On Causal Apportioning and Efficiency in Tort Law

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Abstract

Mainstream economic analysis of Tort Law assumes that efficiency cannot be formally assured by allocating liability according to causal apportioning. In this paper we will present some ways to escape from the full scope of this claim. We start by reviewing the standard conception of causality in the economic analysis of Tort Law, to show how some underlying assumptions influence the currently held view on the relation between causal apportioning and efficiency. Then, we revisit those assumptions to see how plausible they actually are. In the light of this discussion we introduce an alternative framework of causal reasoning in Tort Law. We will show how our model yields a way of allocating liability in terms of a causal apportioning rule. The outcomes obtained through this procedure are closer to efficiency than those prescribed by the mainstream.

1. Introduction

As science historians know too well, scientific disciplines have to face, at some stages, shocking realizations. The past century, for instance, amidst uncountable novelties, exhibited a surprising number of *pessimism-inducing* results in many areas. While seemingly coordinated in time, they were not related to each other, at least in principle. But all of them went against the accepted wisdom of past eras, in which it seemed that exactness and all-encompassing knowledge were attainable. Among these results the best known are Gödel and Turing's theorems in meta-mathematics and Heisenberg's uncertainty principle in quantum mechanics. On the other hand, Arrow's and Sen's theorems in economics challenged the previous wishful and soothing assumptions on the inner workings of human societies.

A similar kind of underlying pessimistic conclusions can be found in modest instances. This is the case of the economic analysis of causation in Tort Law. In spite of the scarce literature on the matter, the claim that *efficiency cannot be formally assured by allocating liability according to causal apportioning* is still the dominant view in the field. As in the aforementioned cases, this conclusion is loaded with negative overtones. It is the purpose of this paper to discuss some ways to escape from the full scope of this claim and the plausibility of its underpinings. In the next section we will review the standard analysis of causality in the economic analysis of Tort Law, in order to show how it influences the current view on the relation between causal apportioning and efficiency. In section 3, we will revisit the ideas of the mainstream to see how plausible they actually are. In the light of this discussion we will introduce an alternative framework of causal reasoning in Tort Law. In section 4, we will show that our alternative model leads to a different conception of efficiency

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in causal apportioning. We will prove, in particular, that there exist a way to allocate liability according to causal apportioning that leads to outcomes that are closer to efficiency than those prescribed by the mainstream. Moreover, we will sketch a kind of decision algorithm for this matter. Finally, we will briefly explore whether this procedure actually goes along with more traditional legal ideas as well as with current philosophical developments in the area.

2. The Standard View

It has been frequently claimed that mainstream Law & Economics disregards the role of causal relations in torts, at least in the usual sense of the traditional legal scholarship. The main reason of this failure seems to hinge on the normative core of the approach, aimed to seek efficiency. So, for Law and Economics the very idea of *cause* would become reduced just to *efficient prevention*. This characterization of causation has been labeled *causal minimalism.*

Calabresi (1970) and later Landes and Posner (1983, 1987) have stated that causation does not play a role in imposing liability. More precisely, for them causality does not play an independent role in the determination of liability and the causation of an injury should be always attributed to the injurer if she has the lower cost of avoidance. This position is summarized in the following claim: *When efficiency analysis is conducted to determine liability, it can be fully pursued without reference to causation*.

Seminal formal models of agents' behavior in the face of an injury (Brown, 1973; Shavell, 1980) also postulate symmetry among the roles of the injurer and the victim and the absence of any independent requirement of causation. As it is well-known, these models have set the benchmark for subsequent economic analyses of Tort Law in which the expected harm is seen as a function of the levels of care taken by both parties. The actions of either one (or both) agents raise the probability of harm and thus can be seen as causes of an expected harm.

Shavell (1980, 1987) has given the explicit characterization of the causal relations involved in tort events. He states that care (or lack of care) is a necessary cause of harm if, given some state of the world, a different level of care would have led to a different level of expected harm. For an action A to raise the probability of harm relative to another action B, there must be a state of the world in which harm occurs *only if A* is taken, and not if the other action B is taken.

Parisi and Fon (2004)[3] make the following claim on the kind of causal inputs that can be found in torts:...*As has been extensively debated in the literature, each party's causal input should not be evaluated in isolation, since in some cases both inputs affect causation of an accident additively, while in other cases they do so multiplicatively, or a mix thereof.*[4] Following the standard line of thought on causality, Parisi and Fon (2004) present a formal model of *comparative causation*. They postulate a rule in which liability is borne on the basis of parties' respective causal contribution to the loss. They define the welfare functions of both parties, $w^i\ (z, x)$ and $w^v\ (u, y)$, where i is the injurer and v the victim. The first one

[3] Summarizing the views of Landes and Posner (1983), Rizzo and Arnold (1980, 1986), Kaye and Aickin (1984), Wright (1985), and Kruskal (1986).

[4] There exists a class of cases in which the causal effects are just additive. Then, it becomes easy to apportion liability upon the amount of causation. Strassfeld (1992) notices that those additive cases help the courts to determine feasible shares of liabilities.

represents the injurer's expected income from undertaking an activity level z with a level of care x while $w^v(u, y)$ is the welfare function of the victim where u is her activity level and y her level of care. Increasing care is costly and leads to decreasing benefits. Moreover, it is assumed that both $w^i(.,x)$ and $w^v(.,y)$ are strictly concave in x and y, respectively.[5]

In turn, let $l(x, y)$ be the expected loss per unit of activity, determined by the levels of care of both parties, and assume it is decreasing and strictly convex in each variable.[6] Since the loss is proportional to the level of activity of both parties, the total loss is assumed to be $zul(x, y)$.

