Law 84-930 was that consumers were taking chances which, in the opinion of the lawmakers (and other supporters of the bill), they should not be allowed to take. In other words, the welfare of children here, as on other occasions, could not be left entirely to their parents. The Committee on Interstate and Foreign Commerce stated (Senate Report No. 2700): "No doubt publicity campaigns to make parents alert to the dangers of deaths in refrigerators are helpful, but they are inadequate to meet the problem. . . . The bill here being reported is essential to protect the lives of the innocent children of this nation." However, we should note that an example of an inexpensive but effective informational campaign directed at adults (including parents) is the action of those manufacturers whose instructional materials accompanying new refrigerators and freezers now include a reminder to the buyer of the potential danger to children of the old unit being replaced.

In conclusion, clear evidence of market failure is absent. As a matter of fact, the publicity given to this hazard in the mid-fifties led to the development of a number of patented workable devices. Indeed, one major manufacturer of applicances adopted a magnetic closure device for one of his models even before P.L. 84-930 was passed.

3.5. Establishing Unreasonableness of the Hazard

3.5.1. Foreseeability, Assumption of Risk, and Abnormal Use. Not all accidents arise in the course of normal use of a product. Some are totally unforeseeable; others are the result of risk assumption by the victim (reflecting his particular preference function); and still others are neither of the above, but constitute misuse of the product. It is not difficult to design an injury information system which distinguishes these from the rest. As examples, football injuries arising profession-

[29] See Appendix B.

ally may be separated from those occurring on school playgrounds; auto accidents on race courses from those on ordinary highways; injuries to fingers caught in meat grinders from those resulting from cases of "assault" with a meat grinder.

Reverting to the refrigerator illustration, the hazard posed to children is foreseeable; no risk-taking behavior on the part of the children can be reasonably assumed; and no cases of misuse have been reported, with the exception of one case of homicide (Pennsylvania, 1965) and one case of suicide (by an adult, Michigan, 1954). (The data on deaths in refrigerators can be adjusted for the former instance.)

3.5.2. The Hazard (*H*). After injury statistics are corrected for unforeseeable injuries, for those arising when unusual risks are assumed, and for those occurring in abnormal use, the need to assess the hazard probabilistically still remains.

Referring again to refrigerator hazard, available data on deaths through entrapment in refrigerators are given in Table 1 on an annual basis, by number of deaths and by number of incidents. Available statistics on sex and age of victims and on month of accident are not presented here.

Given the above data, how should the probability of death in a refrigerator be measured? To what population, that is, should the frequency of recorded deaths be related? Such a population might be associated with the total number of refrigerators in existence, those abandoned, the total number of deaths within the age group 1 through 12 years, or some other aggregate.

The choice of the "denominator" is a matter of definition of the hazard, to depend initially on whether it accords with common sense, but ultimately on whether it proves to be useful. Transporting ourselves back in time to 1955 and 1956, when Congress was considering HR 2181 and HR 11969 (later to become P.L. 84–930), it would have seemed reasonable, considering that a physical device was the focus of attention, to define the hazard as "the probability that a refrigerator in existence in 1956 would be involved in the accidental death of a child." One might refine this measure of the hazard by separating the following three component conditional probabilities: the probability that an abandoned refrigerator will be the cause of death, the probability that a refrigerator *not* in use but not abandoned will be the cause of death, and the probability that a refrigerator in use but temporarily out of service will be the cause of death. Each might be expected to vary over time as the denominator changes. One might even wish to distinguish between refrigerators and freezers.[30] Nevertheless, for other purposes, alternative definitions might conceivably be more appropriate. For example, the hazard might be defined as the probability that the death of a child of a particular age group will be due to a refrigerator rather than to some other cause.

Ideally, the proper sequence in the measurement of a hazard would be to develop a theory of accident occurrence relating to the product in question and then, in light of the theory, to define an appropriate hazard or set of hazards. For example, it may be hypothesized that refrigerator deaths are causally related to the following independent variables: number of refrigerators in existence in different use-states (in storage, operating, abandoned); the number of children in different socioeconomic classes; employment of mothers (at home, not at home); sex; age; geography (urban/rural); presence of siblings; and time of year. If verification of the hypothesis by, say, a multiple regression analysis, indicates some of the factors to be statistically significant, the hazard should be defined accordingly.

