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On Optimal Legal Change, Past Behavior, and Grandfathering

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Abstract: When is it socially advantageous to change legal rules in the light of altered circumstances? In answering this basic question here, a simple point is developed – that past compliance with legal rules tends to reduce the social advantages of legal change. The reasons are twofold: adjusting to a new legal rule often involves costs; and the social benefits of change tend to be only incremental, only in addition to those of past compliance. The general implications are that legal rules should be more stable than would be appropriate were the relevance of past behavior not recognized, and that a policy of grandfathering, namely, of permitting noncompliance, should sometimes be employed. The analysis applies across legal fields, to some degree explaining what we observe but also indicating possibilities for reform, such as in the regulation of air pollution. The analysis is related to conventional reliance-based justifications for the stability of the law and to the literature on legal transitions, both of which are suggested to be misleading.

1. Introduction

The object of this article is to examine a primary question about legal rules, namely, when is it desirable for legal rules to be modified in the light of new circumstances? The major point to be developed is that past behavior may reduce the social advantages of legal change. The general implications are that legal rules should be more stable than would apparently be appropriate, that is, appropriate were past behavior not taken into account, and also that a policy of grandfathering – of allowing noncompliance for parties already participating in an activity and complying with any then-relevant rules[1] – should often be employed.

The kernel of the argument that will be elaborated is easily appreciated. Consider a firm that installed a type of smoke scrubber which satisfied pollution control rules five years ago when the firm built a factory. Suppose that advances in technology have

* Samuel R. Rosenthal Professor of Law and Economics, Harvard Law School. I thank Louis Kaplow and Robert Stavins for comments, John Howell, Christoper Taggart, and Jane van Lare for research assistance, and the John M. Olin Center for Law, Economics, and Business at Harvard Law School for research support. *NOTE TO NBER readers*. This draft was written for a law review audience; there is a brief appendix with a model that sets out the main analytical points. Also, there are some missing footnotes and sentences, indicated by brackets.

[1] This general meaning of "grandfathering" will be employed below. The term "grandfather clause" is defined in the dictionary as "creating an exemption based on circumstances previously existing"; see Merriam Webster's Collegiate Dictionary, 10th ed., 1993. The word "grandfather" and its cognates are widely used, although they do not usually appear in the language of statutes.

resulted in the availability of a new type of smoke scrubber that is superior to the old: the new scrubber reduces pollution even more and it is cheaper to purchase and operate.

Should there be a change in the legal rule requiring the firm to use the new type of smoke scrubber in its factory? Quite possibly not, and for two reasons. First, the social costs of a change would be distinctly positive – the firm would have to purchase the new scrubber, and the firm would often bear various adjustment costs as well (it would have to remove the old scrubber and it might have to engage in retrofitting to accommodate the new scrubber). Second, the social benefits of a change would be only incremental, for if the old scrubber were kept, it would reduce pollution to a certain degree. If the costs associated with a change to the new scrubber would outweigh the incremental social benefits, it would be socially best to permit the firm to continue to use the old scrubber.

In contrast, if a firm were building a factory afresh, the firm should obviously be required to install the new smoke scrubber. The new scrubber costs less than the old type and the social benefits that the new scrubber would yield would be total, not incremental, since by hypothesis there would be no existing factory that would already have installed a scrubber of some type.

This simple example illustrates the conclusion that it may be socially advantageous to grandfather a party that complied with a legal rule in the past, even though the rule should be altered for new participants in the activity.[2]

A closely related conclusion applies where it is impractical for the legal system to treat new participants and past participants differently, in other words, where grandfathering is infeasible. Here, it will often be desirable for the law to remain stable, as no change may be best for the parties who complied with the law in the past.

These conclusions about the importance of prior behavior to the calculus governing the desirability of legal change, of grandfathering, and of legal stability have very broad applicability, as they do not depend on the area of law.

However, two qualifications to the analysis will be noted. The first is that past behavior matters only when it is of a durable nature (a smoke scrubber may last for years). When instead past behavior concerns nondurable, modifiable effort (such as the frequency of inspection of toxic waste-containing tanks for leaks), legal rules should not depend on past behavior and thus should be adjusted in response to all manner of changes in conditions.

The second qualification is that legal rules should reflect past behavior only when the rules are based on legal standards (notably, regulatory standards or due care standards to avoid findings of negligence). When instead legal rules are premised on strict liability, parties will automatically be induced to take past behavior into account in a socially appropriate manner. Hence, under strict liability, there is no basis for grandfathering, say of cabining damages to reflect an earlier anticipated level of harm.

The organization of the article is as follows. In section 2, I develop theoretically the main argument that I have just described. To this end, I examine informally a stylized model of precautions that reduce the risk of harm. There are two periods in the model. In the first, uncertainty exists about the harmfulness of the activity or about the cost or technology of risk-reduction. In the second period, the uncertainty has been resolved –

[2] A similar argument to that of the example demonstrates that it may be desirable to grandfather a party who participated in an activity in the past when there was no legal rule (rather than a less rigorous rule) applying to the activity at the time. See section 3.4 below.

information about the magnitude of harm that the activity might cause and/or about new opportunities for risk-reduction has become available. This information may or may not make it socially desirable for the level of precaution to change. The implications of the desirability or undesirability of change in the level of precautions for the stability of legal rules and for grandfathering are considered. (The model is formally analyzed in an appendix.)

In section 3 I study the role in the model of a number of logically secondary, but sometimes empirically important, factors, including maintenance costs, the scrap value of equipment, transition costs, and modification of property. I also address informational problems that confront legal authorities and I discuss legal policy when grandfathering is too administratively difficult to accomplish.

In section 4, I comment on the law in the light of the analysis. I first ask whether legal rules do, as an approximate matter, exhibit a measure of stability where the analysis suggests that they ought, which is to say, where parties' actions have durable aspects and they are subject to legal standards. I then consider grandfathering. I note that grandfathering can be seen as a general, though implicit, feature of the negligence determination in tort law. I also survey two contexts in which explicit grandfathering is a prominent feature – power plant air pollution regulation and real estate zoning – and I consider how well their characteristics conform to the theory of optimal grandfathering. I suggest that although the observed grandfathering rules appear to be rational in a rough qualitative sense, the rules sometimes appear to suffer from substantial defects. Notably, the grandfathering of out-of-date power plants seems problematic, mainly because it is of long duration and permits old, highly-polluting plants to be maintained and modified significantly yet still to remain grandfathered.

In section 5, I discuss several views found in commentary and scholarly writing about legal change and relate them to the analysis of this article. One view concerns the notion that legal rules ought to be relatively stable because individuals rely on the rules.[3] I find this view unappealing, especially because incentives to participate in activities are not undesirably chilled by otherwise called-for legal change. Another view is found in the literature on "legal transitions," a major claim of which is that grandfathering is socially disadvantageous.[4] I find this conclusion misleading. The conclusion flows from an implicit assumption that liability is strict, whereas in the usual legally relevant contexts – of fault or of regulatory standards – it is patent that grandfathering may have a desirable role to play.[5] I then comment on prior, economically-oriented literature on legal rules. This literature does not address the question of the relevance of past behavior to later optimal behavior and to optimal change in rules.

In section 6, I briefly conclude.

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[3] See, for example, [ ].

[4] See especially Graetz (1977), Kaplow (1986), and Shaviro (2000).

[5] But to be clear, the conclusions of the transitions literature are not misleading, and have relevance, in the area of taxation, to which the literature was originally addressed. The reason is that tax rules can often be viewed as a species of, or analogous to, strict liability rules, rather than rules requiring compliance with legal standards. See section 5 below.

2. A Model of Optimal Legal Change

2.1 Assumptions. In the standard model of potentially harm-creating activity, a party chooses a level of precaution in order to reduce the likelihood of harm.[6] As indicated above, I will consider a two period version of the model, and I will suppose that some parties engage in the activity in both periods while others enter the activity only in the second period.

Two alternative assumptions will be made about precautions. Precautions may be *durable*, notably, involve the acquisition of a safety device, such as the smoke scrubber mentioned above, or relate to fixed physical aspects of property, such as the number and location of exits from a building (but see the next section on the interpretation of durable precautions) or its setback from a boundary line. It will be assumed that if a party invests in a durable precaution in period 1, the party can benefit from it in period 2 without additional cost.[7] If, however, a durable precaution is changed in period 2 from what it was in period 1, a cost, that of the new precaution, will be incurred. For example, if a smoke scrubber of type A is purchased in period 1, and it is replaced by a smoke scrubber of type B in period 2, the cost of the type B smoke scrubber will be borne in period 2. If scrubber A is replaced by scrubber B, the total cost of precautions over the two periods will thus be the cost of scrubber A plus the cost of scrubber B, whereas if scrubber A is used over both periods, the total cost of precautions will be just that of scrubber A.

Precautions may instead be *nondurable*. Typically, nondurable precautions take the form of effort to reduce risk, such as the example from the Introduction of the frequency of inspection of a holding tank for leaks, or the speed with which a vehicle is driven. It is natural to assume that an effort to reduce risk requires the bearing of a cost each period the effort is made, and further that the cost of effort in period 2 is independent of the effort made in period 1. The presumption, for instance, is that the cost of inspecting holding tanks with a frequency of three times a week in year 2 is independent of what the frequency of inspection of the tanks was in year 1. Hence, the cost of nondurable precautions taken in the two periods is assumed to be simply the cost of the precaution taken in period 1 plus the cost of the precaution taken in period 2.

Another assumption that I make is that there is uncertainty at the outset about how harmful the activity is or about the cost or the technology of risk reduction. By the beginning of the period 2, however, the uncertainty is resolved – the nature of the harmful activity or about opportunities for risk reduction is learned. For concreteness, one might imagine that at the beginning of period 1, it is thought that the harm from the activity could turn out to be of anywhere in the range between $100,000 and $1,000,000; but by the beginning of period 2, the true magnitude of the harm becomes known

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[6] See, for example, Brown (1973), and more generally, Landes and Posner (1987) and Shavell (1987). In some versions of the standard model, the exercise of precautions affects not only the likelihood of harm but also its magnitude. This difference is inessential for my purposes, and for simplicity I examine here a model in which only the likelihood of harm is affected by the level of precautions.

[7] The assumption that a durable precaution can be enjoyed in period 2 without any additional cost is made for simplicity. I relax the assumption in section 3, and allow for the possibility that a maintenance cost must be incurred in period 2 to continue to benefit from the precaution.

(perhaps because an accident occurs and reveals the harm).[8] Or one might have in mind a situation such that at the beginning of period 1, it is thought that a technological advance might result in a risk-reducing device that will be twice as effective as present devices and cost the same; but by the of period 1, whether the device is available becomes known. The importance of the assumption that uncertainty is resolved by the beginning of period 2 is that it may then become desirable for precautions and the law to change in the light of the new information and circumstances.

2.2 The interpretation of durable and nondurable precautions. Although in the model the assumption is that the effect of a durable precaution on risk in period 2 is identical to its effect in period 1, it will be apparent that the qualitative character of the conclusions to be reached would be similar as long as the precautions taken in period 1 have some effect on risk or harm in period 2. Hence, a durable precaution should be viewed broadly, as essentially any action that influences the probability or magnitude of harm beyond the present period.[9]

Durable precautions may sometimes be implicit in compliance with a legal rule. For example, suppose that a factory is required use natural gas as a fuel for its power plant (say because the alternative of coal would generate substantial pollution). The burning of gas does not itself constitute a durable precaution, but it may well be associated with such: the factory might have purchased a kind of furnace best suited to burn natural gas, it might have installed a pipe connecting the main gas line to its power plant, and it might have chosen its location in order to be assured of a steady supply of gas. These decisions have a durable aspect because they allow the factory to continue to use natural gas more cheaply in the future.

