Quantum Tort Law:
The Law of Torts in a Probabilistic World

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The Law of Torts in a Probabilistic World

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Disclaimer

The introduction and Chapter II freely borrow from the Article "God's Dice". At the time of the submission the article is forthcoming on the University of Dayton Law Review. The Chapter III is largely taken from "Aristotle and Optimal Deterrence" published on the Jorunal of Politics and Law. Large parts of Chapter IV closely follow the Article, co-authored with Alessio M. Pacces, "A Strict Liability Regime for Rating Agencies." At the time of the submission the article is forthcoming on the American Business Law Journal.

List of Abbreviations

CRA	Credit Rating Agencies
e.g.	*Exempli gratia* (for example)
et al.	*Et alii* / *Et aliae* (and others)
i.e.	Id est (that is)
NESS	Necessary Element of a Sufficient Set
Pr	The probability of not suffering a specific harm
PMC	Private Marginal Cost
PMB	Private Marginal Benefit
SMC	Social Marginal Cost

I. Introduction

1. Introduction

Throughout our history, human beings have always faced events that they could not entirely comprehend.[1] The reactions to these *prima facie* random events are an incredibly powerful proxy for societies' prevailing approach to natural phenomena and to life in general. From this perspective, simplifying to an extreme extent it is possible to identify three phases. From ancient times until Middle Ages, random events were often attributed to gods' will and supernatural forces. In this vein, a storm was perceived as the divine punishment for immoral behavior, while countless little acts were performed to earn the appreciation of divinities. Humans felt powerless against the forces of Nature.

The second phase began with the advent of the scientific method, as it induced a drastic change in the perception of the world. The word 'random' became synonymous of a *temporary* state of ignorance. The power of human intellect was going to overcome the ignorance and to attribute a specific cause for the only apparently random event. The human was turning into a demon,[2] and there was little doubt that the world was going to reveal all of its secrets to this demon.

However, the universe has proven far more complex than scientists had imagined. As Capra noted, '[e]very time the physicists asked nature a question...nature answered with a paradox, and the more they tried to clarify the situation, the sharper the paradoxes became.'[3] The third phase had begun. Chaos theory and quantum mechanics forced scientists to completely change

[1] For an historical perspective, cf David F Nightingale, *Games, gods and gambling: The origins and history of probability and statistical ideas from the earliest times to the Newtonian era* (Hafner Publishing Company 1962). This introduction is a stylized oversimplification of a very complex and nuanced evolutionary process.
[2] The term demon refers to the famous description of determinism offered by Laplace. The French mathematician argued that, given sufficient information, a demon (not different in nature from a human being) would have been able to read the past and predict the future. A more detailed treatment of this point will be offered in chapter II. C Pierre-Simon de Laplace, *Preface to A Philosophical Essay on Probabilities* (first published 1812).
[3] Fritjof Capra, *Tao Physics* (Flamingo 1982).

their perception of the world; the universe was not an open book that was awaiting to be read. Researchers abandoned the ambition of identifying deterministic causes for every event, and probabilistic studies quickly became a widespread reality in many branches of human knowledge. From this perspective, suffices it to think that the study of the micro-world is dominated by something called the indeterminacy principle![4]

2. The Rise and Fall of the Demon

Any philosophical inquiry should start with a clear definition of the terminology. From this perspective, a wide array of definitions of determinism has been advanced and some of them are to a certain extent compatible with the findings of modern science.[5] For the purpose of this work, the focus can be narrowed down to two kinds of determinism; namely Laplacian determinism and metaphysical determinism. Both concepts will be introduced in this section. An important *caveat* is that depending on the definition adopted, determinism is not necessarily synonymous of perfect predictability. However, for the two kinds of determinism considered in this work, this is irrelevant. In fact, Laplacian determinism postulates perfect predictability, whereas for metaphysical determinism our predictive capacity is irrelevant.

The manifesto of Laplacian determinism is found in Laplace's treatise on probability:

> 'We ought to regard the present state of the universe as the effect of its antecedent state and as the cause of the state that is to follow. An intelligence knowing all the forces acting in nature at a given instant, as well as the momentary positions of all

[4] Ibidem.
[5] On this respect, Earman writes that 'There is a tendency in the philosophical literature to fixate on the Laplacian variety of determinism. But other kinds of determinism crop up in physics.' John Earman, 'Aspects of Determinism in Modern Physics' in Jeremy Butterfield and John Earman (eds), *The Philosophy of Physics. Handbook of the Philosophy of Science*, *Part B* (North-Holland 2007) 1373. The focus of this thesis is specifically on Laplacian determinism, as legal treatment of causation seems to postulate its existence.

> things in the universe, would be able to comprehend in one single formula the motions of the largest bodies as well as the lightest atoms in the world, provided that its intellect were sufficiently powerful to subject all data to analysis; to it nothing would be uncertain, the future as well as the past would be present to its eyes.'[6]

In other words, in a deterministic universe the future states are uniquely determined by the preceding ones and by the laws of nature. It is important to note that Laplace's statement affirms more than a metaphysical determinism; it also entails the scientific determinism *a la* Popper.[7] More precisely, this philosopher defines scientific determinism as follows:

> 'the doctrine that the structure of the world is such that *any event can be rationally predicted, with any desired degree of precision, if we are given a sufficiently precise description of past events, together with all the laws of nature*. [emphasis in the original] '[8]

The difference between scientific determinism and metaphysical determinism is therefore that the former implies the possibility to predict future states of the world, whereas the latter is agnostic on the point.

Notably, metaphysical determinism cannot be proven or disproven, and hence its embracement constitutes a mere act of faith.[9] Nevertheless, because scientific determinism

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[6] Pierre-Simon de Laplace, *Preface to A Philosophical Essay on Probabilities* (first published 1812). Quoted from Ernest Nagel, *The Structure of Science* (Harcourt, Brace, and World 1961) 281–282.
[7] Karl Popper, *The Open Universe: An Argument for Indeterminism* (Routledge 1988) 1-2.
[8] Ibidem.
[9] Reichenbach writes that 'This discrepancy [between idealized and actual physical states] has often been disregarded as irrelevant, as being due to the imperfection of the experimenter and therefore negligible in a statement about causality as a property of nature. With such an attitude, however, the way to a solution of the problem of causality is barred. Statements about the physical world have meaning only so far as they are connected with verifiable results'. Hans Reichenbach, *Philosophic Foundations of Quantum Mechanics* (UCP 1944) 2. On this point, also cf Popper (n 7).

implies metaphysical determinism, any proof in favor of the former can strengthen our faith in the latter.

The extreme confidence in the capacity of human beings to comprehend and uncover the mysteries of nature should not be surprising; Laplace was writing in an age dominated by the deterministic triumph of Newtonian physics.[10] The idea of univocally determined causal links was completely pervasive in every field of human knowledge. No matter how unattractive its extreme consequences were, hardly anyone would have questioned that scientific discoveries were leading us to a complete comprehension of the universe.[11]

The works of Immanuel Kant are the best example of how hard it was to depart from this sacred conception.[12] The German philosopher understood perfectly well what were the consequences of embracing the form of determinism generally associated with Newtonian physics; and in fact, he affirmed that disposing of complete information 'we could calculate a human being's conduct for the future with certainty, just like any lunar or solar eclipse.'[13]

Kant's devotion to the deterministic nature of Newtonian physics was as strong as his faith in the free will of human beings, and hence, all his philosophy was dominated by the paradox of *noumena*[14] who were free in themselves, yet relegated to live in a predetermined environment.

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[10] The deterministic character of Newtonian physics is questionable to say the least. Without taking side in this extremely complex debate, we will borrow Popper's terminology and define it as *prima facie* deterministic. Cf Popper (n 7). For a throughout discussion on the alleged deterministic nature of Newtonian physics cf John Earman, *A Primer on Determinism* (vol. 37, Springer 1986).

[11] In the words of Poincaré, 'We have become absolute determinists, and even those who want to reserve the rights of human free will let determinism reign undividedly in the inorganic world at least. Every phenomenon, however minute, has a cause; and a mind infinitely powerful, infinitely well-informed about the laws of nature, could have foreseen it from the beginning of the centuries. If such a mind existed, we could not play with it at any game of chance, we should always lose.' Henri Poincaré (George Bruce Halsted tr), 'Chance' (1912) 22 The Monist 31.

[12] According to Popper 'The power of the belief in 'scientific' determinism may be gauged by the fact that Kant, who for moral reasons rejected determinism, nevertheless felt compelled to accept it as an undeniable fact, established by science.' cf Popper (n 7).

[13] Immanuel Kant, *Critique of Practical Reason* (Werner Pluhar tr, first published 1788, Hackett Publishing Company 2002) 126.

[14] For Kant *noumena* are a priori ideas of pure reason (i.e. not depending upon experience) Cf Theodore Oizerman, 'I. Kant's Doctrine of the "Things in Themselves" and Noumena' (1981) 41 Philosophy and Phenomenological Research 333.

The free will was not powerful enough to free Kant from the demon's chains. Both forms of determinism were postulated to be true.

2.1. Quantum Mechanics, Chaos Theory, and Predictability

Besides its incredible predictive power, quantum mechanics presents two fundamental characteristics.[15] In the first place, during its initial developments, in spite of the astonishing experimental successes obtained, no one had a logical explanation for what was happening.[16] Secondly, in the previous centuries, scientific discoveries had been perceived as a step towards the complete comprehension of our universe. Each of these steps increased the confidence of scientists and reinforced the perception that the ultimate knowledge was becoming closer and closer.[17] Quantum mechanics abruptly ended these tendencies; the more discoveries were being made the more paradoxes emerged and the more the universe looked too complicated to be fully comprehended. Reichenbach captures these two traits when he states that:

> 'It was with the phase of the physical interpretations that the novelty of the logical form of quantum mechanics was realized. Something had been achieved in this new theory which was contrary to traditional concepts of knowledge and reality. It was not easy, however, to say what had happened.'[18]

[15] Quantum mechanics is the branch of physics that aims at describing the microscopic world. Despite the theoretical riddles, it predicts extremely well the behavior of its object of study.
[16] Reichenbach writes 'It is a most astonishing fact that this phase, which led up to quantum mechanics, began without a clear insight into what was actually being done. … This period represents an amazing triumph of mathematical technique which, masterly applied and guided by a physical instinct more than by logical principles, determined the path to the discovery of a theory which was able to embrace all observable data.' Cf Reichenbach (n 9) Preface v-vi. On this regards cf also Capra 'Every time the physicists asked nature a question in an atomic experiment, nature answered with a paradox, and the more they tried to clarify the situation, the sharper the paradoxes became. It took them long time to accept the fact that these paradoxes belong to the intrinsic structure of atomic physics.' Capra (n 3) 76.
[17] This is clearly an oversimplification; however, it captures the change in the prevailing approach exemplified by the words of Laplace and the works of Fritjof Capra.
[18] Cf Reichenbach (n 9) preface vi.

The maze unveiled by the Copenhagen School revealed a reality that had very little in common with the typical portrait painted by the scientists and the philosophers of the previous centuries. 'Quantum theory has.. demolished the classical concepts of…strictly deterministic laws of nature'.[19]

The main problem is that, within quantum mechanics, it is impossible to predict with absolute certainty the behavior of a single particle, regardless of how sophisticated the tools used to explore the reality are. 'We can never predict an atomic event with certainty; we can only say how likely it is to happen'.[20] To the contrary, statistical predictions on a sufficiently large number of particles reach peaks of precisions and accuracy that are alien to most fields of science. From this perspective, one of the building blocks was laid by Heisenberg. Roughly speaking, the indeterminacy principle (for position and momentum[21]) that carries his name denies the possibility to identify the exact simultaneous values of position and momentum of a particle. In other words, it is not possible to have at the same time precise information about the position and the momentum of a particle.[22] This is in sharp contrast with the Laplacian idea of determinism.

There is one widespread misconception about the indeterminacy of observation within quantum mechanics. It is generally assumed that the reason behind the need to adopt statistical predictions is exclusively the unavoidable interaction between the observer and the observed object. In other words, it is often argued that the inevitable disturbance of infinitesimally small objects by the means of observations is the cause of the indeterminacy principle.[23] The obvious corollary to this thesis is that such uncertainty is automatically eliminated if macroscopic

[19] Cf Capra (n 3) 78.
[20] Ibidem.
[21] The momentum is the product of the mass and velocity of a particle.
[22] For a precise formulation of the indeterminacy principle, John Von Neumann, *Mathematical Foundations of Quantum Mechanics* (PUP 1955).
[23] Heisenberg himself embraced this perspective. Cf Reichenbach (n 9) 16.

objects are studied. Although the entire argument against this claim cannot be reproduced here,[24] it suffices to say that also within the realm of classic physics the observational tool alters the observed object, yet not necessarily in an unpredictable way. To be sure, the observational mean is not different in nature from any other physical entity that interacts with the observed object, and hence if its influence on the latter is unpredictable so could be that of any other entity.[25] In other words, the influence of the mean of observation in itself cannot explain the indeterminacy of predictions. Only when combined with the indeterminacy principle it becomes a sufficient condition.[26]

From the considerations developed above, it follows that quantum mechanics cannot be reduced to a strictly deterministic theory, nor its philosophical implications can be relegated at the microscopic level.[27] Although quantum mechanics does not rule out every deterministic explanation of the world,[28] a first mortal wound was inflicted on the demon. In fact, quantum mechanics *is* incompatible with Laplacian determinism.

[24] For a mathematical proof that the disturbance of the observational means is not the cause of the degree of uncertainty in the predictions Reichenbach (n 9) 104. Cf also Hans Reichenbach, 'Ziele und Wege physikalischen Erkenntnis' in Hans W Geiger and Karl Scheel (eds), *Handbuch der Physik* (vol. 4, Springer 1929) 78.
[25] To use the words of Reichenbach 'instruments of measurement do not represent exceptions to physical law' cf Reichebach (n 9) 17. An obvious example of this claim offered by the Author is that '[w]hen we put a thermometer into a glass of water we know that the temperature of the water will be changed by the introduction of the thermometer; therefore we cannot interpret the reading taken from the thermometer as giving the water temperature before the measurement, but must consider this reading as an observation from which we can determine the original temperature of the water only by means of inferences. These inferences can be made when we include in them a theory of the thermometer' cf Reichebach (n 9) 16.
[26] ibid 17.
[27] The most famous description of quantum uncertainty affecting a macro-observable phenomenon is the Schrödinger's Cat. To oversimplify, Schrödinger describes a scenario in which a cat is both dead and alive (more precisely it should be said that the cat is in a superposition of two states – dead cat and live cat). Cf Hilary Putnam, 'A Philosopher Looks at Quantum Mechanics (again)' (2005) 56 BJFS 615.
[28] Cf Toby Handfield, *A Philosophical Guide to Chance* (CUP 2012).

2.2 Chaotic Systems and Predictions

The seeds of a second ambush to the demon were planted by James Clerck Maxwell and Henri Poincaré.

Laplace's determinism is in fact grounded on two hidden assumptions:[29] in the first place, Laplace's hypothesis requires that small causes produce small effects; in other words, small imperfections in the initial data generate only small deviations in the results. However, as both Poincaré[30] and Maxwell[31] noticed, this is not an absolute truth, and in fact it generally holds only for linear systems, while nature is pervaded by chaotic systems. In chaotic systems, small differences in initial conditions cascade through various iterations into drastically different outcomes.[32] Secondly, Laplace assumes that to include more objects into a model it is sufficient

[29] William J Firth, 'Chaos-Predicting the Unpredictable' (1991) 303 BMJ 1565.

[30] In a very famous passage Poincarè states that '[a] very slight cause, which escapes us, determines a considerable effect which we cannot help seeing, and then we say this effect is due to chance. If we could know exactly the laws of nature and the situation of the universe at the initial instant, we should be able to predict exactly the situation of this same universe at a subsequent instant. But even then when the natural laws should have no further secret for us, we could know the initial situation only *approximately*. If that permits us to foresee the subsequent situation *with the same degree of approximation*, this is all we require, we say the phenomenon has been predicted, that it is ruled by laws; but it is not always so. It may happen that slight differences in the initial conditions produce very great differences in the final phenomena; a slight error in the former would make an enormous error in the latter. Prediction becomes impossible and we have the fortuitous phenomenon.' [emphasis original] Cf Poincaré (n 11) 34.

[31] In a lecture delivered in Cambridge in 1873 Maxwell affirmed that 'Much light may be thrown on some of these questions by consideration of stability and instability. When the state of things is such that an infinitely small variation of the present state will alter only by an infinitely small quantity the state at some future rime, the condition of the system, whether it is at rest or in motion, is said to be stable; but when an infinitely small variation in the present state may bring about a finite difference in the state of the system in a finite time, the condition of the system is said to be unstable. It is manifest that the existence of unstable conditions renders impossible the prediction of future events, if our knowledge of the present state is only approximate and not accurate. It has been well pointed out by Professor Balfour Stewart that physical stability is the characteristic of those systems from the contemplation of which determinists draw their arguments, and physical instability that of those living bodies, and moral instability that of those developable souls, which furnish to consciousness the conviction of free will.[emphasis added].' In Lewis Campbell and William Garnett, *The Life of James Clerk Maxwell* (Macmillan 1882) 211.

[32] To have a flavor of the dramatic variance in the results it suffices to recall how nonlinear theory attracted the attention of the scientific community. Higgins writes that 'In 1961, Edward Lorenz, a mathematician-meteorologist working at the Massachusetts Institute of Technology, observed what he believed was order masquerading as randomness. He used simple mathematical model of weather patterns and a computer capable of performing multiple iterations (repetitions). After accidentally imputing an incorrect decimal point in a number, he noted that small variations in initial conditions (temperature or atmospheric pressure) would cascade through various iterations into remarkably different output (weather conditions)' John P Higgins, 'Nonlinear Systems in Medicine' (2002) 75 YJBM 247, 249. As it often happens in these cases, slightly different versions of this story exist. Cf Christian Oestreicher, 'A History of Chaos Theory' (2007) 9 DCN 279.

an increase in the calculation power of roughly the same proportion. Once again, this relationship is not linear as it was imagined by the French mathematician; therefore the increase in calculation power required to analyze complex systems grows at a very fast rate, making it very hard to imagine that complex systems can be captured in their entirety. Given that chaotic systems are extremely sensitive to infinitesimal variations of initial conditions, it is clear why chaos theory poses an insurmountable obstacle to our capacity to make predictions. On the one hand, in any field of human knowledge initial conditions can be defined only with a certain degree of precision, and on the other hand only a limited number of factors can be included in a model. In the words of Poincaré, 'prediction becomes impossible'.[33]

The paradox of isolation offers a nice perspective of the desperate battle that the demon is fighting;[34] to understand causes and effects it is necessary to isolate the components that are being studied. The more we can isolate the components that we want to study, the more precisely we can analyze initial conditions. Clearly, to obtain absolute precision in the definition of initial conditions we would need to completely isolate the component that we want to study. Yet, if we assume that it is possible to completely isolate a specific component, the doctrine of universal causal interdependence is defeated. In other words, to achieve Laplacian predictability we need to be able to define initial conditions with an infinite degree of precision. However the more we approach this goal the more we undermine metaphysical determinism. Complete Laplacian determinism requires the death of metaphysical determinism, yet metaphysical determinism is a necessary condition for Laplacian determinism, so that nothing can be predicted in the way imagined by the French mathematician. Not coincidentally, Reichl writes that 'we now know that the assumption that Newton's equations can predict the future is a

[33] Cf Poincaré (n 11) 34.
[34] Mario Bunge, *Causality: The Place of the Causal Principle in Modern Science* (HUP 1959).

fallacy'.[35] Not even the most deterministic of all theories meets the standard defined by Laplace and by legal scholars.

During the past decades it has been discovered that chaotic systems are ubiquitous in nature, and hence it became evident that the demon was finally defeated. Scientific determinism had to be abandoned thus our faith in metaphysical determinism ought to be weakened.