To appreciate the importance of this procedure, consider the impact of the large number of state laws and local ordinances imposing criminal sanctions on those responsible for abandoning refrigerators. The evidence shows that more than twice as many deaths have occurred in nonabandoned refrigerators than in abandoned ones. It would have been of little value to define the hazard solely in terms of abandoned refrigerators. Furthermore, even if the standard were to eliminate refrigerator deaths entirely, the presence of other significant factors might cause injuries associated with *other* hazards to go up as a result; i.e., there is no reason to believe that the standard would cause a *net* reduction in death rates, or other injuries, taken over all types of hazards.[31] Funding considerations have precluded pursuing this line of analysis.

[30] Public Law 84-930 applies only to household refrigerators; freezers are subject only to voluntary safety standard, to which most manufacturers seem to adhere (Underwriters Laboratories [UL 250], 1971]). I am not aware of the reason for Congress's neglect of freezer doors, given that children have frequently died in freezers. However, a number of bills have been introduced, but not passed, to extend coverage to home freezers and combinations.

[31] The 1958 standard on refrigerator doors did not, of course, eliminate the hazard in subsequent years, as Table 1 shows. This is probably due to the fact that stocks of old-type refrigerators were not eliminated. If we assume the life of an old-type refrigerator to be about fifteen years, peak displacement by new-type refrigerators will occur in the late sixties. The 1969 survey, mentioned earlier, and a telephone survey of police departments in late 1973 concerning accidents occurring between 1963 and 1973 turned up no instance of death in a new-type refrigerator or freezer. However, not enough time had then elapsed for new-type refrigerators to be discarded or stored away in significant numbers.

Without recourse to an expensive survey, it would have been extremely difficult to obtain reliable estimates of the numbers of refrigerators and freezers in use, in storage, or abandoned (but not scrapped) for any year, let alone over a period of time. Thus, it is not possible to calculate the three probabilities that a refrigerator or freezer in use, in storage, or abandoned will be involved in a fatal accident. However, our purpose is not to evaluate the 1958 standard but to illustrate how product hazard might be measured for the setting of safety standards. Hence, we shall be content with only three alternative estimates and quite rough orders of magnitude.[32]

To estimate the probability that a household refrigerator would have been involved in the accidental death of a child in 1956, we relate the number of such incidents in 1956 (i.e., 8) to the total number of household refrigerators in existence during that year. By means of linear interpolation between 1952 and 1960, for which years there are estimates of total households equipped with electrical refrigerators and freezers, an estimate of 50 million units for 1956 was obtained.[33] This number was repeatedly mentioned during the 1955 hearings on H.R. 2181 as the estimated total number of units existing in 1955. The probability of fatal involvement may therefore be computed as 8/50,000,000, or one in 6,250,000. This probability estimate, however, is clearly too crude an estimate for the hazard in question.

Since Congress in 1956 was thinking of the problem in terms of a physical standard on *new refrigerators* (and since it eventually did set such a standard), the relevant measure of hazard would have been the probability that a refrigerator (but not a freezer) sold in 1956 would be involved in a fatal accident during its lifetime. Such a measure could, at that time, have been based only on previous history. Taking the average life of a unit to be fifteen years, and interpreting this (heroically, to be sure) to mean that all refrigerators sold in 1941 were displaced in 1956, we relate deaths involving only refrigerators to this number and obtain an estimate of 7/3,374,000, or about one in 480,000.[34] (For comparison purposes, we may relate the number of incidents in

[32] Sources of the data on sales of refrigerators and freezers used in this section are principally: Miller (1960), Burstein (1960), and *Statistical Abstract of the U.S.*, annual volumes. See Appendix A.

[33] 1950: Refrigerators – 37.8 million; freezers – 4.9 million
1960: Refrigerators – 49.6 million; freezers – 11.2 million
Source: *Statistical Abstract of the U.S.*, 1971. Unless otherwise emphasized, the term "refrigerator" will include "freezer" as well.