Another comment about the generality of the notion of durable precautions concerns training and intellectual capital, and also investment of a sort in the use of particular financial arrangements and reporting practices. If an organization trains its employees to undertake a specific risk-lowering task, say an airline teaches its mechanics to overhaul a kind of aircraft engine according to a set procedure, then the training investment is a form of intellectual capital that has a durable aspect in that it yields benefits every time a trained employee undertakes the task. Likewise, organizations and individuals often make particular financial and contractual arrangements and collect and organize data to satisfy regulatory demands (consider, for instance, how retirement plans must be established, maintained, and reported on to satisfy ERISA regulations). These efforts are substantial, in that they involve learning, the establishment of procedures, legal services, and the like, and they have a durable dimension in that they can continue to be employed after they are made.

In respect to nondurable precautions, the main interpretive observation worth making is that not only effort, but also a physical resource that is consumed within a period should be viewed as an example. The use of a windshield wiper blade might be considered a nondurable precaution assuming the length of the relevant period exceeds

[8] To amplify, the activity is assumed always to cause just *one* level of harm if an accident occurs. What that level is not known in the beginning of period 1, but it is known by the beginning of period 2.

[9] See section 3 and also section A5 of the appendix on variations of the simple assumption that a durable precaution has the same effect in period 2 as it did in period 1.

the life of the wiper blade, for then a different kind of blade could be employed in the next period, and its cost would not depend on that of the prior blade.

2.3 Socially optimal behavior. In order to ascertain how well legal rules function and how they ought to be designed, socially optimal behavior must be delineated. I will usually employ as a social welfare criterion the analytically convenient objective of minimizing social costs, namely, the costs of precautions over the two periods plus the expected harm done. This social goal reflects the notion that precautions as well as harms are socially expensive, so that precautions should be taken only if they accomplish sufficient good in reducing harm.[10]

Given this social objective, what is socially ideal behavior? Let us begin by reviewing the standard one period model of harm and precaution. In this model, the best level of precaution, which I well refer to as the *conventionally optimal level of precaution*, minimizes the cost of precaution plus expected harm in the single period at issue. Thus, if the question is which is better, no precaution or a particular, named precaution, the answer is simple: If the cost of the precaution is less than the reduction in expected harm it brings about, the precaution should be taken. If the cost of the precaution is $1,000 and it lowers the risk of a $500,000 harm from 10% to 8%, it lowers expected harm by 2%x$500,000 = $10,000, so it is worth taking.[11] More generally, the question may be which precaution to take among an array of different precautions, and the possible precautions might constitute a continuum. To determine the optimal level of precautions in this context, one can conceive of deciding how much to spend on precautions by asking whether, by spending another dollar, the expected harm would be reduced by more than a dollar; as long as the answer to this question is yes, the extra dollar should be spent. At a certain point, though, spending another dollar will not be worthwhile, since the effectiveness of precautions will have fallen to just less than a dollar; at this point, the optimal expenditure on precautions will have been reached. In general, the more harmful an activity is, the higher will be the optimal level of precautions, and the optimal level of precautions will rise in a more or less continuous fashion with the expected harmfulness of an activity.

Now let us consider the two period model with uncertainty surrounding the level of harm[12] and first study the case of nondurable precautions, because it is easier to understand. Here the cost of precautions is independent in each period, so we can view the periods separately. Since in period 2 the level of harm that would occur in an

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[10] Were I to consider other social goals, such as compensation of victims of harm, in the social welfare criterion, the qualitative conclusions would not be altered, for they depend mainly on there being a cost-saving advantage to maintaining durable precautions. Inclusion of social goals in addition to those I study would only cloud the analysis, even though in reality of course the social objective is much more broad than minimization of social costs as defined here.

[11] As in this illustration, expected harm means probability-discounted harm. That the expected harm is included in social costs means that society displays "risk-neutrality" with respect to harm rather than "risk-aversion." I make the assumption that society and, below, that decision makers, are risk-neutral mainly for analytical convenience. On risk-neutrality and risk-aversion, see, for example, Pindyck and Rubinfeld (2001), at 155-160 and Shavell (1987), at ch. 8.

[12] The case in which uncertainty concerns the cost (or technology) of risk-reduction is similar, as I will occasionally remark in notes below.

accident is assumed to be known, the optimal level of precaution will be whatever is conventionally optimal for that level of harm. If the level of harm were an accident to occur turns out to be $200,000, then the precaution taken in period 2 ought to be appropriate for a $200,000 potential harm, if the level of harm turns out to be $600,000, then the precaution taken in period 2 ought to be suitably higher, and so forth.[13] In period 1, however, the level of harm that would result from an accident is not known, so that the level of precaution should reflect this uncertainty. In our model, it is readily shown that the optimal level of precaution in period 1 equals the optimal level for the expected harm, should harm occur. For instance, if the harm is equally likely to be anywhere in the range between $100,000 and $1,000,000, then the expected harm conditional on its occurrence is the midpoint of the range namely, $550,000, so the precaution taken in period 1 should be that which is optimal for a potential harm of $550,000.

We can summarize as follows. *In the case of nondurable precautions, the optimal period 1 level of precaution is the conventionally optimal level for the expected harm should harm occur. The optimal period 2 level of precautions is the conventionally optimal level for the then known harm, whatever that may be. Thus, the period 2 level of precaution is generally different from the period 1 level.* Note as well that *optimal precautions for a party who first enters the activity in period 2 is the same as optimal precautions in period 2 for a party who had engaged in the activity in period 1.*

Next let us turn to the case of durable precautions and let us again begin by considering what is best for a party in period 2. I want to show that it is best for the party not to change its precaution from what it was in period 1 unless the harm turns out to be sufficiently high.[14] To illustrate, suppose in period 1 that a party took the precaution of buying a safety device that lowered the risk of harm to 7%. Assume that the harm in period 2 turns out to be $700,000, that the conventionally optimal precaution for harm of $700,000 involves a cost of $20,000, and that that precaution lowers risk to 5%. Should this new precaution be taken? If it is not taken and the old device is employed, the risk will remain at 7%, so the expected harm will be 7%x$700,000 = $49,000, but no added cost of precaution will be incurred. If instead the new, conventionally optimal precaution is taken, the cost of $20,000 will be borne, implying that social costs in period 2 will be $20,000 + 5%x$700,000 = $55,000, which is higher than $49,000. Hence, the new conventionally optimal precaution should not be taken – the party should stand pat with the old precaution. One way of understanding this conclusion is to observe that the cost of a change in precaution is $20,000, whereas the benefit is only due to the *marginal* effect of the 2% drop in risk (that is, 7% – 5%) on expected losses, 2%x$700,000 = $14,000, which is less. If, though, the harm were sufficiently high, then it would be worthwhile changing to the conventionally optimal precaution. For example, suppose that the harm is discovered to be $900,000 and that the conventionally optimal precaution for this harm costs $22,000 and lowers the risk to 4%. Then if the old precaution is kept, social costs will be 7%x$900,000 = $63,000, whereas if the precaution is changed to the

[13] Likewise, in the case where uncertainty attaches to the cost of risk reduction and it turns out to be inexpensive to reduce risk, then the level of precaution ought to be suitably higher.

[14] In the case where uncertainty attaches to the cost of risk reduction, the analogue is that it is best for the party not to change its precaution from what it was in period 1 unless the cost of reduction turns out to be sufficiently low.

new conventionally optimal level, social costs will be \$22,000 + 4%x\$900,000 = \$58,000, so that it will be best for the party to change to the conventionally optimal level of precaution. Here the \$22,000 is worth spending because the marginal reduction in risk of 3% (that is, 7% – 4%) is made valuable by the high potential harm, for it is 3%x\$900,000 = \$27,000.

We can summarize and generalize as follows. *In the case of durable precautions, a party who engages in the activity in period 1 ought to maintain its period 1 precaution in period 2 if the cost of the new conventionally optimal precaution for period 2 harm would exceed the marginal reduction in expected harm that would be accomplished by a change to this precaution.*[15] Hence, *it is socially desirable for the party to maintain its period 1 precaution in period 2 as long as the known harm turns out to fall below a threshold; otherwise, the party should change its precaution to the conventionally optimal level for the known harm.*

Consider now the best level of precaution in period 1. At that time, the harmfulness of the activity is not known, and one might think that the optimal level of precautions is the conventionally optimal level for the expected harm if harm should occur, namely, the conventionally optimal level of harm for harm of \$550,000 in our example. (This was optimal, recall, in the case of durable precautions.) However, *in the case of durable precautions, the optimal level of period 1 precaution is higher than the conventionally optimal level for the expected harm*, *conditional on its occurrence.* The essential reason is that because precautions are durable, when precautions are taken in period 1, it will often be best not to alter them in period 2, as described in the previous paragraph. This means that the social payoff from risk reduction flowing from period 1 precaution may extend to period 2 and thus raises the optimal investment in period 1 precaution (above what it would be in the case of nondurable precaution).

Last, consider what is socially optimal for *a party entering into the activity only in period 2*, so that he will be participating in the activity just that period. He should take *the conventionally optimal level of precautions that is appropriate for the level of harm*, *which is known*, as the model that applies to him is in effect just the standard one period model. In particular, what is optimal for him is different from what is optimal for a party who engaged in the activity the first period, since for that party, as has been emphasized, it is optimal to maintain first period precaution unless the harm is sufficiently high. For example, what might be optimal for those parties who engage in the activity both periods is to choose period 1 precautions equal to the conventionally optimal level for harm of \$600,000 and to maintain period 1 precaution in period 2 unless the harm turns out to exceed \$800,000, in which case it is optimal for them to take the conventionally optimal

[15] This conclusion can be expressed algebraically (see the Appendix for details). Let $p(x_1)$ be the probability of harm resulting from the expenditure on precaution x_1 made in period 1 and let $x^*(h)$ be the conventionally optimal precaution expenditure when harm is known to be h (that is, $x^*(h)$ is the x that minimizes $x + p(x)h$). Then if there is no change in precaution in period 2, social costs are $p(x_1)h$, whereas if precaution is changed to the conventionally optimal level, social costs in period 2 are $x^*(h) + p(x^*(h))h$. Hence, it is best not to change precaution as long as $p(x_1)h < x^*(h) + p(x^*(h))h$.

Similarly, in the case where there is uncertainty about the cost of risk-reduction rather than h, let c be the cost of a unit of precaution, assume that $c = 1$ in period 1, let the uncertain c in period 2 become known at the beginning of period 2, and let $x^*(c)$ be the number of units of precaution x that minimize $cx + p(x)h$. Then it is best not to change precaution as long as $p(x_1)h < cx^*(c) + p(x^*(c))h$.

precaution for the level of harm that is observed. But those parties only entering the activity in period 2 should always take the conventionally optimal precaution for the level of harm that eventuates. Hence, if the harm is between $600,000 and $800,000, it is optimal for those entering the activity to take greater precautions than those who had engaged in the activity the previous period.[16]

2.4 Strict liability. Having described socially optimal behavior, I now consider how it can be achieved. Under strict liability parties pay for the harm that they cause, whatever the harm turns out to be.[17] It is evident that, *because a party bears the full social costs of its decisions under strict liability, the party will make all of its decisions in a socially optimal way. In particular, the party will take optimal precautions each period that it engages in the activity, whether the precautions are durable or nondurable*.[18] For instance, if precautions are durable, the party will only change precaution in period 2 if the harm is sufficiently large; for if the harm is not very large, it will be cheaper for the party to bear higher expected liability payments than to reduce them by spending on the new conventionally optimal precaution.