3. Research Question

Most sciences have reached what was defined above as the third stage of their development and therefore routinely use probabilistic tools. This is not without consequences for legal scholars. In many instances the courts and the regulators have to face the findings of modern science, generally expressed in probabilistic terms.[36] It is therefore interesting to investigate how probabilistic considerations influence the traditional understanding of the law. In other words, the idea behind this thesis can be summarized in a very short question 'what should be the role of probability in tort law?' This question could obviously be extended to other branches of the law, yet the focus will be on tort law only. On the one hand, an excessively broad enquiry would render the subject intractable. On the other hand, tort law seems like a reasonable starting point given the pivotal role played by the causal link in tort cases.

In fact, the first and undoubtedly most important questions emerge with regards to causality. Despite the fact that in many areas of tort law (i.e. toxic cases, medical malpractices, etc.) the evidence that the courts have at their disposal is almost exclusively probabilistic in nature,[37] the

[35] Linda E Reichl, *The transition to chaos: Conservative Classical Systems and Quantum Manifestations* (Springer 2004) 3.
[36] Cf Steve C Gold, 'When Certainty Dissolves into Probability: A Legal Vision of Toxic Causation for the Post-Genomic Era' (2013) 70 WLLR 237, 239; David Rosenberg, 'Casual Connection in Mass Exposure Cases: A Public Law Vision of the Tort System' (1983).
[37] Cf Gold (n 36).

law is still clinging on a deterministic concept of causation.[38] In this vein, although proportional liability[39] and the loss of chance doctrine[40] are steps in the right direction, it will be shown that they are intrinsically deterministic in nature. The first important question is therefore how to reconcile the legal concept of causality with the findings of modern science. This task will be attempted in chapter II.

As the idea of causation is the backbone of tort law, challenging the traditional deterministic concept of causality raises a series of other interrogatives. Firstly, it is important to understand if the debate on the traditional goals of tort law should be reshaped to accommodate probabilistic considerations. More precisely, law and economics scholars argue that tort law should aim at minimizing accident costs,[41] whereas legal philosophers advocate the supremacy of corrective justice.[42] Despite a few attempts to reconcile the two theories,[43] cost minimization and corrective justice are still portrayed as incompatible.[44] For the purpose of this work, it should be noted that both theories are grounded on a deterministic view of causation. Chapter III will investigate whether it becomes easier to accommodate deterrence and corrective justice in a probabilistic world.

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[38] Among the others cf Richard W Wright, 'Causation, Responsibility, Risk, Probability, Naked Statistics, and Proof: Pruning the Bramble Bush by Clarifying the Concepts' (1988) 73 ILR 1001; More recently, Ken Oliphant, 'Uncertain Factual Causation in the Third Restatement: Some Comparative Notes. (2010) 37 WMLR 37 1599.

[39] Richard Delgado, 'Beyond Sindell: Relaxation of Cause-in-Fact Rules for Indeterminate Plaintiffs' 70 (1982) CLR 881; Daniel A. Farber, 'Toxic Causation' (1986) 71 MLR. 71 1219; Saul Levmore, 'Probabilistic Recoveries, Restitution, and Recurring Wrongs' (1990) 19 JLS 691. Against proportional liability cf David A. Fischer, 'Proportional Liability: Statistical Evidence and the Probability Paradox' (1993) 46 VLR 1201.

[40] David A. Fischer, 'Tort Recovery for Loss of a Chance' (2001) 36 WFLR. 605; Steven R. Koch, 'Whose Loss Is It Anyway? Effects of the "Lost-Chance" Doctrine on Civil Litigation and Medical Malpractice Insurance' (2010) 88 NCLR 595; Ali El-Haj, 'The Loss of Chance Doctrine in Medical Malpractice: A Lost Case?' (2010) *Available at SSRN 1674415*; Sandy Steel, 'Rationalising Loss of a Chance in Tort' in Erika Chamberlain, Stephan GA Pitel and Jason W Neyers, J. (eds.), *Tort Law: Challenging Orthodoxy,* (Hart Publishing 2013) 235.

[41] Louis Kaplow and Steven Shavell, *Fairness versus Welfare* (HUP 2009).

[42] Ernest J Weinrib, *The Idea of Private Law* (HUP 1995).

[43] Gary T Schwartz, 'Mixed Theories of Tort Law: Affirming Both Deterrence and Corrective Justice' (1996) 75 TLR 1802, Bruce Chapman, 'Pluralism in Tort and Accident Law: Toward A Reasonable Accommodation' in Gerald Postema (ed.), *Philosophy and the Law of Torts* (CUP 2001) 276; Mark Geistfeld, 'Economics, Moral Philosophy, and the Positive Analysis of Tort Law' in Gerald Postema (ed.), *Philosophy and the Law of Torts* (CUP 2001) 250; Mark Geistfeld, 'Efficiency, Fairness and the Economic Analysis of Tort Law ' in Mark D White (ed.), *Theoretical Foundations of Law and Economics* (CUP 2009) 234.

[44] On this point cf Ernest J Weinrib, 'Deterrence and Corrective Justice' (2002) 50 UCLA LR 621.

Secondly, and from a more practical perspective, the question is whether a probabilistic approach to the law of torts helps to solve riddles that have haunted legal scholars during the recent years. From this perspective, in chapter IV the attention will be on Credit Rating Agencies (CRAs) and on how their activity should be regulated. Credit rating agencies have been accused to have played a significant role in the global financial crisis.[45] In this vein, it has been argued that the incentives of CRAs are impaired by an inherent conflict of interest[46] and by the regulatory benefits attached to high ratings.[47] Thus far both the legal and the economic literature have been unable to identify a workable solution to these problems.[48] Chapter IV will therefore explore the possibility to improve CRAs incentives by exploiting the probabilistic nature of their predictions.

In chapter V it will be shown how the law and economics movement – at least at a first glance – offers very precise predictions as regards to the behavior of human beings.[49] Therefore, it could be claimed that the law and economics movement is the answer to the indeterminacy of predictions. The last question to tackle is whether there is some truth in this claim and an economic approach to the study of the law can resurrect the demon of Laplacian determinism.

4. Methodology

[45] E.g. Krugman writes that 'It was a system that looked dignified and respectable on the surface. Yet it produced huge conflicts of interest. Issuers of debt — which increasingly meant Wall Street firms selling securities they created by slicing and dicing claims on things like subprime mortgages — could choose among several rating agencies. So they could direct their business to whichever agency was most likely to give a favorable verdict, and threaten to pull business from an agency that tried too hard to do its job. It's all too obvious, in retrospect, how this could have corrupted the process.' Paul Krugman, 'Berating the Raters' (2010) 23 New York Times A 144.
[46] Marco Pagano and Paolo Volpin, 'Credit Ratings Failures and Policy Options' (2010) 25 EP 401.
[47] Christian Opp, Marcus Opp and Milton Harris, 'Rating Agencies in the Face of Regulation' (2013) 108 JFE 47.
[48] John C Jr Coffee, 'Ratings Reform: The Good, the Bad and the Ugly' (2010) 1 HBLR 232 and Frank Partnoy, 'Rethinking Regulation of Credit-Rating Agencies: An Institutional Investor Perspective' (2010) 25 JIBL 188.
[49] Steven Shavell, 'Strict Liability versus Negligence' (1980) 9 JLS 1 and William M Landes and Richard A Posner, 'Joint and Multiple Tortfeasors: An Economic Analysis' (1980) 9 JLS 517.

To use the words of Ronald Coase '[t]he practitioners in a given discipline extend or narrow the range of the questions that they attempt to answer according to whether they find it profitable to do so, and this is determined, in part, by the success or failure of the practitioners in other disciplines in answering the same questions.'[50] In this thesis, it is argued that the developments in other disciplines are pushing legal scholars to expand their areas of interest, and hence this work intends to be at the crossroad of the law and three other disciplines: economics, philosophy, and physics. The methodology adopted is therefore interdisciplinary and is driven by the topic of the different chapters. Chapter II discusses the concept of causation in natural sciences and philosophy and therefore the tools of philosophy of science are widely used to offer an interpretation of the findings of modern science. Chapter II and Chapter III use the tools of legal philosophers in order to argue that the findings of natural scientists and philosophers are relevant to the study of the law. Once having established that there are good philosophical reasons to adopt a view of the world that is in line with natural sciences, the thesis becomes purely normative. In this vein, Chapter II and Chapter IV analyze and compare different solutions to practical problems. At this stage, the role of law and economics becomes prominent, as it offers a relatively simple way to compare and rank different policy solutions. From this perspective, a key concept is the notion of efficiency. A policy solution will be considered superior to its alternatives whenever there are good reasons to affirm that it will be more efficient (i.e. it leads to a higher level of social welfare) than the other feasible policies. The concept of corrective justice will also be used to assess the consequences of the solutions presented. Lastly, as chapter V investigates the robustness of traditional law and economics model, a theoretical law and economics approach is adopted.

Notably, as one of the goals is to explore the lessons that legal scholars could learn by looking at other disciplines, technical and mathematical formalizations will generally be avoided

[50] Ronald H Coase, 'Economics and Contiguous Disciplines' (1978) 7 JLS 201.

whenever possible. Although this comes at a risk of some imperfections, it still seems to represent a suitable compromise. Technical language and sophisticated methodologies are generally a powerful boundary among different disciplines, and therefore they are to be avoided if the goal is exactly to overcome these boundaries.[51]

5. Roadmap

This thesis rests on four claims. (*i*) The form of scientific determinism generally associated with Laplace's demon has been abandoned in natural sciences and philosophy, (*ii*) yet the law is still clinging to a deterministic view of the world. However, (*iii*) the indeterministic drift of natural scientists and philosophers should not be overlooked by legal scholars as (*iv*) the effects of the deterministic demon stretch way beyond the analysis of causation. Arguments in support of this first claim have been presented in the second section of this introduction. Chapter II deals with the second claim: it will be briefly shown that deterministic considerations play a fundamental role in the analysis of causation in the law of torts.[52] Probabilistic considerations are sometimes introduced in the analysis, but they are limited to a relatively narrow number of circumstances. In the second part of chapter II it will be suggested that switching to a probabilistic concept of causation could help to solve some of the riddles that have been haunting legal scholars in the recent years (*iii*). A specific approach to probabilistic causation is developed by drawing the distinction between instant torts and lagged torts. More precisely, it will be suggested that the former should be analyzed by using a concept of ex-post probability, whereas the latter requires a focus on ex-ante probability.[53]

[51] Although it has been suggested language and methodologies are only short term barriers. Cf Coase (n 50).
[52] Gold (n 36).
[53] Ex-ante probability refers to the following question 'Given that the driver is speeding, what is the probability that he will cause an accident?' This kind of probability therefore refers to a situation existing before the accident.

Chapter III moves from the assumption that a non-Laplacian view of the world is to be adopted. Moving from this postulate, the goal of chapter III is to show that in a probabilistic world the debate on deterrence theory and corrective justice has to be reframed. Some attempts to accommodate the two apparently incompatible theories have been made, yet they have largely remained unheard.[54] In this chapter, it will be suggested that the focus on probability strengthens the claim that corrective justice and deterrence have to be perceived as necessary complements.

Chapter IV deals with the fourth claim advanced in this work, namely that the demon has also very subtle ways of manifesting itself. In this vein, it will be suggested that a deterministic mindset does not allow identifying appropriate regulation for activities performed through the use of probabilistic models. The focus of this chapter will be on Credit Rating Agencies (henceforth CRAs). More precisely, it will be suggested that it is possible to give CRAs better incentives to produce accurate ratings by tying liability to their probabilistic predictions.

Lastly, in chapter V the lens will be on the economic models of tort law, as there the predictions are often very precise and deterministic in nature. In fact, the fundamental theorems of tort law and economics state that under the classic assumptions any negligence rule gives both parties efficient incentives with respect to care.[55] The activity level theorem asserts that under the classic assumptions no negligence rule gives both parties efficient incentives with respect to activity level.[56] Despite the apparently accurate predictions offered by these theorems, it will be shown that they do not offer any information on the behavior of injurers and victims. In fact, for the theorems to hold it is necessary that care level and activity level are

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Once the accident has taken place, the relevant question becomes whether the harm suffered by the pedestrian was caused by the driver. This enquiry uses ex-post probability (as they follow the accident).

[54] Chapman (n 43) and Geistfeld, *Economics, Moral Philosophy, and the Positive Analysis of Tort Law* (n 43).

[55] The first to label these findings 'the first fundamental theorems of tort law and economics' was Dari-Mattiacci. Cf Giuseppe Dari-Mattiacci, 'Tort Law and Economics' In Hatzis N Aristides (ed), *Economics Analysis of Law: A European Perspective*, (EE 2002).

[56] Shavell, *Strict Liability versus Negligence* (n 49).

independent goods. In other words, law and economics scholars implicitly assumed that whenever a party has an excessive activity level the best reaction of the other party is to reduce the activity level, never to increase the care level.[57] Relaxing this assumption, even the extremely simplified world of the economists is dominated by an indeterminacy principle.

II. God`s Dice: Causation in a Probabilistic World

1. Introduction

[57] This preliminary criticism is slightly imprecise. A more detailed and accurate description of this problem will be introduced in chapter V.

Also limiting oneself to a single jurisdiction, a whole thesis would not suffice to offer an even remotely accurate account of the countless facets of causation in the law.

Therefore, in this chapter I shall only offer a very brief overview. In doing so, I will follow the non-conventional approach of Guido Calabresi and distinguish three concepts of 'cause': 'causal link', '*but for* cause', and 'proximate cause'.[58] This distinction allows to disentangle three different concepts which are important to highlight.

The 'causal link' is the closest relative to the idea of causation studied in natural sciences and in philosophy. The focus is on empirical patterns and on the idea that a certain factor will increase the likelihood of a certain (negative) outcome.[59] It must be noted, however, that technically speaking there is an infinite spectrum of factors that is causally linked to every injury. Therefore, the causal enquiry within the law has to be limited to the connection between actions under the control of human wills and the harm suffered by the victims.[60]

The second concept that has to be presented is the '*but for* cause'. From this perspective, causation is established if the damage would have not occurred *but for* the breach of duty. As traditionally conceived by legal scholars the 'but for' test was considered to be strictly deterministic, however it can be adapted to a probabilistic view of the world. The difference between the two interpretations of the test lies in how often the 'but for' cause (c) is assumed to be followed by the effect (e). If (e) invariably follows (c) then the 'but for' test has a deterministic nature. Conversely, the 'but for' test has a probabilistic form when stated in the following terms 'the probability of (e) occurring but for (c) would have been lower'. In this

[58] Guido Calabresi, 'Concerning Cause and the Law of Torts: An Essay for Harry Kalven, Jr.' (1975) 43 UCLR 69, 71.
[59] Ibidem.
[60] It should be noted that determining which actions are within human control is an incredibly difficult –if not impossible – task. Cf Michael S. Moore, *Causation and Responsibility: An Essay in Law, Morals, and Metaphysics* (OUP 2009) 20-33 and Giuseppe Maggio, Alessandro Romano and Angela Troisi, 'The Legal Origin of Income Inequality', (2014) 7 LDR 1, 15-18 (arguing that it is practically impossible to distinguish between factors within and outside human control).

case, the probability of e following c is never exactly equal to zero or one. When considered in its probabilistic version the 'but for' test closely resembles the 'causal link'.

An interesting evolution of this approach was introduced by Hart and Honoré,[61] and was developed by Richard Wright.[62] The 'necessary element of a sufficient set' (NESS) test that they propose is built on the idea that:

> 'A particular condition was a cause of (condition contributing to) a specific consequence if and only if it was a necessary element of a set of antecedent actual conditions that was sufficient for the occurrence of the consequence.'[63]

Lastly, the elusive concept of 'proximate cause' prevents that the defendants be held liable for the additional harm caused by an intervening event that breaks the chain of causation between the negligent act and the harm.[64] Many (often contradictory) justifications have been presented to explain the emergence of proximate cause in the common law realm;[65] among them especially relevant appears the concern for limiting the compensation owed by the injurer to the foreseeable consequences of his negligent conduct.[66]

It is not hard to prove that among legal scholars a deterministic view of the universe is still prevailing. An influential writer like Wright no earlier than 2011 affirmed that:

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61 Herbert L A Hart and Tony Honoré, *Causation in the Law* (2nd edn 1985, OUP) 109-114.
[62] Cf Wright, *Causation, Responsibility, Risk, Probability, Naked Statistics, and Proof: Pruning the Bramble Bush by Clarifying the Concepts* (n 38)
[63] Ibidem.
[64] There is no consensus on the definition of proximate cause. Cf Black's Law Dictionary 265, 266 (10th edition 2014). Not coincidentally Page Keeton et al write 'there is perhaps nothing in the entire field of law which has called forth more disagreement, or upon which the opinions are in such a welter of confusion'. Cf Keeton Page et al, *Prosser and Keeton on the Law of Torts* (5th edn, W. Page Keeton ed 1984) 263.
[65] For an extensive discussion on the point cf Patrick J Kelley, 'Proximate Cause in Negligence Law: History, Theory, and the Present Darkness' (1991) 69 WUL 49.
[66] One of the pioneers was Frederick Pollock, The Law of Torts (15th ed, 1951). More recently Fishman writes 'common law proximate cause refers to reasonably anticipated consequences or the lack of intervening forces between the challenged activity and harm. The best argument for applying the proximate cause… is that it is not fair to hold actors responsible for every effect that could be causally linked to their conduct regardless of how remote, unusual, or unforeseeable the consequence.' (citations omitted). Robert L Fischman, The Divides of Environmental Law and the Problem of Harm in Endangered Species Act (2008) 93 ILJ 688.

> 'Causal law is a law of nature; it describes an empirically based, invariable, ***nonprobabilistic*** relation between some minimal set of abstractly described antecedent conditions and some abstractly described consequent condition, such that the concrete instantiation of all the antecedent conditions will always immediately result in the concrete instantiation of the consequent condition. Any concrete condition that is part of the instantiation of the completely instantiated antecedent of the causal law is a cause of (contributed to) the instantiation of the consequent.'[67] (emphasis added)

The demons of the past are alive in the realm of the law, while modern science is not. If these axioms are accepted, it is not surprising that when the law is confronted with the findings of modern science – generally expressed in terms of probabilistic relations – many problems arise.

2. Why Should Legal Scholars fight the demon?

In an extremely important article Jacques Hadamard[68] proves that 'no finite degree of precision of initial conditions will allow us to predict whether or not a planetary system (of many bodies) will be stable in Laplace's sense.'[69] The problem however, is that we can never define initial conditions with an infinite precision (neither we can capture with infinite precision the resulting state), and hence probabilistic descriptions of phenomena are here to stay. On this regard, Bunge, one of the most influential philosophers of science of our time, writes that:

> 'This uncertainty in the initial information . . . spoils the one-to one correspondence among neatly defined states even if, as in classical physics, the theoretical values are

[67] Richard W. Wright, 'Proving Causation: Probability versus Belief' in Richard Goldberg (ed), *Perspectives on Causation* (Hart Publishing 2011) 205.
[68] Jacques Hadamard, 'Les Surfaces à Courbures Opposées et Leurs Lignes Géodésique' (1898) 4 J Math Pures et Appl 27.
[69] Cf Pooper (n 7) 40.

supposed to be sharply defined . . . [therefore] *all* laws, whether causal or not, when framed in observational terms acquire statistical features.'[70] (emphasis in the original)

And:

'[W]hether chance is regarded as a radical ultimate . . . or not, statistical determinacy has to be accounted for by every philosophy of modern science; it is no longer possible to state dogmatically that chance is but a name for human ignorance, or to declare the hope that it will ultimately be shown to be reduced to causation.'[71]

Firstly, it is important to note that these words were written over 50 years before the work of Wright,[72] which shows how slowly ideas flow among the different fields of human knowledge. Secondly, Bunge is probably more a determinist than many contemporary philosophers, yet the idea of exclusively nonprobabilistic laws is totally alien to his thought.

