PERFORMANCE BASED CODES:
ECONOMIC EFFICIENCY AND DISTRIBUTIONAL EQUITY

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ABSTRACT

Performance based codes are justified based on their economic efficiency. Economic efficiency can only be achieved if decision makers make the optimum trade off between cost of injuries and injury avoidance activities. Private decision makers may be tempted to achieve cost savings by shifting cost to other parties not involved in the decision process. These "externalities" represent a significant source of market failure. Market failures may be addressed by restructuring the marketplace, regulating private behavior, or public provision of the service itself. All three of these responses have a place in performance based codes. Other market failures can exist and performance based codes must be implemented in a way to increase, not decrease the efficiency of the market.

Efficiency is not the only social goal. Societies also concern themselves with the problem of distributional equity. Distributional equity describes who bears the burdens of specific social policy choices. Performance based codes may raise significant distributional equity problems, especially if the person bearing the burden of the fire risk is unable to participate in the regulatory decision process e.g. homeowners. A short case study of fire retardant treated plywood illustrates the economic problems involved in inadequate performance based analysis.

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INTRODUCTION

A key rationale given for performance based codes has been cost savings in the construction of buildings[1]. Cost savings to building owners are easy to create by reducing the level of safety a code requires in a building. However, the costs savings proposed for performance based codes have normally been the same level of safety at a cheaper price. Improved analysis of fire hazards and suitable technical responses gives promise of a more cost effective approach to the international fire safety problem but economic efficiency gains depend critically on the method of implementation of the performance based code.

Performance based codes are proposed for mixed economies, where regulation in combination with the market place affects the decisions made by building owners or operators. Generally the regulation is designed to carry out the society's policies related to building safety. Building safety regulation is typically justified by economists on the grounds of market failure, in particular externalities. Market failure occurs when the free market cannot be counted on to produce an economically efficient level of building safety. For the purpose of this paper, economic efficiency represents the optimum use of resources. This includes the optimum level of safety. In most societies, there is no absolute agreement on what constitutes an appropriate level of safety, but the most typical formula is that society wishes to realize the maximum social benefit while minimizing the joint sum of the cost of injuries and the cost of injury avoidance activities. It should be noted that this formula represents a policy goal, not a mathematical solution, because there may exist no consensus on the financial values to be applied to various types of injuries. Balancing injuries and costs are very difficult but at least as a goal it gives guidance to regulators in a mixed economy.

Once a policy goal is accepted there are three general approaches to overcoming market failure. The first is to try to correct the market failure by shifting costs and benefits in the marketplace, for example by redefining property rights. The second is direct regulation of the activity, by requiring individuals to actually act at the efficient level of behavior. The third is for the society to actually provide the service itself at an efficient level, rather than depend on a marketplace to bring it into existence. All three of these approaches are relevant to performance based codes.

EXTERNALITITIES

Efficient decision making by private market participants requires that decision makers have both adequate information as to costs, benefits and risks; and the ability to fully absorb the costs of the chosen risks. Unfortunately if parties do not bear the true costs of their actions, they may be tempted to achieve personal costs savings by imposing much larger costs on other parts of society. Economists refer to these as externalized costs, or "externalities". Externalities are one of the most important problems leading to failure of a market to efficiently price goods and services. "Externalities" can represent a substantial source of inefficiency, and often represent the difference between costs to the firm and costs to the society. Therefore, it is possible to create spurious "efficiencies" by allowing a party to achieve cost reductions by shifting risk or other costs to unrepresented parties.

Externalities do not always involve external costs. A building requirement can also provide external benefits, such as protection against conflagration risk. Existing codes may create external benefits as part of the mutual reciprocity of advantage of a regulatory regime. One problem with external benefits is that safety analyses ordered by a private party may not take them into account when determining an equivalent structure. For the purpose of this paper, externalities will refer to any increase in externalized costs, including the reduction of external benefits.

It is a rational social policy to try to reduce externalities by requiring firms to "internalize" the costs. Internalization means that the firm has to bear the costs that would otherwise be shifted to outside parties. In a market economy internalization of costs tends to make the overall decision process more efficient. If internalization is not possible, there may be a condition of market failure. Whatever the response is to this failure, unless overall cost and risk are properly analyzed and assigned, there can be no reasonable expectations that performance based codes will actually save society any money. The problem is especially acute in the United States, where builders, owners, designers, insurers and regulators use a variety of legal strategies to shift responsibility for preventing or compensating injuries caused by building defects.