As a corollary to what was just observed, we can say that *there should be no grandfathering under strict liability.* In the context of strict liability, the meaning of grandfathering is some kind of insulation from liability in period 2 for parties who participated in the activity in period 1, for instance, limiting the magnitude of damages to the harm that was foreseen in period 1, even if the harm turned out to be higher in period 2. Such grandfathering under strict liability is unnecessary to induce optimal precautions and it could be socially undesirable because it could dilute incentives to take these precautions.

2.5 Negligence or regulatory standards. Under the negligence rule or a regulatory standard, parties are required to adhere to a level of precaution that the state chooses. I will assume here that parties comply with the required level of precaution due to the threat of liability for negligence or of penalties for violation of regulatory standards. Hence, the question to be addressed is how legal standards ought to be set, and the answer is simply that the standards ought to equal the optimal levels of precaution described above.

Accordingly, from what we concluded in section 2.3, *if precautions are nondurable, the optimal level of precaution in period 1 is the conventionally optimal level for the expected harm, and the optimal level of precaution in period 2 generally is different and equals the optimal level for the then known harm. Grandfathering is not optimal.*

However, *if precautions are durable, the optimal level of precaution in period 1 exceeds that which is appropriate for the expected harm, and grandfathering may be*

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[16] Observe also that if harm turns out to be less than $600,000, those entering the activity should in principle take precautions that are lower than those who engaged in the activity the first period. This makes sense since, not having invested in a higher level of precautions, those entering the activity should take a level of precautions that reflects only the known harm in period 2.

[17] I abstract from contributory behavior of victims for simplicity.

[18] This conclusion also holds under a corrective tax, such as a pollution tax, that is set equal to the expected harm that a party generates.

desirable. If in period 2 the known harm is below a threshold, grandfathering is optimal – parties who engaged in the activity in period 1 can maintain their period 1 precaution – but parties who enter the activity in period 2 should take the conventionally optimal precaution for the known harm. If in period 2 the known harm exceeds the threshold, then parties who engaged in the activity in period 2 should change their precaution to the conventionally optimal precaution for the harm, which is the precaution that new parties should take.

3. Extensions of the Model

I now want to consider briefly a number of factors to add greater realism to the model. I will focus on the case of central interest, that of durable precautions where legal rules set out negligence or regulatory standards.

3.1 Maintenance cost. It was assumed above that if a party employed his period 1 precaution in period 2, the part would bear no additional cost. But there is often a *maintenance cost* that must be incurred to continue to use a durable precaution, such as the cost of keeping a safety device in good repair or the cost of operating it. Because the bearing of a maintenance cost makes retaining the period 1 precaution less attractive, the social desirability of continuing to use the period 1 precaution in period 2, and of grandfathering, is reduced in consequence. In our illustration where the period 2 level of harm turns out to be $700,000 and grandfathering is optimal, suppose that a maintenance cost of $9,000 must be incurred to continue use of the period 1 precaution. Then if that is done, the precaution-associated cost in period 2 will be $9,000, whereas if the new precaution is taken, the cost will be $20,000. Hence, the net cost of a change to the new precaution would be only $11,000, whereas the marginal reduction in expected harm would be $14,000, which is greater, so that grandfathering would not be desirable. This illustrates the point that, given maintenance costs, grandfathering is optimal only when the cost of a new precaution minus maintenance costs exceeds the marginal reduction in expected harm that would be accomplished by the change in the precaution.

3.2 Scrap value. Another assumption that was made above was that, if a party invested in a durable precaution in period 1 but then changed to a different precaution in period 2, its cost of precautions over the two periods was the sum of the costs of both. This assumption is in keeping with the interpretation that a durable precaution is a safety device and that if a party changes to a new device in period 2, the party obtains no value from the old device. However, in some circumstances, the party could obtain value for the old device by selling it on a second-hand market or by using it elsewhere for some purpose. To the degree that the party can obtain such a *scrap value* for the period 1 device, the social cost of changing the precaution falls. Hence, the social desirability of continuing to use the period 1 precaution in period 2, and of grandfathering, diminishes. To illustrate in our example, we had said that if the new level of harm in period 2 turns out to be $700,000, grandfathering is desirable, for the cost of the new precaution is $20,000 whereas the reduction in expected harm if there is a change to a new precaution is less, $14,000. However, suppose that the old precaution has a scrap value of $10,000. Then the cost of a switch to the new precaution net of scrap value is $20,000 – $10,000 = $10,000, which is less than $14,000, so that a change in precaution would be desirable and grandfathering would not be optimal. In general, when there is scrap value, grandfathering is optimal only when the cost of the new precaution minus scrap value

exceeds the marginal reduction in expected harm that would be accomplished by a change to the new precaution.

3.3 Transition cost. An additional assumption that was made in section 2 was that changing to a new precaution would not involve any cost apart from that of the new precaution itself. Yet in many instances there will be some kind of *transition cost* because, for instance, a safety device used in period 1 will have to be removed, repairs will have to be made where that device had been installed, or redesign may be needed to make use of a new safety device. Such transition costs obviously enhance the social desirability of continuing to use period 1 durable precautions and thus of grandfathering. In our second illustration, where the harm learned in period 2 turns out to be $900,000, we had said that grandfathering was not desirable, since the cost of the new precaution was $22,000, whereas the marginal reduction in expected harm was higher, $27,000. But if there is a transition cost of, say, $8,000, grandfathering would become socially advantageous, since the cost of the switch to the new precaution would effectively be $22,000 + $8,000 = $30,000, exceeding $27,000. When there are transition costs, grandfathering is desirable whenever the cost of the new precaution plus transition costs exceeds the marginal reduction in expected harm that would be accomplished by the change in precaution.

3.4 Grandfathering in the absence of earlier legal standards. In the analysis of section 2 and in the examples that were discussed, it was socially desirable for parties to take positive precaution in period 1. Furthermore, the argument for maintaining period 1 precaution and for grandfathering depended upon the period 1 precaution being positive. For if that were not so, if no precaution were taken in period 1, then the advantage of adopting a new period 2 precaution would be total, not marginal. If a factory did not install any smoke scrubber in period 1, then the pollution reduction accomplished by installing a new kind of smoke would be total, not incremental, only in addition to what another smoke scrubber already accomplished. Hence, the factory would be in the same situation as a new factory; its optimal level of precaution would be the period 2 level and there ought not be grandfathering.

However, once we take into account the factor of transition cost just discussed in the previous section, we can see that the basis for grandfathering might be restored. Even if no precaution is taken in period 1, a party's having participated in an activity in period 1 may well imply that the party would have to incur a transition cost to undertake a period 2 precaution. For example, the factory that was built in period 1 without a smoke scrubber may find the arrestor very expensive to install in period 1, because that might require renovation and redoing the plant design. In contrast, a factory that is to be built in period 2 and knows it must install a smoke scrubber can plan for that. This point is of some relevance because, in reality, we often observe grandfathering when, previously, no legal standard applied, rather than when a positive but weaker legal standard applied.

3.5 Modification of property. Now consider the possibility that parties might wish to *modify their property*. For instance, a factory might want to engage in alterations in order to produce a new good, to make use of a new production technology that would lower its costs, to build a new employee cafeteria – the reasons for modifications are manifold. A modification may affect, and often would lower, the transition costs accompanying a change in durable precautions. Suppose, for example, that a factory must halt production in order to undertaken renovations. During that time, a safety

device could conveniently be replaced with a new one – whereas if the factory were not shut down on account of renovations, replacing the safety device would itself require cessation of operations. Hence, in this example, the modification would eliminate the transition cost of a halt of factory operations since the halt would occur anyway. Another example is where factory modifications require the hiring of architects and engineers. They might charge less to do the work need for installing a new safety device than if that were their only task. Against the background of such examples, let us assume that modification tends to lower transition costs.[19]

To the degree that modifications lower transition costs, modifications will lower the social desirability of continued use of the period 1 precaution and of grandfathering. To illustrate, we discussed in the example of the last subsection that, when transition costs are $8,000, grandfathering is desirable, since the cost of the new precaution plus the transition cost is $30,000, exceeding the reduction in expected harm of $27,000 that the new precaution would bring about. But suppose that a modification would lower transition costs to $1,000. Then grandfathering would no longer be socially advantageous, for the cost of the new precaution plus transition costs would be only $23,000. In general, when there is a modification, there should be no grandfathering when the new, lower transition cost plus the cost of the new precaution is less than the marginal reduction in expected harm.

3.6 Imperfect information of the state. Another factor that I have not yet considered concerns the information that the state (courts or a regulator) requires in order to determine optimal precautions and thus when grandfathering is desirable. In the basic model of durable precaution, the state needs to know the cost of precautions and the reduction in expected harm that precautions bring about over both periods. Further, when the extensions to the model are taken into account, the burden on the state becomes greater, as it needs to reckon maintenance cost, scrap value, transition cost, and the effect of modifications on transition cost.

The state will inevitably suffer from at least some lack of information necessary to the calculation of optimal precautions. As a consequence, it will often have to make decisions on the basis of estimates, perhaps of average characteristics of parties, leading to the possibility of error relative to ideal outcomes. Suppose, for instance, that the state is not able to ascertain actual transition cost, so the state bases its grandfathering on average transition cost. In particular, suppose that the state decides to grandfather because average transition cost is $15,000, which exceeds the threshold of $10,000 above which it is optimal to grandfather. Then, if a particular firm happens to face low transition costs relative to the average, say its transition cost is $5,000, the firm would mistakenly be grandfathered by the state. The social cost of such an error is that society forgoes the opportunity to lower expected harm by more than the cost of so doing. Under a different scenario, a converse error could occur: a firm could be mistakenly required to change precautions rather than grandfathered. Suppose that average transition costs are

[19] It is possible that modifications would affect factors apart from transition cost that are relevant to the desirability of changing durable precautions. For example, scrap value could be affected by a modification (it might be easier to remove an old smoke scrubber, in order to sell it, if a factory is being renovated). But transition cost seems to be the main affected factor, and in any case it would be straightforward to modify what I will say about modifications to take into account their different effects.

$5,000 and the state decides to require all firms to change precautions, but a particular firm faces unusually high transition costs, such as $20,000. This firm ought to be grandfathered but would not be. The social cost of this type of error is that society requires the expenditure of greater resources than it derives benefits through a reduction in expected harm.

3.7 Imperfect information of the state and modification. I return here to the subject of modification and grandfathering because of its connection to imperfect information of the state. To explain, suppose that the state cannot easily determine a party's transition cost so that it cannot base grandfathering policy directly on that cost. The state might then take modification expenditure to be an indirect indicator of transition cost for the reasons given in section 3.4, and thus the state might assume that transition cost tends to be lower the higher are modification expenditures. Under this view, the state might rationally decide against grandfathering when modification expenditures surpass a threshold, for then transition cost might usually be low enough to render grandfathering undesirable.

Although a policy under which modification expenditures exceeding a threshold leads to loss of grandfathering may thus be good on the whole, it will sometimes result in errors relative to the ideal because modification expenditures are only a proxy for transition cost, which is what grandfathering status ought in principle to depend upon. Suppose, for instance, that a factory loses its grandfathered status under the modification policy because it spends heavily on a new employee cafeteria, yet suppose that the expenditure on the cafeteria does not lower the true transition cost associated with a change to a new less polluting furnace and thus should not have resulted in a loss of grandfathering. Or suppose that a factory does not lose its grandfathered status under the policy because it spends only modestly on upgrading its power plant, yet suppose that this upgrading would have lowered the true transition cost of a change to a new furnace and thus should have resulted in a loss of grandfathering.

Another unwanted effect of a policy under which modification expenditures may result in loss of grandfathering is the socially undesirable curtailment of modifications. The reason is that under the policy parties have an incentive to keep modification expenditures below the threshold at which they would lose grandfathered status, even though it might be efficient for them to spend more on modifications. Consider the example just mentioned of a factory that could build an employee cafeteria. The cafeteria might be very beneficial for the employees and thus be desirable to add, yet the factory might well not build the cafeteria if that would mean it would sacrifice its grandfathered status.