According to these different effects, Parisi and Fon (2004) derive the individual causal contributions to the accident, $c^i(z, x)$ and $c^v(u, y)$. They postulate that $c_z^i, c_u^v > 0$ while $c_x^i,\ c_y^v < 0$. This means that, on one hand, a decreasing level of activity of either party leads to a lower corresponding causal contribution to the resulting loss. On the other, an increase of care by an agent has the contrary effect on the expected damages.

They illustrate their claim with two kinds of cases, one in which causal inputs are *complements* and the other where they are *substitutes*. Causal complementarity is represented by a multiplicative causal relationship: the overall causation factor is given by the product of the causal inputs of both parties: $c_i(z, x)c_v(u, y)$. The case of causal substitutability, instead, is captured by means of an additive relationship: the overall causation factor is given by the sum of the causal inputs $c_i(z, x)+c_v(u, y)$. In both cases, the causation factor operates as a normalized index that is multiplied by the total damage. In each of these cases, parties do not fully internalize the effect of their actions, and have, therefore, incentives to engage in an excessive level of activity.

Later on, Parisi and Singh (2010) analyze the efficiency of comparative causation under negligence rule and show that possess some desirable properties. Under the rule both the parties will always choose at least the due level of care or more and so induce at least efficient care as well as equitable distribution of accident loss. However, is unable to create optimal activity level incentives for both parties, but create incentives to moderate their activity levels and increase R&D so as to reduce the expected accident loss.

Putting the emphasis on empirical conditions, Carbonara et al. (2014) set up a bilateral tort model to identify the conditions under which loss-sharing among parties may be desirable in non-negligent accidents unpacking the cheapest-cost-avoider principle into a number of sub-principles. They find that the choice between liability rules depends on a number of factors, which include the riskiness and the value of the activities, the interaction in the production of risk and the return to scale from de activities.

All in all, the oldest work still exhibits the standard point of view in the discipline: The imposition of liability on the basis of pure causal contributions is deemed at least problematic to achieve efficiency. Moreover, the very interaction of causal relations is seen as an obstacle in the path towards the efficient allocation of liabilities whatever the rule in forece. Accordingly, the solutions to that problem are based on strategies that either supposedly disregards the real world causal relations (Singh 2002)[7] or supplement the rule of causal apportionment with non-causal ingredients.[8]

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[5] That is, if $w^i\ (.,x)$ and $w^v\ (.,y)$ wv(·, y) are continuous and twice differentiable, then $w_x^i, w_{xx}^i < 0$ and $w_y^v, w_{yy}^v < 0$.

[6] If $l(x, y)$ is continuous and twice differentiable in x and y, then $l_x\ , l_y < 0$ and $l_{xx}\ , l_{yy} > 0$.

[7] *"...in these studies the term 'cause' does not have any meaning beyond economic (in)efficiency..."*.

[8] Negligence for instance, as an autonomous rule.

3. Towards an Alternative Framework

As said above, Parisi and Fon's model -as the literature generally does stems from an intuitive idea of causation, which is formally described by Shavell (1987:119) as follows:

Definition of necessary causation: *given the state of the world s, taking level of care x_1 is a necessary cause of losses $l(x_1, s)$ relative to taking level of care x_2 if $l(x_1, s) \neq l(x_2, s)$.*

We will focus precisely on this starting point. As it has been said, Law and Economics has usually been called *minimalist* in relation to its approach to tort causation. In some sense, this adjective is used to mean that only a minimal trait is required by Law and Economics scholars to deem a factor as *causally eligible*, in order to satisfy efficiency. In general, the property of being a *necessary cause* is the only one required by the mainstream to qualify an action (or, in turn, and generally speaking, an event) as the cause of a certain harm.

Shavell's characterization of necessary causation is, however, rather unorthodox in terms of causal scholarship. For one thing, it leaves room for ambiguity. The same formula $l(x_1, s) \neq l(x_2, s)$, with $l^1 = l\ (x_1, s)$ and $l^2 = l\ (x_2, s)$, might be understood as defining x_2 as a standard *sufficient* condition of l^2 as well as defining x_1 as a standard *necessary* condition of l^1. To see this, consider the following example. Let x_1 be the event *greeting your neighbor* while x_2 is understood as *shooting your neighbor*. Then, l^1 implies a null loss (corresponding to a state of the world in which your neighbor keeps being alive) while l^2 involves a positive loss (all other things being equal, your neighbor is no longer alive). But then, it does not make much sense to see *greeting your neighbor* (x_1) as a necessary condition of the life preservation of your neighbor. On the other hand, it is sensible to say that *shooting your neighbor* (x_2) is, in general terms, a sufficient condition for her death.

In fact, the characterization of necessary conditions can be presented more clearly in terms of formal logic than by algebraic conditions. The propositional formula $\neg q \rightarrow \neg p$ captures the idea that q is a necessary condition of p. In terms of truth valuations the meaning of this formula is that *the falseness of q guarantees the falseness of p*.[9]

Moreover, the very notion of *necessary condition* in the field of Tort Law is, as in the general realm of causation, by itself ambiguous. *Being shot* is not strictly *necessary* for the result *death*, because death will take place even in the absence of that event. It is not also sufficient, because the same shot could have not led to death if some slight variation of exogenous conditions had been present. *Necessary*, in this context, would only be correct if interpreted as *necessary in the circumstances*, what is something altogether different from the logical idea of *necessary condition*. Aware of that, philosophers and philosophers of law have introduced more precise and refined concepts, like the notions of INUS (*insufficient but non-redundant part of an unnecessary but sufficient condition*)[10] and, particularly, NESS (*necessary element of a sufficient set*)[11] conditions. By means of them, the role of individual

[9] As it is well known, this way of expressing these kinds of relations is not free from problems and criticisms. See the entry on *Necessary and Sufficient Conditions*, in The Stanford Encyclopedia of Philosophy, http://plato.stanford.edu/entries/necessary-sufficient/.

