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Technology & Torts:

A Theory of Memory Costs, Nondurable Precautions and Interference Effects *

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Abstract

This Article amends an important theory by Mark Grady on nondurable precaution (Grady, 1988). We present a formal model on (non)durable precautions which focuses on memory costs, and add three insights to the literature. First, we argue that, under current tort doctrine, the interaction between nondurable precautions and mental costs create a self-sustaining expansion of tort law. Because the risk of liability creates additional interference effects, tort law perpetuates the expansion of awards. Second, we demonstrate that socially excessive suits are more likely to be filed in the event of nondurable technology. This is because a plaintiff does not consider the increase of interference costs as a private cost, when initiating a lawsuit. Third, while new harm-reducing technology likely increases accident rates, it also raises the ratio of trial costs to harm, thus leaving undetermined the overall effect of new technology on the rate of litigation.

Keywords: tort law, tort award, precaution, technology
JEL classification: D72, F02, K34

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1 Introduction

What explains the expansion of tort awards? One possible answer is that advancements in technology have increased the scope of tort liability. Technological progress removes risk from nature and places it in the control of man, inducing additional tort liabilities.[1] According to the economic theory of tort law, an increase in potential liability costs induces potential tortfeasors to implement additional efforts to avoid liability.[2] Some have held that this causes society to engage in excessive levels of precaution in regard to defensive medicine[3] and products liability.[4] At the same time, however, there has been an alleged expansion of the tort system over time, with rising remedies, awards, and insurance premiums.[5] How can both phenomena of (incentives for) excessive precaution and a tort explosion co-exist? Where is the rub?

This Article examines the impact of technology on the evolution of tort awards. In doing so, we rely on Mark Grady's important, yet often overlooked article, in which he distinguishes between various types of precautions created by technology (1988).[6] Certain technology prescribes one-time investments in precaution (durable acts of precaution), while other technological advancements require precautionary measures that involve multiple acts of foreseeing, complying, or remembering (nondurable acts of precaution). [7]

Generally speaking, technology increases the scope of liability exposure. However, by transferring risk from nature to mankind, durable and nondurable technologies have differential effects on liability. Nondurable precaution creates a higher potential of liability exposure because a wider margin of human error exists. Moreover, because tort doctrine does not excuse error and mistakes, tort law effectively creates "pockets of strict liability" in the heart of negligence law (Shavell, 1987; Grady, 1988).

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[1] For instance, novel medical technologies create new opportunities for errors and increase the expectations of medical performance, further widening the scope of negligence.

[2] In a negligence based system, market forces and insurance premiums encourage potential injurers to take further precautions as long as the lower expected liability costs outweigh the cost of the respective extra precautions.

[3] Take, for example, the renewed appeal of more invasive but less risky medical procedures, such as caesarian birth deliveries; *see generally* Kessler & McClellan, 1997 (arguing that the professional conduct of physicians is largely a function of prevailing tort law in the state in which they practice).

[4] Tillinghast-Towers Perrin, U.S. Tort Costs: 2000: Trends and Findings on the Costs of the U.S. Tort System 12 (2002).

[5] In some areas of law, such as medical malpractice, commentators speak of a malpractice explosion. *See* Danzon, 1985: 142-43. For a public choice explanation of the growth of tort law *see* Zywicki, 2001.

[6] One notable exception is Heald, 1993 (discussing the role of cognitive scripts in processing task management).

[7] Also, in order for durable precaution measures to be effective, they often are to be combined with many short lived (nondurable) acts of precaution. For instance, once a dialysis machine is purchased, it has a long service life; however, once the machine is installed, it needs to be properly connected to the patient, the machine and the interaction with the patient must be tested, progress needs to be regularly monitored, the machine needs to be maintained, etc.

In this Article we provide a formal model, which demonstrates that the use of nondurable precaution technology is more likely to result in an accident than the use of durable technology. The differential effect of durable and nondurable technology on negligence is attributed to the higher compliance costs associated with the former.[8] This result confirms the theory suggested by Grady (1988) and provides insight into the role that technology plays in the evolution of tort awards. Although we may expect tort law to provide incentives to invest in safer technology – encouraging innovation in durable precaution technology over nondurable types – the effectiveness of such incentives depends largely on innovation cycles. We posit that tort awards will increase whenever technological progress is not able to substitute nondurable with durable technologies.

An essential characteristic of nondurable precaution technology is a high degree of multi-tasking. As a growing body of studies on cognitive control suggests, multi-tasking involves considerable memory costs and complications, including the occurrence of interference effects between various tasks. From these findings, it appears that compliance costs for nondurable precautions are higher than previously assumed. This provides additional grounds for anticipating a high number of negligence cases arising out of nondurable precautions. By contrast, the relative simplicity of precaution measures associated with durable technology creates a lower potential for negligence. Even if negligence is found with regard to a durable precaution technology, interference effects from liability costs will be modest due to the low degree of multitasking involved.

Given the existence of interference effects, we argue that, tort litigation imposes at least two additional costs that are unique to nondurable precaution technology. First, the fear of litigation adds a layer of potential interference for nondurable precautions. For instance, if a doctor's concern of medical malpractice forces her to check up on a dialysis machine every ten minutes, it will become harder for her to remember to check up on another machine that must be monitored regularly. In this regard, the tort system imposes additional mental costs that interfere with existing processing tasks. Due to additional interference effects, tort litigation may generate a self-sustaining effect on tort awards for errors involving nondurable precautions. Second, as we illustrate formally in this paper, nondurable technology is more likely to induce socially excessive litigation. This results because plaintiffs do not consider the increase of prevention costs of other activities created by litigation as a private cost. By contrast, due to lower degrees of interference effects, durable precaution technology poses a lesser risk of socially excessive litigation.

When new technology brings about a significant reduction in accident costs, the savings that result may, in fact, spawn an increase in the number of accidents. As we demonstrate more formally below, reduced accident costs may decrease the amount invested in precaution, which will thus lead to more instances of negligence. Additionally, following a reduction in the average amount of harm per accident, due to new harm-reducing technologies, comes an increase in the ratio of trial costs to harm. Therefore, the overall impact of new

[8] This difference is amplified by the unwillingness of courts to consider memory costs as a defense to negligence (Grady, 1998: 295).

technology on litigation rates is ambiguous as the increase of accidents may be offset by the fact that many new suits may have negative expected values.