The detrimental curtailment of modification expenditures together with the problem of erroneous grandfathering decisions constitute implicit costs of the policy under which the degree of modification expenditures determines grandfathering status. Of course, these costs do not mean that the policy is inadvisable, but they do suggest that there might be significant value in obtaining direct information about transition costs.

3.8 Second-best legal change in the absence of grandfathering. Grandfathering involves administrative costs, for it requires the state to determine whether, or for how long, parties have participated in an activity and have complied with legal rules. Moreover, the problems described in the last two sections diminish the social value of grandfathering. In view of these administrative costs and problems, it may be

best for the state not to engage in grandfathering and thus simply to change the law or not to do so for all parties, without inquiry into their past participation in activities and their compliance with legal rules.

Under the assumption that the state does not grandfather, its best decision will reflect a comparison of two types of error cost. If the law is kept stable, the error cost is that from failing to obtain risk reduction from those parties who ought to change their precautions, including from new entrants to the activity. If the law is altered, the error cost is that from forcing those parties to bear the costs of change who ought not to have to adopt new precautions. Whether it is best on net to keep the law stable or to alter it may be viewed as reflecting a comparison of these two types of error cost. As a general matter, the greater the fraction of individuals who engaged in an activity in the past, the more durable and expensive their investments in precautions, the greater the transition costs associated with change, and the less the advantage in adopting new precautions, the more likely it will be that the law should remain stable.

3.9 Effects of legal change on participation in activities. I have not examined the effect of legal change and of grandfathering on the decisions of parties whether to participate in potentially harmful activities. I have so far taken participation as a given even though, in fact, participation in activities may well be influenced by legal rules and thus by changes in rules.

One would generally expect the possibility of new enhanced required levels of precaution to reduce parties' participation in activities.[20] Grandfathering by definition should counter this tendency and work to preserve parties' incentives to engage in activities.[21]

What can be said about the social desirability of these effects on participation in activities? In order to answer this question, the reader should be reminded that under legal standards, there is a basic tendency for parties to engage in potentially harmful activities to a socially excessive extent. The reason is that parties do not have to pay for harm caused, provided that they comply with the legal standards. For example, a firm that installs smoke scrubbers as mandated by pollution regulations will not have to pay for the pollution it still causes. If a party does not have to pay for the harm its activity generates, it might participate even though the benefits to it are too low to make it socially worthwhile.[22] This problem of socially excessive participation in activities exists whatever is the optimal legal standard, and hence, it exists when the optimal legal

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[20] It is only upward changes in required precautions that are at issue if parties have invested in durable precautions, since it would never be socially worthwhile for these parties to spend funds to replace a durable precaution with a less effective precaution (even if new entrants into the activity in question are asked to meet only a lower standard of precaution).

[21] Another effect of grandfathering is that it may lead parties to participate earlier in activities, in order to benefit from grandfathering.

[22] For example, it may be that consumers would not be willing to buy a product if its price included not only material production costs but also impounded the harm from the pollution associated with its manufacture. On the fundamental problem that the negligence rule (and regulatory standards) fail to moderate adequately parties' participation in potentially harmful activities, see originally Shavell (1980). As emphasized there (and see here below), the problem does not exist under strict liability, for parties must pay for harm due to their activity under that rule regardless of their degree of precaution.

standard is raised. That the prospect of higher legal standards reduces the motive to participate in activities thus hardly signals a social problem –even parties' diminished incentives to participate tend to be socially excessive. Accordingly, it would be a mistake of policy to employ grandfathering so as not to discourage participation in activities. The the case for grandfathering must rest on the inefficiency of requiring changes in precautions.

Now consider the effect of legal change under strict liability, which is to say, the effect of changes in the level of damages. If damages might increase, this will tend to reduce participation in activities and conversely if damages might fall. Such effects on participation in activities are socially desirable. The essential reason is that, under strict liability, parties are as a general matter induced to make optimal decisions whether to participate in activities because they bear the costs of their activities. In particular, if a party refrains from participating in an activity because of the prospect of having to pay possibly higher damages, this is socially desirable, reflecting the point that the benefit from participation is not sufficient to outweigh the expected harm it generates. Again, then, there is no reason to employ grandfathering so as not to discourage participation in activities (and no other call to employ grandfathering, as explained in section 2.4).

4. The Law in the Light of the Theory

I now discuss briefly certain aspects of the law against the background of the analysis of legal change and past behavior in the preceding sections. I first observe that the law seems to exhibit a general constancy that I see in part as a reflection of the importance of past behavior. I then examine when and how the law employs grandfathering.

General stability of the law. Legal rules appear to me to display a significantly greater degree of stability on the whole than would be expected were the only reason for that the avoidance of additional administrative costs (the burden on legislators and on courts of considering and of promulgating new rules). If the avoidance of administrative costs were the sole factor favoring legal stability, then legal rules would probably be modified much more often than they are in reality, for added administrative costs are likely to be small in relation to the benefits that even quite modestly altered behavior would bring about for large populations of actors. Were administrative costs the only consideration disfavoring legal change, I believe that all manner of our regulations and legal duties would be amended in a more or less continuous fashion along with advances in the technology of risk reduction and the development of information about hazards.

That legal rules do not change with this frequency I suggest is explained importantly by the fact that individuals and firms make many decisions to take what I described as durable precautions in the theoretical analysis. In particular, many of their decisions have lasting aspects, such that real risk reduction without any, or with only modest, added cost is accomplished when parties carry on as they have in the past, whereas compliance with new rules would be expensive and effectively squander their prior investments in risk reduction. The reason that their decisions tend to have lasting aspects is that the decisions often involve investment in physical capital that is directly or implicitly required by legal rules, or investment in training and intellectual capital, or investment in financial, contractual, or reporting practices (recall section 2.2).

Further, in many contexts, it would be costly or impractical for the legal system to take parties' past investments in compliance into direct account, determining who made what investments in the past and their present effectiveness, in order to grandfather some of them. Hence, the law must often apply to all parties uniformly, and thus either remain the same for the entire population engaged in an activity or change for the whole population (see section 3.8). For this reason, and in statistical recognition of the parties who have made durable investments in past compliance, the law will frequently best remain fixed even though improvements in technology or new information may seem to call for its modification. Only when a sufficient fraction of the parties who complied in the past ought to change and satisfy the new duties – only when the pressures for change have built to a certain point – will it be socially advantageous for the law to be modified.

Grandfathering as a feature of the law. Although as just stated the law tends to exhibit stability, and practical difficulties may prevent the legal system from taking past behavior into explicit account, grandfathering is still a widely-encountered aspect of our legal system.[23] Areas in which grandfathering is observed include pollution regulation;[24] land use and real estate zoning ordinances;[25] building and safety codes;[26] licensing of professionals;[27] the enforcement of wills and trusts;[28] ownership of firearms;[29] and

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[23] [See the note below on United States. Foreign legal systems also use grandfathering, although they do not use that term to describe the practice. For example, in France... and in Germany....]

[24] For a general description and survey of grandfathering and its effects in regard to pollution regulation, see Stavins (2006). He relates grandfathering to, among other legislation, the Clean Air Act, Air Pollution Prevention Control, U.S. Code Title 42, Chapter 85; the Clear Water Act, U.S. Code Title 33, Chapter 26, and the Safe Drinking Water Act, U.S. Code Title 42, Chapter 26A; Hazardous Waste Management Sections, U.S. Code Title 42, Chapter 82; and various state and local mandates. See also, for example, Becker and Henderson (2000), Crandall (1983), Crandall, et al (1986), Gollop and Roberts (1983), Gruenspecht (1982), Nelson, et al (1993), and Swift (2000).

[25] See, for example, Anderson (1986), vol 1., ch. 6, and vol. 3, ch. 20; *Corpus Juris Secundum*, vol. 101A, (St. Paul: Thompson West, 2005), "Zoning and Land Planning," § 101, by Francis Amendola et. al.**;** and Metzenbaum (1955), vol. 2, ch. X-g.

[26] See, for example, *American Jurisprudence*, 2nd ed., vol. 13 (St. Paul: Thompson West, 2000), "Buildings," § 5, by Eric C. Surette; *McQuillin: The Law of Municipal Corporations 3rd ed., vol.* 7A*,* (St. Paul: Thompson West, 2005) § 24.512; *Corpus Juris Secundum,* vol. 39A, (St. Paul: Thompson West, 2003), "Health & Environment," § 52, by Charles J. Nagy.

[27] Many statutes allow grandfathering of old licensees when new requirements are established. See, for example, *Idaho Code*, sec. 54-213 (Lexis 2006) concerning accountants, *Arkansas Code Annotated* sec. 17-28-310 (2006) concerning electricians, *Minnesota Annotated Statutes* sec. 487.08 (Lexis 2005) concerning judicial officers, and *Mississippi Code Annotated* sec. 73-53-7 (2005) concerning veterinarians.

[28] See, for example, *Uniform Probate Code*, sec. 8-101 (2001) concerning provisions for transition, *Uniform Probate Code* sec. 2-506 (2001) concerning execution of wills, *Uniform Trust Code*, sec. 1106 (2001) concerning trust relationships.

[29] See, for example, *District of Columbia Court Rules Annotated*, sec. 7-2501.01 (Lexis 2006) concerning possession of unregistered handguns; Fox Butterfield, "As Expiration Looms, Gun Ban's Effect Is Debated," *New York Times*, 10 September 2004, sec. A, p. 14.

immigration status.[30] Also, as I will suggest below, grandfathering is an implicit feature of the negligence determination under standard tort principles. That grandfathering should be a common feature of the law is, of course, what one would expect in the light of the theoretical analysis presented here and, as has been emphasized, the view that compliance with legal rules involves many decisions with durable aspects. Additionally, it is worth noting that the type of grandfathering that we see is what one would predict, in the sense that it focuses on durable forms of compliance, as will be evident, for example, when I discuss some of the specifics of grandfathering in regard to electric utility plants and zoning. To my knowledge, grandfathering is not applied to readily modifiable behavior of parties, such as their driving speed. In other words, at least the gross characteristics of grandfathering are what one would expect in principle.

Tort law and implicit grandfathering. Grandfathering seems to be a latent feature of tort law, due to the manner in which the negligence rule is likely to be applied. As a general matter, a party will be found negligent for failing to take a precaution that resulted in harm if the cost of the precaution was less than the risk-reduction benefit that it would have generated.[31] In a negligence determination, the risk-reduction that the courts would naturally consider I believe to be the reduction from the level of risk that the actor *already* was accomplishing, without taking the precaution in question, and for this basic reason the negligence determination should result in desirable grandfathering. Consider an example similar to that in the Introduction: A refinery had installed device A to reduce the risk of an explosion. This device was state-of-the-art five years ago, when the refinery was built, but a new, cheaper device B that is slightly more effective in risk-reduction became available last year. If the refinery did not install B last year and as a result an explosion occurred, would a court hold the refinery negligent? It is unlikely, since the court would presumably reason that the additional risk-reduction that device B would have accomplished would be slight, given the risk-reduction already generated by device A. Yet if the refinery had just been built last year and had installed device A even though B was available at the time, the refinery would be found negligent for not having chosen the safety device that was more effective and cheaper. In other words, the duty of care for a new facility is different from that for an old facility. This illustration shows why conventional application of the negligence rule should lead to grandfathering, even though it would not be described as such.

Regulation of power plant air pollution and grandfathering. Electric power generating plants are an important source of air pollution, responsible for approximately two-thirds of the country's SO_2 emissions, a quarter of its NO_x emissions, and two fifths

[30] See, for example, Department of Justice, Immigration and Naturalization Service. "Adjustment of Status To That Person Admitted for Permanent Residence; Temporary Removal of Certain Restrictions of Eligibility," RIN: 1115-AF19, *Federal Register* 66, no 58 (March 2001): 16383.