The scenario does not change much if we refer to a philosopher cited by Wright himself: Sosa. In the introduction to a collection of articles on causation Sosa and Tooley write that:

'One of the more significant developments in the philosophy of causation in this century has been the emergence of the idea that causation is not restricted to deterministic processes . . . .One suggestion, advanced by philosophers such as Reichenbach, Good, and Suppes, is that probabilistic notions should play a central role in the analysis of causal concepts.'[73]

Nevertheless, law scholars have largely adopted two antithetical perspectives with regards to the debate on causation in the scientific and in the philosophical arena: on the one hand, it has

[70] Cf Bunge (n 34) 72.
[71] *Id*. at 17.
[72] Cf Wright, *Proving Causation: Probability versus Belief* (n 67).
[73] Ernest Sosa and Michael Tooley, *Causation* (OUP 1993).

been argued that the traditional *but for* test conforms to philosophers' and scientists' idea of causation,[74] whereas on the other hand, it has been affirmed that causation in the law has little (if anything) to do with philosophical or scientific considerations.[75] As I have shown, the former perspective is for the most part false, whereas the latter is extremely dangerous. On these premixes, and especially on the consideration that the law is interested in identifying causal links in concrete single cases, let us analyze how the traditional version of the 'but for' test, the NESS test, and proximate cause perform in the light of modern science.

The analysis needs not be too long; the deterministic version of the 'but for' test and NESS require that causes are necessary and sufficient, yet in a non-Laplacean world no cause is both necessary and sufficient In a probabilistic world, a set of causes can produce or not produce a specific outcome, however *one single outcome will never be the necessary result of any set of causes*.[76] The other side of the coin is that *no set of causes is a sufficient condition for any outcome*. The deterministic version of the 'but for' test and NESS can only survive in a Laplacean universe. In the one where we live, however, they lead to the conclusion that no liability ever exists, because no conduct can be a necessary and sufficient condition for any harm.

The elusive concept of 'proximate cause' does not fare better. The common wisdom is that the doctrine of proximate causation prevents the defendants from being held liable for events

[74] Among the others, Wright affirms that '[t]he act must have been a necessary condition for the occurrence of the injury. The test reflects a deeply rooted belief that a condition cannot be a cause of some event unless it is, in some sense, necessary for the occurrence of the event. This view is shared by lawyers, philosophers, scientists, and the general public.' Richard W Wright, 'Causation in Tort Law' (1985) 74 CLR 1735, 1775.
[75] Cf e.g. Jane Stapleton, 'Choosing What We Mean by Causation in the Law' (2008) 73 MLR 433. (noting that '[t]raditionally, lawyers disdained philosophical enquiries into "causation" as being too abstract or vague').
[76] Wright writes that '[a] fully specified causal law or generalization would state an invariable connection between the cause and the consequence: given the actual existence of the fully specified set of antecedent conditions, the consequence **must** (emphasis added) follow. In other words, the fully specified set of antecedent conditions is sufficient (emphasis original) for the occurrence of the consequence' This definition of the term sufficient is incompatible with probabilistic causation Wright, '*Causation in Tort Law*' (n 74) 1789.

that are 'too remote'[77] so to limit the compensation owed by the injurer to the foreseeable consequences of his negligent conduct.[78]

Borrowing (part of) the taxonomy developed by Mark Grady, let us consider two faces of foreseeability: 'freakish risks'[79] and the paradigm SDK ('scientists didn't know').[80]

In the category of freakish risks are included all those unusual and abnormal consequences of a determinate action that are too rare to be foreseen. Interestingly, there is simply no reason to talk about proximate cause in order to exclude these events from the scope of liability. According to the traditional economic analysis of law, compensation is due only when the expected harm (magnitude of the harm times the probability) is higher than precaution costs.[81] By definition, a 'freakish risk' will have a very low probability of materializing and therefore the expected harm will systematically be much smaller than the harm itself; compensation will generally not be triggered. In other words, the frequency of an event is a factor that should enter the negligence calculus and not the debate on causation.

The SDK paradigm deals with a very different set of cases, in which it is not known ex-ante that a certain conduct is dangerous. Take for example the *Overseas Tankship (U.K.) Ltd. V. Morts Dock & Engineering Co.* case.[82] Here, the defendant did not prevent the bunker oil of his ship from reaching the Sidney Harbor. Given the state of the art of scientific knowledge, this situation was perceived as relatively safe because bunker oil was considered nonflammable when spread on water. However, the bunker oil soon ignited and destroyed the plaintiff's dock.

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[77] Cf Black's Law Dictionary (n 64) 265-266.
[78] Cf Frishman (n 66) 688.
[79] The term is borrowed from Steven Shavell, 'An Analysis of Causation and the Scope of Liability in the Law of Torts' (1980) 9 JLS 463, 490.
[80] Mark F Grady, 'Causation and Foreseeability', in Jennifer Arlen (ed), *Research Handbook on the Economics of Torts* (EE 2014) 114, 133.
[81] This is generally known as the Learned Hand formula. Cf *United States v. Carroll Towing Co.*, 159 F.2d 169, 173 (2d Cir. 1947) (advocating the use of a formula for determining whether a person's conduct fell below the appropriate standard of care). Efficiency requires that marginal costs and benefits are considered.
[82] *Overseas Tankship Ltd. v. Morts Dock & Engineering Co.* (Wagon Mound 1), [1961] 1 A.C. (P.C.) (appeal taken from N.S.W.).

The court decided that no compensation was due because the accident was not foreseeable at the time in which the defendant negligently allowed the bunker oil to escape from its ship. This is despite the fact that ex-post it became clear that the 'untaken precaution' would have been effective (and efficient) in preventing the harm. Grady concludes that 'to impose liability in this situation for a possibly efficient act could only reduce activity levels or induce inefficient precaution substitutions.'[83]

Let us analyze this problem in a probabilistic context in which scientific knowledge is inherently probabilistic. Let us define t_0 the time of the accident and t_1 the time when it becomes known that bunker oil is flammable also when spread on water. In t_0 the injurer thought that there was a probability p_0 of an accident, whereas in t_1 scientific studies suggested that the probability was equal to p_1 (with $p_0 < p_1$). Due to the limits of scientific knowledge, neither p_0 or p_1 is equal to the real probability (say p^*), however scientific studies suggested that p_1 was a more accurate approximation of p^*. Foreseeability then reduces to the choice between the less or the more accurate approximation of p^* in the negligence finding. Adopting a dynamic perspective, contrarily to what Grady says, this choice involves a trade-off recognized by the law and economics literature.[84] In terms of efficiency, by opting for p_0 the court will prevent the effects described by Grady, whereas choosing p_1 the court will incentivize research and development activities. Similarly, if the problem is framed in terms of corrective justice, it might be more or less desirable that unknown risks are borne by the injurer depending on the concept of fairness adopted. It is however apparent that this trade-off has nothing to do with causation. In the case described, for example, it might be considered fair that the injurer bears

[83] Grady (n 80) 134.

[84] This trade-off in the law and economics literature is generally framed in terms of strict liability versus negligence, with the former giving more incentives in discovering new risks. Cf e.g. Alfred Endres and Regina Bertram, 'The Development of Care Technology under Liability Law' (2006) 26 IRLE. 503 (2006). The problem in this context is similar. If firms are shielded from new risks because courts will adopt p_0, they will have less incentives in discovering new sources of risk and new remedies.

the losses because the plaintiff's dock was destroyed as a direct consequence of his activity. Alternatively, one could argue that it would be unjust to force the injurer to pay for a harm he could have not foreseen. In either case, the causal process underlying the accident is still the same and has nothing to do with the decision of holding the injurer liable or not.

Lastly, also the idea that an event might break the chain of causation is problematic. As noted by Morse '[i]t is metaphysically implausible that there are "sharp breaks" in the "causal chains" of the universe that would provide moral rationale for the same sharp breaks in legal doctrine … [C]ausation just keeps rolling along.'[85]

In other words, as the concept of proximate cause implies causal chains, which in turn are fictitious,[86] it is detached from the modern debate on causality. Thus, it is not surprising that proximate cause becomes a vehicle to introduce policy goals that are not related to the cause-effect relationship.[87]

Recently, Michael Moore offered an interesting alternative description of the concept of intervening cause. In his view, the strength of legal causation diminishes 'over the number of events through which it is transmitted.'[88] This conceptualization of the idea of intervening cause is however unworkable in a world (like ours) in which time and space are continuous and not discrete. In a continuous world, no matter how contiguous two events might appear in time and in space, there are always infinite events separating them. Let us assume that it is possible to represent a series of events on a Cartesian Plane where the horizontal axis is the time and each

[85] Stephen J Morse, 'Moral Metaphysics of Causation and Results' (2000) 88 CLR 879, 880.
[86] On this regard, Bunge writes that 'Just as ideal objects cannot be isolated from their proper context, material existents exhibit multiple interconnections, therefore the universe is not a heap of things but a system of interacting systems. As a consequence, a particular effect E is not only the product of the *vera e primaria causa* C…but of many other factors.' Cf Bunge (n 34) 128.
[87] Although taking a different path, a similar conclusion was reached by the early U.S. Realists. In their perspective proximate causation devices were "word of magic whereby unprincipled limitation-of-liability decisions could be achieved a twill or whim by untrammeled judges". Cf David W Roberston, 'Allocating Authority among Institutional Decision Makers in Louisiana State-Court Negligence and Strict Liability Cases' (1996) 57 La L Rev 1079, 1114.
[88] Moore (n 60) 153.

event is a point (event-point). If the series of events is represented by a continuous function (i.e. we are not describing a discrete world), there will always be infinite event-points separating any two given event-points. Or, to go back to the issue of proximate causation, there will always be infinite event-points separating the "proximate" cause and the "proximate" effect. Alternatively, the problem could be framed in the following way. Let us assume that we want to understand how many event-links separate the proximate cause A from the proximate effect B. We will define event-link any event that has an effect on A and B. As shown by the paradox of isolation described in section 2.2. of the introduction, it is impossible to perfectly isolate some events from the others. To put it differently, there are no absolute boundaries in nature and hence every event has some direct or indirect influence on A and B. Because we live in an infinitely large universe, and because no boundary can be drawn between any event and A/B, there will always be infinite event links separating A and B.

A possible counterargument would be that most of these events only have a negligible impact on A/B relationship. However, this argument adds an additional layer of complexity. First it presupposes that it is possible to measure the intensity of the connection between any given event-link and A/B. Second, even accepting this unlikely assumption, this line of thought implies that an arbitrary threshold must be drawn to decide what is the minimum intensity accepted for an event to be considered as event-link. This entirely arbitrary choice that is not causal in nature would in turn determine whether the number of event links is low enough or not. Notably, also the choice of number of event-links that renders a cause not proximate is entirely arbitrary and not causal in nature.

In short, unless absolutely arbitrary thresholds are introduced that the number of event links separating two given events is always infinity. Therefore, if legal causation loses strength when the number of event-links is high then legal causation can never be established.

3. The Probabilistic Approach to Causality

Before developing the argument in support of probabilistic causation, a preliminary remark is required. As the demon of scientific determinism has been defeated by modern science, there is no longer any reason to postulate metaphysical determinism. The pendulum has swung from a kind of scientific knowledge that prima facie suggested the existence of metaphysical determinism to the presumption that chance is to be considered a radical ultimate. The fact that metaphysical determinism itself has not been falsified should not be perceived as a proof of its strength, but as a sign of its inherently conjectural nature.[89]

The inadequateness of deterministic causation as an approach to explore the world has violently emerged over the last decades. Suffices it to think to toxic torts to understand that what has been discussed in the previous sections is far from being a purely philosophical and abstract whim.[90] Some scholars had hoped that scientific discoveries would have ameliorated (if not solved) the problem of indeterminate causation in this area, yet the reality is drastically different; a 'deeper knowledge will extend rather than resolve the problem of causal indeterminacy.'[91] In this vein, the scientists operating in the field have no doubt; the

[89] Cf Popper (n 7) and Reichenbach (n 9) 2.
[90] Steve Gold gave an influential definition of 'toxic torts'. He wrote that a toxic tort is 'an alleged personal injury and related harm resulting from exposure to a toxic substance -usually a chemical but perhaps a biological or radiological agent.' Steve Gold, 'Note, Causation in Toxic Torts: Burdens of Proof Standards of Persuasion, and Statistical Evidence' (1986) 96 YLJ 376, 376. On this regards, Robinson writes that 'The recent onslaught of "toxic," "catastrophic injury," or "mass disaster" tort cases has made heavy demands on the tort system. The litigation is complex, the victims are numerous, the aggregate losses are daunting, and uncertainty over the causal origins of injury creates exceptional problems of proof.' Glen O Robinson, 'Probabilistic Causation and Compensation for Tortious Risk' (1985) 14 JLS 779, 779.
[91] Cf Gold (n 36) 240.

'probabilistic description of the mutation process cannot be replaced by a deterministic one',[92] given the importance of stochastic events.[93]

3.1 A Pure (ex-ante) Probabilistic Approach

A pure (ex-ante) probabilistic approach to causation is grounded on four building blocks:

1. The main asset of any potential victim is formed by the probability of *not* suffering a specific harm (Pr).
2. Causation is established whenever Pr is affected by the (negligent) conduct of a potential injurer.
3. Compensation is due when - given the level of scientific knowledge – it should be concluded that Pr was reduced by the (negligent) conduct of the tortfeasor.
4. Compensation must be proportional to the Pr lost.

Given its importance, some elaboration is required on the first point. In a probabilistic world it is impossible to be certain of being immune from a specific kind of harm. Even the most remote risk will always have a positive probability of materializing. A statement of the kind 'I have contracted the disease D because the firm A has polluted the environment' is therefore incorrect. The only possible statements are in the following form 'because the firm A has polluted the environment, I had a greater chance of contracting the disease D'. In other words, the victim has never had an entitlement to not contracting the disease D. The victim was merely entitled to not being on the receiving end of negligent conducts that increased the probability

[92] Anatoly Ruvinsky, *Genetics and Randomness* (CRC Press 2010) 39.
[93] Robin Holliday, 'DNA Methylation and Epigenotypes' (2005) 70 *Biochemistry* 500. The number of articles in which the role of probabilistic considerations is emphasized is enormous and rapidly growing. For an in depth analysis of the role of probability in toxic cases, cf Gold (n 36).

of contracting D. From these considerations it follows that the asset of the victim with regards to the disease D is not his entitlement to being healthy, but the probabilities that he had of not contracting the disease.

One crucial piece of the puzzle is therefore that subjecting another person to risk (i.e. reducing his probability of not being harmed) constitutes harm in itself. On this regard, Stephen Perry argues that as far as we can discriminate between the victims that contracted D due to firm A's pollution and those who contracted it due to the background risk, it makes no sense to consider risk compensable harm.[94] Three important implications naturally follow.

Firstly, Perry's argument postulates the existence of the demon and, in fact, he echoes Laplace by affirming that 'a distinction can be drawn *in principle* between the two categories of cases'.[95] However, chaos theory, quantum mechanics, and the works of Hadamard have shown that perfect predictability cannot be achieved, and therefore it is not possible to perfectly discriminate among different causes. Not in practice, not in principle. Not surprisingly, the only arguments used by Perry to rule out the indeterministic hypothesis are extremely weak. On the one hand, he makes an unsubstantiated claim on the allegedly deterministic nature of the causal process analyzed by the House of Lords in the famous case *Hotson v. East Berkshire Area Health Authority*.[96] On the other hand, he relies on the controversial philosophical thesis that the indeterminism at a macroscopic level is simply washed off.[97] In a world in which scientific determinism does not hold, Perry's arguments lose all of their strengths.

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[94]Stephen Perry, 'Risk, Harm, and Responsibility' in David Owens (ed), *Philosophical Foundations of Tort Law* (OUP 1995) 338.
[95] *Id*. at 334.
[96] [1987] 1 App. Cas. 750 (H.L.). Perry writes that 'in many of the fact situations in which risk damage has been alleged, the causal processes at work seem more likely to have been deterministic than indeterministic in character. This is true of *Hotson,* for example, where the House of Lords made the very plausible assumption that at the time the plaintiff arrived at the hospital *either* enough blood vessels were still intact to make his injury treatable, *or* enough had been destroyed to make avascular necrosis inevitable'. There is *nothing* however that can induce one to think that the causal process was indeed deterministic. Perry (n 94) 338.
[97] Perry (n 94) at 337. On this regard, Putnam writes 'That there is something special about macro-observables seems tremendously unlikely. Putnam (n 27) 628.

Secondly, it is clear that the thesis advocated in this chapter goes beyond merely supporting proportional liability. By exorcising the demons of scientific determinism, the philosophical foundations of a new conception of harm are laid. As recognized by Perry himself, in a probabilistic world material harm is not the only possible kind of harm.[98] In this vein, the harm can be defined as the reduction of this probability caused by the injurer. The need for this new conception of harm is even more pronounced now that technological progress is turning the traditional conception of physical harm into a 'hopelessly imprecise screening devise'.[99] In fact, as Jamie Grodsky nicely put it, new technologies are dismantling the risk-injury divide by making it impossible to draw a bright line distinction between risk and harm.[100]

Thirdly, it is possible to provide an answer to those who claimed that legal scholars should not follow natural sciences in their indeterministic drift.[101] As proven by Perry, the only way to detect the existence of a kind of harm based on ex-ante probabilities is to acknowledge that scientific determinism is a relic of the past.[102] At the same time, clinging on scientific determinism would not make this harm evaporate. It would simply make the law blind to it.

Notably, hidden in a probabilistic approach there is a risk of infinite regress. Once a probabilistic view of the world is embraced *tout court*, it must be recognized that also probabilistic predictions are reliable only with a certain probability. A statement in the form 'Firm A has increased the probability of contracting disease D by 10%' can only be as reliable as the studies on which it is grounded. If a probabilistic approach is embraced to stay away from

[98] Perry is perfectly aware that his argument holds only in a purely deterministic world. In fact, he writes that '[i]n the indeterministic case there seems to be a true detrimental shift in position that is simply not present in the deterministic case' Perry (n 94) 338.
[99] *Potter v Firestone Tire & Rubber Co*., 863 P.2d 795, 810 (1993).
[100] Not surprisingly, she also notes that 'there is no consistency in the courts as to what constitute physical injury'. Jamie A Grodsky, 'Genomics and Toxic Torts: Dismantling the Risk-Injury Divide' (2007) SLR 1671, 1685. Cf also Scott Aberson, 'Note, A Fifty-State Survey of Medical Monitoring and the Approach the Minnesota Supreme Court Should Take When Confronted with the Issue' (2006) 32 WMLR 1095, 1115.
[101] Cf Wright, '*Causation, Responsibility, Risk, Probability, Naked Statistics, and Proof: Pruning the Bramble Bush by Clarifying the Concepts*' (n 38) 1029.
[102] Perry (n 94) 338.

the deterministic demon, compensation should be scaled down to account for the finite accuracy of the study. Acting otherwise, the result of the study would be considered absolutely true and this is in sharp contrast with a probabilistic view of the world. That is to say, if the harm is equal to 10 and the reliability of the study is 90% compensation should equal 9 (10*0.9). Unfortunately, this is only the tip of the iceberg. Also the reliability of the probabilistic study can be determined only with a certain probability, say for example again 90%. To account for this factor, compensation should be lowered to 8.1 (10*0.9*0.9). As in a probabilistic world determinist statements are barred, this chain of probabilistic statements is clearly infinite. In this vein, the original value of compensation has to be multiplied for an infinite number of factors, all strictly smaller than one. It follows that, no matter how large the harm is and how accurate the studies are, the compensation owed by any injurer will always tend to zero.

Albeit apparently abstract, this consideration has an immediate practical implication. Most of the literature has generally portrayed all-or-nothing and proportional liability as mutually exclusive alternatives,[103] whereas in a probabilistic world they become necessary complements. As also probabilistic predictions only have a finite confidence, a probabilistic approach is unworkable without drawing an arbitrary and artificial deterministic line to temper its consequences. In section V, I will try to establish where this deterministic line should be drawn.