The influence of nondurable precautions on the expansion of tort law reflects poorly on the legal and economic theories surrounding tort law. To date, law and economics scholars have focused almost exclusively on economic decisions involving durable precautions.[9] Most tort accidents, however, involve situations where mishaps result because of mistakes, safety omissions, or split second errors; i.e. situations where prevention measures had to be repeated and remembered (nondurable precautions), rather than instances requiring a single, isolated measure to be taken (durable precautions). By neglecting to account for the difference between durable and nondurable precautions, economic theory has commonly failed to analyze some of the elements that are crucial in determining tort awards.[10] Yet, as discussed below, understanding the effects of nondurable precaution is crucial to understanding the evolution of tort law.

The paper is organized as follows. Section 2 provides a formal model to demonstrate the differing effects of durable and nondurable technologies on accident rates. Section 3.1 updates the model with relevant insights from the literature on cognitive psychology regarding mental costs and interference effects. Section 3.2 formalizes and discusses the gap between social and private incentives to sue over accidents involving nondurable precaution technology. Section 3.3 considers the impact of harm-reducing technology on the rate of accidents and litigation. Finally, Section 4 concludes.

2 Durable and Nondurable Precaution: General Model

This Section models the different effects durable and nondurable technologies have on accident rates. Consider the following basic model of negligence-based liability.

The *private cost function of the injurer* under the rule of negligence is given as:

$$PC(x) = \begin{cases} x, \text{if } \mathrm{x} \geq \mathrm{x}^* \\ x + p(x) \cdot H, \text{if if } \mathrm{x} \prec \mathrm{x}^* \end{cases} \quad (1)$$

[9] As Grady (1998) observes, virtually all classic economic inquiries of tort law examine whether an injurer should, from a cost-benefit perspective, have engaged in a unique act of prevention. Classic examples include installing a spark arrester (Coase, 1960; Demsetz, 1972), and renting a barge (Landes & Posner, 1987, pp. 85-86). Cited in Grady, 1998: 301.

[10] In an interesting article, Nussim and Tabbach (2009) take into consideration the differences between durable and nondurable precaution. In their conception, precautionary measures are durable in nature when they are effective or endure for all (or at least more than one) activity level, and certainly need not be taken per unit of activity (Nussim & Tabbach, 2009). The focus of this article is different than theirs. They show that, for an important set of cases, care and activity levels are complements and that this leads to several counter-intuitive results. Our model focuses directly on the (or a) source of the durable-nondurable division (memory costs) and examines some consequences of the presence of such costs (e.g. on the social versus the private incentive to sue).

where x = the level of precaution, $p(x)$ = the probability of an accident when precaution x is taken (with $p' < 0$ and $p'' > 0$), and H = the harm if an accident occurs.

The social cost function is:

$$SC(x) = x + p(x) \cdot H \qquad (2)$$

To find the optimal amount of precaution x^*, we minimize $SC(x)$, so that $SC'(x) = 0$

Injurers take the optimal amount of precaution under the rule of negligence (when due care is equal to optimal care). If injurers engage in lower levels of precaution, they will bear the full social costs of the accident (Dari-Mattiacci & Parisi, 2005).

2.1 Nondurable Precaution: The Effect of Memory Costs

Next we consider the differences between durable and nondurable precaution technology by explicitly considering memory investments as a part of compliance costs.[11]

We formalize accidents involving nondurable precautions as follows: during time period T, there is an expected number of N 'critical moments', where harm H may occur. For example, a nurse needs to check on a machine 500 times; if she forgets to check the machine, harm may occur. In time period T-1, the potential injurer must decide how much she will invest in developing memory; this investment level determines the percentage of cases in which she will forget/remember to take precaution. If, for example, the nurse practices 3 hours per year, she will remember to check the machine 98% of the time, or 490 out of 500 instances; if she practices 4 hours per year she will remember to check the machine 99% of the time, or 495 out of 500 occasions.

The *private cost function* of the injurer under the rule of negligence (the injurer is liable for damages every time he forgets to take precaution and harm occurs) is given as:

$$PC_{nd}(c_{nd}) = c_{nd} + N \cdot R_{nd}(c_{nd}) \cdot x^* + N \cdot (1 - R_{nd}(c_{nd})) \cdot p(0) \cdot H \qquad (3)$$

where c_{nd} = the level of investment in memory, $R_{nd}(c)$ = the probability that the potential injurer will remember to take precaution, with $R'nd \succ 0$ and $R''nd \prec 0$.

When the injurer makes an investment c_{nd} in memory, he will remember to take precaution with probability $R_{nd}(c_{nd})$) for any critical moment (there are N

11 The cost of remembering to use precautions is the main element of compliance costs, see Grady (1988). Another type of compliance cost is the cost of noticing risk every time. However, as Grady (1988) notes, this cost may be a corollary of memory costs. If someone didn't notice risk, it is frequently because he has forgotten to take the precaution of looking for it.

in total). The potential injurer will take optimal care x^* when he remembers to take precaution. With probability 1-$R_{nd}(c_{nd})$, he will forget to take precaution for any critical moment. In that case, there is a chance of $p(0)$ that harm H will occur, for which the injurer will be liable.

To find the amount that the injurer will invest in memory, we minimize his private cost function. The injurer chooses c_{nd} so that:

$$\begin{aligned} & PC_{nd}'(c_{nd}) = 0 \\ & \Leftrightarrow 1 + N \cdot R_{nd}'(c_{nd}) \cdot x^* - N.R_{nd}'(c_{nd}).p(0) \cdot H = 0 \\ & \Leftrightarrow R_{nd}'(c_{nd}) \cdot [N \cdot x^* - N \cdot p(0) \cdot H] = -1 \\ & \Leftrightarrow R_{nd}'(c_{nd}) = 1/[N \cdot p(0) \cdot H - N \cdot x^*] \end{aligned} \tag{4}$$

In order to illustrate the effect of memory costs, consider the following numerical example. A nurse can spend 4 hours each year on training with a new machine. The cost of training is \$5,000 per 4 hour session. If the nurse follows this training course, there is a 99% probability that he will remember how to use the machine properly. On the other hand, if the nurse elects to spend 20 hours each year on training, he will remember how to use the machine properly with complete certainty (100%), however, the cost of which will amount to \$25,000. There are 500 critical moments and the cost of precaution equals \$100. If no precaution is taken at all, there is a 2% chance of harm. Harm equals \$10,000. Will the nurse make the additional investment so that he will always remember to use the machine properly? If the nurse spends 4 hours, his total expected costs equal \$5,000 + 0.99 x 500 x \$100 + 0.01 x 0.02 x 500 x \$100,000 = \$64,500. If the nurse spends 20 hours in training, his total expected costs equal \$25,000 + 1 x 500 x \$100 = \$75.000. In this example, the nurse will select a memory accurateness of 99% instead of 100%. Next we turn to the case of durable precaution.