[31] See, for example, the description of the negligence determination in Dobbs (2000), ch. 7, and the discussion in Landes and Posner (1987), pp. 85-88, 102, and in Shavell (1987), pp. 19-20.

of its CO_2 emissions.[32] These plants are regulated in significant ways under the Clean Air Act of 1970 and amendments to it.[33]

A salient feature of the Clean Air Act is grandfathering: power plants built before 1970 do not face the standards applying to plants built afterward, which are obligated to meet more rigorous, contemporaneous pollution control requirements. Many of these plants, mostly coal-fired, still operate today and are responsible for most of the air pollution generated by power plants.[34]

Although plants built before 1970 are grandfathered, a plant may have to forfeit its grandfathered status if it is modified. That happens under certain EPA regulations only if a plant carries out a major modification resulting in a significant increase in regulated pollutant emissions;[35] if the change in the plant does not significantly increase such emissions or if it constitutes routine maintenance, grandfathering status is ordinarily preserved.[36] The definitions and interpretations of a "significant" increase in regulated pollutants and of "major modifications" versus "routine maintenance" have been the subject of continuing debate and litigation, given their importance to firms because of the

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[32] *See* Arnold W. Reitze, Jr., *State and Federal Command-and-Control Regulation of Emissions from Fossil-Fuel Electric Power Generating Plants*, 32 ENVTL. L. 369, 371–72 (2002).

[32] The original Clean Air Act, passed in 1963, provided grants to state governments for research and air pollution control programs, acknowledged the danger of motor vehicle exhaust, and promoted emissions standard development for motor vehicles and stationary sources. *See* Am. Meteorological Soc'y, Legislation: A Look at U.S. Air Pollution Laws and their Amendments, *at* http://www.ametsoc.org/sloan/cleanair/index.html (last visited July 3, 2006). The current national air pollution program is based on the 1970 Clean Air Act amendments, enacted the same year that the EPA was established. Further significant amendments were made in 1977 and 1990. Pub. L. No. 95-95; 91 Stat. 685; Pub .L. No. 101-549, 104 Stat. 2399. For useful accessible internet sources on the Clean Air Act, *see* Envtl. Literacy Council, Clean Air Act, *at* www.enviroliteracy.org/article.php/6.html (last visted July 3, 2006); Environmental Protection Agency, Clean Air Act, *at* www.epa.gov/air/oaq_caa.html (last visited July 3, 2006). *See also* Nat'l Res. Def. Council, Clean Air & Energy, *at* www.nrdc.org/air/default.asp (last visited July 3, 2006). Other general sources on the Clean Air Act include MARK S. SQUILLACE & DAVID R. WOOLEY, AIR POLLUTION (3d ed. 1999); ROY S. BELDEN, THE CLEAN AIR ACT (2001); and ARNOLD W. REITZE, JR., AIR POLLUTION CONTROL LAW: COMPLIANCE AND ENFORCEMENT (2001).

[34] *See, e.g*, Reitze, *supra* note 31, at 384 –85; Deepa Varadarajan, *Billboards and Big Utilities: Borrowing Land-Use Concepts to Regulate "Nonconforming" Sources Under the Clean Air Act*, 112 YALE L.J. 2553, 2553–54 (2003).

[35] *See, e.g.,* 40 C.F.R. [ ].

[36] *See, e.g.,* 40 C.F.R. [ ]. These features of the regulation of modifications are applicable under the rules of New Source Review in "attainment" areas (where goals under the National Ambient Air Quality Standards have been met), to which I will largely refer in the text. The regulation of modifications is different in non-attainment areas. *See* Environmental Protection Agency, New Source Review: Basic Information, at http://www.epa.gov/nsr/info.html (last visited July 5, 2006). Moreover, modifications are also governed by the New Source Performance Standards ("NSPS"), which state in part that an alteration amounting to a "reconstruction" could result in the loss of grandfathered status even if the amount of pollution does not increase. To be a "reconstruction," the cost of the alteration must exceed 50% of the cost of building a comparable new facility and meeting NSPS regulations must be technologically and economically feasible. *See* 40 C.F.R. § 60.15(b).

financial advantage of sustained grandfathering.[37] Whether a modification results in a significant emissions increase varies from pollutant to pollutant,[38] and complicated subrules govern the calculation of increases.[39] Whether a change is major or constitutes routine maintenance depends on a number of factors, especially on the expenditures made in proportion to the capital costs of replacement components.[40]

What can be said about the grandfathering of power plants under the Clean Air Act in the light of the analysis of this article? That there should be some grandfathering of power plants is obviously consistent with the analysis. On one hand, the costs of changing pollution control methods are often large, involving significant expenditures on durable capital and perhaps alterations of plant design, and on the other hand, the equipment in place already achieves a reduction in pollution, making the benefits of compliance with new control methods marginal rather than total in nature.

Yet the potentially unlimited duration of grandfathering of plants raises questions. With the passage of time, an initial social advantage of grandfathering of a plant may diminish and then disappear, for two basic reasons. First, the expenses of maintaining and repairing old plants tend to increase over time, as equipment and buildings degrade. This reduces the cost advantage of grandfathering (see section 3.2). Second, the pollution control benefits of changes in abatement methods tend to rise over time, as the technology of pollution reduction advances. Moreover, it seems that, in fact, the expected harm due to pollution has increased (for example, the greenhouse effect is now believed to be serious[41]). These factors increase the marginal payoff from change, such as switching fuel from coal to natural gas. It is of course possible that administrative cost savings could justify an unlimited-in-time grandfathering rule, but given the high social costs of pollution, that does not appear plausible. Hence, it seems that a superior regime to that of the Clean Air Act would limit the duration of grandfathering of power plants or require a showing of evidence for its continuation.

The conditions under which modifications result in loss of grandfathering also provoke some skepticism.[42] A significant reason is that in important contexts any modification that does not raise the level of pollution is permitted – only modifications

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[37] *See, e.g.*, *Wisconsin Elec. Power Co. v. Reilly*, 893 F.2d 901 (7th Cir. 1990); *United States v. Duke Energy Corp*., 278 F. Supp. 2d 619 (M.D.N.C. 2003); *United States v. Alabama Power Co*., 372 F. Supp. 2d 1283 (N.D. Ala. 2005); Notice of Final Action on Reconsideration, 70 Fed. Reg. 33838 (June 10, 2005) (summarizing debate over rule governing equipment replacement as routine maintenance). See also "Decision Leaves High Court As EPA's Last Option To Reverse NSR Ruling," 7/13/06, *Clean Air Rep.* (summarizing recent court decisions concerning the same).

[38] *See* 40 C.F.R. §§ 51.166(b)(23), 51.166(b)(39).

[39] [ ]

[40] *See, e.g.,* [ ].

[41] *See* Nat'l Res. Def. Council, Global Warming, *at* http://www.nrdc.org/globalWarming/default.asp (last visted July 7, 2006); Union of Concerned Scientists, Global Warming, at http://www.ucsusa.org/global_warming (last visited July 7, 2006).

[42] Note to reader of this draft: What follows in the remainder of this discussion of power plant modifications is very preliminary – in part because I am still trying to untangle the complexities of the rules about modifications under the Clean Air Act and the litigation related to them.

that increase pollution may result in loss of grandfathering. This approach seems mistaken. It could well be that a modification does not increase pollution yet ought to result in the loss of grandfathering status (see section 3.5) because it results in an opportunity to relatively cheaply install up-to-date pollution control technology, or to change from coal to natural gas, and thereby substantially lower emissions.

A more basic question about modifications and grandfathering may be raised. As I discussed in section 3.7 especially, modifications are relevant to the decision whether to continue grandfathering *only to the degree that they inform us about the costs of changing to new pollution control technology.* However, the EPA criteria that determine whether a modification is classified as major generally are not closely tied to the costs of changing to new technology, and in some contexts these costs are not even mentioned as a relevant factor.[43] Importantly, the amount spent on a modification could represent only a modest proportion of replacement costs of a major plant component and yet the modification could lead to a good opportunity to install better pollution control methods; and conversely, the amount spent could constitute a large proportion of replacement costs without leading to an attractive opportunity to conform to new standards.

These observations lead one to ask whether it might be worthwhile pursuing the direct approach of estimating whether, as a consequence of a modification, the costs of making a change to a new method of pollution control at a plant are or are not less than the incremental benefits. Given the importance of power plants to the pollution problem, it might well be desirable to employ this direct approach to deciding grandfathering status when a modification is made rather than to use the present indirect approach, which focuses on the magnitude of modification expenditures, even though it may be administratively less complex.

Regulation of real estate by zoning and building codes, and grandfathering. In most areas of the country, real estate is regulated by zoning ordinances, building codes, and related rules, with requirements covering, among many other factors, lot size, setback distances of structures from property lines, percentages of land area covered by structures, height of structures, the safety and adequacy of the design of structures, and the materials and methods of construction.[44]

These regulations often include grandfathering provisions. The general nature of the grandfathering is that if a structure was built before the passage of the regulation, the structure is permitted to be noncompliant and without limit of time.[45] Thus, if a setback rule says that buildings must be at least 50 feet from roads, but a building that was constructed beforehand and is only 30 feet from a road, the building will not ever have to be moved or demolished in order to comply. Still, not all regulations allow

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[43] In a recent reconsideration of its New Source Review rules, the EPA maintained that certain expenditures be considered routine maintenance if they do not exceed a 20 percent threshold, and did not cite costs of modernization as a relevant factor. See Notice of Final Action on Reconsideration, *supra* note 36. However, this 20 percent threshold rule was overturned on March 17, 2006, by the U. S. Court of Appeals for the District of Columbia Circuit; see [ ]. [Hence,]

[44] [ ]

[45] [..]

grandfathering, for instance, a rule that fences be built of certain materials[46] and certain safety requirements, like [ ], must be adhered to by all parties.[47]

A grandfathered structure may lose its grandfathered status if modified. A typical rule would disallow continuation of grandfathering if the cost of the modification exceeded a percentage, such as 50%, of the value of the structure.[48]

The grandfathering of real estate as just summarized seems broadly consistent with the analysis of this article, as is illustrated by setbacks. A home that is only 30 feet from a road, instead of 50 feet as required by a zoning rule, presumably would be very expensive to move; the cost would be in the tens of thousands of dollars. The social benefit of having a greater setback is probably largely aesthetic and much lower than the cost of moving the home.[49] If so, the grandfathering of a noncomplying setback would be socially sensible, and similar observations seem to apply to many other regulated aspects of real estate, such as building dimensions and height. At the same time, the exceptions to grandfathering also seem to display rough rationality. A noncomplying fence that is unsightly and inexpensive to remove appears to make economic sense to force to replace (costs are low, the benefits of the present fence are negative, not positive), and likewise for a noncomplying [ ] (costs are not great, the benefits of compliance are large especially because they involve enhancement of personal safety).

That the grandfathering that we observe is typically indefinite in duration also seems explainable. The passage of time is not likely to change greatly the high cost of changing the location or physical characteristics of structures, or of lot size, nor is it likely to alter substantially the lower and usually aesthetic benefits of compliance. (Note the contrast between this conclusion and the opinion above that grandfathering of power plants should be of limited duration, because both the costs of noncompliance and the incremental benefits of compliance rise over time.)