[10] Mackie fathered the term, first suggested to him by Stove. See Mackie (1980), pp. 62, note 5.

[11] The so-called *NESS test* was originally suggested by Hart and Honoré (1985). See also Wright (1985).

events in the causation of torts can be more precisely described. Accordingly, we will assume from now on that the NESS category captures the essence of causal conditions better than *necessary*, *but-for* and other somehow related kind of concepts or denominations.

In fact, legal scholars like Wright (1985, 1988) strongly advocate for the practical use of the NESS test (i.e., checking if the candidate is a necessary element of a set, being this set *as a whole*, necessary for the focused result) over the *but-for* one, even as the only guideline on how to detect *genuine* causality in the field.

This, on the one hand, is a gain in precision, for the *NESS* category avoids the aforementioned ambiguity involved in *but for*. However, it conveys, on the other, a definite proposal of legal policy, advocating for the usage of commonsense criteria of causation over any aim-oriented procedure. The latter is notwithstanding problematic as it assumes that commonsense criteria are either free from implicit aim-orientations or if they are not, only their very orientations would have accounted for legal purposes. Hence, there does not exist a full consensus on the role of the NESS test and its relation with causal inquiries. Other scholars claim (against Wright's proposition) either that the NESS test is only the first step in a complex procedure or that the usual stages in causal inquiries in Tort Law, namely the quests for the *actual* and the *proximate* causes of a harm, are just cover-ups for legal policy decisions on liability.

The re-examination of the usual examples in the Law and Economics literature can show clearly that the way in which the usual expressions (acts, omissions, events, etc.) are related to torts might also be captured by employing the notion of NESS conditions. So, the NESS test, as the first step of a complex procedure, yields a semantically gain without any loss indeed. That is, the search for causal allocations of liability can begin by checking whether or not a causal-candidate factor is a NESS condition, but then it has to move forward to the selection of those of them that also are efficient.

In formal terms, the NESS test can be re-interpreted as a preliminary procedure intended to find *eligible* causal factors (Mackie, 1980) to individual harms. However, only if, additionally, their contribution is consistent with our goal, a factor can be deemed a legal cause.

A digression is on point here. We do not agree with the usual viewpoints that either complaint about or are satisfied with standard Law and Economics strategies for transforming the *proper*, *original* or *commonsense* meaning of *causality* in an unorthodox way. We assume, instead, that if the NESS requirement holds for some elements, almost any goal-oriented screening procedure among them should be legitimately regarded as an orthodox causal inquiry (Acciarri, 2009). We will not debate this proposition in detail in this paper. Nevertheless, we will present some examples of usual causal reasoning in order to illustrate the point.

Still, an additional challenge remains. Usual causal quests tend to choose *causes* in the sense of *picking some individual factors* (events, states, etc.) *and discarding others*. Whatever the method employed to make this choice, its result ends up being a *discrete* determination -any element that is a certified NESS condition will become deemed either a *cause* or a *no-cause* of a certain consequence. Then, we may conclude that seeing causal inputs as continuous variables alters the meaning of causal relationships. Nevertheless, taking them to be so fits properly into the economic theory of torts. This is only apparently a paradox.

Notice that we do not equate the fact of *being a causally eligible factor* of certain harm with *making a quantifiable causal contribution* to the same outcome. The NESS test determines the quality of being a causally eligible factor and checking that quality (i.e., passing the NESS test) is a pre-causal determination. This first step of the procedure is made on logical and discrete basis.

Among the NESS conditions of harm, we select a sub-set of elements on the basis of their causal influence (represented, at this stage, by real numbers) in light of efficiency.

To summarize, our procedure undergoes the following stages:

• *Stage 1*: find the factors that pass the NESS test for the harm. This describes a class C^{NESS}.

• *Stage 2:* define, among the elements that passed the first stage, a sub-set of *legal causes* as $C^C = \{c \in C^{NESS}: c > 0\}$ (each $c \in C^C$is seen as a real variable). For simplicity´s sake, we will find only a set of two causal factors, one of them depending on the victim and the other of another person, deemed the *injurer*. It is important to notice that the quality of *injurer* itself is, in our model, defined on the basis of this procedure and it is not regarded as exogenous. Most of our developments apply also to multiple injurers frameworks but that issue is out of the range of this paper.

• *Stage 3:* allocate liability between $c \in C^C$ (i.e., between victim and injurer) according to their respective causal contribution.

Stage 1, as seen, is a logical test. A causal factor (event, omission) is a NESS condition if and only if.

~~The NESS test can be presented as follows. Given a class of n potential causal factors $C = \{C_k\}_{k=1}^{n}$ of an event E, a particular factor $\bar{C}$ is NESS if and only if, C is a sufficient cause of E (i.e. E would have occurred as long as C occurred), then $\bar{C} \in C$ and $C \backslash \{\bar{C}\}$could not be a sufficient cause of.~~

The NESS ~~(necessary element of a sufficient set of causes)~~ test can be presented as follows. Given a class of n potential causes $C = \{C_k\}_{k=1}^{n}$ of an event E, a particular $\bar{C}$ is NESS if and only if, C is a sufficient cause of E (i.e. E would have occurred as long as C occurred), then$\bar{C} \in C$ and $C \backslash \{\bar{C}\}$could not be a sufficient cause of E .