2.2 Durable Precaution

We formalize accidents involving durable precautions as follows: during time period T, there is an expected number of critical moments N. In time period $T-1$ the potential injurer has to decide how much to invest in memory so that he will remember to take the durable precaution just before period T begins. The durable precaution will prevent damage for N critical moments in time period T.[12] A durable precaution requires the potential injurer to make an investment in memory for *one single precautionary measure* that takes place *just before* time period T; while a nondurable precaution requires that the investment cover *several precautions* that take place *during* time period T. Consider the following hypothetical example. A doctor must purchase the newest state-of-the-art dialysis machine for the upcoming year, and must remember to order it

[12] For simplicity and clarity we assume that these measures of durable precaution do not need to be supplemented with nondurable ones.

ahead of time.[13] The doctor therefore needs to make a memory investment to ensure that he will order the machine ahead of time, for instance, before year's end. Note that we simplified this example by stating that the injurer must take the precaution *just before* time period T, and that it is no longer possible to do so *during* time period T.

The *private cost function* of the injurer under a rule of negligence is[14]:

$$PC_d(c_d) = c_d + R_d(c_d)\cdot y^* + N\cdot[1 - R_d(c_d)]\cdot p(0)\cdot H \quad (5)$$

where c_d = the level of investment in memory, $R_d(c)$ = the probability that the potential injurer will remember to take precaution, with $R'd \succ 0$ and $R''d \prec 0$.

When the injurer makes an investment c_d in memory, he will remember to take precaution with the probability $R_d(c_d)$. The potential tortfeasor will take optimal care y^* when he remembers to take precaution. With probability 1-$R_d(c_d)$, he will forget to take precaution. In that case, for every critical moment (there are N in total) there is a chance of $p(0)$ that harm H will occur for which the injurer will have to pay the injured.

Again, the potential injurer will choose a level of investment in memory that minimizes his private cost function:

$$\begin{aligned} & PC'_d(c_d) = 0 \\ & \Leftrightarrow 1 + R_d{}'(c_d)\cdot y^* + N\cdot[-R'_d(c_d)\cdot p(0)\cdot H] = 0 \\ & \Leftrightarrow R_d{}'(c_d) = 1/[(N\cdot p(0)\cdot H) - y^*] \end{aligned} \quad (6)$$

2.3 Comparing durable and nondurable precaution

For durable precautions, we obtain the optimal level of investment in memory c_d* from:

$$Rd'(c_d) = 1/[N\cdot p(0)\cdot H - y^*]$$

For nondurable precautions, we obtain the optimal level of investment in memory c_{nd}* from:

$$Rnd'(c_{nd}) = 1/[N\cdot p(0)\cdot H - N\cdot x^*]$$

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[13] Such a dead line could exist, for instance, because the doctor's office is updating the computer system on the first day of the following year, and their current dialysis machine is incompatible and therefore must be purchased *before* the date.

[14] It follows from the classic model of negligence that the injurer will take optimal precaution when he remembers he has to take precaution.

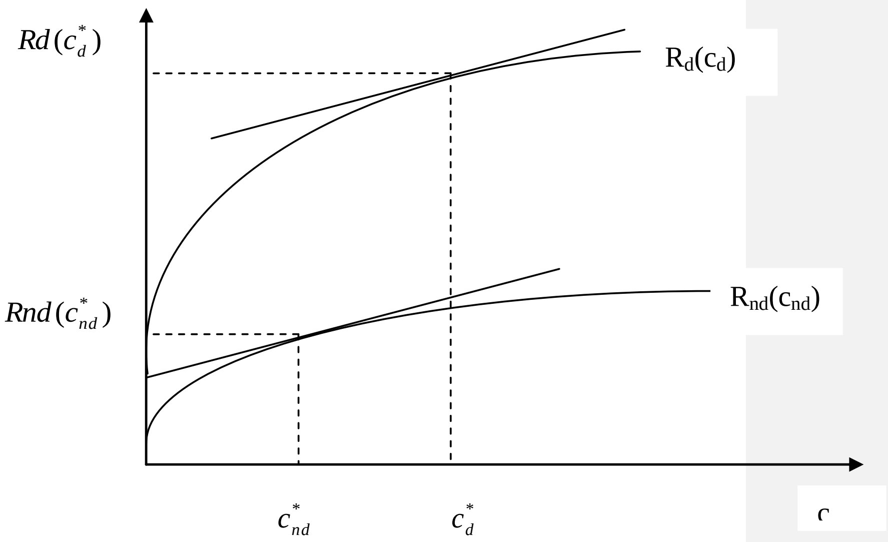
We will now compare the optimal levels of investment in memory for durable and nondurable precautions for three situations: (1) $N \cdot x^* = y^*$, *(2)* $N \cdot x^* > y^*$ and *(3)* $N \cdot x^* < y^*$. We will assume that $Rd(c) > Rnd(c)$ and that $Rd'(c) > Rnd'(c)$ for all c. These assumptions are likely to hold in many instances (see however section 2.4.4). Generally, it's easier (less costly) to remember something once, with a certain probability, than it is to remember it several times with the same probability. Also, it's easier (less costly) to remember something in the near future than it is to remember something in the future that is further away. An additional investment in memory will often have a larger effect for durable precautions than for nondurable ones, at any given level of current investment.