Finally, that modifications may result in loss of grandfathering status if their cost surpasses a threshold is understandable for the general reasons explained in the discussion in section 3.7. For example, a major renovation of a home may provide an opportunity to cheaply bring wiring up to code requirements, since walls are likely to be opened up, electricians, carpenters, and painters will be on-site, and the like. Of course, this is not to say that the percentage criterion not be improved, perhaps made dependent on the nature of the noncompliance. Also, it is possible that when a modification is made, its expense should not be examined, but rather the direct approach should be pursued of estimating whether and how much the cost of compliance (that of bringing the wiring up to code) really does change as a consequence. The problem with this direct approach is its administrative expensive in relation to that of use of the modification expenditure threshold, and thus it may well be inadvisable. (Note again the contrast with the case of power plants, where incurring the administrative cost of the direct approach

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might be justified by the magnitude of the costs and the benefits of optimal regulation of each single power plant.)

5. Related Views and Literature

I comment here on the general notion that the law ought to be stable because it is relied upon, on the literature concerning legal transitions, and on economically-oriented writing on optimal legal rules.

The standard view that the law should favor stability, since parties rely upon this. A frequently expressed view is that parties rely in many ways on legal rules, expecting them to remain more or less as is, suggesting that the law should display relative stability.[50]

There are two apparent rationales for this view, and neither holds intellectual appeal. The first rationale is that, as a matter of fact, individuals believe the law to be stable and that this expectation should not be disappointed. This rationale is problematic. On one hand, it is not evident that individuals actually believe the law to be stable. We would expect individuals' beliefs to be molded by their experience, and in reality legal rules, or at least many of them, are seen to be in considerable flux. On the other hand, the claim that individuals' expectations about legal stability (whatever these expectations may be) should not be upset requires elaboration to be meaningful. The unfolding of a legal policy that is different from what was predicted should be related clearly to expenses they would then have to bear or to some psychological detriment in order for us to understand why it should lower social welfare even though the policy has a social purpose.

The second ostensible rationale for the standard view is economic or instrumental in character, that participation in activities might be undesirably chilled if parties cannot confidently predict the law.[51] Is this so? As I explained in section 3.9, incentives to participate in possibly harmful activities tend to be socially *excessive* under a regime of legal standards, and there is no reason to believe that this underlying problem is fundamentally altered when legal standards change in the optimal way – that is, according to the analysis offered here, which includes grandfathering (and so not as often as would otherwise seem appropriate).[52] As I also noted above, incentives to participate in activities tend to be socially optimal under a regime of strict liability, because parties pay for the harms they cause. Hence, there is no reason to refrain from allowing damages to reflect harm when its magnitude differs from what parties had earlier thought likely.

Nonetheless, the foregoing is obviously not meant to deny that if legal standards are revised without proper basis, without due attention to costs and incremental benefits,

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[52] It is true that incentives to participate in an activity may be reduced due to uncertainty about future standards, but that does not signal a social disadvantage. It may be socially desirable for parties to reduce participation if there is a chance that the activity will be quite dangerous and thus call for more precautions to be taken. The question one should ask is whether the reduction in incentives is less than, equal to, or greater than the socially desirable reduction.

or if damages were permitted to exceed harm, then parties' motives to participate in activities could be undesirably dulled.

Literature on legal transitions. Beginning with an article by Michael Graetz,[53] a literature on proper responses to legal change has developed, focusing on tax law, but coming to broader conclusions, especially by Louis Kaplow,[54] and notably that grandfathering is generally undesirable.[55] The question addressed in this "transitions" literature is whether grandfathering or some other form of relief ought to be granted to parties who are negatively affected by a socially desirable change in a legal rule. The nub of the answer offered is no, for doing so it is said would undermine the change in the rule. If a tax rule is modified in a socially good way, then grandfathering or compensating those hurt by the rule change would contravene its purpose. The only real basis for grandfathering discussed in the transitions literature is as an implicit form of insurance against the burden of a rule change, but the literature argues that parties ought to lump legal changes or perhaps rely on private insurance markets if possible. Grandfathering is thus found to be inadvisable as a kind of relief and to interfere with advantageous changes in law.[56]

What can be said about this negative conclusion about grandfathering in the transitions literature in relation to the conclusion developed here that grandfathering is often socially good? The difference in conclusions flows from a difference in assumptions, but the main assumption made in the transitions literature – that legal change for the group who might be grandfathered is socially desirable – renders that literature irrelevant in most (not all, see the next paragraph) domains where grandfathering is at issue. Consider again the example of the new type of smoke scrubber that is superior to the old type of scrubber and costs the same amount, so that the socially desirable legal standard would require any new plant to install the new scrubber. In the transitions literature, the question that would be asked is whether grandfathering of old plants with their old scrubbers is socially good, *assuming* that a legal rule requiring these plants to replace their old scrubbers with new ones is socially desirable. Of course, the answer to this question is immediate; it is a tautology that grandfathering would not be desirable (except as a form of financial relief). But here, as the reader knows, I do not assume that the old plants ought to install new scrubbers. Whether the new scrubber should be installed by old plants is really the question, to which the answer is sometimes no and sometimes yes, depending on its cost and the incremental benefits that would be yielded. And in reality, the policy-relevant question is usually similar. The typical question facing policy makers is whether it is socially desirable for a new legal standard to apply to those who complied with old standards, whether old electric power plants should have to install new pollution abatement equipment, whether homes built before new setback rules should have to comply with new setbacks, and so forth. Because the

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[55] See Graetz (1977) and Kaplow (1986), and see also Logue (2003) and Shaviro (2000).

[56] Kaplow (1986) at pp. 584-587.

transitions literature does not address these questions, but rather supposes the answer to them is yes, the literature is unhelpful when these are the questions at issue.

I hasten to say, however, that in the arena of taxation, to which the transitions literature was originally directed, there is good reason to think that that literature is relevant, and this observation can be seen to be consistent with the analysis here. To illustrate, suppose (as does Kaplow in an example[57]) that a tax rule is designed to reduce pollution and that the tax is set equal to the expected harm caused by polluting activities.[58] If new information develops showing that pollution is more harmful than had been thought, it is readily shown that it is socially desirable for the tax be increased commensurately – so that, in particular, there should be no grandfathering in the form of retention of the old, lower tax for parties who had been paying only that. The logic leading to this conclusion is essentially that supplied above in section 2.4 explaining why, under strict liability, damages should be raised if harm turns out to be high and thus why there should be no grandfathering. As stated there, the argument was that if parties have to pay for harm done, their incentives will automatically be socially correct, and among other things, they will have the right motive to alter their smoke scrubbers or to keep them, as the case may be.[59] In sum, to the extent that tax rules can be likened to strict liability rules, or that legal rules literally are strict liability rules, grandfathering is undesirable. Yet to the extent that legal rules ask for legal standards to be met, grandfathering may be desirable, and the question of interest is whether or not it is. Such legal rules seem to me to greatly dominate strict liability rules in importance, or at least to be the usual form of rule applying when issues of grandfathering arise.

Economically-oriented literature on legal rules. There is a now well-developed literature on optimal behavior to prevent harm and its inducement through use of legal rules. This economically-oriented literature generally views parties as choosing precautions on a blank slate – past behavior is not considered.[60] Hence, what the present article contributes to economic analysis of legal rules and optimal behavior is the examination of the influence of past behavior on presently optimal behavior and the implications of this dependence for legal rules.

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[58] [How often tax rules can be so viewed is another issue. Of course, many tax rules are intended to raise revenue, and in a way that does not unduly distort socially desirable behavior. When so, arguments similar to that about to be given may also apply.]

[59] [Thus, it should be noted that although under strict liability it is socially desirable for the legal rule to change for all parties, regardless of past behavior, this does not mean that how they behave will be independent of past behavior. Their induced behavior will very much depend on past behavior. In contrast, when the rule is a legal standard, since the standard is in effect a command how to behave, the standard must recognize past behavior in order to issue the right command to those who complied in the past.]

[60] The paradigm for the use of legal rules to channel behavior desirably is that developed in the literature on the economics of tort law, on which see generally Calabresi (1970), Landes and Posner (1987), and Shavell (1987).

6. Conclusion

I have considered here the general question whether, and how, legal rules should change in the light of new circumstances and conditions. The main point of emphasis has been that the steps that it is socially desirable for parties to take depend on their past actions when those actions have durable aspects. This gave rise to the conclusion that it is often undesirable for parties to make changes, even though a new entrant into a regulated activity ought to take previously unrequired actions. And what flowed from that conclusion was that grandfathering may be desirable, or else, if grandfathering is infeasible, that it may be best for legal duties not to be altered.

The issues addressed here seem to me to important to a consideration of legal change because of my empirical judgment that much of our behavior that is regulated by law displays significant durable aspects. Hence, explicit recognition of that point in the analysis of legal change should be included in our intellectual agenda.

Also, one hopes, the analysis offered above of legal change may help to clarify thinking and sometimes offer guidance to policymakers and courts. A specific example, it seems to me, concerns the influence of modifications on grandfathering status. Here, the approach of policymakers and courts has been (see x above) that if modifications are sufficiently substantial, then parties who would otherwise be grandfathered should no longer be. This approach has apparently been based on a rough intuition, rather than on a clear appreciation that the underlying reason why modifications matter to grandfathering policy is that they may be associated with a lowering of the cost of making changes to new legal standards. Were legal authorities to incorporate this point into their thinking, they could improve their treatment of modifications – by attending to changes in the cost of compliance with new standards, rather than focusing on modification expenditures per se – and they could sometimes avoiding gross errors of policy, such as I argued have been made under aspects of the Clean Air Act treatment of modifications. The problems with grandfathering and modifications serves to illustrate a more general lesson, which is that because consideration of past behavior may greatly complicate desirable setting of legal standards, the appeal of strict liability or of corrective taxes increase. By adopting strict liability, legal authorities eliminate in a fell swoop the need to explicitly consider past behavior, and parties themselves automatically are led to take it into proper account.

Last, let me comment on the positive aspect of the analysis of this article. I have suggested that the fact that we observe grandfathering, and more generally, a certain measure of stability in the law, is in important respects explained by central point of the analysis here, namely, that the expense of legal change may not be worth the incremental benefits over the benefits that we obtain from our past compliance with legal rules. What I have not examined, however, is without doubt an important part of the explanation for the existence of grandfathering. Namely, grandfathering is in the selfish interest of incumbents in an activity, especially of firms in an industry, and allows them to benefit without appearing to stand in the way of legal change.

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Appendix: Formal Model

I here present a formal analysis of most of the content of sections 2 and 3 of the text. Because the interpretation of the model has been addressed there, I will aim for brevity below.

A1. Basic model. Risk-neutral parties engage in a potentially harmful activity. The probability of harm each period depends on the level of precautions in that period. The magnitude of the possible harm is not known in the first period, but it is learned before the second period decision about precautions is made.[61] Let

x_i = level of precautions in period i, $i = 1, 2$; $x_i \geq 0$;
$p(x_i)$ = probability of an accident in period i; $p'(x_i) < 0$; $p'(x_i) \to -\infty$ as $x_i \to 0$; $p''(x_i) > 0$;
h = harm if an accident occurs;
$f(h)$ = probability density of h in the first period; h is known in the second period; $h \geq 0$.[62]

Some parties engage in the harmful activity both periods; others engage in the activity only in period 2.

One assumption that will be considered is that precautions are *nondurable* (best interpreted as modifiable effort to prevent an accident). Under this assumption, the cost of precautions in each period is x_i, so that the total cost of precautions for a party who engages in the activity both periods is $x_1 + x_2$; costs of precautions each period are independent. If a party engages in the activity only in the second period, his cost is x_2.

The alternative assumption is that precautions are *durable* (best interpreted as acquisition of a device to reduce accident risk). In this case, it is assumed that if x_1 is the level of precautions that a party takes in period 1 and this is not changed in period 2 (that is, $x_1 = x_2$), then there is no additional cost incurred by the party in period 2, so that the cost of precautions over the two periods is just x_1; but if precautions are altered in period 2, the cost of precautions over the two periods is $x_1 + x_2$. (The interpretation of this assumption is that a different level of precautions corresponds to purchase of a different device in period 2 that replaces the period 1 device.[63]) If a party engages in the activity only in the second period, his cost is x_2.[64]

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[61] That harm is uncertain rather than that the cost of precautions or their productivity is uncertain is inessential to the main qualitative conclusions. See section A5 below.