In the case that $E \equiv h$ (the harm) and C is the class of the potential causal factors of harm, $\bar{C} \equiv f_i$ is a legal causal factor under the control of agent i, the *injurer*, as long as

1. f_i passes the NESS test (i.e. without its contribution the harm would not have happened), and
2. i is different from the victim and can potentially exert the causal input f_i^* such that joint with a causal input of the victim, f_v^* , minimizes $f_k + f_v + l(f_v, f_k, s)$ for any f_k in C .

Stage 2, as seen, involves a kind of screening different from stage 1. Among all the NESS factors, we will choose one depending on the victim (again, only for the sake of simplicity) and another which completes the optimal binary set of causal inputs, which defines the quality of *injurer*. This assumption is crucial, for instance, to select an injurer out of multiple agents who omitted to take precautions. It is, obviously, a counterfactual determination: we will qualify as *injurer* only the agent who *is able* to exert the optimal causal input (given the victim´s optimal one) either if it has been actually exerted or if a different course of action has been taken.

In further paragraphs we will describe in more detail the screening process involved in the second stage. Then, we will mostly concentrate on the third stage of the procedure.

4. Revisiting the Canonical Framework

While the main focus of this paper is on the analysis of causal apportioning, this may be seen as a subsidiary issue of a broader subject matter: a general economic theory of causation in tort law (Acciarri, 2009). Although its full development exceeds the scope of this work, some of the main goals for such theory are the following:

• To provide an account of the general notions of causal reasoning.

• To elaborate a thorough view of its subject matter, adequate to the usual concepts of causal reasoning specific to the legal field. At least for the instances in which legal causal reasoning is seen as a particular case of general causal reasoning.

• To provide means to distinguish among all the events in the world, those that could be regarded either as legal causes or non-causes of harms.

• To yield analytical tools that assign liability on the basis of legal causes with the aim of achieving economic efficiency.

• To focus on causal apportioning, as a way to determine how to split liability, according to the purpose of the analysis, among the agents.

As it was shown above, usual criticisms from the legal camp point basically at the second item, blaming the standard economic analysis for giving a misrepresentation of the actual role of causal relations in Tort Law. Authors on the economic side, in turn, often implicitly, accept this contention assuming that causation has a different meaning than in the legal field (Singh, 2002).

On the other hand, the economic analysis of law faces a major problem in dealing with the third goal. By assuming that omissions could also be considered legal causes, Shavell's (1987) algebraic characterization of *necessary* ~~*cause*~~ *condition* as equal to *legal cause*, yields an almost infinite number of *legal causes* due to the omissions of many agents. Worse yet, in the usual analyses the legal causes are seen as given. Procedural positions (plaintiff, defendant) are equaled to ~~substantial~~ substantive ones (victim, injurer) although no strict correspondence between both categories exists. Clearly, a plaintiff must be either a victim (of her defendant) or not and, correlatively, a defendant must be either an injurer (of her victim) or not. The causal issue, precisely, plays a central part in this determination. It is easy to see that the defendant would be the injurer of her plaintiff if and only if she caused (in a legally relevant sense) harm to her victim. Only recently (Salvador Coderch et. al., 2004) the mainstream theory has been refined in order to deal with this difficulty.

Finally, modern theoretical developments have also dealt with the fourth and fifth goals (Singh, 2002; Parisi and Fon, 2004 y 2010; Carbonara et al., 2014). Nonetheless, up to some extent, and deliberately or not, they disregard some of the first three issues.

In the rest of this section we will sketch a theoretical framework aimed to accomplish the objectives enumerated above. Far from trying to prove here that our theoretical sketch captures every one of the goals, we will only suggest a seemingly coherence with them. Moreover, our focus will be on analyzing a simple procedure to deal at the same time with the third, fourth and fifth of those goals. We will suggest some simple features that could make a theory of causation in Tort Law ~~*probably*~~ ~~consistent~~*compatible* with our first and second goals and would encompass some modern developments intended to deal with the rest of them in a coherent apparatus. This framework may also show that some sort of apportioning of liability on the basis of causal contribution can yield allocations much closer to efficiency than it was usually believed possible. This can be done in ways less tributary of non-causal ingredients. Moreover, we will suggest that this is possible without any significant redefinition of traditional legal procedures and respecting the usual philosophical concepts on this matter. In addition, our formal procedure will apportion liability on causal basis by generating an efficient and unique Nash Equilibrium outcome. It will also apportion the loss in excess over the efficient outcome, between inefficient-behaving parties in a locally efficient way.

As it is well known, instead of the one-step approach that characterizes the standard economic strategy of relating a contributing factor to harm, most legal systems apply a two-step ~~approach~~one[12]. This procedure undergoes two conceptually distinguishable phases. The first ~~one~~ checks whether a candidate causal factor is a NESS condition of the harm.[13] The procedure enters the second phase once the first one yields a positive answer. It only intends to verify whether the candidate factor, verifying a NESS condition, makes a positive contribution to the harm.

This kind of approach may also be employed to find causes and consequences in everyday life. However, exploring this possibility is far beyond the scope of this paper. Nonetheless, we will try to show that this kind of two-step approach, being closer to usual commonsense and legal purposes, might also be an analytical tool more consistent with the goal of detecting efficiency than the one usually employed by Law and Economics scholars.