Economic evaluation of the true social cost of code compliance should be a feature of any performance based code. One of the goals of the economic analysis should be to identify the externalities involved in any performance based code and identify methods of internalizing such costs to the decision maker.

TYPES OF EXTERNALITIES

Engineers involved in performance based codes often identify with the interest of the "client" in doing any analysis. Normally the client is the owner of the building who is usually in a position to protect his or her own interests. Analysis of externalities usually begins by examining the interests of participants who are in a more limited position to protect themselves. The most important group to examine are the inhabitants of the building themselves. Fire can affect their lives, their property, their jobs and their general well being. While protection of life safety is a typical goal of performance based codes, it is not always clear that such codes value lives at their true social worth. It is not unusual in the United States for the regulatory "social valuation of life" used for employed individuals to exceed several million dollars. Risk analysis using values in this range are routinely described as reasonable. However, there exists no formal mechanism which requires building owners or operators to take this value into account in designing or operating a building.

Part of the problem is that there is simply no system which forces a building owner or operator to be responsible for the potential injuries which might be caused. Legal liability is a totally inadequate basis for imposing the social valuation on the building owner since personal injuries are often undervalued by insurance based tort liability systems. The Dupont Plaza Hotel, for example, carried only 1 million dollars in insurance, despite operating with hundreds of millions of dollars in human risk[2]. Further many legal regimes do not provide for automatic payment of the full value of claims to injured persons. Plaintiffs are often required to prove "fault" on the part of the builder. The builder claims that they employed competent engineers; the engineers claim that they used accepted techniques and as a result there is no "fault". A second approach is to use limited liability companies which have only a modest net worth. In the case of fire safety the injury often occurs after the expiration of the statutes of limitations or repose. Such statutes require an action to be filed in a few years after the building is built, rather than after the injury. Damages allowed in legal actions may severely understate the actual injuries. There are also problems in determining which defendant caused an injury. All these factors limit the ability of the legal system to hold decision makers accountable. Medical costs are a special concern. In an environment where medical expenses are paid by other parties, the risk cost of injuries may be externalized, and inappropriate technologies may be adopted which would not be accepted if firms had to bear the full medical costs of the injuries they produce.

Damage to tenant's property is also ignored in the many performance codes since it is not a cost faced by the building owner/operator. However, if the displaced occupants of a building seek public assistance for housing or economic support, society then bears some of the cost created by the building's designer. Finally the risk of conflagration is one of the more important externalities in some environments. The Oakland California fire indicated that even modern cities are not immune to fire spread. The creation of an exposure risk clearly impacts on persons who are not involved in the analysis.

Response to Externalities

The primary method of reducing externalities is to impose the cost of injuries on the decision makers who build, own or operate the building. In the case of building risk, the primary method would be to require building owners or operators to carry adequate insurance payable on a strict liability basis for both personal injury and property damage. Such a response would act to internalize the risk costs which would otherwise be spread to consumers and other parties not represented in the code process. It would also internalize to the building owner any errors in the risk analysis under the performance based code. This would tend to make such analyses more accurate and reliable. If the risk analyses supporting the performance based code is sufficiently accurate, an efficient market will develop in insurance. Such insurance would represent an efficient method of pricing the reliability of the fire risk assessments produced by fire safety experts.

OTHER MARKET FAILURES

Externalities are not the only impediment to an efficient market. Performance based codes may also reduce the level of standardization related to building fire safety. Prescriptive codes can create a sufficient demand for standardized fire safety products to allow for economies of scale in production. Such standardization can act significantly to reduce costs if there is a competitive market in the standardized product.

Performance based codes may also increase information search costs. Under prescriptive codes, the fire safety level in buildings may be roughly equivalent across a large number of structures. As a result, the market for space in buildings may function more efficiently.