2.3.1. The total costs of prevention, short of the investments in memory, are the same ($N \cdot x^* = y^*$)

Now
$$\begin{aligned} Rd'(c_d^*) &= 1/\left[N \cdot p(0) \cdot H - y^*\right] \\ Rnd'(c_{nd}^*) &= 1/\left[N \cdot p(0) \cdot H - N \cdot x^*\right] = 1/\left[N \cdot p(0) \cdot H - y^*\right] \end{aligned} \quad (7)$$

Thus $Rd'(c_d^*) = Rnd'(c_{nd}^*)$

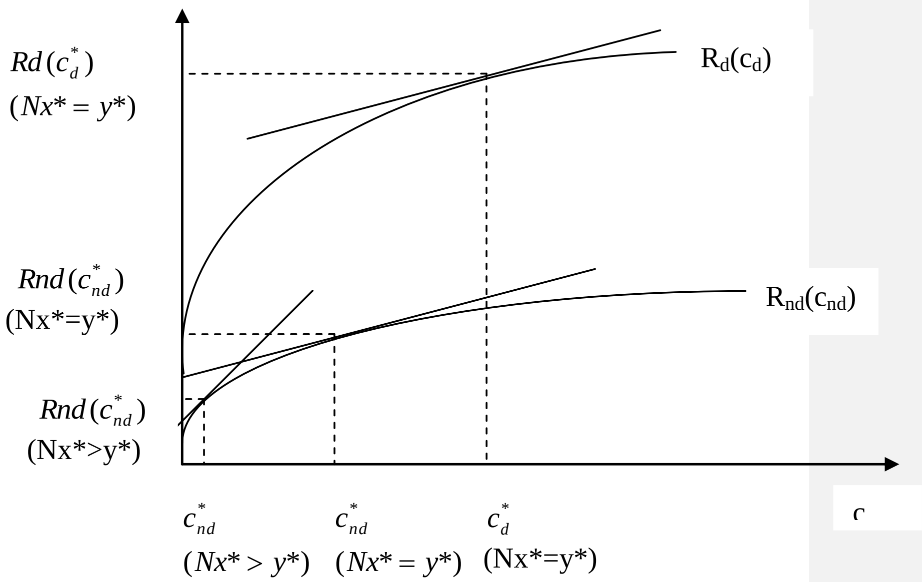
Given that $R' \succ 0$, $R'' \prec 0$ and $Rd'(c) \succ Rnd'(c)$ for all c, it follows that $cd^* \succ cnd^*$.



Because the level of investment in memory is higher for durable than it is for nondurable precaution (and given that $Rd(c) \succ Rnd(c)$), remembering to take durable precaution is more likely accomplished than remembering to take nondurable precaution.

2.3.2. The total costs of prevention, short of the investments in memory, are larger for nondurable precautions than for durable precautions ($N \cdot x^* > y^*$).

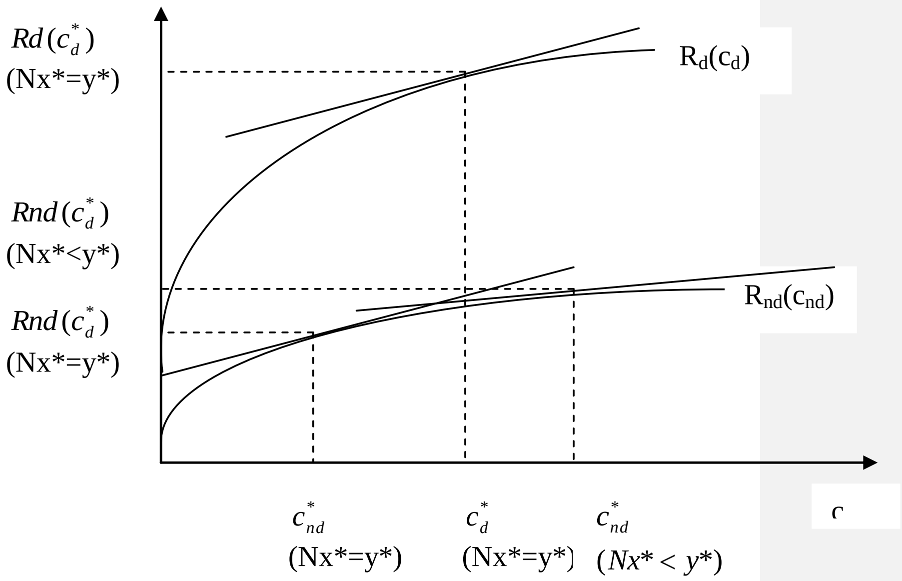
When $N \cdot x^* > y^*$, then $Rd'(c_d^*) < Rnd'(c_{nd}^*)$. Consequently, the level of investment in memory and the probability of remembering to take nondurable precautions is even smaller than in the previous case and thus smaller than for durable precautions (holding y* constant). The intuition behind this is simple: the costs that need to be made in case one remembers to take care become larger for nondurable precautions. It thus becomes less worthwile to remember to take care.



2.3.3. The total costs of prevention, short of the investments in memory, are smaller for nondurable precautions than for durable precautions ($N \cdot x^* < y^*$).[15]

When $N \cdot x^* < y^*$, then $Rd'\left(c_d^*\right) > Rnd'\left(c_{nd}^*\right)$. Consequently, the level of investment in memory and the probability of remembering to take nondurable precautions is larger than in the case in which $N \cdot x^* = y^*$ (holding y* constant). The level of investment and the probability of remembering can either be larger or smaller for nondurable precautions than for durable ones. The figure below is limited to only one of these situations: the investment in precaution is larger for nondurable precautions, but the probability of remembering is still lower.

[15] Note that if repeating a task leads to habit formation then the cost of performing the task can come down with time. In other words, there could be a negative relationship between N and the costs of precaution: as N increases, the costs of precaution may decrease.