3.2 A Possible Counterargument

Although probabilistic analysis of causality is gaining momentum among philosophers and has become pervasive in nearly every field of human knowledge, some problems still exist. Given the practical nature of the enquiry and the need for the law to provide answers in states that are

[103] Cf Steven Shavell, 'Uncertainty over Causation and the Determination of Civil Liability' (1985) 28 JLE 587, 587-590.

extremely far from idealized experiments, I will not discuss systematically each of these criticalities.[104] One point, however, needs to be addressed. The traditional probabilistic approach to causality defines as cause an event that *increases* the probability that a certain outcome will materialize, whereas some events that are generally considered causes *reduce* the probability of an effect.[105] As explained by Sosa and Tooley, this is a problem that must be addressed by any probabilistic theory of causation.[106] Suppose that two different kinds of disease exist; the first (C) is fatal with a probability of 0.1 and the second (D) with a probability 0.8. Let us also assume that each disease confers immunity against the other. Finally let us also assume that at least half of the people contract D.[107] As noted by Sosa and Tooley 'both the unconditional probability of death, and the probability of death given the absence of the first disease, are greater than the probability of death given the presence of the disease, even though, by hypothesis, the disease does cause death with a certain probability.'[108]

It seems that both for practical and for philosophical reasons the relevance of this problem might be limited. Firstly, the problem with the example presented above is that it equates death as an effect from any possible cause. It is hard to imagine that any theory on causality adopting this approach will take us far. For example, if we assume that C causes a fatal heart attack, whereas D causes a deadly loss of blood the apparent contradiction disappears. In fact, C would increase the chances of a heart attack and D would increase the probabilities of a deadly loss of blood. If we recognize that causes have infinite facets but we assume that outcomes are univocally defined, the emerging contradictions will be due to this asymmetric treatment more

[104] As an example, it is way outside the scope of this chapter to discuss an issue as the Einstein-Podolsky- Rosen problem, defined by Reichenbach a 'causal anomaly'. For a debate on this problem, Cf Bas C Fraassen, 'The Einstein-Podolsky-Rosen Paradox' (1974) 29 *Synthese* 291.
[105] Patrick Suppes, 'Conflicting Intuitions about Causality' (1984) 9 MSP 151.
[106] Sosa & Tooley (n 73) 20.
[107] In this simplified example, no other causes of death exist.
[108] Sosa and Tooley (n 73) 20. They write '[Under the assumptions described] both the unconditional probability that one will die within the relevant period, and the probability of death given that one does not have the first disease, must be equal or greater than 0,4, whereas the probability that one will die if one does not contract the first disease is only 0.1' thus proving the conclusion presented above.

than to our definition of cause. Conversely, if we admit that we can never define initial conditions with absolute precision (also because they are characterized by infinite dimensions) we should admit that *also outcomes cannot be proven to be absolutely identical*. The apparent paradox is vanished already. Secondly, given the modest purpose of this chapter (the enhancement of probabilistic considerations in the law) the importance of this problem is limited. Therefore, instead of talking about causes, I will say that an event has a *causal effect* whenever it *affects* the probabilities of a given outcome.

To understand the gist of this problem let us reproduce the example described above with a slight modification. In order to make the idealized scenario relevant to tort law I will assume that C and D are causally related to the pollution produced by two factories A and B. All the other assumptions are identical. The pollution from A causes the disease C (fatal in one tenth of the times), whereas B causes the disease D (that kills 80% of the people who are infected). Once again, I assume that each one of these diseases completely immunizes against the other.

Four different scenarios are possible, depending on the level of information available:

1) It is not known that the pollution caused by A and B affects the probability of contracting C and D. In this case no liability can be imposed on the two firms.

2) It is known that pollution from one of the firms causes the disease with a certain probability, whereas no information is available with regard to the other firm. In this case, it is unavoidable that the firm who is introducing a known risk will be held liable, while the other will go unpunished.

3) All the relevant information is known, apart from the fact that one disease protects against the other. In other words, it is not known that the disease C is actually 'beneficial'. In this case, it is desirable to impose liability on both firms. Liability cannot

be excluded on the ground that pollution from one firm might have a beneficial effect in terms of reducing other dimensions of risk. The reason is simple: this possibility can *never* be ruled out, hence liability would not be imposed on any conduct.

4) All the information is known. Assuming that there are no policy reasons to shut down firm D, then it is socially desirable that firm C is not held liable. This is because the pollution caused by firm C is paradoxically preventing more deaths than it is causing. However causation *is not the mechanism to achieve this outcome*. In fact, causation *is* established. A affects the probabilities of C happening. Yet, A should still be shielded from liability due to the positive externalities of its activity.

This result can be achieved either through tort law or by introducing a system of social insurance. In the former case, let us assume that A could have prevented the harm by buying a device that fully eliminates its pollution. If positive externalities are introduced in the negligence calculus,[109] A will be found negligent only if the cost of the device is lower than the harm it prevents minus the positive externalities. As this difference is negative, no matter how cheap the device is, A will never be considered negligent.

Alternatively, a social insurance system would introduce the possibility that the victims of C will be compensated by a public fund instead of being compensated by A. It should be noted that this solution has already been adopted in many countries for victims of vaccines.[110] Although at a first glance this context might appear drastically different, A is *de facto* a vaccine against the disease D. Regardless of the path followed, causation is the wrong tool to protect A because the causal link cannot (and should not) be denied. It is a matter of efficient care.

[109] For a treatment of how the legal system deals (and ought to deal) with positive externalities cf Giuseppe Dari-Mattiacci, 'Negative Liability' (2009) 38 JLS 21.

[110] Cf, among the others, Laine Rutkow, Brad Maggi, Joanna Zablotsky, and Thomas R Oliver, 'Balancing Consumer and Industry Interests in Public Health: The National Vaccine Injury Compensation Program and its Influence During the Last Two Decades' (2006) 111 PSLR 681.

3.3 The Hidden Demon of Law and Economics

Law and economics scholars have long advocated the use of probabilistic notions in the law, yet paradoxically in most cases they did so while relying either implicitly or explicitly on a strictly deterministic view of the world.

A prominent example of determinism in disguise are the works from Steven Shavell on uncertain causation.[111] Already in the set-up of his model Shavell reveals his Laplacean credo by assuming that 'there is one and only one entity for which the following statement is true: "The accident would not have occurred in the absence of the entity."'[112] And that 'When an accident occurs, there will be a chance that the entity that caused it will not be known to the court . . . but the conditional probability that the entity caused the accident will be determined by the court.'[113] The former statement is typical of Laplacean one to one relationships between causes and effects, whereas the latter is a reference to epistemological uncertainty.

Although one might be tempted to question whether these statements are merely working assumptions or a declaration of agnosticism about the nature of the world, in other parts of his analysis Shavell reveals his deterministic credo. Without the need to dig for nuances, Shavell portrays proportional liability and the 'all or nothing' approach as mutually exclusive, without recognizing the problem of infinite regress associated with a probabilistic approach. In this vein, Shavell assumes that the probabilistic signal received by the court is perfectly accurate and thus the judge can assess with 100% accuracy the probabilistic contribution of each factor. As he overlooks that also probabilistic predictions have a finite level of accuracy,[114] in his framework courts are assumed to have perfect information on the causal links taking place in a probabilistic

[111] Cf especially Shavell, *Uncertainty over Causation and the Determination of Civil Liability* (n 103).
[112] *Id.* at 590.
[113] *Ibidem.*
[114] In his model the court can perfectly observe the conditional probability that an accident caused by the party appears to be of ambiguous origin, and the conditional probability that an accident caused by the natural agent appears to be of ambiguous origin. *Id.* at 591.

world (even better than quantum physicists). In turn, this rules out every uncertainty surrounding causal investigations.

Therefore, attempting to locate Shavell's work in a probabilistic world would produce a paradoxical result. In a probabilistic world a probabilistic signal is all that there is to know about causal links; as this signal received by the court is assumed to be perfect, Shavell's work on uncertain causation *de facto* rules out the existence of uncertain causation. Predictably, Shavell concludes that the 'use of proportional liability results in the same outcome that would be observed in absence of any uncertainty over causation.'[115]

Moreover, Shavell writes that '[t]his principle [of fairness] is in perfect accord with the use of a threshold probability criterion in the determination of liability. On the other hand, the principle would be violated by use of proportional liability, as a party would suffer some sanction even when it was unlikely that he caused a harm.'[116] This argument mirrors perfectly the one advanced by Glenn Robinson and by Ariel Porat and Alex Stein, thus showing that many influential law and economics scholar wear the same disguise.[117]

Following Shavell's assumptions, however, every injurer that could be held liable reduced the victim's chances of not getting harmed. Consequently – according to his own model – there is no risk that liability is imposed on parties who did not cause any harm.[118] His argument on fairness only holds in a world where the following syllogism is true: (*i*) if there is a binary relationship between causes and effects, (*ii*) and if such relationship can be identified at least in principle then (*iii*) risk creation is not harm in itself. In short, Shavell's argument only holds in

[115] *Id*. at 599.
[116] *Id*. at 605.
[117] Robinson (n 90) at 786 and Ariel Porat and Alex Stein, 'Indeterminate Causation and Apportionment of Damages: An Essay on Holtby, Allen, and Fairchild', (2003) 23 OJLS 667, 681.
[118] Recall in fact that reducing the chances of not getting harmed *is* the only form of harm in a probabilistic world. Claiming that compensation would not perfectly mirror the amount of risk created would not suffice to save Shavell's argument. In fact, under the assumption that risk creation is harm this problem would be even more severe under an "all or nothing" approach.

a deterministic world, and hence it is possible to offer a univocally deterministic account of the assumptions underlying his model.

3.4 A Spurious (ex-post) Probabilistic Approach

An alternative way to include probabilistic considerations in the study of causation is what I will define a spurious (ex-post) probabilistic approach. This approach is generally referred to as proportional liability,[119] and one of its macroscopic application was the market share liability imposed on some pharmaceutical firms.[120] This framework is grounded on a deterministic idea of the world and probabilistic considerations are included only when justified by specific characteristics of the case. Namely, the uncertainty surrounding causal investigations is regarded to be above a certain threshold.[121]

Under this approach, compensation is triggered only in the presence of material harm and the focus is shifted on ex post probability. The questions are framed in the following form 'what is the probability that the accident that has taken place was caused by the alleged injurer?'

This is the traditional compromise advocated by law and economics scholars when an idea of probabilistic causation in the law was proposed. This approach has the relevant advantage to

[119] E.g. John Makdisi, 'Proportional Liability: A Comprehensive Rule to Apportion Tort Damages Based on Probability', (1988) 67 NCLR 1063.
[120] For an extensive discussion of the theory behind proportional liability and its applications cf David A Fischer, 'Products Liability--An Analysis of Market Share Liability - I Introduction' (1981) 34 VLR 1623.

[121] Cf Richard Delgado (n 39). Cf also *Sindell v. Abbott Laboratories* 26 Cal. 3d 588, 607 P.2d 924, 163 Cal. Rptr. 132, cert. denied, 101 S. Ct. 285 (1980) (where the California Supreme Court developed a causation theory based on market shares).

allow reaching efficient outcomes provided that some very restrictive assumptions are verified.[122]

The logic behind this approach can be captured with the following example. Let us assume that a doctor negligently gives a pill with strong side effects to 10 patients and they all die. Let us further assume that this pill is responsible for the death of 7 of the patients, but due to epistemological uncertainty it is impossible to identify them. Lastly, let us assume that the loss suffered in each fatality is 10. It follows that the harm caused by the doctor is 70. Perfect compensation and optimal deterrence are achieved if he is made to repay each one of its 7 victim with 10. However, this solution is not viable because by assumption it is not known who the seven victims are.

Framed in terms of ex-post probability the relevant question is 'what is the probability that a given patient has been killed by the pills?'. If we assume that patients are identical the answer is 70% for each patient. In this vein, proponents of this approach argue that perfect compensation cannot be achieved. However, optimal deterrence will be obtained if the doctor compensates each victim with 7, because he will have to pay a sum that is equal to the harm caused. For this approach to be a viable strategy the ex-post probability must be known.

4. Normative Implications

Having defined the two possible approaches to probabilistic causation, the question is how they should be combined to develop a workable and philosophically sound approach to the issue of causation. For the sake of simplicity, I will divide tort cases in two macro-categories: traditional

[122] For example, the courts must receive a perfect probabilistic signal on the causal relationship between the conduct and the harm. Cf Shavell, *Uncertainty over Causation and the Determination of Civil Liability* (n 103) 589-590. All the assumptions and the proof are spelled out in Chapter V.

torts, and new generation torts. The difference between the two kinds of cases is the prima facie degree of uncertainty surrounding causal investigations. In traditional cases the causal link can be established prima facie in a deterministic way, whereas causal indeterminacy plagues new generation cases also on the very surface.

4.1 Traditional Torts

Examples of traditional torts are a car hitting a pedestrian or a defective product exploding and hurting a consumer. Events of this kind are generally considered a good reason to embrace a deterministic concept of causation and to postulate the deterministic nature of the world. Both these statements ignore the fact that traditional torts can also be explained by assuming probabilistic relations between causes and effects. To defeat the deterministic argument it suffices to state that cars hitting pedestrians will cause harm with an extremely high probability. In a more precise language, traditional torts can be coherently interpreted within the probabilistic framework by saying that given a certain cause the probability of an event approaches 1. To counter this argument a determinist would have to prove that this causal relationship not only manifests with a probability that is close to 1, but that no exception can ever be found. The impracticability of this quest has been known since Hume.[123]

An important consequence is that whoever argues in favor of a deterministic concept of causation (in the Laplacean sense) will never be able to rule out the probabilistic theory. Furthermore, any deterministic theory runs against the finding of modern science and modern philosophy which emphasize the importance of probabilistic relations, especially at an epistemological level. Consequently, the only reason to advocate a strictly deterministic

[123] Cf Hume David, *An Enquiry Concerning Human Understanding* (PF Collier & Son (1910), [1748]).

concept of causation is an *a priori* belief on the nature of the world. The traditional concept of causation imposes therefore such unverifiable dogma on the world.

From a practical perspective, traditional torts are easily handled both by a deterministic and a (ex-post) probabilistic approach to causation. In fact, by assumption we are dealing with cases where the causal link is established with a probability that departs only infinitesimally from 1. It follows that by adopting a spurious (ex-post) probabilistic approach also compensation would be rounded up to cover for the entire harm.).[124] In other words, there is no practical reason to revive the demon when the focus is on traditional torts as defined here.

4.2 New Generation Cases

Toxic torts and medical malpractice cases constitute prominent examples of this category of cases. Here, causal indeterminacy haunts every step of causal investigation and a deterministic fiction is unworkable given the explicitly and intrinsically probabilistic nature of the evidence available to the courts.[125]

4.2.1. Ex – Ante versus Ex – Post Probability

I have defended the idea of a pure probabilistic approach to the study of causation, yet two problems remain open. First, it might be objected that the ex-ante probability of an event is generally extremely hard to measure. This perception stems from the fact that, besides their prima facie deterministic nature, traditional cases also have an additional characteristic trait.

[124] Let us assume that a car hits a pedestrian breaking its leg. Let us also assume that the ex-post probability is equal to 99.999999% and that a leg is worth 100000€. Under the probabilistic approach, the compensation owed would be equal to 99999,999. This number will be rounded to 100000.
[125] Cf Gold (n 36) 319-320.

For traditional torts, it is generally easier to answer questions regarding the ex-post probability ('what is the probability that the harm suffered by the pedestrian was caused by the careless conduct of the driver that hit him?') than investigating ex-ante probability ('how much the careless driving of the injurer increased to risk of an accident for a certain pedestrian?'). In turn, this has generated a bias in the legal arena that automatically assumes ex-ante probability to be always harder to assess.[126]

Unfortunately, the most discussed stream of new generation cases, asbestos related claims, strengthened this bias.[127] In fact, asbestosis and mesothelioma belong to the category of 'signature diseases'. The peculiarity of this kind of cases is that they 'nearly always occur as a result of exposure to a certain substance'.[128] Hence, determining the ex-post probability that a specific substance was the actual cause of the disease is relatively easier, at least in comparison to cases involving non-signature diseases.[129] However, because for any substance there is generally more than one source, also assigning the ex-post probability to any specific source is not a trivial task. The enormous controversy surrounding causal investigation in asbestos related litigation testifies that investigating the ex-post probability is problematic even for signature diseases.[130] More importantly, non-signature diseases are rare,[131] so they should be regarded as the exception rather than the norm. In this vein, a theory of causation on new generation cases should not be grounded on cases involving asbestosis or other non-signature diseases.

[126] For example, the Third Circuit stated that "[R]ecognizing [monitoring] does not require courts to speculate about the probability of future injury." *In re* Paoli R.R. Yard PCB Litig. *(Paoli **I**),* 916 F.2d 829, 852 (3d Cir. 1990). Not recognizing however, that also adopting an ex-post perspective the courts need to speculate about probability.
[127] For an overview, Cf Stephen J. Carroll, et al., *Asbestos litigation* (Rand 2005).
[128] Cf, e.g., Margaret A Berger, 'Upsetting the Balance between Adverse Interests: The Impact of the Supreme Court's Trilogy on Expert Testimony in Toxic Tort Litigation', (2001) 64 LCP 289, 298.
[129] Cf, e.g., Donald G. Gifford, 'The Peculiar Challenges Posed by Latent Diseases Resulting from Mass Products ' (2005) 64 MLR 613, 688 (noting that unlike other tort cases asbestosis and mesothelioma are signature diseases 'in which there is a clearly evident and exclusive causal connection' to asbestos exposure).
[130] Carroll et al. (n 1275).
[131] Grodsky (n 100) 1731.

Despite this bias, new generation cases often rely on epidemiological studies and do not involve signature diseases. Epidemiological studies explicitly attempt to measure the increase in the risk of a certain outcome associated with a given event (not coincidentally called 'risk factor').[132] Therefore, as the focus of many of these studies is forward-looking, there is no reason to postulate that the information available on ex-post probability is systematically superior to the information available on ex-ante probability.[133] Therefore, because using ex-ante probability in new generation cases means to speak the same language of many modern scientific studies, in many instances – especially when no signature disease is involved – it will be practically more convenient than investigating ex-post probability. Take, for example, the mentioned study on the association between smoking and cancer. As this research focused on the risk created by smoking, the output of the study was an association between smoking and cancer based on ex-ante probability.

It is not my intention to claim that the information available on ex-ante probability is systematically more accurate. Yet, also the opposite claim cannot be defended; it cannot be stated *a priori* that information on ex-post probability is always more readily available. That claims regarding ex-ante probability are mere speculations, whereas the ex-post causal link can be assessed in a (quasi) deterministic way is a myth that should be dispelled.

[132] For example, the association between tobacco smoking and cancer derives from studies assessing the incidence of tobacco as a 'risk factor' for the development of cancer. Cf Wolfgang Ahrens, Klaus Krickeberg, and Iris Pigeot, 'An Introduction to Epidemiology', in Wolfgang Ahrens and Iris Pigeot (eds), *Handbook of Epidemiology* (2014) 14 ('One of the milestones in epidemiological research was the development of rigorous case-control designs, which facilitate the investigation of risk factors for chronic diseases with long induction periods. The most famous study of this type, although not the first one, is the study on smoking and lung cancer by Doll and Hill'). The parallelism with the ex-ante and ex-post investigations in the law is nicely shown by the words of the influential epidemiologist Rodolfo Saracci when he wrote 'The prospective study observes events in their natural course from causes to possible effects. Computing and comparing incidence rates or risks of chronic bronchitis in smokers and non-smokers seeks to answer the question: how often do smokers develop the disease compared to non-smokers? A case-control study observes the events in a reverse sequence, from effects to possible causes. It starts from the disease and seeks to answer the question: what proportion of people with chronic bronchitis have been smokers compared to people with no disease?' Rodolfo Saracci, *Epidemiology: A Very Short Introduction* (OUP 2010) 111.