[34] We know that in 1959, 60 per cent of deaths involved refrigerators. Applying the same percentage to 1956, we estimate 11 × 60 per cent = 7 refrigerator deaths. In 1971, out of the ten deaths reported, 7 involved refrigerators.

1971 to the number of refrigerators sold in 1956, a ratio of 7/3,382,000, or about one in 450,000). Estimates for years prior to 1956 can also be computed, but that is not necessary for our purpose.

Finally, given that state and local governments were concerned primarily with *abandoned* refrigerators and freezers as sources of hazard, a measure of the hazard should be the probability that a refrigerator or freezer abandoned in, say, 1956 would lead to a fatal accident.[35] On the assumption that 80 per cent of the 3.382 million refrigerators sold in 1956 were destined to be replacements (Miller, p. 197), whereas only 10 per cent of the 1 million freezers sold were for replacement, we estimate total displacements in 1956 as 2.806 million units,[36] to which we relate the 11 deaths. This yields a probability estimate of about one in 255,000. This estimate is, of course, much too rough, since not all displaced refrigerators and freezers are *ordinarily* abandoned; some are kept as second units and others are scrapped immediately. The hazard from abandoned refrigerators and freezers is therefore higher than indicated. On the other hand, since the numerator includes incidents in "nonabandoned" units, which probably account for more than half the cases, the hazard is considerably overstated.

3.5.3. Hazard Avoidance (H_β and H_α). The mandatory physical standards adopted on October 30, 1958, for refrigerators, and the similar, but voluntary standards adhered to since then by most manufacturers of home freezers, are examples of β-type avoidance measures. The evidence, insofar as it has been possible to ascertain,[37] shows no deaths of children caused by units complying with these standards. Such evidence is certainly heartening. However, in the fourteen years from 1959 till 1972, 313 deaths were reported, more than twice the number of deaths reported in the thirteen years prior to 1959. It appears that the long-term solution which Congress sought to bring about has indeed been achieved, but no solution for the short-term has been realized.[38]

[35] Since the U.S. Congress could have jurisdiction only over sales of refrigerators and freezers, states and municipalities were left with the responsibility for hazards arising from the existing stocks. By 1955, most states had already passed criminal liability laws with regard to abandonment.

[36] This is close to 2 million units estimated to be discarded annually, as mentioned in the 1955 hearings on HR. 2181.

[37] See Appendix B.

[38] I have seen no reports of incidents where children emerged from magnetic-door units after being inside them. The fear has been expressed that children who enter refrigerators, magnetic or otherwise, in play might be overcome by lack of oxygen before

As for α-type avoidance, three measures may be identified with respect to refrigerator hazards: (a) The warning literature (published by the Association of Home Appliance Manufacturers) which now accompanies new refrigerators and freezers, and the various warnings stamped on such units, as specified in UL250, the voluntary standard for safety, required by Underwriters Laboratories; (b) the varied literature on refrigerator and freezer hazard published by the Department of Health, Education, and Welfare—Public Health Services (DHEW-PHS) and the National Safety Council, among others; (c) the state criminal codes and local ordinances relating to abandonment and outside storage of refrigerators and freezers.

How much have these α-measures contributed to safety? It is difficult to assess the impact on consumer behavior of these actions; I am not aware of any studies which have attempted to make this assessment. However, we may accept as reasonable the Congressional view that additional public information of the kind provided in 1955 would have had no significant lasting effect on consumer behavior.[39]

3.5.4. The Cost of Injury (J) and the Costs of Avoidance (V_α, C_β). Since the outcome of an accident in our illustrative case is either death or no-death, the problem of estimating J is somewhat simplified. Though the life of a child can never really be exchanged for money, society surely has on occasions made decisions which imply a value placed on life.[40] Funds for this study, however, did not permit an estimation of the value of a child's life by inference from any particular social decision.