2.4 Discussion and extensions

2.4.1. General

The model above shows that under several conditions the level of investment in memory will be higher for durable than for nondurable precaution; i.e. remembering to take durable precaution is more likely than remembering to take nondurable precaution. As a result, there will be more cases of negligence involving nondurable precautions than durable precautions.[16] Because, by

[16] Note that we have proven that there will be less negligence for durable precautions even under the worst-case scenario (the injurer has to remember to take his durable precaution *just before* period *T* starts). In reality, the injurer will often have a large amount of time during which he can remember to take his precaution (e.g. if he forgets on Monday, there is still a chance on Tuesday; if he forgets on Tuesday, there is still a chance on Wednesday, etc.). This means that for durable precautions, the injurer can remember to take precaution with almost certainty, by investing a very small amount in memory. In that sense, the model for durable precaution would resemble the classic model of negligence very well. Nondurable and durable

comparison, durable prevention technology has a relatively lower potential for liability from human error, the tort system encourages innovation[17] in durable precaution technology.[18]

But there are limits on the amount of direction that the tort system can impose on technological progress. First, some injurers do not have an economic incentive to invest in safety; either because there is no adequate reward or because they have rendered themselves immune from sanctions.[19] Second, and more fundamentally, technological innovation is only partially susceptible to external influence. Although it is widely recognized that market forces help shape the course of innovation,[20] scholars recognize that innovation also runs an independent course. Evidence in support of the theory of technological opportunity[21] suggests that markets often follow innovations, and not vice versa.[22] Accordingly, the tort system only has a limited ability to effectuate changes between durable and nondurable technologies.

This insight generates the following hypothesis regarding the interaction between the tort system and innovation: damage awards will accumulate at times when innovation introduces new risk-transferring technologies in the form of nondurable precautions, rather than durable precautions. In this sense, "tort explosions" may occur whenever innovation lags behind the demand of the tort system to create durable technology; i.e. tort awards trace the non-availability of some types of innovation (durable) after a more primitive innovation (nondurable) has transferred risk from nature to the (imperfect) control of man. This argument is to be contrasted with traditional theories of technological lag, which assign liability to the actor(s) responsible for not implementing readily available technologies that would have been safer and more effective under the circumstances.[23]

2.4.2. The choice between durable and nondurable precautions

In this section, we examine the choice by the potential injurer between durable and nondurable care technology. If the potential injurer decides to use nondurable care technology, his expected pay-off equals:

$$PC_{nd}(c^*_{nd}) = c^*_{nd} + N \cdot R_{nd}(c^*_{nd}) \cdot x^* + N \cdot \left(1 - R_{nd}\left(c^*_{nd}\right)\right) \cdot p(0) \cdot H$$

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precautions can thus be described, respectively, as memory-intensive and non-memory-intensive precautions.

[17] *See* Sage: "innovation that improves safety often happens in the shadow of liability." (cited in Hyman & Silver, 2005).

[18] In effect, by not forgiving human errors, which are more frequent when precaution technology involves nondurable compliance, courts encourage innovation in durable technologies. Grady, 1998: 302-310.

[19] On the former, see Hyman & Silver, 2005. On issues of judgment proof tortfeasors, *see* Lopucki, 1998.

[20] On the so-called *market pull theory*, see Schmookler, 1962.

[21] Schumpeter, 1934; Scherer, 1982.

[22] For a review of empirical studies, see Astebro & Dahlin, 2005.

[23] Grady,1988: 298 (with reference to Danzon, 1985)

If the potential injurer decides to use durable care technology, his expected pay-off equals:

$$PC_d(c_d^*) = c_d^* + R_d\left(c_d^*\right)\cdot y^* + N\cdot\left[1 - R_d\left(c_d^*\right)\right]\cdot p(0)\cdot H$$

A potential injurer will prefer to use durable over nondurable precaution technology if:

$$c_d^* + R_d\left(c_d^*\right)\cdot y^* + N\cdot\left[1 - R_d\left(c_d^*\right)\right]\cdot p(0)\cdot H <$$
$$c_{nd}^* + N\cdot R_{nd}(c_{nd}^*)\cdot x^* + N\cdot\left(1 - R_{nd}\left(c_{nd}^*\right)\right)\cdot p(0)\cdot H$$

If Nx*=y* or Nx*>y*, the total costs are always larger for nondurable precautions than for durable ones. We can see this as follows:

$$c_d^* + R_d\left(c_d^*\right)\cdot y^* + N\cdot\left[1 - R_d\left(c_d^*\right)\right]\cdot p(0)\cdot H =$$
$$c_d^* - R_d\left(c_d^*\right)\cdot (N.p(0).H - y^*) + N\cdot p(0)\cdot H <$$
$$c_d^* - R_d\left(c_{nd}^*\right)\cdot (N.p(0).H - y^*) + N\cdot p(0)\cdot H <$$
$$c_d^* - R_{nd}\left(c_{nd}^*\right)\cdot (N.p(0).H - y^*) + N\cdot p(0)\cdot H \leq$$
$$c_d^* - R_{nd}\left(c_{nd}^*\right)\cdot (N.p(0).H - N.x^*) + N\cdot p(0)\cdot H =$$
$$c_{nd}^* + N\cdot R_{nd}(c_{nd}^*)\cdot x^* + N\cdot\left(1 - R_{nd}\left(c_{nd}^*\right)\right)\cdot p(0)\cdot H$$

Note that there are several reasons why a potential injurer may decide to switch from nondurable to durable precaution technology. For example, the costs of remembering to take nondurable precaution may rise, for instance because of interference effects (see further). Also, the costs of nondurable precautions (x^*) may increase, or the costs of durable precautions (y^*) may decrease.[24]

[24] Many risk-dumping technologies are probably used on a large scale after their (often) initial high costs have dropped. As an example of risk-dumping technology, Grady (1988) mentions a buzzer in an aircraft that sounds when the pilot attempts a landing with the gear detracted, which reduces the losses from failures to maintain high compliance rates for nondurable precautions (manually checking gear status).

2.4.3. Activity levels

We have seen that the probability of remembering to take nondurable precautions is unambiguously smaller than the probability of remembering to take durable precautions when Nx*=y* or when Nx*>y*. Under these conditions, we should see more accidents when care is nondurable, given constant activity levels. However, the type of precaution (durable or nondurable) can influence the activity levels of potential tortfeasors. In the previous section, we have seen that when Nx*=y* or Nx*>y*, the total costs are always larger for nondurable precautions than for durable ones. The reason is of course that nondurable precautions have a disadvantage compared to durable precautions[25] (but see the next section). The consequence is that activity levels will be lower for nondurable precautions, and this reduces the total number of accidents.[26] As Grady (1988) notes, "when people realize that their reasonable memory lapses will also yield a legal penalty, it encourages them to avoid low-value activities".