Let us start by exploring the essence of the first step. As suggested above, to avoid the ambiguity of natural language, we will rely, explicitly, on a procedure that checks whether or not a candidate factor is a NESS condition of certain harm. We loosely conceive as *factors* many different entities, like states, (positive or negative ones) events, facts, etc., as to cover the various uses of the expression in legal matters. So, for instance, the state of *being alive* will be as much a NESS condition of the death of a person as the event of *shooting the victim*.

For our purposes, this first step does not define anything else but the quality or property of being a NESS condition. However, this, as said, only makes a factor a potentially causally eligible one to tort law purposes. As shown in the aforementioned example, *shooting the (would-be) victim* fulfills this requirement, so, we can claim that this event contributed, in this sense, to the death of the victim. Nonetheless, up to this point, we cannot claim that this or any other factor (as *being the victim alive*) made a positive contribution, *in the usual quantitative sense of Law and Economics*, to the harm suffered by the victim. Each of these factors is individually necessary to complete a set of joint factors that is sufficient to bring about the harm, but no one of them has, so far, any quantifiable participation in the causation.

As we said above, this first step may be common to any situation in which causes for something are sought. The next step, however, is less generally applied (and yields less neutral results) when other goals are pursued. If we were asked about the cause of a plane crash we could easily identify the gravity pull of Earth and the failure of a turbine, among others, as NESS conditions (and so, be considered potentially causally eligible factors). But we will rarely mention both conditions as causes in the same footing. As an illustration of how gravity acts on objects, a plane crash shows what it can *cause*. But, instead, in an accident report the emphasis would be on the turbine failure as the *cause* of the plane crash.

The difference exhibited in these examples is not just a matter of information. What matters, when something is deemed a cause of some event, is fundamentally the goal of the

[12] The expression *two-step approach* is the usual name of a category generally assumed by mainstream European scholars. This kind of approach is said to be also a trend in American Law. See Schwartz (2000). The two-step approach described in this paper, however, differs from the one described by Salvador-Coderch et al. (2004). Nonetheless, both are complementary: while they emphasize on the scope of liability (an issue intentionally disregarded in this paper), we focus on the apportionment of liability.

[13] In legal terms this involves to check whether it fulfills *but-for, actual cause, cause in fact* or similar conditions.

inquiry. Consequently, if we were pursuing the goal of allocating efficiently liabilities, we would choose among the already selected factors, in the way that best suits our efficiency-oriented inquiry. Once the choice is made, the resulting factors are the ones we will actually indict as (legal) *causes*.

At this point, a clash of intuitions seems to be involved in the procedure. On one hand, as said, the choice of causally eligible factors (NESS factors) described above is *discrete*. On the other, we seek to assign to each of those that will be actually chosen as causes a *proportion*. That is, treat their causal influence as a *continue variable*. In fact, there is no real contradiction. Both steps are clearly distinguishable and the differences between one and the other are neat. Again, the example with other causality-seeking fields is useful. Physicists analyzing complex real world phenomena select some potentially causing factors and then quantify the amount that each of them contributes to the overall behavior. In this case the same is true. Commonsense inquiries usually operate in a similar way. We can name a few factors (say, a strong wind or the lack of maintenance) as causes of an event (the collapse of an old wall), but will consider some as more important than the others. If we were asked, we would be willing to attribute *a higher proportion in the causation* to them.

To show with a little bit of formal notation how this two-step approach operates, let $\{f_k\}$ be a family of NESS conditions and thus, causally eligible factors of harm $l(.,s)$, being only one of them, f_v , in control of the victim. Furthermore, assume that the legal decision maker picks f_i and f_v (and not others) as legal causal factors of $l(.,s)$ in order to reach an efficient allocation. Then, any other f_k is not seen as eligible for this purpose and is straightforwardly deemed a non-causal factor of $l(.,s)$, in legal terms. We consider a state of the world s and a combination of conditions that optimize the sum of causal contributions and the loss that arises from the harm $l(.,s)$.

Employing vectors enumerating the possible actions (and omissions) by the agents is a choice of representation intended to capture both the basis of causal reasoning as well as the usual way of running economic analyses in the field. *Causal inputs* represented in these vectors, then, involve all the dimensions of the influence of an agent on the consequent harms. So, we can associate a real number to each single action in order to denote the cost of lowering that influence. Hence $f_i, f_v \geq 0$. That cost encompasses the burden of the precaution (this term, in its usual sense) taken to perform the action and the cost of decreasing the level of activity to a certain point. Parisi and Fon (2004) against Landes and Posner (1987: 70-71) and Gilles (1992), -who suggest that courts take into account activity levels in their assessment of negligence whenever it is feasible to do so-, claim that no threshold of *optimal activity level* is generally invoked by legal rules as a liability allocation mechanism, accounting for the difficulty of pinpointing a critical value separating efficient from inefficient activity levels. So, they claim, *absent such critical threshold, no discontinuity in the parties' expected liability can be created*.

Activity level is employed as a component of causal inputs. Yet it remains the difficulty for the court to observe the actual level of activity. But this, rather unavoidable feature of reality is not an obstacle for our analysis: Many dimensions of negligence are plainly unobservable (e.g., how focused was a driver on the road) and some straightforward manifestations of the level of activity, on the contrary, are clearly apparent (e.g., the quantity of liquid transported by a pipeline). So, in our model, the difficulty to observe activity levels in some actual cases as well as some dimensions of precaution is not a *formal* constraint.