An alternative approach is to take the valuations placed on children by juries or judges in cases of wrongful death. Ordinarily, such awards include the present value of a child's monetary contributions to his parents, compensation for pain and suffering and loss of companionship, and occasionally punitive damages. Again, for budgetary reasons, a thorough review of awards over, say, the past ten to twenty years was out of the question. However, reference was made to 49 *American Law Reports* (*ALR*) 3d 934 under "Damages—Death of a Minor,"

attempting to come out. In experiments conducted in 1955—clearly far from approximating the real situation—some children made no attempt to come out once entrapped (Bain, 1958).

[39] If one were evaluating the current standard, it would be legitimate to ask whether its adoption in 1958 dampened the enthusiasm with which α-actions of different kinds might have been pursued.

[40] It is often claimed that our society values children more than adults. If so, this is some compensation for their lack of the vote. It is interesting to note that in the weighting scheme of the CPSC, the severity index of an injury is doubled if a child is involved.

which contains annotated cases dating back to 1941 in which the courts were called upon to consider the excessiveness or adequacy of awards of damages for personal injuries resulting in the death of minors. No instance was found of an award, considered not excessive, above $75,000 for a child under six years of age. It thus seems that an estimate of $100,000 would be rather on the high side as an average value of a child's life, and therefore quite a conservative estimate for our purpose.

The safety standard which the National Bureau of Standards, Department of Commerce (NBS–DOC) promulgated on August 1, 1957, pursuant to the 1956 Act, resulted in the universal adoption by industry of a magnetic door-closure device. This device, though effective, appears to have been the least expensive of the devices known at that time. Cost estimates presented in 1955 for all such devices, including some similar to the current one, ranged from 85 cents to $10. I am told by knowledgeable individuals whom I have consulted that the average cost of manufacturing the current device is actually less than the average cost of the mechanical devices that were replaced by it.[41] Taking into consideration developmental and administrative costs, it seems reasonable to assume that the net marginal cost (C_β) of adopting the present safety device is very small or even zero. I have been unable to determine, however, whether maintenance cost and food-keeping efficiency have changed.

As for the cost of avoidance (V_α) by consumers/parents, it depends on the base from which increases in α are made and obviously on the nature of these additions. Although in 1956, educational and informational campaigns might have been escalated at a moderate cost, the impact (H_α) would probably have been barely noticeable. Putting the matter differently, to produce a significant effect on the hazard, the cost of this kind of α-action would have been extremely high. However, I am aware of no studies which have attempted to determine to what extent consumers were aware of refrigerator hazards, how efficiently such knowledge might be transmitted to them, how long it might remain in their consciousness, and so on. This does not mean that current α-actions, as for example, the first one mentioned in 3.5.3, are not effective as far as they go.

As alternative α-actions which might have been considered, municipalities could have offered to haul away old refrigerators, or to secure those in storage, at zero price, the cost of the operation to be covered

[41] Not, however, less than the average cost of the "burstable" devices which were coming into use in the early fifties on cheaper model refrigerators and freezers. The cost differential there might have been in excess of 60 cents.

by taxes. The *net real* cost to society may not be great. This line of inquiry will not be pursued here.

3.5.5. Is Refrigerator Entrapment an Unreasonable Hazard? In addressing this question, we shall follow the accident "theory" implicit in the deliberations that took place in the mid-fifties prior to enactment of P.L. 84-930. According to this theory, two main hazards were to be distinguished. One hazard was associated with refrigerators and freezers which would be added to the then existing stock and over which Congress could exercise jurisdiction. The other hazard was associated with the existing stock, over which states and municipalities had jurisdiction. A secondary distinction was also made between refrigerators and freezers, perhaps on the ground—since found to be unjustified—that a closure device suitable for refrigerators would not be suitable for freezers.

With regard to the hazards from refrigerators yet to be acquired, the class of β-actions under consideration was expected to eliminate the hazard entirely. Thus, the injury cost avoided per unit, $-JH_\beta$, discounted at, say, 6 per cent over fifteen years, would be approximately $\$100{,}000 \times .41726 \times 1/480{,}000 = 9$ cents.[42]

Since the cost of avoidance, C_β, was assumed to be zero, this hazard was unreasonable and the β-action contemplated justified. Had C_β been in excess of 9 cents, the hazard would have been judged reasonable and the β-action unjustified. However, it should be recalled that at the time of legislation, the estimate of this cost exceeded 9 cents.