[62] It could be assumed that uncertainty about the level of harm is not completely resolved after period 1, but this would not alter the nature of the conclusions.

[63] A different formulation would correspond to an interpretation of a change in durable precautions in which the period 1 device is not replaced but enhanced or supplemented in period 2. As discussed in section A5, the main conclusions about grandfathering would not be different under this assumption.

[64] The model of durable precautions and of uncertain harm bears some similarity to models of irreversible investments (since a change in a durable precaution results in its loss) and uncertainty, notably with regard to resource and environmental economics; see, for example, Arrow and Fisher (1974), Dixit and Pindyck (1994) at 412-418, and Weitzman (2003) at 60-65 and 139-145. But the emphasis in the latter literature is different: it is on the point that irreversible steps are better not to take until uncertainty is resolved (it is better to refrain from cutting down a forest until it is known how much value it will have to

A2. Socially optimal precautions in the basic model. The social goal is to minimize expected social costs, where social costs are the costs associated with the precautions x_i and of harm caused. For convenience, denote the x that minimizes $x + p(x)h$ by $x^*(h)$; that is, $x^*(h)$ is the optimal level of precautions if h is the harm resulting from an accident in a single-period model where the cost of precautions x is x. Note that $x^*(h)$ is uniquely defined and positive for all positive h and that $x^*(h)$ is increasing in h.[65] We will call $x^*(h)$ the *conventionally optimal level of precautions* for harm h.

In the case of nondurable precautions, social costs for a person engaging in the activity both periods are $x_1 + p(x_1)h + x_2 + p(x_2)h$. In period 2, when x_2 is chosen, h is known, so that it will be optimal for x_2 to minimize $x_2 + p(x_2)h$. Hence, the optimal x_2 is $x^*(h)$. In period 1, when x_1 is chosen, h is not known, so the optimal x_1 minimizes $x_1 + p(x_1)\mathrm{E}(h)$, where $\mathrm{E}(h)$ is the expectation of h. Thus, the optimal x_1, is $x^*(\mathrm{E}(h))$. For a person engaging in the activity only in period 2, social costs are $x_2 + p(x_2)h$, so optimal precautions for him in period 2 are $x^*(h)$, the same as for a person who had engaged in the activity both periods. To summarize, we have

Proposition 1. In the case of nondurable precautions, if a person engages in the activity both periods

(a) optimal precaution in period 1 is $x^*(\mathrm{E}(h))$, that is, the conventionally optimal precaution when expected harm is $\mathrm{E}(h)$;

(b) optimal precaution in period 2 is $x^*(h)$, the conventionally optimal precaution when harm is h.

(c) It follows that optimal precaution in period 2 is different from that in period 1 with probability one.

If a party engages in the activity only in period 2,

(d) optimal precaution in period 2 is $x^*(h)$, the same as optimal precaution for a party who engaged in the activity in period 1.■

Part (c) is true because h will be different from $\mathrm{E}(h)$ with probability 1 (only by coincidence would the continuously distributed h turn out to equal $\mathrm{E}(h)$).

In the case of durable precautions, consider the optimal x_2 conditional on x_1. If $x_2 = x_1$, expected social cost in period 2 is $p(x_1)h$. If x_2 is different from x_1, expected social cost in period 2 is $x_2 + p(x_2)h$, so that it will be best that $x_2 = x^*(h)$. It follows that if h is such that

(1) $p(x_1)h \le x^*(h) + p(x^*(h))h$,

then it is optimal for x_2 to remain at x_1; otherwise, x_2 should be changed to $x^*(h)$.[66] Condition (1) holds for h in an interval $\mathrm{I}(x_1) = [0, b(x_1)]$, where $0 < h^*(x_1) < b(x_1)$, and

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the environment). Here, the emphasis is on what should be done after uncertainty is resolved (whether durable precautions should be changed after the magnitude of harm becomes known).

[65] The first-order condition $1 + p'(x)h = 0$ determines $x^*(h)$ if this is satisfied for some x, and such an x must be unique given the assumption that $p''(x) > 0$. For any positive h, the first-order condition must hold for some x, given the assumption that $p'(x) \to -\infty$ as $x \to 0$.

[66] For simplicity, I assume that where (1) holds with equality, x_2 remains at x_1, and I adopt similar conventions later without comment.

where $h^*(x)$ is defined as the h satisfying $x^*(h) = x$.[67] The explanation is as follows: if $h < h^*(x_1)$, so that $x^*(h) < x_1$, it would make no sense to change and lower precaution, since x_1 can be maintained as the level of precaution at no additional cost; and as long as h is not too much higher than $h^*(x_1)$, it is not desirable to raise precaution to $x^*(h)$ since that would entail bearing the entire cost of $x^*(h)$ whereas x_1 can be maintained for free.

We next describe the optimal choice of x_1, denoted by x_1^*. Social costs as a function of x_1 are

(2) $S(x_1) = [x_1 + p(x_1)E(h)] +$

$$+ [\Pr(I(x_1))][p(x_1)E(h|I(x_1))] + \int_{b(x_1)}^{\infty} [x^*(h) + p(x^*(h))h]f(h)dh,$$

where Pr means probability. The first term on the right is expected social costs in period 1, the second term is expected social costs if h is in the interval $I(x_1)$, when it is optimal to leave precaution unchanged at x_1, and the third term is expected social costs if h is above the interval $I(x_1)$, when it is optimal to change precaution to $x^*(h)$. Differentiating (2) yields the first-order condition determining the optimal x_1,

(3) $[1 + p'(x_1)E(h)] + [\Pr(I(x_1))][p'(x_1)E(h|I(x_1))] = 0.$

Note that (3) reflects two effects of an increase in x_1: the direct effect in the first period; and the indirect influence in the second period, that because it will be optimal to maintain x_1 for h in $I(x_1)$, there will be a second period effect as well, which is to lower the expected costs of harm then. (Changing x_1 also alters the endpoint $b(x_1)$ of $I(x_1)$, but this has no first-order influence on social welfare.[68]) It follows from (3) that $1 + p'(x_1)E(h) > 0$, implying that $x_1^* > x^*(E(h))$. In other words, the optimal first period level of precaution x_1^* is higher than it would be were the first period the only concern, for there is a second-period expected payoff as well.

If a party engages in the activity only in period 2, since social costs are $x_2 + p(x_2)h$, it will be best that $x_2 = x^*(h)$. Thus, his precaution may be different from that of a party who engages in the activity both periods.

We therefore have established the next result.

Proposition 2. In the case of durable precautions, if a person engages in the activity both periods

(a) optimal precaution in period 1 is determined by condition (3) and exceeds $x^*(E(h))$, the conventionally optimal precaution for expected harm of $E(h)$;

(b) optimal precaution in period 2 remains equal to period 1 precaution x_1^* if harm h is in $I(x_1^*) = [0, b(x_1^*)]$ (that is, if h satisfies $p(x_1^*)h \le x^*(h) + p(x^*(h))h$), but optimal precaution is the conventionally optimal level $x^*(h)$ if h is higher.

(c) It follows that optimal precaution in period 2 is different from precaution in period 1 with a probability less than one (equal to that of h exceeding $b(x_1^*)$).

If a person engages in the activity only in period 2,

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[67] For $h \le h^*(x_1)$, we know that $x^*(h) \le x_1$. Hence, $p(x_1) \le p(x^*(h))$, implying that (1) holds. For $h > h^*(x_1)$ the left side of (1) grows faster with h than the right, since the derivative of the left with respect to h is $p(x_1)$ and the derivative of the right is $p(x^*(h))$, and the latter is smaller since $x^*(h) > x_1$. Hence (1) does not hold for h sufficiently large, and $b(x_1)$ is as claimed and is unique.

[68] That is, the terms obtained by differentiation of (2) due to changes $b(x_1)$ reduce to zero, since (1) holds with equality at this point.

(d) optimal precaution in period 2 is the conventionally optimal level $x^*(h)$. Hence, optimal precaution for a new entrant is less than for a prior participant if $h < h(x_1^*)$, exceeds that for a prior participant if h is in $[h(x_1^*), b(x_1^*)]$, and is equal to that for a prior participant if $h > b(x_1^*)$.■

A3. Optimal legal rules in the basic model. Having determined optimal behavior, let us discuss how it can be achieved under legal rules. We consider two types of legal rule. Under the first, strict liability for harm, parties are assumed to pay for any harm h that they cause.[69] Under the second, parties' precautions are regulated; we assume that they are required to obey a standard of precaution (and that this is effectively enforced). When a legal rule in period 2 depends on a party's precaution in period 1, we will say that grandfathering applies.

Under strict liability, since a party pays for all harm, a party's private problem is the same as the social problem, so that it is clear that a party will choose precautions in a socially optimal manner.

Remark 1. Under strict liability, parties will choose socially optimal precautions. In particular, they will do so in both periods, regardless of whether precautions are durable or nondurable, and grandfathering will not be desirable.■

Under regulation, presuming that the state has sufficient information to calculate optimal precautions, it can achieve them, so, in view of Propositions 1 and 2, we can state

Remark 2. Under optimal regulation of precautions, parties are required to choose optimal levels of precaution. In the case of nondurable precautions, grandfathering is not optimal; precaution in period 2 is $x^*(h)$ whether or not parties engaged in the activity in period 1. In the case of durable precautions, grandfathering may be optimal; parties who engaged in the activity in period 1 maintain their precautions at x_1^* unless h turns out to exceed $b(x_1^*)$, whereas parties who enter the activity in period 2 set precautions equal to $x^*(h)$.■

A4. Extensions. I here sketch several extensions of the model of durable precautions (interpreted as devices).

(a) *Maintenance cost, scrap value, and transition cost.* Suppose that if the precaution x_1 is kept in period 2, a maintenance cost m will be incurred; that if precaution changes in period 2, the period 1 precaution can be sold for scrap value $s(x_1)$; and that if the precaution changes in period 2, a transition cost t will be incurred (associated, say, with the removal of the period 1 device).

Now reconsider the optimal x_2 conditional on x_1. If x_2 is different from x_1, expected social cost in period 2 will be $x_2 + p(x_2)h - s(x_1) + t$, so that it will again be optimal that $x_2 = x^*(h)$. Hence, if h is such that

(4) $p(x_1)h + m \leq x^*(h) + p(x^*(h))h - s(x_1) + t$

it will be optimal for x_2 to remain at x_1; otherwise, x_2 should change to $x^*(h)$. Note that if $s(x_1) + m > t$, condition (4) holds less often than (1). This makes sense, since scrap value and maintenance costs are factors that make keeping x_1 less attractive, whereas transition cost makes keeping x_1 more attractive. With condition (4) replacing (1), one can

[69] A fine paid to the state equal to harm, or a corrective tax equal to expected harm, is equivalent to strict liability.

determine a revised condition for x_1^* analogous to (3), but I will omit the details here (and likewise I will omit discussion of x_1^* below with regard to modifications).

Under strict liability, behavior will be optimal, appropriately reflecting scrap value, maintenance cost, and transition cost, but under regulation the regulator must take them explicitly into account.

(b) *Modification of property.* Suppose that modification of property may be undertaken in period 2 and will yield a private gain for parties (such as a renovation allowing a factory to produce goods at lower cost), where the gain depends on the magnitude of the modification investment. Let $g(k)$ be the gain from modification given the investment k, where g is increasing and concave in k. Modification is assumed also to result in the lowering of the transition cost of a change in precaution (such as when a renovation at a factory would allow an opportunity for easier replacement of pollution control equipment). Thus, let transition cost $t = t(k)$, where t is decreasing and convex in k.