[133] Robinson (n 90) 793.

An additional objection that could be raised is that everyone is exposed to some form of risk in a way or another, thus admitting compensation for risk would be imposing an excessive burden on the legal system. There are a number of problems with this view. First, this statement clings on the idea that also *de minimis* risks should be taken into account. However, if we apply the same logic to the traditional conception of harm, it is just equally true that everyone is harmed in a way or another. [134] For instance, pollution is causing an unlimited number of minimal injuries to each one of us, yet these harms are not cognizable by the law, and rightfully so. I cannot go to a court and demand compensation because I can jog for 50 feet less due to breathing polluted air. Implicit in any legal system is the idea that some *de minimis* harm cannot be compensated. If a similar implicit (or even explicit) threshold is applied to risk, the threat of excessive litigation is already tempered. Second, it is at least dubious that people would sue on the basis of very small risks as they are associated to very small compensations.

4.2.2. When and How to Apply the Pure Probabilistic Approach

I suggest that the pure probabilistic approach ought to be the norm and departures from it are to be grounded only on normative reasons or practical considerations. Incidentally, this is what I advocate with regards to traditional torts.[135] Because, as a practical matter, for traditional cases the deterministic fiction and the ex-post probabilistic approach are generally much easier to handle, and hence a switch from the default rule of an ex-ante framework is justified.

However, for new generation cases the situation is reversed. The deterministic fiction is unworkable, while the objections against an ex-ante probabilistic approach appear untenable

[134] Cf, for example, *Rainer v. Union Carbide Corp.*, 402 F.3d at 621 (6th Cir. 2005) (stating that 'Accepting the plaintiffs' claim would therefore throw open the possibility of litigation by any person experiencing even the most benign subcellular damage').
[135] Cf Section 4.1 of this chapter.

without the demon's support. Therefore, for new generation cases a move from the pure probabilistic approach is justified only in those circumstances in which there is much more information available on ex-post than on ex-ante probability.

The case for an ex-ante probabilistic approach is especially, but not only, compelling for lagged torts.[136] The reason is that the ex-post probabilistic approach is based on a necessary imprecision in the definition of the concept of harm. As stated above, if we admit that (also in principle) we live in a world that we can interpret only in probabilistic terms, then the asset of a victim should be considered the probability of not getting harmed. Consequently, the harm comes into existence as soon as this probability is reduced, regardless of the moment at which the material harm will emerge. Thus, while the spurious probabilistic approach can be effective for prima facie deterministic instant torts, it is inappropriate for lagged torts. The reason is simple: an ex-post approach becomes effective only after a material harm has taken place. In the case of lagged torts a material harm does not arise immediately, and hence there will be a certain time interval in which the asset of the patient has already been harmed, but tort law is completely ineffective. Take, for example, smoking and cancer. As a risk factor, smoking increases the chances of contracting cancer almost from the very first cigarette. Yet, the law of torts is ineffective until the cancer is diagnosed.

4.2.3. The Demon in the Probability

As stated above, embedded in any probabilistic approach, be it spurious or pure, there is a problem of infinite regress. Unless the deterministic fiction is somehow reintroduced into the

[136] The problems created by lagged torts with regards to causation are certainly not a new discovery. On this regard, cf Robinson (n 90) 779-784; William M Landes and Richard A Posner, 'Tort Law as a Regulatory Regime for Catastrophic Personal Injuries' (1984) 13 JLS 417, 427-341.

picture, no compensation can ever be awarded due to the necessarily infinite length of the chain of probabilistic claims. I argue that the demon should be standing at the second step of this chain of probabilistic claims. Harm should be intended in a purely probabilistic sense, and hence be defined in terms of Pr. At the same time, the compensation owed should be scaled down to reflect the accuracy of the probabilistic study. After this additional step, the probabilistic chain of causation should be interrupted.

In practical terms, this solution equals to adopting the proportional approach traditionally advocated by the law and economics literature, but incorporating the new definition of harm presented in this work. This solution would therefore allow exploiting all the efficiencies of the proportional approach identified by the law and economics literature,[137] while adopting a definition of harm that is consistent with the findings of modern science. Because of this definition of harm, it is possible to prevent the void created by lagged torts, and to exploit the knowledge created by studies on ex-ante probability.

5. Conclusions

In this chapter, I have argued that a purely probabilistic concept of causation should become the norm, whereas deterministic causation and ex post probabilistic causations should be considered a heuristic tools only when there are practical justifications. In other words, I claim that there should be a shift in the 'burden of proof'. At the present time, the standard analysis is still deterministic in nature while to frame causation in probabilistic terms it is necessary to prove that in a certain context the epistemological uncertainty is above a given threshold. That is, the burden of proof is on the shoulders of advocates of probabilistic causation that must

[137] Cf Shavell, *Uncertainty over Causation and the Determination of Civil Liability* (n 103) 589-590.

explain why deterministic causation would not work in the case at hand. To the contrary, I claim that probabilistic causation should be the default option, unless it can be proven that deterministic causation is a workable heuristic tool. In this sense, the burden of proof would lie with the proponents of deterministic causation that must explain why a departure from a probabilistic analysis is justified for a given category of cases.

III. Aristotle and Optimal Deterrence: The Goals of Tort Law in a Probabilistic World

1. Introduction

In the past decades a heated debate has emerged between the champions of the Aristotelian corrective justice[138] and the supporters of economic efficiency.[139] Despite few attempts of reconciliation,[140] it appears that there is an enormous gap between the opposing doctrines, as they seem to imply completely incompatible policies. Moreover, it seems that law and economics scholars and moral theorists cannot find a common ground to debate. The scholars on each side seem to be much more concerned with refining their own theory than with finding an agreement. Not surprisingly, the more the two theories are refined the more they become abstract and impenetrable to the scholars of the other faction. On the one hand, economists have developed models that are extremely complex and sophisticated. On the other hand, corrective justice theorists are becoming more and more interested in the fascinating, yet challenging work of Immanuel Kant. From this perspective, even many legal scholars are skeptical that the framework developed by the German philosopher can be useful. The idea that law can be presented as lean, minimal and self-contained seems to be in sharp contradiction with the pluralism advocated by many contemporary scholars.[141]

Starting from the Kantian's argument of conceptually sequenced ideas, in this chapter I will suggest that the friction between the two theories is only illusory. Not only corrective justice

[138] George P Fletcher, 'Fairness and Utility in Tort Theory' (1972) 85 HLR 537; Robert A Epstein, 'A Theory of Strict Liability' (1973) 2 JLS 151; Jules L Coleman, 'Moral Theories of Torts: Their Scope and Limits: Part I' (1982) 1 LP 371.
[139] On this point, Guido Calabresi, *The Cost of Accidents: A Legal and Economic Analysis* (YUP 1970); Richard A Posner, 'A Theory of Negligence' (1972) 1 JLS 29; Kaplow and Shavell (n 41).
[140] Cf Chapman (n 43) and Geistfeld (n 43).
[141] Ernest J Weinrib, 'Law as a Kantian Idea of Reason' (1987) 87 CLR 472.

and deterrence are not mutually exclusive, but they should be considered necessary complements. The one without the other cannot offer a satisfying description of tort law as a whole. Furthermore, I will show that relaxing the assumption on the deterministic nature of the world strongly reinforces the claim that corrective justice requires deterrence.

2. The Goals of Tort Law

Law and economics scholars would chase optimal deterrence in order to maximize welfare. It is conventional wisdom that optimal deterrence can be achieved only if damages are equal to the harm times the inverse of the probability that compensation is due.[142] The obvious implication is that the use of punitive damages should be widespread, since such probability is strictly smaller than one. With regards to sanctions, one of the core ideas advocated by Becker is that if sanctions are monetary and individuals are risk neutral in wealth, then optimal sanctions tend to infinity.[143] At a first glance it might appear that, from an economic perspective, the obvious solution to achieve optimal deterrence at the least cost would be to increase the magnitude of the fines and to introduce (or enhance, depending on which side of the ocean we stand) punitive damages.

Conversely, it is not possible to offer a single definition of corrective justice and hence for now the focus will be on the original definition offered by Aristotle. According to him, corrective justice involves the notion of balance, or *equipoise*, between two individuals.[144] Torts can be considered transactions that alter this balance; corrective justice aims at righting the scales. As corrective justice sees remedies as a mean to undo the wrongs,[145] it is straightforward

[142] Mitchell A Polinsky and Steven Shavell, 'Punitive Damages: An Economic Analysis' (1998) 111 HLR 869.
[143] Gary S Becker, 'Crime and Punishment: An Economic Approach' (1968) 76 JPE 169.
[144] Aristotle (Trans: Martin Ostwald), *Nicomachean Ethics* (Library of Liberal Arts 1962).
[145] Cf Weinrib, *Deterrence and Corrective Justice* (n 44).

that compensation should equal the harm.[146] Using a more formal language, a superficial look at deterrence theory might induce one to think that the probability of detection by public authorities should tend to zero (with the consequent introduction of enormous fines), and compensation should always exceed the harm. Corrective justice implies neither of these two policies.

Not only the opposing doctrines have completely diverging policy implications, they are usually assumed to be absolutely incompatible because they rest on opposite axioms. As it will be shown, the only common trait is that they are both grounded on a deterministic concept of causation.

2.1 Deterrence Theory

The idea of sanctions (or more generally punishment) to deter unwanted behavior has a millenarian history,[147] but an economic formalization is owed to the pioneering works by Becker,[148] Calabresi,[149] and Posner.[150]

According to the economic theory of deterrence, a potential injurer will be optimally deterred only if his expected liability is equal to the potential harm that his conduct might cause. In mathematical terms optimal deterrence will be achieved if:

$$P_f * M_f + P_d * D = H \qquad (3.1)$$

[146] We are considering the simple case in which the harm suffered by the victim is equal to the gains of the tortfeasor. It is controversial which measure should be used when the harm and the gain are not identical. For an insightful discussion of the problem cf Ernest J Weinrib, 'Restitutionary Damages as Corrective Justice' (2000) 1 TIL 1.
[147] For an overview, cf Richard N Lebow, 'Thucydides and Deterrence' (2007) 16 Security Studies 163.
[148] Cf Becker (n 143).
[149] Cf Calabresi (n 139).
[150] Richard A Posner, *Economic Analysis of Law* (Vol 5, Aspen Law & Business 1998).

Where M_f is the magnitude of the fine attached to the wrongful action. P_f is the probability that a fine will be inflicted on the injurer. D is the amount that the injurer will have to pay to compensate the victim. P_d is the probability that compensation will be due, and H is the harm suffered by the victim.

A few key points should be noted. Firstly, this very general formulation is extremely flexible and can be adapted to a very diverse set of cases. A driver that is considering the opportunity of speeding will take into account both the expected fine and the expected liability from a possible accident, and hence (3.1) appropriately describes his incentives. Clearly, this is not always the case, as often no sanction is attached to a conduct that generates a tort. In these cases, the expected fine will be equal to zero and the total expected liability[151] will be equal to the expected damages. Optimal deterrence will be achieved for $P_d * D = H$.

Secondly, the right hand of the equation represents the harm suffered by the victim, instead of the benefit gained by the injurer. In fact, if the only concern is to maximize overall efficiency, a certain conduct is desirable whenever the benefits are greater than the expected harm. If the expected liability of the injurer is exactly equal to the expected harm, he will engage in the activity if and only if its potential benefits are greater than that. The injurer will be able to compensate the victim, while still keeping some of the benefits derived from his conduct. In other words, it is at least potentially possible to achieve a Pareto improvement. That is, at least one person is better off, while no one is worse off.

Thirdly, when $M_f > 0$ and $P_f > 0$, neither the expected fine ($P_f * M_f$) nor the expected compensation ($P_d * D$) should be equal to the harm, but their sum should be. Notably this

[151] The label total liability will be used to denote the sum of the fine and the damages. Similarly, total expected liability indicates the sum of the expected fine and the expected damages.

mathematical representation would be incomplete whenever a tort destroys resources, thus generating a deadweight loss[152] (*DWL*) for the society. (3.1) becomes:

$$P_f * M_f + P_d * D = H + DWL \qquad (3.2)$$

If the injurer is not induced to consider the deadweight loss, it will impose an externality on the society and engage in inefficient conducts.

The condition imposed by (3.2) is necessary but not sufficient to maximize social welfare, especially in case of bilateral accidents. In order not to give victims excessive (or insufficient) incentives to sue (3.2) should be divided into the following equations:

$$Pf * Mf = DWL \qquad (3.3)$$

$$P_d * D = H \qquad (3.4)$$

(3.3) and (3.4) have to hold simultaneously. The reason to impose these additional conditions can be understood focusing on (3.4). In fact, if $P_d * D > H$ the victim would potentially be better off if the accident takes place, and hence, he will have no incentives to take any precaution (and might even actively try to increase the probability of an accident). On the other hand, if $P_d * D < H$ the victim is forced to internalize some of the expected losses caused by the injurer, thus will adopt an excessive level of care or a sub-optimal activity level.

In other words, to induce both parties to behave optimally the expected fine should be equal to the deadweight loss caused by the conduct, while the expected compensation owed by the injurer should equal the expected damages.

[152] In economics, a deadweight loss is a loss of efficiency caused by a sub-optimal state of the economy. Jerry A Hausman, 'Exact Consumer's Surplus and Deadweight Loss' (1981) 71 AER 662.

As stated above, if the only goal to be achieved is economic efficiency, the seminal paper by Becker implies that P_f should tend to zero, while the monetary fine should tend to infinity.[153] At the same time, since P_d is strictly less than one, D should always exceed H. Such a solution might appear extreme, and in fact law and economics scholars have identified many reasons why Becker's claim only works under certain conditions and up to a certain threshold.[154] However, within certain limits, Becker's claim is widely regarded as correct; therefore, an economist would not hesitate to call for higher sanctions whenever the probability of detection of a certain conduct is low. At the same time, it is dominant in the economic literature the idea that compensation should equal the harm times the inverse of the probability that compensation is due.[155]

2.2 Corrective Justice

Just like deterrence theory, corrective justice has an illustrious tradition and its roots go as far as ancient Greece. Unlike deterrence theory, though, it is impossible to offer a description that would be accepted by all the scholars that consider it to be the corner stone of private law. For this reason, only the aspects that are relevant to the discussion at hand will be underlined.

The most important characteristic of corrective justice is the connection between the two parties, and hence, its focus is invariably on binary relationships. Corrective justice inevitably deals with pairs of actors, generally labeled as the doer and the sufferer of an injustice. The position of the doer and the sufferer are inextricably tied together, because 'the doing and the suffering of an injustice are the active and passive correlates of each other'.[156] In other words

[153] Cf Becker (n 143).
[154] David Friedman and William Sjostrom, 'Hanged For A Sheep: The Economics Of Marginal Deterrence' (1993) 22 JLS 345.
[155] Cf Polinsky and Shavell (n 88).
[156] Ernest J Weinrib, 'The Juridical Classification of Obligations' in P Birks (ed), *The Classification of Obligations* (OUP 1997) 41.

the link between the doer and the sufferer is the most characteristic trait of corrective justice. In the second place, as Weinrib writes:

> 'the plaintiff's [sufferer] suit is an attempt to vindicate a right that the defendant [doer] has unjustly infringed' and the 'remedy rectifies the injustice and thereby reflects its structure and content.'[157]

A very important point is that rectification is considered to be aimed at undoing the wrong, therefore the remedy has to be a response to the factors that are constitutive of the injustice. To use Aristotle terminology, corrective justice aims at achieving fairness and equality and can be expressed in terms of equality of quantities, explicitly defined in mathematical terms by the philosopher. The equality should not be intended in a literal sense, but in a notional one. Equality consists in people having their own and the holdings of the parties prior to the interaction constitute the relevant baseline. In other words, before the interaction the doer (A) and the sufferer (B) will have a certain endowment that is assumed to reflect equality:

$$A = B \tag{3.5}$$

After the interaction the doer will now have something that belongs to the sufferer, and hence:

$$A > B \tag{3.6}$$

As stated above, corrective justice aims at righting the scales by bringing A and B in the situation described by (3.5). Furthermore, the victim should ideally be in the same situation in which she was before the interaction. We write:

$$At_1 = At_0 = Bt_1 = Bt_0 \tag{3.7}$$

[157] Weinrib, *Restitutionary Damages as Corrective Justice* (n 146).

To denote that at the time t_1, the sufferer should not only be equal to the doer at time t_1, but should also be equal to herself at time t_0. Notably, this equality cannot be considered merely referring to wealth, yet money has to be an - at least imperfect - substitute of the relevant variable. It would make very little sense to claim that the harm should be rectified by a wealth transfer if this was not the case.

If money is not considered an (imperfect) substitute for the relevant variable, it becomes impossible to fit in the corrective justice framework the fact that in every developed legal system the largely predominant route taken by courts to compensate the sufferer is to attach a monetary value to the injustice. If the idea that tort law is shaped by corrective justice is defended, it should also be adopted the idea that wealth is the closest substitute of the relevant variable. It is possible to imagine a wide range of different remedies (e.g. the doer could be forced to work for the sufferer for a certain time or to provide a certain service), however if monetary compensation is the (quasi) universally accepted remedy it must be concluded that money is in fact the best substitute available for the relevant variable.

Having defined the two main goals of tort law, the result produced by a probabilistic framework can be compared to the ones achieved by more traditional approaches.

3. An Impossible Marriage?

The first attempt at lessening the gap between corrective justice and deterrence was performed by Gary Schwartz.[158] However, his work only created a small chink in the wall that separates the two theories. The central point raised by Weinrib in reply to Schwarz is that corrective

[158] Cf Schwartz (n 43).

justice is intrinsically focused on the binary relationship between the doer and the sufferer, whereas this relationship hardly has any relevance for deterrence theorists. In the words of Posner, it makes economic sense to take money from the defendant in order to induce him to take cost-justified precautions, 'but that the damages are paid to the plaintiff is, from an economic standpoint, a detail'.[159] Furthermore, deterrence theory introduces exogenous goals like loss spreading that are incompatible with the framework developed by corrective justice theorists.

> 'It seems that loss spreading is over-inclusive as a goal of tort law, and the idea that money should be exacted from some for the benefit of others in order to spread the burden of a catastrophic loss as lightly and as widely as possible is as pertinent to non-tortious injury as to a tortious one.'[160]

If the goal is to exploit the concept of diminishing marginal utility in order to maximize social welfare there is no reason to even introduce tort law. A combination of social insurance and progressive taxation appears to be more appropriate.[161] From this perspective, the efficacy of tort law is strongly limited by the requirement of causation that is indeed heterogeneous to the idea of loss spreading. For instance, it could be argued that a centralized system of social insurance might be extremely cheaper in terms of administrative costs than the elephantine apparatus necessary to support tort law. At the same time, incentives could be preserved by calibrating insurance premiums on the level of risk of each individual. Given the focus on overall utility adopted by economists, it is paradoxical that only plaintiffs who are lucky enough to be harmed by a wealthy defendant do not have to bear a concentrated loss. A system of social insurance would be much more coherent as it allows every defendant to obtain compensation,

[159] Cf Posner (n 94).
[160] Cf Weinrib, *The Idea of Private Law* (n 42) 37.
[161] Cf Calabresi (n 139).

not just the ones that were hit by deep pocketed injurers. Even if compensating every victim would result in only partial compensation - holding constant the total amount of compensation paid by the class of injurers - for the very principle of decreasing marginal utility social insurance should be favored by the same scholars who claim that tort law has to achieve loss-spreading. [162] The burden of proving why tort law should be an appropriate mechanism to achieve loss spreading lies on law and economics scholars.