2.4.4. Relaxing the assumption that $Rd(c) > Rnd(c)$

Repeating a task again and again may lead to greater familiarity with that task. In some situations, this could lead to a greater probability of remembering to take nondurable precautions than durable ones (for an identical level of investment).[27] More formally, it could be the case that $Rd(c) < Rnd(c)$. This could reverse some findings of the previous sections.

3 Technology & Tort Litigation

In this section we expand our basic model by including an analysis of the impact that technology has on the rate of tort litigation. First, we broaden the analysis by taking into account the existence of interference effects that occur when various cognitive tasks are combined (Section 3.1). Second, we compare the social costs of litigation in the context of nondurable versus durable precaution technology (Section 3.2). Finally, we consider the impact of harm-reducing technology on the rate of accidents and litigation (Section 3.3).

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[25] For any level of investment c, the probability of remembering is larger for durable precautions. When Nx*>y*, there are two disadvantages.

[26] When Nx*<y*, activity levels could be either smaller or larger under nondurable precautions than under durable ones. In this case, nondurable precautions have one advantage and one disadvantage compared to durable precautions.

[27] This could especially be the case if there's some feedback after each "critical moment" (or at least after some of these moments) when precaution is nondurable and if durable precautions can only be purchased, installed etc. at some limited points in time (so that any feedback effect for durable precautions would not have a direct effect).

3.1 Multitasking and Interference Effects

An essential characteristic of nondurable precaution technology is a high degree of multi-tasking. Nondurable precaution technologies often set out a number of tasks, and also commonly prescribe a specific sequence and/or timing of compliance measures.

A growing body of studies in cognitive science suggests that the costs of simultaneously processing different tasks are higher than typically assumed. For instance, studies on executive control document how individuals' reaction times are substantially slower and, usually, more prone to error when tasks are changed.[28] In the literature on cognitive control, such switch costs are attributed to the use of distinct components in the control processes of task-setting,[29] and to the occurrence of interference effects between the various tasks,[30] also known as dual task interference.[31]

These findings further suggest that the multitasking aspects of nondurable precaution will impose higher prevention costs.[32] Because interference effects exist between various measures of nondurable precaution, the costs of nondurable precautions in the defendants' other activities will rise due to the efforts required by the first task. For example, if a new dialysis machine requires a doctor to check up on it every ten minutes, it will become harder for her to remember to check up on another machine that also requires regular monitoring. The memory costs involved in remembering to check the first machine increase because the doctor needs to check the second machine as well. As such, interference effects increase overall potential liability.[33] By contrast however, liability from interference effects involving durable precaution technology will be more modest because of the low degree of multitasking

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[28] Interestingly, the costs from alternating tasks are reduced but not removed when individuals are given an opportunity to prepare (residual costs).

[29] Rogers & Monsell, 1995; Rubinstein, Meyer and Evans, 2001.

[30] Meuter & Allport, 1999. *See* also on inhibition effects Allport & Wylie, 1999.

[31] For a review, *see* Monsell, 2003. But *see* Heald (1993) on the process of "scripting". If a series of tasks are simply repeated over time, individuals develop cognitive patterns (so-called *scripts*) that significantly reduce the costs of remembering what is "scripted" (performance occurs in a semi-automatic fashion). Even though total memory costs are high (requiring an ex-ante investment), the marginal costs for nondurable precautions are almost zero once the script is in place. While we do not disagree with this finding, there are at least two reasons to assume that compliance costs of nondurable precautions are non-negligible even when considering the benevolent effects of scripting. First, findings in cognitive science demonstrate that memory costs are high whenever multi-tasking involves some amount of switching. The effect of scripting will be limited mostly to instances where little or no (ad hoc) alterations are required in the sequence or list of tasks. Second, in industries that have a high rate of innovation, the long run effects of scripting will be rather modest, given the regular introduction of new technologies and processes.

[32] Multitasking "requires capacities over and above the capacities required for the individual tasks". Miller, 1900, at p. 234.

[33] Note that with variable activity levels, the potential injurer may be induced to decrease his activity level when the interference among various tasks increases. This will reduce the number of accidents.

involved.[34] If a doctor simply needs to turn a machine on once, the costs of turning on another machine remain relatively static. This is because the durable act of turning a machine on is not as memory-intensive vis-à-vis regular monitoring.

3.2 Social and Private Costs of Litigation

If we consider interference effects as a major part of the compliance costs associated with nondurable precaution technology, tort litigation imposes two additional costs.

First, the potential for liability itself may generate an additional layer of interference. That is, the fear of litigation may exasperate interference effects and, consequently, induce more errors involving nondurable precaution. For instance, if a concern for medical malpractice forces a doctor to check up on a dialysis machine every ten minutes, it will become harder for her to remember to check up on another machine that must be monitored regularly. In this regard, the tort system imposes additional mental costs that interfere with existing processing tasks. Potential defendants become more cautious when completing a given task after tort liability has introduced a potential negligence claim toward that activity.

According to some commentators, tort law may increase mistakes and errors. For instance, in the field of medical malpractice, liability costs discourage error reporting and service improvements.[35] Interference effects provide a novel account of the correlation between liability and medical error: the fear of a lawsuit alone might induce additional mistakes. When rising liability costs increase cognitive costs and interference effects, compliance costs increase. Additional errors and mistakes will then give rise to added liabilities and will further sustain the initial interference effect imposed by the fear of liability. By contrast, litigation on durable precautions has a lower potential for interference effects due to the relative simplicity of durable precaution technologies. Even if liability is common with regard to a durable precaution, interference effects from potential liability will be modest because of the low degree of multitasking involved.

Second, multitasking and interference effects may increase the gap between the social and private costs of litigation. When considering the private costs of a lawsuit, a plaintiff does not consider the increase of prevention costs of other activities, as created by litigation. There thus may be too many lawsuits filed involving accidents.[36] As we illustrate more formally below, nondurable technology is more likely to induce socially excessive litigation than durable

[34] For instance, there is evidence that switching costs are substantial, even (and especially) when a switch is made to an easier task. *See* Allport & Wylie, 1999.

[35] For a review of this argument, and theoretical and empirical evidence to the contrary, *see* Hyman & Silver, 2005.