Accordingly, social welfare in period 2 is $g(k) - k - p(x_1)h$ if there is grandfathering and $g(k) - k - [x^*(h) + p(x^*(h))h + t(k)] = g(k) - k - t(k) - [x^*(h) + p(x^*(h))h]$ if there is not grandfathering.

Given k and thus $t(k)$, grandfathering is socially desirable when

(5) $p(x_1)h \leq x^*(h) + p(x^*(h))h + t(k)$

(abstracting for simplicity from maintenance cost and scrap value).

Consider the optimal k and the optimal choice about grandfathering in period 2. Let k^* maximize the net return from investment $g(k) - k$, so that k^* is determined by $g'(k) = 1$. Also, let k^{**} maximize $g(k) - k - t(k)$, the net return from investment minus transition cost; thus k^{**} is determined by $g'(k) - t'(k) = 1$. It is clear that $k^{**} > k^*$;[70] the reason is that there is a payoff from k in addition to increasing g, which is decreasing t.

If there is grandfathering, the optimal k is k^*, for social welfare given grandfathering is $g(k) - k - p(x_1)h$ and k^* maximizes the first two terms. Likewise, if there is no grandfathering, the optimal k is k^{**}, for social welfare when there is no grandfathering is $g(k) - k - t(k) - [x^*(h) + p(x^*(h))h]$.

Hence, to determine whether grandfathering is optimal, we can compare social welfare under grandfathering and k^* to that without grandfathering under k^{**}. If

(6) $g(k^*) - k^* - p(x_1)h > g(k^{**}) - k^{**} - t(k^{**}) - [x^*(h) + p(x^*(h))h]$,

then grandfathering is optimal, whereas if (6) does not hold, then grandfathering is not optimal and optimal precaution is $x^*(h)$.

Note that the optimal solution as just described reflects the following factors. First, the value of modification, due to the gains it yields, may, as a byproduct, lower transition cost enough to make a change in precaution optimal, when otherwise grandfathering would be optimal. If a change in precaution is optimal, then modification investment should be higher than were its direct gains the only benefit from it, because it also results in reduced transition cost.

Again, under strict liability, behavior, and thus modifications as well as precautions, will automatically be optimal. Under regulation, the regulator must determine the optimal solution, but note that as long as the regulator determines whether or not grandfathering is permitted, the parties will be induced to choose the right

[70] We know that $g'(k^*) - t'(k^*) = 1 - t'(k^*) > 1$. Thus, to satisfy $g'(k) + t'(k) = 1$, k must be raised from k^* (since $g''(k) - t''(k) < 0$). .

modification investment: If grandfathering is permitted, parties will of course not spend on a new precaution, and thus will choose k to maximize $g(k) - k$, so will choose k^*; if grandfathering is not permitted, parties will bear $t(k)$, will choose k to maximize $g(k) - k - t(k)$, so will choose k^{**}.

(c) *Imperfect information of the state.* For the state to achieve optimal behavior, it must have certain information. Under strict liability, all it need do is observe harm h. Under regulation, however, it must be able to observe precaution and to calculate optimal precaution, implying that it must know all functional relationships. This gives rise to a host of problems that were described in section 3.5. Hence, for example, suppose that the state cannot observe maintenance cost m, knows only its distribution. Then the state must make a decision about grandfathering on the basis of its knowledge of the distribution of m. If the state disallows grandfathering, because m is on average large, it will sometimes make errors, since parties for whom m is small, who should be grandfathered, will have to change precaution, and so forth.

(d) *Imperfect information of the state and modification.* It is worth taking particular note of the implication of imperfect information with regard to modification of property because of the policy importance of modification and grandfathering. As discussed in section 4, we observe that grandfathered status is often removed if the degree of modification is sufficiently large. A rationale for this type of rule is that the magnitude of modification k may serve as an implicit indicator of unobservable transition cost – with a major modification signalling a low transition cost t and thus a lesser need for grandfathering. However, because high modification investment k results in loss of grandfathering, such investment may be inefficiently discouraged under the rule.

To demonstrate these points we must modify the model so that there is variation in the levels of modification investment k that parties wish to choose.[71] A natural way to do this is to assume that the productivity of modification investment varies across the population of parties: let the gain from modification investment k be $\theta g(k)$, where θ is a productivity parameter (a party's type), drawn according to some probability distribution over the positive numbers. Let $k^*(\theta)$ maximize $\theta g(k) - k$ and $k^{**}(\theta)$ maximize $\theta g(k) - k - t(k)$, and note that $k^*(\theta) < k^{**}(\theta)$ and that both are increasing in θ.[72]

The determination of the socially optimal outcome in period 2 is essentially as described in (b). It can be verified that if grandfathering is optimal for parties of type θ', then grandfathering must be optimal for parties with $\theta < \theta'$.[73] Hence, unless grandfathering is optimal for all θ or for no θ, there must exist a critical value, say θ_c,

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[71] Otherwise the state can, as I noted above in (b), calculate what is optimal for the (identical) individuals and just allow or disallow grandfathering, whichever is optimal.

[72] Optimal modification investment $k^*(\theta)$ is determined by $\theta g'(k) = 1$. Implicitly differentiating with respect to θ gives $g'(k) + \theta g''(k)k^{*\prime}(\theta) = 0$, so that $k^{*\prime}(\theta) = -g'(k)/\theta g''(k) > 0$. That $k^{**\prime}(\theta) > 0$ is shown similarly.

[73] Grandfathering is optimal at a θ when the analogue to (6) holds, namely, when $\theta g(k^*(\theta) - k^*(\theta) - p(x_1)h > \theta g(k^{**}(\theta)) - k^{**}(\theta) - t(k^{**}(\theta)) - [x^*(h) + p(x^*(h))h]$. We want to show that if this inequality holds at θ', it must hold for lower θ. To establish that, it is clearly sufficient to demonstrate that $\theta g(k^*(\theta) - k^*(\theta) - [\theta g(k^{**}(\theta)) - k^{**}(\theta) - t(k^{**}(\theta))]$ is decreasing in θ. But the derivative of this expression with respect to θ is (by the envelope theorem) just $g(k^*(\theta)) - g(k^{**}(\theta))$, which is negative since $k^*(\theta) < k^{**}(\theta)$.

such that for $\theta \leq \theta_c$ grandfathering is optimal and for higher θ it is not. This is the interesting case[74] and is what we will consider. Accordingly, at the optimum parties with $\theta \leq \theta_c$ choose $k^*(\theta)$ and parties with higher θ choose $k^{**}(\theta)$, so that the graph of investment k is increasing in θ, with a discontinuity at θ_c, where it rises from $k^*(\theta_c)$ to $k^{**}(\theta_c)$.

Now assume that the state cannot observe transition cost t so cannot base grandfathering on t (or on θ, which is unobservable) but can observe modification investment k and base grandfathering on it. The state can select a critical value k_c and allow grandfathering only if $k \leq k_c$ and in this way implicitly attempt to mimic the optimum. Given k_c, it is clear that parties for whom $k^*(\theta) < k_c$ will choose $k^*(\theta)$ and thus will be grandfathered.[75] Also parties for whom $k^*(\theta)$ exceeds but is sufficiently close to k_c will choose k_c in order to be grandfathered – in other words, there will be a mass point of parties at k_c.[76] Parties with larger θ will not find it worthwhile to choose k_c in order to be grandfathered and will thus choose $k^{**}(\theta) > k_c$. By choosing k_c in a second-best optimal way (close to $k^*(\theta_c)$), the state can approximate optimal behavior, but optimal behavior cannot be achieved, at least because of the massing of individuals at k_c who do not invest more (not $k^*(\theta)$) in modification in order to preserve their grandfathered status.

(e) *Second-best legal change in the absence of grandfathering; incentives to participate in activities.* What was said in sections 3.7 and 3.8 is clear and nothing need be added here.

A5. Robustness of the model

I here discuss why relaxing either of two assumptions that were made in the model would not change the qualitative nature of the conclusions.

(a) The assumption that a durable device must be replaced rather than supplemented: I assumed for simplicity that a durable precaution was a device, such as a smoke arrestor, and that if the precaution were to change in period 2, a new device would be needed and would replace the old device. Thus, I assumed that if the period 2 precaution x_2 is different from x_1, then x_2 needs to be spent in period 2 and the probability of harm is just $p(x_2)$. However, another assumption that fits certain situations is that the period 1 device can be enhanced or supplemented with another device. For instance, perhaps a new component can be installed in the period 1 smoke arrestor or perhaps another smoke arrestor can be added so that two smoke arrestors function to control pollution instead of one. In such situations it is natural to assume, though, that it is less

[74] Otherwise the state can achieve optimality simply by allowing grandfathering or disallowing it for all parties.

[75] They are clearly better off at any k grandfathered than not, and since they can choose the optimal k and be grandfathered they must prefer this.

[76] If a person for whom $k^*(\theta) > k_c$ chooses $k \leq k_c$, he will be best off at k_c, given concavity of the objective function and that $k^*(\theta) > k_c$, and his utility will be $\theta g(k_c) - k_c$. If he chooses $k > k_c$, since he will not be grandfathered, his best choice of k will be $k^{**}(\theta)$, and his utility will be $\theta g(k^{**}(\theta)) - k^{**}(\theta) - t(k^{**}(\theta)) - x^*(h)$. He will do whichever is better. Now at the θ such that $k^*(\theta) = k_c$, we have $\theta g(k_c) - k_c = \theta g(k^*(\theta)) - k^*(\theta) > \theta g(k^{**}(\theta)) - k^{**}(\theta) - t(k^{**}(\theta)) - x^*(h)$. Hence, it must be true in a positive neighborhood above this θ that $\theta g(k_c) - k_c > \theta g(k^{**}(\theta)) - k^{**}(\theta) - t(k^{**}(\theta)) - x^*(h)$, in other words, that choosing k_c is better than not being grandfathered and choosing $k^{**}(\theta)$ in this neighborhood.

efficient to spend x_1 on a period 1 device and then an additional amount x_2 to supplement it than to spend the same amount $x_1 + x_2$ at once on device. Under this assumption, grandfathering may well be desirable, since the relative lack of efficacy of spending to supplement x_1 may make staying put best, even though new entrants spend $x^*(h) > x_1$.[77]

(b) The assumption that uncertainty in the second period concerns the magnitude of harm rather than the technology or cost of risk reduction: If the uncertainty in period 2 concerns the risk reduction function instead of the harm, it is evident that the main qualitative conclusions reached would not be altered. For example, suppose that in period 2, the probability of harm is given by $p(tx)$, where x is expenditure and t is an uncertain technological or cost parameter. If $t > 1$, then by spending x, the effective expenditure is greater than x, so this corresponds to a technological advance or a reduction in cost. Then the choice for a party in the second period is between not changing precaution, so that the risk of harm would be $p(x)$, and changing precaution and spending the $y^*(t)$, the y that minimizes $y + p(ty)h$. Grandfathering is then best if $p(x)h < y^*(t) + p(ty^*(t))h$, and the analysis would proceed along the lines that were developed above.

[77] To amplify, the second period probability of harm might be written as $p(x_1, x_2)$, where $p(x_1, 0) = p(x_1)$ and the partial derivative with respect to x_2, $p_2(x_1, x_2) < 0$, that is, spending x_2 helps to reduce the risk from $p(x_1)$. In such situations, suppose that $p_2(x_1, x_2) > p'(x_1 + x_2)$, that is, spending an additional dollar in period 2 after the period 1 device is installed reduces risk less than spending that dollar on a better period 1 device. Then it is possible that $-p_2(x_1, 0)h < 1$, so that it is not worth supplementing the period 1 device even though $x^*(h) > x_1$.