Let us analyze the situation as a game between the injurer i and the victim v. Their choices will be their respective causal inputs. More formally, agent $k = i, v$ chooses f_k as to minimize her costs, which will be determined by an assignation rule that allocates cost according to the roles of the parties in the causation of damage. This rule takes a reference level, a profile (f_i^*, f_v^*) of causal inputs that minimize the social cost at state s $C_s(f_i, f_v, s) = f_i + f_v + l(f_i, f_v, s)$, where l, the loss function is monotonic as to ensure that (f_i^*, f_v^*) is unique.

With these provisos, under strict liability the cost of loss is assigned to i and v according to the following rule[14]:

- If $f_v \geq f_v^*$ then $l(f_i, f_v, s)$ is fully assigned to i .
- If $f_v < f_v^*$ while $f_i \geq f_i^*$, $l(f_i^*, f_v^*, s)$–, denoted l^*, is assigned to i and $\Delta l = l(f_i, f_v, s) - l^*$, to v. When $f_i < f_i^*$ while $f_v \geq f_v^*$ both l^* and Δl are assigned to i, i.e. the full loss $l(f_i, f_v, s)$ is assigned to i.[HAA1]
- Finally, if $f_i < f_i^*$ and $f_v < f_v^*$, the social cost is adjudicated as follows. l^* is assigned directly to i while Δl is partitioned in three fragments:

$$\Delta l = (f_i^* - f_i) + (f_v^* - f_v) + \Delta C_s$$

where $\Delta C_s = C_s(f_i, f_v, s) - C_s(f_i^*, f_v^*, s)$. Then a proportion θ_i of Δl is assigned to i, such $\theta_i \Delta l = (f_i^* - f_i) + \frac{\Delta C_s}{2}$ and θ_v is assigned to v such that $\theta_v \Delta l = (f_v^* - f_v) + \frac{\Delta C_s}{2}$ [15]

The adjudication rule is summarized in the following matrix:

	$f_v \geq f_v^*$	$f_v < f_v^*$
$f_i \geq f_i^*$	$\langle f_i + l(f_i, f_v, s), f_v \rangle$	$\langle f_i + l^*, f_v + \Delta l \rangle$
$f_i < f_i^*$	$\langle f_i + l(f_i, f_v, s), f_v \rangle$	$\langle f_i + l^* + \theta_i \Delta l, f_v + \theta_v \Delta l \rangle$

As a first step, let us show that the rule is well-defined, i.e. it does not inadvertently benefit a party doing less than the socially optimal level of effort:

Lemma 1

We have that for every pair (f_i, f_v) such that $f_i \in [0, f_i^*]$ and $f_v \in [0, f_v^*]$ but $(f_i, f_v) \neq (f_i^*, f_v^*)$, $\Delta l > 0$.

Proof: *Let us consider the three possible cases in which $f_i \in [0, f_i^*]$ and $f_v \in [0, f_v^*]$ while $(f_i, f_v) \neq (f_i^*, f_v^*)$:*

1. $f_i = f_i^*$ and $f_v < f_v^*$: *by the minimality of social cost we have that* $f_i^* + f_v + l(f_i^*, f_v, s) > f_i^* + f_v^* + l^*$. *Thus* $\Delta l = l(f_i^*, f_v, s) - l^* > f_v^* - f_v > 0$.
2. $f_i < f_i^*$ and $f_v = f_v^*$: *same as case 1.*

[14] Notice that this rule just distributes $C_s(f_i, f_v, s)$ between i and v.

[15] It is easy to see that a higher proportion of Δl is assigned to the agent that deviated the most from the optimal causal input. But other than this, nothing indicates that the attribution to each party is fair.

3. $f_i < f_i^*$ and $f_v < f_v^*$*: again, by the minimality of social cost,* $f_i + f_v + l(f_i, f_v, s) > f_i^* + f_v^* + l^*$. Then, $\Delta l = l(f_i, f_v, s) - l^* > (f_v^* - f_v) + (f_i^* - f_i)$. *Since* $(f_i^* - f_i) > 0$ *and* $(f_v^* - f_v) > 0$ *it follows that* $\Delta l > 0$.
Then we have:

Proposition 1
(f_i^*, f_v^*) is the unique Nash equilibrium of the game.

Proof: *The proof can be divided in two parts. First we show that* (f_i^*, f_v^*) is *a Nash equilibrium. That is, no unilateral deviation from* (f_i^*, f_v^*) *is profitable. To see this, we will consider the possible deviations of either player:*

- *Deviations of* i*:*
- Let i *choose* $f_i \neq f_i^*$, *instead of* f_i^*. *Then, her cost will be* $f_i + l(f_i, f_v^*, s)$ *instead of* $f_i^* + l^*$. *Suppose this move were profitable. This would mean that* $f_i + l(f_i, f_v^*, s) < f_i^* + l^*$. *But then, adding* f_v^* *to both sides we get* $f_i + f_v^* + l(f_i, f_v^*, s) < f_i^* + f_v^* + l^*$, *which contradicts the minimality of the social cost at* (f_i^*, f_v^*) .

Then, no profitable deviations from(f_i^*, f_v^*) *exist for* .