With regard to the hazard from the existing stock, it was pointed out earlier (3.5.3) that a marginal increase in the level of α-action known then would have produced no practical effect on H, i.e. $H_\alpha = 0$. Obviously, this implies that the hazard was reasonable and nothing could be gained by expending resources at a higher rate on α-type avoidance actions.

The above determination of the reasonableness of the hazard is crucially dependent on the estimates of probability and other parameters. Hence, the illustrative nature of the computations should again be emphasized. Furthermore, it should be noted that "reasonableness" is a relative concept, and depending upon our technical capabilities, our inventiveness, and our familiarity with the hazard, what might have appeared reasonable twenty years ago may conceivably be regarded as unreasonable today, and vice versa.[43]

[42] The present value of one dollar at 6 per cent discount rate, for $n = 15$, is \$.41726.

[43] For a similar view of the law, see my "Reasonable and Unreasonable Hazards in Law and Economics."

3.6. Summary and Conclusion

I set out to examine the problem of measuring risk when the primary purpose of the measurement is to decide whether a safety standard can be justified. Since the standard would be required only if the hazard was judged to be unreasonable, it was necessary to develop a criterion of reasonableness., Although it *assumes* some theory of accident occurrence which is necessary for the selection of relevant alternative injury-avoidance measures and for assessing their impact, this criterion is formally economic.

In order to demonstrate the operationality of the criterion, it was applied to an illustrative, but actual, case. It was pointed out that measurement procedures, especially with regard to risk of injury, had to be explicitly designed with this criterion in mind and implicitly in accordance with the underlying theory of accident occurrence. Finally, although the discussion did not purport to show how standards should be set nor how to evaluate them once set, the implication was clear that an analysis of the kind illustrated was essential for public action in the product safety area.

APPENDIX A

TABLE A.1

Estimates of U.S. Sales of Refrigerators and Freezers 1946–1957 (thousands)

Year	Refrigerators (2)	Freezers (3)	Refrigerators (4)
1946	2,100	210	1,997
1947	3,400	607	3,126
1948	4,495	690	4,495
1949	4,284	485	4,284
1950	6,020	890	6,000
1951	3,731	1,050	3,698
1952	3,195	1,141	3,196
1953	3,650	1,090	3,287
1954	3,425	975	3,135
1955	3,825	1,100	3,896
1956			3,382
1957			3,164

NOTE: Data are net of exports. Gas units are not included.
SOURCE: Columns 2 and 3 are from Burstein (1960). Column 4 is from Miller (1960).

APPENDIX B

According to a memorandum on file at NBS, the Office of Engineering Standard Services (OESS) conducted a survey in 1969 of incidents of refrigerator entrapment deaths occurring in the preceding decade. Police departments were contacted in cities where incidents were reported to have happened. This information was obtained from the Refrigeration Service Engineers Society, Des Plaines, Ill. Responses were received regarding 104 of these incidents, representing a total of 154 deaths.[44] Of these incidents, 69 involved refrigerators or refrigerator-freezers, 16 involved portable picnic coolers, 14 involved freezers, and 7 involved iceboxes. None involved magnetic door closures.

A check of the files in the OESS showed that they still had the survey responses for 79 of the 104 incidents. The 16 cases concerning the picnic coolers were apparently removed and used in the development of the current voluntary safety standard for picnic coolers. The other nine could not be accounted for. Tables B.1 and B.2 present a summary of the information presently in the OESS file.

In order to bring the 1969 OESS survey up to date, a list of the names, dates, and locations of all reported incidents from January 1969 through June 1973 was obtained from the Society's international headquarters in Des Plaines, Illinois. I then obtained telephone confirmation that 29 of the 31 incidents in the U.S. during that time period did not involve magnetic doors. In one case, there was no information as to the type of closure in the police file, and in the other, the file could not be located. The following tables (B.3 and B.4) provide a summary of the information concerning only accidents in the U.S.