These considerations lead Weinrib to write that:

> 'This difference does not preclude the two approaches from arriving at the same results. [however] concurrent results would not efface the theoretical differences that generated them. Nor, of course, would these results indicate the existence of a mixed theory. All we would have is a coincidence of results from two independent theories.'[163]

In other words, deterrence would be an effect of the law, instead of being a cause. The door is opened to the possibility that corrective justice and deterrence theory, while incompatible in the way presented above, may still coexist as conceptually sequenced ideas. In the words of Weinrib:

> 'In this sequenced argument, corrective justice is prior to deterrence because it illuminates the nature of the wrongs that positive law deters. Deterrence is then necessary as a further element in this sequence by virtue of being implicated in the actualization of corrective justice through the legal institutions of positive law.'[164]

[162] Guido Calabresi, *The Costs of Accidents*, (n 139) 39–45.
[163] Cf Weinrib, *Deterrence and Corrective Justice* (n 44) 628.
[164] Ibid, 639.

Clearly this idea will hardly please deterrence theorists as this sequenced argument denies that deterrence has any relevance for the content of the norms themselves. As Weinrib himself admits:

> 'situating deterrence within a conceptually ordered sequence that includes corrective justice affirms both corrective justice and deterrence without resolving the tension between them when each is claimed a ground of the norms.'[165]

3.1 The Need for Corrective Justice

To build a legal system on the theory of deterrence presupposes a series of assumptions that is hard to feel comfortable with. To mention a few: agents have to estimate the probability of every accident and the probability that their conducts are discovered. Furthermore, individuals need to be aware of the legal standards (that needs to be optimal as well) and they need to know the value of the expected fine. Although achieving a good level of deterrence still intuitively seems a desirable goal, the idea of optimal deterrence appears to be very far from reality.

Moreover, the fact that every legal system takes very seriously the bilateral nature of the relationship between the doer and the sufferer can hardly be explained as a mere coincidence or as the cheapest way to achieve optimal deterrence.

No matter how rooted is economic thought into oneself, it is very hard to contest that corrective justice offers a powerful explanation for the existing tort law. Most of the features of modern tort law seem to be perfectly explainable from a corrective justice standpoint and such theory provides a straightforward focal point around which policies can be shaped. At the same

[165] Ibidem.

time, as correctly argued by Weinrib, corrective justice and deterrence cannot contemporarily determine the contents of the norms.[166] Nevertheless, a piece of the puzzle is still missing.

Corrective justice rests on two very strong assumptions: (*i*) the doer is identified and is actually held liable. There can be no corrective justice without compensation. In other words, for corrective justice to be achieved the probability that a certain conduct is discovered should tend to 1. (*ii*) The wrong does not destroy resources, only transfers them from the sufferer to the doer. In Aristotle's work, a wrong implies a mere transfer of resources, not what is known in economics as a deadweight loss.[167] Let us recall (3.2) and let us remember the conditions imposed by (3.3) and (3.4).

$$P_f * M_f + P_d * D = H + DWL \quad (3.2)$$

$$Pf * Mf = DWL \quad (3.3)$$

$$P_d * D = H \quad (3.4)$$

As the portion of the segment is merely transferred from one party to the other, $DWL = 0$. Moreover, in order to achieve corrective justice the doer has to be held liable and damages have to be awarded, thus $P_d = 1$. Lastly, the compensation received has to equal the harm suffered. The equation (3.2) becomes $D = H$.

This is a different way to restate Aristotle's line of reasoning in the passage cited above. AE is equal to CD, and should be taken away from the doer and assigned again to the sufferer.

Notably, under these assumptions also optimal deterrence is achieved. If the interaction between the doer and the sufferer takes place in an ideal world, corrective justice cannot be

[166] Ibidem.
[167] Aristotle writes 'Let the lines AA', BB' and CC' be equal to one another; from the line AA' let the segment AE have been subtracted, and to the line CC' let the segment CD have been added, so that the whole line DCC' exceeds the line AE' by the segment CD and the segment CF; therefore it exceeds the line BB' by the segment CD. Cf Aristotle (n 90).

attained without achieving also optimal deterrence.[168] It is important to be aware that in an ideal setting the two doctrines are perfectly compatible, as they lead to an identical outcome.

It should be noted that while perfect corrective justice automatically implies optimal deterrence, the reverse does not hold. In fact, in an ideal world, optimal deterrence can be achieved for any suitable combination of P_d and D, whereas corrective justice requires P_d to be equal (or at least approaching) to one. As calibrating the relevant parameters in order to achieve corrective justice automatically implies that also optimal deterrence is achieved (whereas the opposite does not hold), it seems that the idea of conceptually sequenced arguments is the best compromise available. From this perspective, the conclusion drawn by Weinrib is correct: norms should be grounded solely on corrective justice considerations and deterrence only comes as a consequence of the norms and institution created in order to achieve corrective justice.

Although this line of reasoning appears to be flawless, it points to the first rift in the castle erected by corrective justice theorists: social institutions that enforce the law are not perfect and come at a cost that is ultimately borne by each doer and each sufferer through their taxes. In the next section, the main problems created by an approach based exclusively on corrective justice will be examined.

3.2 Shaping the Target: The Limits of Corrective Justice

[168] It is important to note that in the ideal world described by economists the administrative costs are assumed to be equal to 0; therefore $D = H$ is a satisfying equilibrium. Cf Shavell, *Strict Liability versus Negligence* (n 49). Even if administrative costs are taken into account this solution would still minimize primary and secondary accident costs. The discrepancy between deterrence and corrective justice would be then limited to tertiary costs. For a definition of primary, secondary and tertiary costs cf Louis T Visscher, 'Tort Damages' in Michael Faure (ed), *The Encyclopedia of Law and Economics* (2nd ed, EE 2009).

Every work on corrective justice underlines the importance of the link between the doer and the sufferer on which the whole law of torts is based. Although the importance of this link is not questioned, there is something misguiding in the way it is usually worded. It is generally stated that such a link is created by the wrong, whereas it is more correct to state that the wrong is part of the link.

A slightly modified version of an example offered by Aristotle can enlighten the difference: Let A be a builder, B a shoemaker, C a house and D a shoe. If A and B decide to trade C and D, a link is established. In the eyes of the philosopher, the bargain should be characterized by a proportionate requital. Only then the city can be held together. In fact, considerations of rectificatory justice arise in connection with both voluntary and involuntary transactions.[169] In both cases the predominant trait is the link between the parties, and in both cases the goal is to achieve corrective justice. If there are no relevant constraints, the builder and the shoemaker will exchange their products only if neither of the two will be worse off. Therefore, the bargain will take place only if the builder and the shoemaker obtain something that they consider to be worth at least as much as the price they are paying.[170] For obvious reasons Aristotle's terminology does not coincide with the one usually employed in modern economics, yet conceptually he is not too distant from welfare economics. In fact, Aristotle writes:

> '[that] demand holds things together as a single unit is shown by the fact that when men do not need one another, i.e. when neither needs the other or one does not need the other, they do not exchange.'[171]

[169] Cf Aristotle (n 90).
[170] Aristotle includes gratitude, friendship etc. in the calculus. This approach is compatible with modern economic theory.
[171] Aristotle (n 90).

There is clearly no mention of Pareto efficiency, surplus from the trade, and all the terminology that is present on any modern economic textbook, yet the underlying idea seems to be very similar. Furthermore, Aristotle explicitly states that:

> 'to have more than one's own is called gaining, and to have less than one's original share is called losing, e.g. in buying and selling and in all other matters in which the law has left people free to make their own terms.'[172]

In other words, it is firmly rooted in Aristotle the idea that parties engaging in voluntary transactions can set the terms they consider to be better for them. The positive opinion that Aristotle has of voluntary trade suggests that parties who willingly engage in a transaction will opt for terms that imply a proportionate requital, thus keeping the city united. Given the importance that Aristotle attributes to the *poleis*[173], to preserve voluntary transactions can be considered a priority. This conclusion is perfectly compatible with the principle of modern economics that any voluntary transaction leads to an increase in total welfare.

Now let us assume there are only two builders in our *polis*, A and E, and that all the shoemakers need a house. Let us also assume that A and E stipulate a secret agreement to artificially raise the price of C in terms of D for all the shoemakers. The shoemakers are now forced to accept the terms imposed by A and E and to pay an excessive price. As the shoemakers are not free to make their own terms, these transactions are in the domain of what Aristotle calls involuntary transactions. If the link is created by the 'wrong' corrective justice comes into play at this stage. Theoretically, the builders should be forced to return the surcharge to the shoemakers that have bought a house. Moreover, as suggested by basic economic theory, in order to raise the price the builders had to restrict the output, hence forcing some shoemakers

[172] Ibidem.
[173] The *poleis* (sing. *Polis*) means cities in Greek. It is the term commonly used to describe the 'city-states' of the ancient Greece.

to sleep on the street. In this scenario, perfect corrective justice cannot be achieved. It is impossible for builders and shoemakers to return to the situation preceding the wrong. In fact, asking the builders to return their extra profits is not sufficient to compensate the shoemakers that were forced to sleep on the street. If A and E are simply asked to produce more houses and sell them to the homeless shoemakers, this would not repay them for the nights they spent on the street. Conversely, if the builders are forced to pay damages in addition, their situation would become worse than the initial one. To use Aristotle's terminology, it is impossible to satisfy the condition imposed by (3.7) simply because the sum of the segments is not the same before and after the interaction. In other words, whenever the sum of the segments is shortened the wrong cannot be undone.

This conclusion is strengthened by looking at other accidents that destroy resources in a more evident way. Product liability or car accidents are prominent examples. A firm has very little to gain from a product that explodes in the hands of its customer causing a serious injury. It might be argued that the gain is the saving in precaution costs, yet it is a heroic claim that there is an equality of any sort between them and the harm. Similarly, monetary compensation cannot restore the initial situation. From this perspective, it makes very little sense to shape the law to achieve a goal that is beyond our reach. It would be much more interesting to develop a comprehensive theory to understand which deviations from the ideal corrective justice should be accepted.

However the friction between the real world and corrective justice as intended by Aristotle is only an illusion. Aristotle's idea is that voluntary transactions create a binary link that is as strong as the one usually underlined by corrective justice theorists with regards to wrongs. The philosopher is suggesting that both voluntary and involuntary interactions create a binary relationship between the parties embracing the whole interaction, not just the wrong. To use the above mentioned example, the link between the consumer and the firm is created when the

defective product is purchased (voluntary interaction) and not when the product explodes (involuntary interaction) causing the harm. In the first part of the binary relationship justice is achieved through proportionate requital. The binary relationship between the parties is altered when the product explodes and the judge tries to equalize it. Yet, as a voluntary relationship appears to be way more desirable, not only for the society (*polis*) but also for the parties themselves, norms that will prevent voluntary relationships to be altered by involuntary interactions are desirable. In other words, it is not contested that corrective justice must be the starting point to understand tort law, nor it is being claimed that deterrence and corrective justice should simultaneously coexist in determining the content of the law. The idea of a conceptually sequenced argument that moves from corrective justice is accepted.

However, instead of claiming that corrective justice and deterrence are lying on a straight line, it seems that they are lying on a circle. Norms should be shaped to guarantee that corrective justice is ensured (both voluntary and involuntary acts). However, as voluntary interactions are preferable - and involuntary transactions cannot always be corrected - norms should be created to avoid that voluntary interactions are altered by wrongs. In turn, these norms will affect the way in which wrongs are treated when they cannot be avoided. A clear example is precautionary measures, as they interfere with parties' interaction before the wrong actually takes place.

Not only corrective justice and deterrence should both inform the norms, even though via a sequentially ordered argument, it seems that the one without the other is detached from reality. Deterrence theory cannot illuminate the connection between the parties and, without the cage of corrective justice, it leads to embrace exogenous goals that are heterogeneous and partially incompatible with the core characteristics of tort law. Corrective justice can illuminate how to handle voluntary and involuntary transactions; yet, it cannot take into account that the former are a value that should be preserved.

3.3 Equality of What?

Until now a very obvious question has been intentionally avoided. In terms of what the parties should be considered equal? How can equality be restored if the object of this equality is not known?

The reason why this question has not been answered is simple: it is irrelevant for this inquiry. No matter what the relevant variable is, the argument presented here still holds. To prove the point let us assume that equality is defined in terms of Kantian rights. Understood as a manifestation of Kantian's rights, private law protects rights and not welfare.[174] According to Kant, rights are of two kinds: the right to bodily integrity and the right to external objects of the will.[175] Moreover, the relevant gains and losses are normative, not factual[176]. In fact, by inducing one of the clients of her competitors to opt for her products a firm is causing a factual loss to her rival. However, as such loss is not normative in character it is of no interest for private law. Let us go back to our example of the defective product. In the framework developed by Kant, the firm realized a normative gain but no factual gain, whereas its customer suffered both a factual loss and a normative loss. Coherently with the idea of justice developed by the German philosopher, the focus is on the correlative normative gains and losses of the parties. Specifically, the normative loss of the victim consists in the violation of her right to bodily integrity, whereas the normative gain for the firm results from negligently injuring her.

The only mean available to the court to correct the normative loss suffered by the plaintiff is to award monetary damages. Yet, it is very optimistic to assume that a certain amount of money

[174] Cf Weinrib, *Law as a Kantian Idea of Reason* (n 141).
[175] Immanuel Kant (ed and trans Mary Gregor), *The Metaphysics of Morals* (CUP 1996, [1785]).
[176] Normative gains and losses refer to what one ought to have (as defined by the relevant norm), whereas factual gains and losses refer to what one factually had. Cf Weinrib, *The Idea of Private Law* (n 42).

is enough to restore the right to bodily integrity. Using economic jargon, money is not a perfect substitute of the right violated, otherwise bodily integrity would be tradable. More simply, money will not buy the plaintiff a new hand nor is it possible to define exactly the value of the one he has lost (as proven by the enormous variance in the compensations awarded for serious body injuries). In other words, as compensation can only happen through money - and money is not a perfect replacement for Kantian rights - the sum of the length of the two segments will inevitably be shorter after the product explodes. Corrective justice will therefore become impossible to achieve. The only way to achieve equality is to preserve the voluntary transaction, trying to avoid that it is altered by the involuntary interaction. This line of reasoning applies to any variable that is not a perfect substitute for money.

Conversely, if equality is defined in terms of wealth (or as a perfect substitute) any interaction that destroys economic resources inevitably shortens the sum of the segments, thus making corrective justice impossible to achieve.

In short, for any choice of the relevant variable an involuntary transaction can shorten the size of the segments making perfect corrective justice unattainable.

4. The 'Second Generation' Mixed Theories: Commonalities

Following the path opened by Schwartz, new attempts have been made to accommodate corrective justice and deterrence. From this perspective, the theories advanced by Geistfeld and Chapman call for special attention and will be further investigated in this section. Although both authors advocate the idea that a mixed theory is inevitable, there are some important differences with the framework proposed in this work.

The most obvious point of contact between the framework developed here and the theories advanced by Geistfeld[177] and Chapman[178] is the idea that corrective justice and deterrence not only can coexist, but that they ought to.[179]

Building on the sophisticated tools of social choice, Chapman takes a step further and tries to suggest concrete ways to accommodate the two allegedly heterogeneous goals. More importantly, Chapman suggests the adoption of a conceptually sequenced argument, thus it seems that no relevant friction exists with the framework developed here.[180] Similarly, Geistfeld recognizes the 'symbiotic relationship' between economic analysis and normative principles, demonstrating how the former is often needed to give a practical and concrete meaning to the latter.[181] It is also correctly underlined how the need to incorporate deterrence concerns is strengthened by the imperfect compensatory mechanisms available to the courts.

4.1 The 'Second Generation' Mixed Theories: Differences

Moving from the idea of path dependency,[182] Geistfeld tries to address the most fundamental objection raised by moral philosophers: the structure of tort law system hardly seems the optimal choice to minimize accident costs and hence it cannot be considered coherent with the goal of optimal deterrence. It would be very puzzling, or so they say, to pursue a goal by creating something that is inappropriate for the task.

[177] Cf Geistfeld (2001) (n 43).
[178] Cf Chapman (n 43).
[179] Cf Geistfeld (2009) (n 43).
[180] Cf Chapman (n 43).
[181] Ibidem.
[182] Path dependency implies that our choice depends not only on where we are now, but also upon where we were in the past. Cf among the others Paul David, 'Clio and the Economics of QWERTY' (1985) 75 AER 332.

The answer provided by Geistfeld can be divided in two parts: (*i*) although an omniscient legislator concerned with efficiency might adopt a different solution if he could start from zero, behind the structure of tort law there are historical reasons that justify its existence; (*ii*) it is possible to offer an interpretation of tort law in terms of economic efficiency.[183]

With regards to the first claim Geistfeld argues that:

> 'the tort system was initially designed in the twelfth and thirteenth centuries to implement corrective justice for cases in which the defendant criminally injured the plaintiff…[however] legal decision makers rejected natural-law justifications in favor of more pragmatic, instrumentalist justifications… The tort system could not wholly reject its corrective origins in favor of an overtly instrumentalist approach, as any change in judicial decision-making is constrained by the requirements of stare decisis.'[184]

This historical description is certainly accurate, yet a few caveats should be made. Firstly, introducing some regulatory purposes into the picture does not automatically lead to accident costs minimization.[185] Secondly, assigning such central role to *stare decisis* appears to be in sharp contrast with the evidence from legal systems in which precedents are not binding, as they cling more on corrective justice than common law countries. In other words, either civil law countries have developed equally effective means to preserve the uniformity of the law over time, or there had to be another reason not to abandon corrective justice. Notably, accepting the former explanation, the enormous body of economic literature underlining the wonders of *stare decisis* would lose much of its credibility.[186] However, even admitting that the

[183] Cf Geistfeld (2001) (n 43).
[184] Ibid, 254.
[185] Ibidem.
[186] Cf Jonathan R Macey 'Internal and External Costs and Benefits of Stare Decisis' (1989) 65 Chi Kent L Rev 93.

distinguishing role of *stare decisis* has been systematically overstated,[187] there would still be no explanation for the persistence of corrective justice over the centuries. An alternative justification could be introduced by abandoning the extremely reductionist approach typical of welfare economics and by allowing holism to play a part. In order to introduce this justification it is necessary to briefly sketch out the centuries old debate between holists and reductionists.

4.1.1. Reductionism

There is no univocal definition of methodological individualism[188]and the crucial ambivalence is whether the *explanantia* of social phenomena has to be found in individuals alone or in individuals plus relations between individuals.[189] According to Popper,[190] methodological individualism rightly insists that the 'behavior' and the 'actions' of collectives must be reduced to the behavior and the actions of human individuals. The use of the term 'reduced' implies that according to a methodological individualist the goal of social science should consist exclusively of statements about individuals.[191] Societies can be considered an aggregation of individuals and hence welfare maximization (or accident costs minimizations) can be achieved through the maximization of private welfares aggregated according to the relevant criteria. Let us now accept the conjecture advanced by Kaplow and Shavell that welfare functions can be all-encompassing and include every facet of individuals' welfare.[192] It follows that any conception of justice that is not coherent with the goal of maximizing the aggregation of individuals' welfare should not be pursued. As the debate between moral theorists and economists emerged

[187] Cf Ugo Mattei and Roberto Pardolesi, 'Law and Economics in Civil Law Countries: A Comparative Approach' (1991) 11 IRLE 265 and Woraboon Luanratana and Alessandro Romano 'Stare Decisis in the WTO: Myth, Dream or a Siren's Song? (2014) 48 JWT 773.
[188] On this regard, Steven Lukes, 'Methodological Individualism Reconsidered' (1968) 19 BJS 119; John O'Neill, *Modes of Individualism and Collectivism* (Heinemann Educational 1973); Lars Udehn, *Methodological Individualism: Background, History and Meaning* (Routledge 2002); ID, 'The Changing Face of Methodological Individualism' (2002) 28 ARS 479.
[189] Geoffrey M Hodgson, 'Meanings of Methodological Individualism' (2007) 14 JEM 211.
[190] Karl Popper, *The Open Society and its Enemies* (Routledge 1945).
[191] Cf Hodgson (n 184).
[192] Kaplow and Shavell (n 41).

exactly because corrective justice and welfare maximization lead to divergent conclusions, corrective justice has no reason to exist in a reductionist world. However, almost every legal system assigns a prominent role to corrective justice.