[36] Note that there may be a gap between the social and private costs of litigation, even if there is no interference cost. The memory cost itself is sufficient for the divergence between the social and private costs of litigation.

technology.[37] The potential for socially excessive litigation is higher with regard to nondurable precaution technology because of the additional multitasking and interference effects. By contrast, because of the lower degree of multitasking, durable precaution technology poses less risk of socially excessive litigation.

To illustrate this point, consider the following formal exposition. Under the classic model of negligence, there are no social costs of suing because injurers always take due care and consequently, victims never file; i.e. deterrence is achieved at no cost. When memory costs are considered, suing becomes possible under a negligence regime (see our model above in Section 2). We adopt Shavell's classic model (1982) on the difference between private and social incentives to sue, as follows:

The victim will sue if, and only if, $Cp < H$.

Suing becomes socially optimal when:[38]

$$[1 - R(c)] \cdot p(0) \cdot (Cp + Cd + Cs) + c + R(c) \cdot x + MOA\,(c) < [p(0) - [R(c) \cdot p(x) + (1 - R(c)) \cdot p(0)]] \cdot H \qquad (8)$$

where c denotes the investment in memory and x denotes the precaution expenditures that injurers will be induced to take if a suit is brought.

The left-hand side of the inequality represents the social cost of suing. It is necessary to distinguish between four terms. The first term, $[1 - R(c)] \cdot p(0) \cdot (Cp + Cd + Cs)$, represents the expected litigation costs of the parties and the State. The second term, c, equals the memory investment of the injurer. The third term, $R(c).x$, equals the cost of precaution, multiplied with the probability that the injurer will remember to take precaution. The last term, $MOA\,(c)$, represents the increase in memory costs, as created by the interference effects that are associated with the injurer's other activities.

The right-hand side of the inequality represents the social benefit of suing. The probability that harm will occur when the injurer invests c in memory and takes precaution x (instead of nothing) drops from $p(0)$ to $R(c) \cdot p(x) + (1 - R(c)) \cdot p(0)$: for an investment c, the injurer remembers to take precaution x with probability $R(c)$, in which case harm will occur with probability $p(x)$; the injurer forgets to take precaution with probability $1\text{-}R(c)$, in which case harm will occur with probability $p(0)$.

Holding everything else equal, an increase in c raises the memory-intensiveness of precautions. There are at least two reasons why suits will be socially less optimal when c rises. First, it becomes relatively more expensive to remember to take precautions. Second, a higher c leads to additional interference effects in relation to the other activities of the injurer. In other words, as c increases, the precaution costs of the injurer's other activities increase as well.

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[37] In the standard economic model, socially undesirable levels of litigation may occur when there is a gap between private and social incentives to sue (Shavell, 1982). Because a plaintiff does not take into account the deterrent effect of a lawsuit on the behavior of injurers, she will initiate too many or too few suits. When the private gains of litigation are larger than the social benefits, there will be a tendency towards excessive suits. When the social benefits are larger than the private gains, a socially inadequate amount of suits, for the purpose of deterrence, will be initiated.

[38] For the sake of simplicity, we assume that there is only one critical moment (N=1).

Litigation over failed acts of nondurable precaution will lead to higher social costs involving nondurable precaution technologies than durable ones. This holds true even if durable and nondurable precautions are equally costly and equally capable of reducing the probability of an accident. This point ties into the ongoing debate over socially excessive litigation where, according to some, high rates of litigation are causing defensive medicine, higher professional insurance fees, and an increase in costs of the health care system.[39] The distinction between durable and nondurable technology provides a novel way to approach this argument. Interference effects arising out of nondurable technologies might induce additional claims, resembling a self-sustaining effect on liability, without providing countervailing public benefits.

3.3 Harm Reducing Technology and Litigation Rates

Aside from preventing accidents, technology may also bring about significant reductions in the costs of those accidents that do occur. For instance, an advancement in injury treatment technology may substantially reduce the costs of harm *H* in the event of an accident. Ironically, such a cost savings in accidents may lead to an increase in the number of accidents, especially those involving nondurable technology. For instance, new technology that substantially reduces the harm caused by car accidents, may lead to lower levels of safe driving.[40]

Consider this point in the context of our model above. Intuitively, when the consequences of being held liable become less severe, conditions may become optimal for a potential injurer to invest less in remembering to take precautions. More formally, the net benefit of remembering to take precaution, p(0).H – x*, may become smaller when H becomes smaller.[41]~~Formally, the net benefit of remembering to take precaution equals *p*(0).*H* - *x** (which is always positive). We can see that *p*(0).*H* - *x** increases with a rise in the level of harm *H* (and decreases when *H* falls), because *p*(0).*H* is an increasing and linear function, while *x**(*H*) is an increasing but concave function: $dx^*/dH > 0$ and $d^2x^*/dH^2 < 0$.[42] In other words, when harm *H* decreases, there can be more negligence.~~

[39] For a review, *see* Danzon, 1995.

[40] Note that this is different from the general argument that new technology may increase negligence because of the higher availability of harm reducing technology (e.g., a doctor may forget to use an antiseptic that was previously unavailable). Grady, 1988.

[41] This is the case if p(0) < x*'(H).

[42] Note that we assume that p'''(x*) > $-\frac{2}{H}\frac{p''(x^*)}{\frac{dx^*}{dH}}$, since

$$\frac{d^2x^*}{dH^2} = -\frac{2}{H}\frac{dx^*}{dH} - \frac{p'''(x^*)}{p''(x^*)}\left(\frac{dx^*}{dH}\right)^2 .$$

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It is important to note that, although there may be more instances of negligence, new harm-reducing technology does not necessarily induce higher levels of tort litigation. Because such technology reduces the average amount of harm per accident, the ratio of trial costs to harm increases. Hence, an increase in accidents may be accompanied by a relative reduction in litigation, caused by the higher level of lawsuits with negative expected values.

4 Conclusions

Technological progress transfers risks by taking them out of nature and putting them into the hands of man. Such man-made control is relatively straightforward when technology prescribes one-time investments in precaution (durable precautions). However, complexity can arise in regard to other precaution measures, for which technology imposes multiple acts of foreseeing, complying, and/or remembering on the part of the potential injurer (nondurable precautions).

We provided a formal model demonstrating that accidents involving nondurable technology occur more frequently than those involving durable technology.[43] Moreover, the interference effects created by nondurable technology may induce additional claims, thus creating a self-sustaining effect on liability (Section 3.1) without any countervailing public benefits (Section 3.2).