- *Deviations of v:*
- Let v *choose* $f_v > f_v^*$, *instead of* f_v^*. *Her cost will be* f_v *which, by assumption is larger than* f_v^*, *and is thus an unprofitable choice.*
- Suppose that v´s choice is $f_v < f_v^*$. *The cost is* $f_v + \Delta l$. *Suppose, by contradiction, that* $f_v + \Delta l < f_v^*$. *By definition of* Δl *this is equivalent to* $f_v + l(f_i^*, f_v, s) < f_v^* + l(f_i^*, f_v^*, s)$. *Then, adding* f_i^* *to both sides we have* $f_i^* + f_v + l(f_i^*, f_v, s) < f_i^* + f_v^* + l(f_i^*, f_v^*, s)$, *contradicting the minimality of social cost at* (f_i^*, f_v^*). *Thus, the deviation is not profitable.*

Now, we have to show that no other Nash equilibrium exists. According to the arguments given above to show that (f_i^*, f_v^*) *is an equilibrium, v never finds profitable to choose* $f_v > f_v^*$. *Then, the only possible candidates are:*

- (f_i, f_v) *such that* $f_i < f_i^*$ *and* $f_v < f_v^*$. *Consider the assessment of* v *.If she remains at* (f_i, f_v) *she has a cost* $f_v + \theta_v \, \Delta l$ *while if she unilaterally deviates to* f_v^* *her cost would be* f_v^*. *Suppose that* (f_i, f_v) *is a Nash equilibrium, i.e.* $f_v + \theta_v \, \Delta l < f_v^*$ *. Then, we would have that* $(f_v - f_v^*) + \theta_v \, \Delta l < 0$. *The same argument for* i *would indicate that* $(f_i - f_i^*) + \theta_i \, \Delta l < 0$. *Adding this two inequalities we would have that* $(f_v - f_v^*) + (f_i - f_i^*) + [\theta_v + \theta_i] \, \Delta l < 0$. *But this mean that (since* $\theta_v + \theta_i = 1$) $f_i + f_v + l(f_i, f_v, s) < f_i^* + f_v^* + l(f_i^*, f_v^*, s) f_v^*$, *contradicting the minimality of the social cost at* (f_i^*, f_v^*). *This means, that at least one,* i or v *has a profitable deviation from* (f_i, f_v), *which is thus not a Nash equilibrium.*
- (f_i, f_v) *such that* $f_i > f_i^*$ *and* $f_v < f_v^*$. *Then, i´s cost is* $f_i + l^*$*while if he deviates to* f_i^* *his cost would be* $f_i^* + l^*$. *But then, since* $f_i > f_i^*$ *, the deviation lowers his cost. That is,* (f_i, f_v) *is not a Nash equilibrium.*

Alternatively, under negligence, we can consider a rule that allocates costs according to causal inputs as follows:

- If $f_i > f_i^*$ then $l(f_i, f_v, s)$is fully assigned to v. This captures the very essence of negligence.

- If $f_i < f_i^*$ while $f_v \geq f_v^*$, $l(f_i, f_v, s)$is fully assigned to i.
- Finally, if $f_i < f_i^*$ and $f_v < f_v^*$, the rule assigns costs in the same way as under the *strict liability* rule.[16] [HAA2]

The following matrix shows the ensuing game between i and v under the negligence rule:

	$f_v \geq f_v^*$	$f_v < f_v^*$
$f_i \geq f_i^*$	$\langle f_i, f_v + l(f_i, f_v, s)\rangle$	$\langle f_i, f_v + l(f_i, f_v, s)\rangle$
$f_i < f_i^*$	$\langle f_i + l(f_i, f_v, s), f_v\rangle$	$\langle f_i + l^* + \theta_i \Delta l, f_v + \theta_v \Delta l\rangle$

We have again that:

Proposition 2
(f_i^*, f_v^*) is the unique Nash equilibrium of the game.

Proof: *It is trivial to show that* (f_i^*, f_v^*) *is a Nash equilibrium. It is not profitable for either i or* v *to deviate (just consider the proof under the strict liability rule with the roles of* i *and* v *exchangedidentical in the only visible candidate, i.e. if* $f_i < f_i^*$ *and* $f_v < f_v^*$ *)*[HAA3]. *On the other hand, by a similar argument as in the proof under strict liability, no other profile constitutes a Nash equilibrium.*

As it is easy to see, the main difference between negligence vs. strict liability is preserved, as long as if the injurer behaves in the optimal way, the loss is fully assigned to the victim in negligence and it is not, under strict liability.

However, at this point it is possibleThe ensuing scheme conveys other interesting features. Keeping its formal efficienty properties untouched, it also allows to pursue (and to meet) additional goals, and even to deal with at least some variants of *corrective justice*. Namely, we can fulfill the standard Kaldor-Hicks criterion inducing the desired Nash equilibrium and at the same time *locally verify additional efficiency criteria*. We have seen so far that our allocation criteria, either under negligence or under strict liability only demand that Δl is appropiately shared between i and v in proportions θ_i and θ_v , respectively. Being $\theta_k > 0$, actual amount of θ_k is not relevant to our results.[HAA4]

Hence, a specially interesting way to do it consists in simply applying the *CG*-procedure of Aumann and Maschler (1985) on Δl. The CG rule, as it is known, is called so because it was introduced by Aumann and Maschler as a generalization of the (C)ontested (G)arment rule from the Talmud.

[16] See that, if l^* is assigned to the victim instead of to injurer in this case, the properties of the rule will be identical in relation to the equilibrium of the game. This gives room to pursue additional goals of legal policy with no variation of social cost.