4.1.2. Holism

At the other end of the spectrum, proposers of what Phillips calls Holism 2, advocate the five theses of organicism:

> '(*i*) The analytic approach as typified by the physico-chemical sciences proves inadequate when applied to certain cases ….(*ii*) the whole is more of the sum of its parts, (*iii*) the whole determines the nature of its parts, (*iv*) the parts cannot be understood if considered in isolation from the whole, (*v*) the parts are dynamically interrelated or interdependent.'[193]

Moreover, even after a whole is studied, it cannot be explained in terms of its parts. From the perspective of an organicist, individuals are only a part of the whole society, thus it is not possible to gain any understanding of the individuals if we do not have knowledge about society as whole. The main claim is that merely aggregating individuals' welfare does not provide exhaustive information on the welfare of a society considered as a whole. An economist will probably perceive this claim as absurd given the dominance of welfare economics. At the same time, some social scientists might even consider this claim to be dangerous due to the gross misinterpretation that totalitarian states made of Hegel's[194] and Gierke's[195] theories respectively on ethical state and human groups.

[193] Denis C Phillips, *Holistic Thought in Social Science* (SUP 1976) 6.
[194] Georg W F Hegel (Trans J V Miller), *The Phenomenology of Spirit* (OUP 1977 [1807]).
[195] Otto von Gierke, *Das Wesen der Meschlichen Verbände* (Duncker & Humblot 1902).

However, holistic thought is a fundamental component of most sciences. Beside historical reasons, there seems to be little justification to rule out *a priori* its relevance in a context where wholes (human societies) are extremely complex. Admitting the possibility that social welfare is not a mere aggregation of individuals' welfare opens the door to the hypothesis that a concept of justice embedded in the society has an independent value. On the one hand, this would explain why corrective justice has not been abandoned by courts in any country, regardless of the existence of *stare decisis*. On the other hand, despite the attempts made by Kaplow and Shavell[196] to offer an 'anti-darwinist'[197] explanation of legal systems evolutions, it explains why the concept of justice has been present in one form or another in every human society.

The third and more fundamental concern raised by Geistfeld's theory regards the causes underlying the 'lock-in' effect created by tort law.[198] Geistfeld argues that:

> 'Even if it would be cost-effective to change regulatory institutions, that change must be legislatively implemented. The various costs that individuals or groups would incur to the displacement of the tort system give them a substantial incentive for forming interests groups to defeat such legislation.'[199]

However, interest groups are usually well organized by people with strong gains from particular government actions.[200] To introduce the possibility that the macro-system – tort law as a whole – exists as a response to lobbying, implies that also the single norms composing the macro-system were implemented and are defended due to interest groups' pressure.

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[196] Cf Kaplow and Shavell (n 41).
[197] With the term 'anti-darwinist' the authors intend that the evolutionary process systematically resulted in the inferior outcome of societies based on fairness concerns. A devastating criticism to this argument on completely different grounds is advanced by Jules Coleman. Cf Jules L Coleman, 'The Grounds of Welfare: Fairness Versus Welfare' (2003) 112 YLJ 1511.
[198] The importance of his metaphor of the 'curvy road' should not be overestimated since it simply proves that some costs are associated to every change.
[199] Cf Geistfeld (2001) (n 43).
[200] Cf Mancur Jr Olson, *The Logic of Collective Action: Public Goods and the Theory of Groups* (HUP 1971, revised edition).

Furthermore, interest groups also actively promote the implementation of legal rules that might favor them, instead of merely engaging in defensive lobbying.[201] Lastly, it is well established that it is easier to organize pressure to address a specific and narrow issue than to promote a widespread interest like the preservation of tort law as a whole.[202] In fact, the number of parties concerned is bound to be relatively smaller and their interests are likely to be more homogeneous.

These hypotheses rule out what is left of cost minimization concerns. Tort law is described as a mean to protect the interests of the most powerful and better organized interests groups. Paradoxically, the historical account described by Geistfeld leads to a mixed theory between corrective justice and the Marxian idea that law is merely a mean to protect dominant classes (or powerful interest groups).

5. Probability and the Goals of Tort Law

The aim of the previous sections was to accommodate the two goals of tort law within the traditional deterministic framework. In this section, it will be shown that relaxing the assumption on the deterministic nature of the world strengthens the claim that deterrence and corrective justice cannot be treated as mutually exclusive.

In order to understand why, let us recall that there is only one definition of harm that is compatible with a world in which the demon has been defeated. As in a probabilistic world even the most remote risk has a positive probability of materializing, the harm must be represented by the reduction in the ex-ante probabilities of not getting harmed. As shown in chapter III, a statement of the kind 'I have been harmed because the injurer has been negligent'

[201] Ibidem.
[202] Ibidem.

is incorrect. The only possible statement is 'since the injurer has been negligent, my ex-ante probability of not getting harmed have been reduced'. However, once this conception of harm is embraced, the chimera of the non-Aristotelian version of corrective justice becomes even more elusive.

Given the definition of harm adopted in this thesis, the pure probabilistic approach is the only one that satisfies the requirements of corrective justice. In other words, if a traditional legal scholar is to defend the concept of corrective justice in a probabilistic world, he also has to accept that the emergence of material harm must be totally irrelevant to the law. If the pollution of firm A reduces the probability that a victim has of not contracting the disease D, then the victim should be entitled to compensation regardless of the fact that she might actually not contract the disease. Furthermore, also the amount of compensation owed to the victim would be identical in the case in which she contracts the disease and in the case in which she does not.

Besides being unworkable, this conclusion is probably unacceptable for most legal scholars. No legal system treats exactly in the same way a victim who has suffered a material harm and an individual who did not suffer any harm in the traditional sense. Therefore, as a complete surrender to the demon comes at a too high price, deterrence is needed to minimize the departure from perfect corrective justice.

6. Conclusions

'For we are inquiring not in order to know what virtue is, but in order to become good, since otherwise, our inquiry would have been of no use.'

Aristotle, Nicomachean Ethics book II

For over two millennia corrective justice has been the foundation of tort law, and private law in general. Most instrumentalist approaches that are so much à la mode, pursue goals that are in contrast with the basic features of tort law, and hence appear inadequate to offer a comprehensive account of its characteristics.

No theory has been developed that can replace corrective justice, and no satisfying explanation has yet been offered on how it could coexist with deterrence.

The idea of pure corrective justice is surely very appealing, yet it appears to be of little use, because involuntary interactions tend to irremediably alter the equality between parties. Similarly, enforcement is far from perfect. In this vein, it should not be neglected that Aristotle's inquiry was practical in nature. He did not aim to develop a framework to achieve justice in an ideal world but to improve the concrete one he was facing. By disregarding that the probability of compensation will very rarely be close to one and that the complete undoing of a wrong is often impossible, Aristotle ethics is transformed into something completely abstract.

Corrective justice is fundamental to underline the link between the parties and to offer an account of the main features of tort law. However, it completely ignores the fact that voluntary transactions are a value that should be protected. Not to maximize social welfare or to spread losses, but to preserve a just interaction between the parties.

Corrective justice and deterrence should therefore be considered conceptually sequenced ideas. However, they appear to be lying on a circle, instead of a straight line. Not only corrective justice and deterrence should both inform the norms, even though through a sequentially ordered argument, it also seems that one without the other is detached from reality.

On the one hand, deterrence theory cannot illuminate the connection between the parties and, without the beneficial influence of corrective justice, it tends to include exogenous goals that

are heterogeneous and partially incompatible with the core characteristics of tort law. On the other hand, corrective justice is extremely hard to achieve in a probabilistic world, while it ignores that voluntary transactions are a value that should be preserved.

IV. The Hidden Demon and Credit Rating Agencies

1. Introduction

In the introduction to this work, it has been claimed that the deterministic demon has very subtle ways of impairing the function of a legal system. From this perspective, Credit Rating Agencies represent an interesting example of the threats associated to a deterministic mindset. Many U.S. courts have placed CRAs under the umbrella of the first amendment on the freedom of speech[203] thus implying that ratings 'must be provable as false before liability can be assessed.'[204] However, as it will be argued in this chapter, this standard is unworkable for the kind of probabilistic predictions issued by rating agencies. The reason is simple: unless an event is given 100% probability, a probabilistic prediction cannot be falsified by observing the single factual outcome. Obviously, we should still not accept as true any probabilistic claim. For instance, it could be argued that Italian athletes have 99% chances of winning a gold medal in every competition during Olympic Games. This statement is very likely to be false, yet observing any single contest in which an Italian athlete did not win the gold medal is not enough to disprove it.

Similarly, it is not surprising that Courts cannot infer the falsity of ratings by assessing the specific case at hand. However, the more the number of observations approaches infinity the more it is possible to discriminate between true and false probabilistic claims. To have absolute certainty (or to prove beyond any reasonable doubt to use legal terminology) the number of observations should indeed be infinity. This threshold is relevant in criminal cases; whereas for CRAs it applies the much less demanding 'preponderance of evidence' test (at most the

[203] Cf for example *Jefferson County School District No. R-1* v. *Moody's Investor's Services, Inc.*, 175 F.3d, 848-856 (10th Cir. 1999) affirming that 'The First Amendment protects S&P's preparation and publication of its ratings.'
[204] *Milkovich v. Lorain Journal*, 497 U.S.1 (1990) and *Philadelphia Newspapers, Inc v. Hepps*, 755 U.S. 767.

relevant test could be considered the 'standard of clear and convincing evidence'). It follows that ratings can be considered 'false' during a civil case if over a sufficiently large number of observations the materialized outcome is far enough from the probabilistic predictions.

In a recent case, the U.S. Court of Appeal for the Sixth District stated that:

> 'We find no basis upon which we could conclude that the credit rating itself communicates any provably false factual connotation. Even if we could draw any fact-based inferences from this rating, such inferences could not be proven false because of the inherently subjective nature of Moody's ratings calculation.'[205]

The emphasis on the word subjective is misguiding, as it should be placed on the probabilistic nature of the predictions offered by CRA. Although discussing every implication of the debate on the First Amendment lies outside the scope of this work,[206] it must be noted that it is symptomatic of a deterministic mindset applied to an inherently probabilistic problem. As soon as we stop trying to assess the quality of ratings using deterministic categories (i.e. was the single rating true or false?) new paths to regulate CRAs activities are uncovered. In this chapter, it will be shown that a probabilistic approach can provide better incentives to CRAs thus increasing social welfare.

2. Credit Rating Agencies

The behavior of credit rating agencies (henceforth CRAs) has been under careful scrutiny in the past decade, particularly in the aftermath of the global financial crisis. It has been argued that the incentives of CRAs are adversely affected by an inherent conflict of interest determined

[205] *Compuware Corp. v. Moody's Investors Servs. Inc*., 499 F. 3d 520, 529 (6th Cir. 2007).
[206] For an accurate description on this regard cf Caleb Deats, 'Talk That Isn't Cheap: Does the First Amendment Protect Credit Rating Agencies' faulty Methodologies from Regulation?' (2010) 110 CLR 1818.

by the 'issuer-pays model'[207] and by the licensing power that financial regulations relying on ratings implicitly grant to CRAs.[208] In this perspective, ratings are inflated[209] either because issuers collude with CRAs in fooling investors or because, all else being equal, investors demand assets with higher ratings in order to enjoy regulatory benefits. Inflated ratings, the argument runs, support asset bubbles, which are in turn a major determinant of financial crises.[210] Although the exact contribution of ratings to the global financial crisis is not discussed, following the mainstream literature it is assumed that accurate ratings are valuable for the society, whereas inflated ratings may reduce welfare, particularly when ratings have regulatory relevance.[211]

It is acknowledged that ratings are ultimately predictions and thus they can be as accurate as our ability to forecast the future can be. This observation has important consequences on how, in this chapter, it is argued that the incentives of CRAs should be policed. CRAs should be in principle allowed to choose how much to commit to the accuracy of their prediction, if to commit at all. That being said, a rating is defined as inaccurate if the implied predictions is not borne out by the actual unfolding of events. To simplify, a rating with a certain letter grade (for example Double-A+) is inaccurate if the frequency of default of firms or bonds with that letter grade is higher or lower respectively than the maximum (for example 0.0006) and the minimum

[207] Krugman (n 45).
[208] As noted by Opp, Opp and Harris if regulatory benefits of high ratings are above a certain threshold, a rating agency 'finds it profitable to stop acquiring any information and merely facilitates regulatory arbitrage through rating inflation' Opp, Opp and Harris (n 47) 47.
[209] The idea that ratings are inflated generally accepted both by legal scholars and economists. One notable exception is a study by Gorton and Ordoñez (2014) citing inter alia the study by Park (2011). This study, however, does not deny that the triple-A subprime-related securities turned out to be riskier than implied by their initial rating. Rather, their point is that few of these securities actually defaulted and that the losses stemming from such defaults were quantitatively small (too small to justify a global financial crisis. Cf Gary Gorton and Guillermo Ordoñez, 'Collateral Crises' (2014) 104 AER 378; Sun Young Park, 'The Size of the Subprime Shock' (Unpublished manuscript, Korea Advanced Institute of Science and Technology 2011).
[210] Charles W Calomiris, 'The Subprime Turmoil: What's Old, What's New, and What's Next' (2009) 15 JSF 6.
[211] Among the others, cf Patrick Bolton, Xavier Freixas and Joel Shapiro, 'The Credit Ratings Game' (2012) 67 JF 85.

(for example 0.0002) probability of default associated with the letter grade.[212] There is rating inflation when the frequency of defaults turns out to be higher than the upper bound on the predicted probability of default.[213] A rating is accurate when the defaults actually observed for a given class of rating fall within the range of probabilities and other measurable items (for instance, loss given default) implied by the CRA issuing a certain letter grade.[214]

In this chapter, it is argued that the accuracy of ratings can be improved via regulatory intervention, particularly by introducing a special liability rule for CRAs. This approach has been little explored by the literature. Apparently, a more straightforward solution to the problem of rating inflation could be based on eliminating its determinants by regulation. In this vein, all references to credit ratings could be scrapped from financial regulation in order to eliminate the regulatory benefits from high ratings.[215] This is, incidentally, the approach chosen by the U.S. legislation with the Dodd-Frank Act of 2010.[216] Likewise, it could be argued along with a number of commentators[217] that the issuer-pays model of CRAs remuneration is simply to be prohibited in order to eradicate the conflict of interests.

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[212] The example is taken from Fitch's historical (annualized) default experience. Cf Joshua Coval, Jakub Jurek and Erik Stafford, 'The Economics of Structured Finance' (2009) 23 JEP 3.

[213] For a formal definition of rating inflation, see section 5 of this chapter.

[214] In this chapter, it is considered also the opposite reason of inaccuracy, namely rating deflation. However, for the reasons discussed in section 4, addressing this problem is not so interesting for policymaking. Under the status quo, where CRAs hardly face any liability, CRAs always have incentives to inflate ratings. Introducing liability may induce CRAs to systematically underrate financial assets. However, at some point this strategy would make ratings uninteresting for issuers and investors. Section 5.2 explicitly discusses why inducing CRAs to be moderately conservative with ratings is desirable, particularly in the case of structured finance products.

[215] Cf Mark J Flannery, Joel F Houston and Frank Partnoy, 'Credit Default Swap Spreads As Viable Substitutes for Credit Ratings' (2010) 158 UPLR 2085. They argue that Credit Default Swap could to a certain extent replace ratings for regulatory purposes.

[216] Section 939A of the Wall Street Reform and Consumer Protection Act of 2010 (the Dodd-Frank Act) requires each Federal agency to remove references to credit rating. The implementation of this provision has proven difficult, although major agencies like the Federal Reserve Board and the Securities and Exchange Commission have ultimately found ways to issue the necessary regulations. The approach in the EU has been different. While EU legislation also aims at reducing over-reliance on ratings (see the Capital Requirements Directive IV and the recent Regulation 462/2013 and Directive 2013/14/EU on credit ratings), it explicitly acknowledges that financial regulation cannot simply do away with ratings in the absence of viable alternatives.

[217] Mathis, McAndrews and Rochet advocate the introduction of a new business model for CRAs that they call platform-pays model. Cf Jerome Mathis, James McAndrews and Jean-Charles Rochet, 'Rating the Raters: Are Reputation Concerns Powerful Enough to Discipline Rating Agencies?' (2009) 56 JME 657. Other alternatives are explored in John C Jr Coffee, *Gatekeepers: The Professions and Corporate Governance* (OUP 2006).

As straightforward as they may sound, these radical proposals of regulatory intervention are too farfetched. Rating agencies play a crucial role in helping to overcome information asymmetries not only between issuers and investors, but also between the latter and financial regulators. In the absence of viable alternatives to assess creditworthiness and credit risk, it is at least doubtful that financial regulation could just do without ratings.[218] Similarly, the public good nature of ratings – the use of ratings does not diminish their availability to others; and investors who do not pay for ratings can hardly be excluded from their use – might frustrate the attempt to introduce a workable alternative to the issuer-pays model.[219] More importantly, moving away from the issuer-pays model would not solve the problem so long as regulatory benefits are present. Because at least some regulated investors demand high ratings irrespective of their informativeness, switching to an investor-pays model is unlikely to stop rating inflation.

Abandoning the realm of radical reforms, even more modest changes of the status quo proposed so far seem to suffer from serious drawbacks. For example, let us consider two of the most popular incremental reforms in the policy debate. One proposal is to increase competition between CRAs.[220] The other is to increase the transparency of their ratings.[221] Both reforms aim at reducing the ability of CRAs to collude with issuers or investors to generate inflated ratings. However, competition between CRAs is set to make matters worse because of the practice of so-called 'rating shopping'. Because issuers can solicit[222] as many ratings as they wish but pay for rating only if they request publication, more competition between CRAs may actually result in more rating inflation.[223] To be sure, rating shopping could be prohibited, for example by

[218] Cf Coffee, *Ratings Reform: The Good, the Bad and the Ugly* (n 48).
[219] Frank Partnoy, 'The Siskel and Ebert of Financial markets: Two Thumbs Down for the Credit Rating Agencies' (1999) 77 WULQ 619.
[220] Cf Partnoy, *Rethinking Regulation of Credit-Rating Agencies: An Institutional Investor Perspective* (n 48).
[221] Cf Pagano and Volpin (n 46).
[222] In this chapter, unsolicited ratings, which typically concern sovereign issuers, are not discussed.
[223] Becker and Milbourn show that 'increased competition from Fitch coincides with lower quality ratings from the incumbents: Rating levels went up, the correlation between ratings and market-implied yields fell, and the ability of ratings to predict default deteriorated.' Cf Bo Becker and Todd Milbourn, 'How Did Increased Competition Affect Credit Ratings?' (2011) 101 JFE 493.

requiring issuers to pay for ratings in advance[224] and CRAs to disclose also unfavorable ratings. This solution may not solve the problem of implicit rating shopping, though, as issuers could learn the CRAs' assessment informally before entering into a contract with them.[225] At the same time, forcing issuers to pay for ratings without knowing their contents may generate moral hazard. If CRAs can save on their costs after having secured an income independent of their assessment, eventually this would lead to the collapse of the market for ratings.[226]

The economic literature on CRAs has been so far unable to identify a workable policy, whether radical or incremental, that could ameliorate the incentive problems leading to rating inflation. However, the problem is in principle a simple one to solve: CRAs should earn market profits from producing accurate ratings but be punished if they produce inflated ratings, at least inasmuch as this behavior results in negative externalities to society. Since Coase[227]and Calabresi,[228] law and economics identifies in the legal liability one of the instruments for policing incentives to produce negative externalities. In the presence of negative externalities, liability can improve welfare if transaction costs are sufficiently high to prevent market forces from coping with the problem. In the context of CRAs, transaction costs are high when reputational concerns are insufficient to stop the production of inflated ratings. However, because this is a classic commitment problem, it can be improved by appropriate enforceable contracts,[229] including liability for ratings that turn out to be inaccurate. In this case, CRAs should be able to *choose* how much exposure to liability is necessary to commit to levels of accuracy that investors (and thus issuers) find acceptable to sustain a market for ratings. The situation is different when reputation is not just insufficient to commit CRAs to a level of

[224] This is the essence of the so-called Cuomo Plan, named after the New York State Attorney General who proposed this approach. As noted by Bolton, Freixas and Shapiro, this approach does not eliminate rating shopping in the absence of an explicit obligation to disclose also unfavorable ratings. Bolton, Freixas and Shapiro (n 211)
[225] Cf Pagano and Volpin (n 46).
[226] Cf Bolton, Freixas and Shapiro (n 211).
[227] Ronald H Coase, 'Problem of Social Cost' (1960) 3 JLE 1.
[228] Cf Calabresi (n 139).
[229] Robert D Cooter and Thomas S Ulen, *Law and Economics* (6th ed, Addison-Wesley 2011).

accuracy of their choice, but is displaced altogether by the ability of CRAs to support regulatory arbitrage, for instance because investing in a Triple-A asset of whatever creditworthiness brings regulatory benefits. In this situation, it is impossible to put the Coase Theorem back to work. On the one hand, CRAs are unambiguously better off opting out of any liability. On the other hand, those who suffer from inflated ratings (for example unregulated investors fooled by high ratings; or taxpayers bearing the cost of bailouts) can hardly negotiate with CRAs a commitment to accurate ratings even if that would improve welfare. In this case, the market is unable to correct the negative externalities problem. Hence, regulation should set a minimum degree of exposure to liability as a condition for ratings to enjoy regulatory relevance.