A further market failure problem may be the requirement for public fire protection. Most performance based codes assume a specific level of fire brigade response, but few include a specific cost item to pay for such protection if it is not provided free by the municipality. Public fire protection, including injuries to firefighters, is a true cost of building operation and safety, and is especially important if the performance based code is being used to justify elimination of built in fire suppression in a building. Fire protection is a very complex "public good". Any fire risk analysis which makes a claim based on efficiency has to incorporate the true costs of municipal services required in the analysis.

Distributional Equity

In addition to economic efficiency, some methods of fire risk analysis raise serious issues of fairness in the distribution of risk. Distributional equity is concerned with the fairness of the distribution of the costs and benefits among the persons affected by the decision. In particular it focusses on who bears the injury burden. Many fire safety models aggregate the overall risk to life in a building and assume that a lower risk of life means the design is "better"[3]. However this approach does not take into account distributional equity. Consider for example a stadium design which shows mathematical equivalence to the safety of a code approved design, but achieves that safety by providing much better safety to 2/3 of the crowd, and much less safety to the unlucky remainder. Even assuming that the analysis is correct, it is not automatically legitimate to describe the stadium design as safer if the price for safety to one group is increased risk to another. Societies do not normally allow one group to be saved by condemning another, nor do they always evaluate every risk on the same value criteria.

Sometimes the problem of distributional equity exists because purportedly equal levels of fire safety produce disproportionate risks to some particularly vulnerable people. In fact, one suggested version of a performance based code simply eliminated protection of the handicapped or others who cannot rescue themselves. This is one method of reducing costs, but it is problematical whether it is efficient. One could almost certainly argue that it is not fair.

Unless the proponents of a risk based analysis have a socially accepted method of valuing all the lives, and knowing which ones are worth more, the result produced by the shift may be neither equitable nor efficient. The concept of Pareto optimality is useful in this case. In fire risk analysis, fire safety would be pareto optimal if no one is worse off in the performance based code building than in one built in accordance with the existing code. This is a much stricter standard than used in most fire risk assessment, because it requires detailed local evaluation of fire risk[4].

It is not uncommon for there to be a conflict between social goals of economic efficiency and distributional equity. Some economic analysis ignores distributional equity in its entirety. However, the history of social response to disaster is replete with examples of protection of individuals even at the expense of economic efficiency. It cannot be assumed that performance based codes will not have to meet the same requirements.

OPERATIONAL PROBLEMS

Economists have routinely identified a number of operational problems in translating even a broadly acceptable theory of economic efficiency into action. In the real world, there are a variety of problems such as local monopolies, public bureaucracies, missing information and lack of consensus on economic values which hinder the development of efficient and fair systems. As a result it cannot automatically be assumed that even a valid physical model of fire safety can be automatically implemented in different social environments[5].

As just one example of the complicated process of promoting economic efficiency, consider the current problem of hurricane resistance. Insurers and builders are currently engaged in an aggressive political debate over the provision of wind and storm resistance for houses in the coastal areas of the United States. Insurers hit hard by Hurricane Andrew are pressing for much tighter performance based requirements. Builders resist because the improved houses cost more. In at least one study, the reduction in insurance premiums was much less than the increased cost of the improved structure. On the other hand, insurance rates are regulated and housing costs are not. Politically it may be easier to protecting against storms by hiding the cost in the price of the homes than make it obvious through insurance premiums. For both sides the critical issue in making the cost determination is the probability of hurricane winds in any given area, a prediction with huge uncertainties in the risk estimate[6].

Insurance will be critical in any performance based code regime. In particular the development of an efficient insurance market requires a fairly low level of uncertainty in the risk estimate (at least for a large number of occupancies treated as a pool). A major source of inefficiency in the insurance process is miscalculation by owners, builders or regulators of the benefits and costs of various fire safety approaches. While this miscalculation does not always have the direct social impact of externalities, it can represent a substantial disruption of the process and should be analyzed. A serious miscalculation of the fire risk of a structure can lead to bankruptcy and closure of the building, if it cannot be brought into compliance with the risk rates under the code.