[44] Over the period of this survey, 130 incidents were reported by the Refrigeration Service Engineers Society. Therefore, coverage of the tabulation exceeds 75 per cent. It should be noted that the Society relies on its members to report incidents in their areas. It is therefore possible that some incidents have not been reported.

TABLE B.1

Year	Incidents	State of Use				Kind of Unit Involved		
		Abandoned	Storage	Used	Unknown	Refrigerator	Freezer	Icebox
1968	1	1	0	0	0	1	0	0
1967	17	6	10	1	0	14	3	0
1966	10	5	3	2	0	7	1	2
1965	10	3	3	2	2	9	1	0
1964	6	4	10	2	0	14	2	0
1963	5	1	3	1	0	3	0	2
1962	8	2	4	2	0	5	2	1
1961	8	2	3	3	0	6	2	0
1960								
1959	6	1	2	2	1	4	1	1

TABLE B.2

		State of Use				Kind of Unit Involved		
Year	Deaths	Abandoned	Storage	Used	Unknown	Refrigerator	Freezer	Icebox
1968	1	1	0	0	0	1	0	0
1967	28	9	18	1	0	21	7	0
1966	17	8	3	6	0	12	3	2
1965	20	7	6	3	4	18	2	0
1964	25	8	14	4	0	21	3	2
1963	8	1	5	2	0	6	0	2
1962	13	2	4	2	0	7	4	2
1961	12	2	3	3	0	7	3	2
1960								
1959	8	2	3	2	1	5	1	2

TABLE B.3

		State of Use				Kind of Unit Involved			
Year	Incidents	Abandoned	Storage	Used	Unknown	Refrigerator	Freezer	Icebox	Unknown
1969	7	4	3	0	0	6	1	0	0
1970	10			2	8	7	3	0	0
1971	6	2	4	0	0	4	2	0	0
1972	4		1	2	1	3			1
1973	4	2	2	0	0	3	1	0	0

TABLE B.4

		State of Use				Kind of Unit Involved			
Year	Deaths	Abandoned	Storage	Used	Unknown	Refrigerator	Freezer	Icebox	Unknown
1969	12	4	8	0	0	11	1	0	0
1970	17			2	15	12	3		2
1971	8	2	6	0	0	6	2	0	0
1972	7		2	3	2	3			1
1973	8	4	4	0	0	3	1	0	0

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Comments on "Risk Measurement and Safety Standards in Consumer Products"

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IN this paper, V. L. Broussalian is concerned with the important practical problem of determining when safety hazards are "unreasonable" in the sense that they justify public action by governmental agencies such as the Consumer Product Safety Commission. As I understand it, a major objective of the paper is to direct the attention of governmental policymakers to the salient conceptual and empirical issues surrounding this kind of regulation. In this perspective, Broussalian's paper deserves credit on a number of points. First, he shows that in a well-functioning market, there is no reason to suppose that any "unreasonable" hazards should exist.[1] He then identifies the kinds of market imperfections, such as transactions costs, possible difficulties in establishing product liability insurance, high litigation costs, and third-party effects that might lead to products with unreasonable hazards. One clear implication of Broussalian's discussion in my judgment is that the existence of unreasonably hazardous products cannot be assumed a priori and the burden of proof is appropriately assigned to those who would maintain that the market is not working well. Broussalian is also correct in emphasizing that the issue of the existence of unreasonable hazards is essentially an empirical matter that raises a variety of difficult measurement problems. By conducting much of the analysis in terms of a concrete case—refrigerator hazards—Broussalian is able to convey vividly an understanding of the nature of these empirical problems.

Despite my generally favorable reaction to this paper, there are several specific issues on which it can be challenged. The central theme of the paper is to devise a reasonable way of deciding when an unreasonable product hazard exists. Broussalian's definition of an unreasonable hazard is given by equation 1, which says that a hazard is unreasonable if the marginal gain from reduced injuries and deaths exceeds the marginal cost of reducing the hazard. This is basically a cost-benefit criterion which, like most such criteria, is easy to accept in principle but much harder to implement in practice. In the usual cost-benefit situation, it is relatively easy to identify costs and extremely difficult to define and measure benefits. In Broussalian's specification, there appear to be serious measurement problems on both the cost and benefit side.