The lack of attention paid to nondurable precautions in economic theories of tort law is in line with the courts' refusal to consider the increased compliance costs imposed by new technology. With only a handful of exceptions,[44] American courts have refused to excuse mistakes, confusion, and inadvertence when considering negligence in accidents (Grady, 1994). Of course, allowing such defenses would impose unreasonably high information costs on courts (everyone could argue that they "forgot" to take precaution) and also would, arguably, reduce the incentives to invest in durable precaution technology (Grady, 1988; Shavell, 2008). Yet, the reluctance of courts to consider the compliance costs resulting from nondurable technologies may well affect the evolution of tort awards. It is likely that we will see a rise in tort awards whenever technological progress is unable to substitute nondurable with durable technologies. Such liability pressure is likely to be valuable when the benefits of moving to durable technology can be achieved at low costs, or when there are significant accident costs stemming from nondurable technologies. On the other hand, whenever innovation is inelastic, tort-based incentives for innovation increase the costs of the tort system without providing countervailing benefits.

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[43] Except in some situations in which the total costs of prevention, short of the investments in memory, are smaller for nondurable precautions than for durable precautions.

[44] *See*, *e.g.*, Wittman, 1981.

References

[1] Allport, D.A. & Wylie, G. (2000), *Task-Switching, Stimulus-Response Bindings, and Negative Priming*, in S. Monsell & J. Driver (Eds.), CONTROL OF COGNITIVE PROCESSES: ATTENTION AND PERFORMANCE XVIII (pp. 357-376). Cambridge, MA: MIT Press.

[2] Astebro & Dahlin (2005), *Opportunity knocks*, RESEARCH POLICY 34, 1404-1418.

[3] Calabresi, G., THE COSTS OF ACCIDENTS (1970).

[4] Coase, R, *The Problem of Social Cost*, 3 J. L. & ECON. 1 (1960).

[5] Danzon, P. (1985), Medical Malpractice: Theory, Evidence and Public Policy.

[6] Dari-Mattiacci, Giuseppe and Parisi, Francesco, *The Economics of Tort Law*, in Backhaus, Jürgen G. (ed.) *Elgar Companion to Law and Economics* (2nd ed.), Ashgate: Edward Elgar, 87-102 (2005).

[7] Grady, M. (1988), *Why Are People Negligent? Technology, Nondurable Precautions, and the Medical Malpractice Explosion*, 82 NORTHWESTERN UNIVERSITY LAW REVIEW 293-334.

[8] Grady, M. (1994), *Reps Ipsa Loquitor and Compliance Error*, UNIVERSITY OF PENNSYLVANIA LAW REVIEW, Vol. 142 (3): 887.

[9] Heald Paul J., *Mindlessness and Nondurable Precautions*, GEORGIA LAW REVIEW, VOL. 27: 673 (1993).

[10] Hyman David A. & Charles Silver, Believing Six Improbable Things: Medical Malpractice and 'Legal Fear', HARVARD JOURNAL OF LAW AND PUBLIC POLICY, Vol. 28 (2004).

[11] Hyman David A. & Charles Silver, *The Poor State of Health Care Quality in the U.S.: Is Malpractice Liability Part of the Problem or Part of the Solution*, 90 CORNELL L. REV. 893-993 (2005).

[12] Demsetz, H.,*When Does The Rule of Liability Matter?*, JOURNAL OF LEGAL STUDIES .Vol. 1: 13 (1972).

[13] Kessler Daniel P. & McClellan Mark B., *Medical Malpractice: External Influence and Controls: The Effects of Malpractice Pressure and Liability Reforms on Physicians' Perceptions of Medical Care*, 60 LAW & CONTEMP. PROB. 81 (1997).

[14] Landes W. & R. Posner, THE ECONOMIC STRUCTURE OF TORT LAW (1987).

[15] Meuter R.F.I. & Allport D.A., *Bilingual Language-Switching and Naming: Asymmetric Costs of Language Selection*, 40 JOURNAL OF MEMORY & LANGUAGE 25-40 (1999).

[16] Monsell, Stephen, *Task Switching*, 7(3) TRENDS IN COGNITIVE SCIENCES 134-140 (2003).

[17] Nussim, Y. & Tabbach A.D. (2009), *A Revised Model of Unilateral Accidents*, INTERNATIONAL REVIEW OF LAW AND ECONOMICS, VOL. 29, ISSUE 2, 169-177.

[18] Rogers, R.D. & Monsell, S. (1995), *Costs of a Predictable Switch between Simple Cognitive Tasks*, 124 JOURNAL OF EXPERIMENTAL PSYCHOLOGY: GENERAL, 207-231.

[19] Rubinstein, J.S., Meyer, D.E. & Evans, J.E. (2001), *Executive Control of Cognitive Processes in Task Switching*, 27 JOURNAL OF EXPERIMENTAL PSYCHOLOGY: GENERAL, 763-797.

[20] Shavell, S. (1982), *The Social versus the Private Incentive to Bring Suit in a Costly Legal System*, 11 J. LEGAL STUD. 333.

[21] Shavell, S., ECONOMICS AND LIABILITY FOR ACCIDENTS, NEW PALGRAVE DICTIONARY OF ECONOMICS, 2nd Edition, (2008).

[22] Scherer, F. M. (1982), *Demand-pull and Technological Opportunity: Schmookler Revisited*, JOURNAL OF INDUSTRIAL ECONOMICS, 30, 225-37.

[23] Schmookler, Jacob (1962), *Economic Sources of Inventive Activity*, THE JOURNAL OF ECONOMIC HISTORY, 22, Nr. 1, pp. 1-20.

[24] Schumpeter, J. A. (1934), THE THEORY OF ECONOMIC DEVELOPMENT.

[25] Wittman, Donald (1981), *Optimal Pricing of Sequential Inputs: Last Clear Chance, Mitigation of Damages, and Related Doctrines in the Law*, *The Journal of Legal Studies*, Vol. 10, No. 1, pp. 65-91

[26] Wylie, G. & Allport D.A. (2000), *Task Switching and the Measurement of "Switch Costs"*, 63 PSYCHOLOGICAL RESEARCH 212-233.