One of the major problems with applying traditional benefit/cost analysis is that fire safety deals with complex probabilistic analysis of rare catastrophic phenomena. Benefit cost analysis began in the environment of regulated utilities to determine the economic viability of such capital intensive projects. Later it was applied to safety and environmental projects, but typically in areas where there is little dispute over the underlying probabilistic environment. Auto accidents, workplace safety and toxic exposures are high frequency events with small uncertainties to be calculated in the risk estimate. It is not immediately clear that there exists an equivalent well understood methodology for such analysis with low frequency, high effect accidents.

Calculation of the risk/cost of rare catastrophic events is one of the most complex economic analyses undertaken by economists. Each probabilistic variable tends to add uncertainty to the risk estimate. Further, it is not clear that such uncertainty can be controlled mathematically, since any new technology being proposed may introduce new risks which are not provided for in the underlying model. One of the primary problems with using regression style analysis is that it measures the mathematical relationships among variables whose "real" relationship to an underlying causative model is assumed. While mathematical tests for multicolinearity and related complications can be performed, if the underlaying causative relationships are unknown the model may be worthless.

This specific problem is particularly acute in the use of mathematical models to support the "any new technology is acceptable" approach[7]. There is no a priori reason to assume that a new technology can be evaluated in an existing empirical model. Variables and appropriate levels may be technology specific.

One problem with uncertainty is that even adequate insurance may not satisfy regulators who are charged with protection of the public safety. While they may be willing to allow a specified level of risk, they may be unwilling to tolerate substantial uncertainty in the risk estimate. One method of handling varying levels of uncertainty in performance based codes is the development of an "uncertainty budget". To be in total compliance with the code, the building may have no more than x level of uncertainty in the model underlying its performance.

Loss of the property itself can have effects far beyond the simple loss of the structure. Buildings often represent vital concentrations of employment, housing or materials. Jobs lost from the demise of a firm that has been destroyed will ripple through the local economy and may impose a high level of public cost.

A final issue is that while much of the abstract discussion of performance based codes has taken place in the "commercial" context of office buildings, in fact some of the first suggestions for the use of such codes has been in the area of residential structures. Purchasers and inhabitants of residential structures are usually ordinary consumers, who do not have the sophisticated resources to question the assumptions made by the builders and regulators. Further, this group has traditionally looked to the state for greater protection.

CASE STUDY: FIRE RETARDANT TREATED PLYWOOD

Some of these effects can be shown in a case study. Town houses in the United States normally form a row facing on a street. Traditionally they were required to have parapetted fire walls to limit the spread of fire from one unit to another. Architects pressed code officials for the use of fire retardant treated plywood (FRT Plywood) to meet the requirements for fire separation. The code officials accepted the material for fire safety. It was generally accepted that FRT plywood meets a performance standard for fire safety. However, no one tested the treated plywood for durability. In fact under the conditions in which it was installed FRT plywood was much less durable than the plywood it replaced[8]. A few years after it was installed, the plywood started failing, creating leaks and making the roofs unsafe for walking, in particular for firefighters. The failure was due to a complex relationship among the inherent qualities of the treated plywood, the installation procedures, and the ambient air temperatures. The cost of replacing the plywood was far greater than the cost savings from the installation. The total loss was in the thousands of millions of dollars. However, by a combination of legal rules, transaction costs and bankruptcies, the great bulk of the cost of this debacle has fallen on the individual homeowners[9]. The following conclusions can be drawn from the FRT case:

1) The methods for evaluating the performance of the new technology were demonstrably inadequate.

2) The technology, while complying with existing performance based standards, created unforeseen new problems not measured by the existing analysis.

3) No risk analysis was performed to indicate the consequences of an inadequate performance based assessment.

4) The cost savings accrued to the builders, but the cost of replacement fell on the homeowners.

5) An entirely new risk to fire fighters was created.

6) None of the decision makers could be effectively held financially responsible for the injuries.

As a final note, this is just the most recent such case, one could easily argue that aluminum wire represented a similar situation.

CONCLUSION

If performance based codes are to be implemented based on economic efficiency, it is critical that there be a full analysis of the economic effects on all parties to the building process. All relevant costs must be identified, externalities must be reduced and other market failures must be addressed. Distributional equity is also a legitimate social concern, and the effect on particularly vulnerable groups should be examined. Efficient implementation of a performance based code will require sophisticated insurance systems and may require changes in legal doctrines and regulatory systems. Failure to do so can lead to economic disasters.

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