The evaluation of benefits requires estimation both of the monetary value of injury and for human life, as well as the *marginal* effect of accident-avoiding actions on the probability of distribution of injury or death. These are difficult measurement tasks but are presumably within the scope of economic analysis.[2] Evaluation of the costs of avoiding

[1] Much of Broussalian's discussion makes reference to the nonexistence of unreasonable hazards in perfectly competitive markets. It can also be shown, however, that a profit-maximizing monopolist would not have an interest in producing products that impose unreasonable hazards on consumers.

[2] For example, at this Conference, Rosen and Thaler have presented a paper that takes up the question of evaluating human life.

accidents raises problems that are not so easily resolved. Broussalian rather casually introduces the function $V_i(\alpha)$ to represent the cost of accident-avoiding activities for individual *i*. According to equation 1, the aggregate cost for consumers is obtained by summing $V_i(\alpha)$ across individuals. It is far from clear that any meaningful interpretation can be given to this procedure. For example, what set of individuals should we sum over to get this measure of cost: current users, potential users, or some other group? Should the existence of a small fraction of users with high marginal cost of accident avoidance be the criterion for deciding whether a product should be eliminated from the market or modified in any substantial way? Is it reasonable to treat excessive caution on the part of individual A as a perfect substitute for foolhardy behavior on the part of individual B, as the summation in equation 1 implies? By stating the criterion function as he does, Broussalian implicitly makes interpersonal utility comparisons. This is a far more subjective basis for assessing the reasonableness of product hazards than the paper seems to suggest.

Another serious problem with Broussalian's specification is the assumption that the output of the commodity, that is, X, is fixed. Instead of maximizing social welfare, Broussalian uses the criterion of minimizing social cost for a given level of consumption.[3] The difficulty here is that a governmental policy that increases costs is likely to lead to a decrease in the quantity of the good consumed. This decrease in quantity will lead to a reduction in consumer welfare that may be of substantial magnitude. The importance of this kind of welfare loss has been made clear by recent work of Sam Peltzman, which assesses the net benefits of the 1962 amendments to the Food, Drug, and Cosmetics Act.[4]

It may be objected that the conditions given by equations 2 and 3 of Broussalian's paper should be fulfilled at *every* level of output if we are to satisfy efficiency criteria. The problem is harder than this, however, because the practical tradeoff may be between a low level of output where (2) and (3) are satisfied and a higher level of output where (2) and (3) are violated. It is entirely possible that net social welfare is greater in the latter case.

In view of these problems, one may have serious doubts as to whether any significant headway can be made in empirical implementa-

[3] See section 2.2.1 of Broussalian's paper.

[4] Sam Peltzman, "An Evaluation of Consumer Protection Legislation: The 1962 Drug Amendments," *Journal of Political Economy* 81 (September/October 1973): 1049–1091.

tion of Broussalian's model. Unfortunately, the case of refrigerator hazards dealt with in his paper does little to dispel these concerns, because it does not require one to face the really difficult questions. Broussalian notes that the cost of the magnetic door-closure device is less than the cost of the mechanical device that it replaces. Given this cost advantage of the safer device, we do not have to worry very much about the accuracy of our assessment of the expected marginal gain. The new device would be preferred even if all we could claim for it is the avoidance of an injury that would cost a nickel 100,000 years from now. Similarly, Broussalian asserts that the marginal gain H_α of greater caution by consumers is negligible, so that we never really face the problem of how to assess the vaguely defined marginal cost of avoidance function V_α.[5]

In summary, I wish to emphasize that my reservations about this paper are not meant to detract in any way from the great merit I see in this line of research. The general problem Broussalian raises is significant and he has made a heroic effort to come to grips with the hard questions. I hope that he and others will be encouraged to continue the search for answers to these questions.

[5] However, Broussalian's arguments about H_α raise the possibility that consumers are *excessively* cautious with respect to refrigerator safety and we are then faced with the problem of welfare loss of the opposite kind.