The CG rule proceeds by ~~dividing~~ assigning $l(f_i, f_v, s)$ ~~in two and assigning one share to i and the other to v~~ as previously shown in each of the ensuing cases according to the aforementioned rules. Being defined Δl, as previously done, as the difference $l(f_i, f_v, s) - l(f_i^*, f_v^*, s)$ and defining $\Delta f_k = f_k - f_k^* \Delta$, for $k = i, v$. Then, the apportionment of causal attribution yields ρ_i for the injurer and ρ_v for the victim:

$$\rho_i = \frac{\Delta l - (\Delta l - \Delta f_i)^+ - (\Delta l - \Delta f_v)^+}{2} + (\Delta l - \Delta f_v)^+$$

$$\rho_v = \frac{\Delta l - (\Delta l - \Delta f_i)^+ - (\Delta l - \Delta f_v)^+}{2} + (\Delta l - \Delta f_i)^+$$

where the operator $(.)^+$ is such that $k^+ = \max(0, k)$. That is, for each argument, it yields either its absolute value (if the argument is non-negative) or zero.

It can be easily checked out that $\rho_i + \rho_v = \Delta l$. That is, it shares the socially ~~excidingly~~exceedingly loss between both parties, in proportion of their causal contribution. In this sense, the shares can be deemed *fair*, since the split depends on the degrees of causation. Furthermore, this division is *efficient:*

Proposition 3: *The allocation $\langle \rho_i, \rho_v \rangle$ yields an efficient apportionment of the losses due to deviations from $\langle f_i^*, f_v^* \rangle$.*

Proof: *Immediate from the fact (Aumann and Maschler, 1985) that the CG-rule yields the nucleolus of the corresponding allocation game. The nucleolus, in turn, yields the unique outcome in the core of the game, i.e. an efficient assignment of dues to both parties.*

That is, efficient allocations of causal attribution can be reached by following this rule, once the causes have been detected by the two-step procedure. Being this allocation in the nucleolus, it minimizes the advantages of any party over the other, and being in the core it achieves this efficiently.[17]
Furthermore, we have that:

Proposition 4
If $\Delta l > \Delta f_i + \Delta f_v$, the allocation $\langle \rho_i, \rho_v \rangle$ is such that $\rho_j \geq \Delta f_j \; for \; j = i, v$.

Proof: *If $\Delta l > \Delta f_i + \Delta f_v$, then (notice that $\Delta l - \Delta f_j \geq 0 \; for \; j = i, v$) by way of contradiction assume, without loss of generality, that $\rho_i < \Delta f_i$:*

$$\rho_i = \frac{\Delta l - (\Delta l - \Delta f_i) - (\Delta l - \Delta f_v)}{2} - (\Delta l - \Delta f_v) < \Delta f_i$$

by a simple algebraic manipulation we have:

[17] Here *efficiency* covers all the meanings in Economics: an element in the core of an allocation game is Pareto-optimal, verifies the Hicks-Kaldor condition and verifies Shapley's axiom of efficiency. See Mas-Collel et al. (1995).

$$\Delta l + \Delta f_i - \Delta f_v < 2\Delta f_i$$

that is, $\Delta l < \Delta f_i + \Delta f_v$. *Absurd.*

5. Concluding Remarks

Some final observations might be significant at this point. First, we are far from claiming that actual liability systems, as they are in the real world, will lead unconditionally to efficiency by taking into account the causal influences on the harms. Rather, we tried to show that theoretical relations between abstract concepts hidden in the characterization of the usual legal tools may lead to efficiency in this area, identifying the requirements for that goal. More specifically, we suggest that the contradiction between an efficient allocation of liability on the basis of causal apportioning and efficiency in general is not as stark as claimed. At least, that there is not such a contradiction on the level of theoretical relations, for any kind of allocation. While Aumann and Maschler's *CG*-principle is intended for just two parties, a variety of methods of fair division have been designed for *n*-person contexts, all of them yielding efficient allocations (Brams and Taylor, 1996).

Additionally, we have shown that the basis on which mainstream Law and Economics stated the issue leads to two problematic consequences. First, the deviation from some usual cornerstone notions of philosophy and traditional legal scholarship. Second, in spite of doing so, it does not provide any gain in terms of the achieving efficiency, the main normative goal of Law and Economics.

By introducing an alternative framework, we intended to overcome both weaknesses in a single stroke. On the one hand, at a theoretical level, our strategy succeeds in providing an acceptable procedure for allocating liability on the basis of causal apportioning, applicable even to the hard cases of causal complements and causal substitutes, that have shown to be the source of inefficiencies in the mainstream framework.

On the other, our set of assumptions seems to go along with the toolbox of traditional legal scholarship and with the current philosophical conceptual framework on causality. The application of the NESS test, the two-step approach and even the treatment of causal apportioning goes in this way. By means of the first step, the *factual* aspect of the causal judgment (the most general one) is fulfilled. The second step, in turn, fulfills another universal characteristic of any causal inquiry, which consist in filtering the rough material provided by the first step. The result of this step, however, is far from being neutral. It is, instead, goal-oriented, and this is the reason for why we do not face an endless listing of factors every time we ask for the cause of everyday or more complex events. Therefore, if our goal is to achieve efficiency, our screening among the NESS conditions of an event would in the end select those that will allow to allocate liability in an efficient form. At this stage confronting *legal policy reasons* with *causal determinations* probably makes little sense.

With respect to the actual scope of our analysis, it is clear that it is to improve the theoretical understanding of the problem of allocating liability on causal grounds. However, since the real world is far from being as neat as required in our exercise, there are many aspects of the problem that remain unsolved. Even so, we think we suggested potential headways towards a better understanding to the problem and opened venues for further research.

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