In this chapter, the introduction of a simple and legally workable strict liability rule is advocated to improve the incentives of rating agencies: CRAs should be liable to pay damages whenever a bond or a company they rate defaults. This is different from the approach taken by regulation on both sides of the Atlantic in the aftermath of the global financial crisis. While in the US and, more recently, in the EU, CRAs have been subject to liability based on negligence (if not gross negligence or even intent),[230] it is suggested that CRAs should face strict liability with three strong limitations. First, damage compensation should be capped at a multiplier of the CRA's income. Second, liability should operate with a timeframe apt to shield CRAs from systemic risk. Third, at least in the absence of regulatory benefits, CRAs should be able to decide how much to commit to their ratings by choosing a certain degree of liability exposure.

[230] In the U.S., the exemption of CRAs from liability as experts pursuant to Section 11 of the Securities Act of 1933 was removed in 2010 (see Dodd-Frank Act § 939G). As a result, CRAs are currently subject to liability under a due diligence standard provided that they are named as experts in the prospectus, which they can and do refuse. Cf Coffee, *Ratings Reform: The Good, the Bad and the Ugly* (n 48). On this side of the Atlantic, a EU-wide liability of CRAs was only introduced in 2013. 'Where a credit rating agency has committed, intentionally or with gross negligence, any of the infringements listed in Annex III having an impact on a credit rating, an investor or issuer may claim damages from that credit rating agency for damage caused to it due to that infringement' (art. 35a, 1, Reg. (EC) no. 1060/2009 as amended by art. 1, (22), Reg. (EU) no. 462/2013).

These limitations are set in order to avoid crushing liability. Crushing liability deters a socially valuable activity, like the production of accurate ratings, by imposing on the actor subject to it a liability in excess to the harm that it causes to the society. A rule of strict liability would be crushing for CRAs if they were liable for more than their revenues from selling ratings that are as accurate as possible, given the limits of the existing forecasting models as reflected by the chosen level of commitment. Likewise, crushing liability would stem from correlated defaults requiring CRAs to pay damages, however capped. For simplicity, these correlated defaults are called systemic risk. Systemic risk cannot be insured and, because CRAs are effectively silent about systemic risk, they should not be responsible for it.[231]

In other words, a strict liability rule leads CRAs to produce more accurate ratings under the three limitations sketched out above. To begin with, the damages are capped based on the income from rating divided by the highest probability of default associated with the letter grade of the defaulted asset. This condition is sufficient to disallow profits from rating inflation without discouraging ratings altogether. More precisely, CRAs facing this strict liability make no loss conditional on the absence of rating inflation as revealed by the difference between the predicted default rate and the actual frequency of defaults.

Moreover, a correction is introduced to protect CRAs from defaults depending on systemic risk. Two different approaches for corporate bonds and for structured finance products are needed, because they have a very different exposure to systemic risk. Corporate defaults tend to be strongly correlated only in the medium to long term. Therefore, as far as corporate bonds are concerned, liability should operate only for a limited period after the production or the confirmation of a rating. Although this is sufficient for corporate bonds, the defaults of

[231] As noted by Coval, Jurek and Stafford, credit ratings 'are silent regarding the state of the world in which default is likely to happen.' Therefore, ratings are uninformative about systemic risk. Cf Coval, Jurek and Stafford (n 212).

structured finance products tend to be correlated also in the short term, particularly in a financial crisis.[232] Because in this situation strict liability may discourage CRAs from rating structured finance altogether, an alternative solution to cope with systemic risk is proposed. Whenever extraordinary default rates are arguably dependent on systemic risk, liability should be conditional on inaccuracy being confirmed by the law of large numbers. When a public authority announces a financial crisis status, liability would be imposed on CRAs only if the frequency of observed defaults departed from the predictions made by CRAs over a sufficiently large number of cases and a sufficiently large time span, thus protecting CRAs from violent short-term fluctuations in the default rates. While limiting the extent to which strict liability over-deters ratings, particularly of structured finance products, this solution is countercyclical as it rewards the CRAs that were more conservative in their assessments during the upswing phase of an asset bubble.

Finally, CRAs are allowed to decide how much to commit to a certain rating, that is to the probabilities of default and the other estimates associated with each letter grade, by choosing the degree of exposure to liability. This condition allows liability to reflect the uncertainty of the forecasting models available to CRAs. The limited ability to foresee the future, along with the unobservability of several variables affecting the performance of the market for rating, is the reason why it is advocated a contractual approach to CRAs liability. This approach, however, creates a problem. In the presence of regulatory benefits, CRAs may choose an inefficiently low level of commitment and profit from providing regulated investors with artificially high ratings.[233] To address this issue, regulation should require that CRAs face a minimum degree of liability exposure for their rating to enable regulatory benefits. This solution

[232] Cf Coval, Jurek and Stafford (n 212).
[233] Cf Opp, Opp and Harris (n 47).

would still allow CRAs to choose their commitment levels with investors, but only in the absence of the negative externalities created by inflated ratings with a regulatory value.

3. Related Literature

As stated above, in the literature on CRAs, the existence of rating inflation is rarely disputed. However, the causes underlying rating inflation are not settled and there are different theories in this regard.

According to a first strand of literature the fundamental reason why CRAs tend to inflate their ratings is that they are paid by the same issuers that they rate. In this vein, the problem of rating inflation would be solved if one could simply make investors pay for ratings, which is complicated by information leakage and the related free riding problem.[234] However, even if it were possible to do away with the issuer-pays model, the case for legal intervention would not be straightforward. In a well-functioning market, reputational sanctions and competitive pressure could prevent opportunistic behavior by CRAs, regardless of the paying scheme adopted.

Many theoretical models have been developed to demonstrate how rating inflation emerges under different assumptions, thus suggesting the existence of market failures. Bolton, Freixas and Shapiro[235] show that rating inflation can be driven by investors' naivety and by the freedom granted to issuers to purchase the rating that they prefer, which allows for rating shopping. Because the marginal investors may be unsophisticated and thus unable to identify and punish inaccurate ratings, CRAs will face lower reputational sanctions from inaccuracy while profiting

[234] Cf Pagano and Volpin (n 46).
[235] Cf Bolton, Freixas and Shapiro (n 211).

from selling inflated ratings to issuers. Skreta and Veldkamp[236] emphasize that rating inflation might emerge also in the presence of truth-telling CRAs if there is sufficient heterogeneity in the predictions of their models. A similar point is made by Sangiorgi, Sokobin and Spatt.[237] They argue that heterogeneity in CRAs' predictions results in rating inflation even if explicit rating shopping is forbidden. The reason is that rating shopping can always occur implicitly. Because the methodologies of rating agencies are transparent to a certain extent, the issuer can select the CRA that uses model assumptions allowing for the highest possible rating.

Opp, Opp and Harris[238] take a different approach and show that rating inflation can depend exclusively on the regulatory function assigned to the ratings. Because ratings are embedded in financial regulation worldwide, regulated investors benefit from investing in highly rated securities even if the ratings are inaccurate. This strategy, for example, may lower the regulatory capital requirements for banks; may protect institutional investors from the threat of liability; and so forth.[239] The underlying assumption is that the value of these regulatory benefits passed on to CRAs via the issuers' fees exceeds the reputational sanction stemming from inflated ratings. The implications of this approach are twofold. On the one hand, it is not necessary to assume investors naivety to explain inflated ratings. On the other hand, to the extent that inflated ratings depend on a demand by regulated investors, having investors rather than issuer pay for them cannot possibly ameliorate the problem.[240]

Although due to identification problems rating inflation is hard to show empirically, there is some empirical evidence suggesting its presence as well as its dependence on several market

[236] Vasiliki Skreta and Laura Veldkamp, 'Ratings Shopping and Asset Complexity: A Theory of Ratings Inflation' (2009) 56 JME 678.
[237] Francesco Sangiorgi, Jonathan Sokobin, and Chester S. Spatt, 'Credit-rating Shopping, Selection and Equilibrium Structure of Ratings' (2009) Unpublished working paper.
[238] Cf. Opp, Opp and Harris (n 47).
[239] Cf Partnoy, *Rethinking Regulation of Credit-Rating Agencies: An Institutional Investor Perspective* (n 48).
[240] Cf Charles W. Calomiris, (2009) 'A Recipe for Ratings Reform' *The Economists' Voice* 6.11: 1-5.

failures. Using a panel dataset covering from 1999 to 2009, Xia and Strobl[241] find that the issuer-pays practice leads to higher ratings than the investor-pays practice. Baklyar and Galil[242] gather empirical evidence on the Israeli corporate credit rating market and show that one agency (Midroog) systematically inflated ratings, whereas another (S&P-Maalot) inflated its ratings only as a response to rating shopping. Becker and Milbourn[243] hint at rating inflation only indirectly. Their study reveals that the entry of Fitch in the market for ratings worsened the quality of ratings. This finding suggests that the adverse effects of rating shopping on rating inflation outweigh the benefits of increased competition.

The lesson to be learnt from the theoretical and the empirical literature is that a combination of market failures and regulatory distortions probably exists. Ratings tend to be inflated because there are naïve investors, which make reputation a weak constraint on rating shopping, *and* because there are regulatory benefits, which allow CRAs to cater to the investors' demand for artificially high ratings. Moreover, there is no easy way in which the market or regulation can overcome these problems. If the marginal investors are naïve the market cannot easily self-correct. Put differently, because transaction costs prevent efficient contracts on the provision of ratings from being written, the Coase Theorem breaks down. Regulation could paternalistically protect naïve investors by prohibiting the issuer-pays model, rating shopping, or even both of them. However, this approach would hardly be effective. On the one hand, in the absence of a regulator or a court who can screen rating quality, a market for ratings deprived of its typical features may collapse because of free riding[244] or moral hazard.[245] On the other hand, so long as financial regulation lacks viable alternatives to ratings for assessing credit risk, ratings will

[241] Gunter Strobl and Xia Han, *The Issuer-Pays Rating Model and Ratings Inflation: Evidence from Corporate Credit Ratings* (Unpublished working paper, 2012).
[242] Inna Baklayar and Koresh Galil, 'Rating Shopping and Rating Inflation: Empirical Evidence from Israel' (2011) *Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1903827*
[243] Cf Becker and Milbourn (n 223).
[244] Cf Pagano and Volpin (n 46).
[245] Cf Bolton, Freixas and Shapiro (n 211).

still be inflated despite any prohibition of issuer-pays and/or rating shopping when the regulatory benefits from inflation are high enough.

It is assumed, along with the mainstream literature, that ratings are valuable for the society because they reduce asymmetric information in finance.[246] However, this is conditional on ratings being above a certain accuracy threshold, which for simplicity it is assumed to be exogenously determined by the existing forecasting technology. Based on the findings of the existing literature, there are two reasons why CRAs may produce inaccurate ratings. One is a commitment problem.[247] Ratings are inflated because investors at the margin cannot recognize and punish inaccurate ratings (or cannot reward only accurate ratings), which prevents CRAs from committing to accurate predictions. The other reason is the presence of negative externalities in financial markets.[248] Because financial regulation currently relies on ratings to cope with such externalities, inaccuracy of ratings adversely affects not only the investors purchasing the rated assets for regulatory benefits, but also their counterparties as well as the taxpayers who bear the costs of bailing out regulated investors. Furthermore, neither unsophisticated investors nor financial regulators can second-guess the quality of ratings. CRAs could not produce anything valuable otherwise. It follows that there is a case for a different kind of legal intervention than proposed so far. Rather than tampering with how the market for ratings works or scrapping the distortions stemming from financial regulation, in this chapter it is proposed to subject CRAs to legal liability while keeping the rest of the status quo.

Unfortunately, precisely because it is difficult for a third party to second-guess ratings, it has been virtually impossible to prove in front of American courts the negligent behavior of rating agencies and the portion of losses suffered by investors that is attributable to their conduct.

[246] Lawrence J White, 'Markets: The Credit Rating Agencies' (2010) 24 JEP 211.
[247] Cf Cooter and Ulen (n 229).
[248] Dirk Heremans and Alessio M Pacces, 'Regulation of Banking and Financial Markets', in Alessio M Pacces and Roger J Van den Bergh, *Regulation and Economics* (Edward Elgar 2012).

Therefore, as shown by the legal literature,[249] CRAs have been de facto immune from liability claims. Moreover, particularly in the U.S., the rating agencies have often been able to escape liability by invoking the protection of the First Amendment available to journalists, whose liability is subject to an actual malice standard. Despite the efforts of legislators on both side of the Atlantic, this situation is not likely to change in the near future.[250] Acknowledging the difficulty to police the incentives of CRAs through a negligence standard for tort liability, the law and economics literature has suggested imposing a punishment on CRAs that produce inaccurate ratings by paying them with the debt they rate.[251] The approach proposed in this chapter has the important advantage to allow corrections for systemic risk, which are obviously not available for debt. Building on one of the policy recommendations by Bolton, Freixas and Shapiro[252] to fix the weakness of CRAs' reputational constraint, the enhancement of legal liability is advocated. However, differently from them as well as from the rest of the literature, a complete liability regime supporting the production of accurate ratings (as accurate as allowed by the available forecasting technology) without undermining the existence and the functioning of a market for ratings is designed.

The function of CRAs is to provide investors with certifications of the quality of financial assets, which is a form of gatekeeping.[253] Strict liability, if appropriately designed, would incentivize CRAs to supply such certification services as accurately as possible. The idea to

[249] Cf Deats (n 206).
[250] In the U.S., CRAs face now more difficulties to invoke the protection of the First Amendment. However, it has been practically impossible to activate the CRAs' liability as experts under Section 11 of the Securities Act of 1933 introduced by the Dodd-Frank Act. Cf Coffee, *Ratings Reform: The Good, the Bad and the Ugly* (n 48). With regard to Europe it is doubtful that the gross negligence standard that was introduced by art. 35a, Reg. (EC) no. 1060/2009 as amended by art. 1, (22), Reg. (EU) no. 462/2013 will change the status quo. In fact, it will be very hard to prove in courts (i) the grossly negligent behavior, (ii) the causation, and (iii), the portion of the losses suffered by investors that is attributable to the CRA's conduct. Haar provides a comprehensive comparative discussion of the recent legal developments concerning the civil liability of CRAs. Brigitte Haar, 'Civil Liability of Credit Rating Agencies after CRA 3-Regulatory All-or-Nothing Approaches between Immunity and Over-Deterrence' (University of Oslo Faculty of Law Research Paper 2013).
[251] Yair Listokin and Benjamin Taibleson, 'If You Misrate, Then You Lose: Improving Credit Rating Accuracy Through Incentive Compensation' (2010) 27 YJR.
[252] Cf Bolton, Freixas and Shapiro (n 211).
[253] Reinier H Kraakman, 'Gatekeepers: the anatomy of a third-party enforcement strategy' (1986) 2 JLEO 53.

introduce strict liability for gatekeepers is not new.[254] Importantly, taking into account that the gatekeepers income is very small relative to the investors' losses from underperforming financial assets, these proposals have always capped gatekeepers' liability at a portion of the damages on grounds that a full liability exposure would deter gatekeeping altogether. This problem is germane to that of crushing liability described by Shavell and Ben-Shahar[255] among others: if potential injurers are liable for damages in excess to the harm they cause to the society, they may refrain from engaging in valuable activities in the first place.

The problem of crushing liability is particularly severe for CRAs. The main characteristic of rating agencies is the probabilistic nature of their predictions. To rate a company triple-A is not equal to categorically exclude the possibility of its default; it merely implies a very small probability that default will happen. The logic behind the introduction of a strict liability rule to govern an activity generating losses with a certain probability is that the producer is assumed to be in the best position to insure (or self-insure) against the losses and to raise prices accordingly.[256] If one tries to apply the same logic to rating agencies, however, three major problems arise.

Firstly, it is possible to insure only against uncorrelated risks. The global financial crisis has shown that, especially in the medium-to-long term, defaults of firms and financial assets can be significantly correlated. For the purpose of this chapter, these correlations are termed systemic risk. Because strict liability makes the injurer residual risk bearer, under such regime CRAs would have to pay damages, however limited, stemming from systemic risk, which cannot be

[254] Coffee and Partnoy gave birth to a very lively debate on this point. Cf John C Jr Coffee, 'Gatekeeper Failure and Reform: The Challenge of Fashioning Relevant Reforms' (2004) 84 BULR 301; Frank Partnoy, 'How and why Credit Rating Agencies are not like other Gatekeepers' in Yasuyuki Fuchita and Robert E Litan (eds), *Financial Gatekeepers: Can They Protect Investors?* (Brookings Institution Press and Nomura Institute of Capital Markets Research 2006).
[255] Omri Ben-Shahar, 'Causation and Foreseeability' in Michael Faure (ed), *Tort Law and Economics* (Edward Elgar 2009).
[256] George L Priest, 'The Current Insurance Crisis and Modern Tort Law' (1987) 96 YLJ 1521.

insured. Consequently, in order to introduce a workable strict liability rule, the CRAs must be protected against the risk of correlated defaults. Two different ways to deal with this problem are suggested; one with respect to the business risk of corporate bonds and another one, more general, to cope with extraordinary events – like financial crises – which would make strict liability incompatible with the production of ratings, particularly of structured finance products.

Secondly, like other gatekeepers, CRAs cannot face liability for losses significantly larger than the value of their business. Making CRAs pay damages corresponding to the investors' losses from the default of a large rated company would be obviously unreasonable. Because most of these losses would have occurred also in the absence of rating, the expected liability of CRAs could not be possibly compensated by higher fees. Facing such a liability exposure, CRAs would refrain from producing ratings in the first place. Fortunately, it is not necessary to make CRAs liable for the full amount of investors' losses in order for them to have incentives to produce accurate ratings. As suggested by Coffee[257] for other gatekeepers, it is sufficient to cap the liability at a multiple of their fee income. The problem with this and other similar approaches is the arbitrariness of the multiplier.[258] To overcome this problem, the multiplier independent on the probability of default assigned and on the fee received by the CRA. Importantly, under this regime, CRAs cannot make losses unless their predictions are inaccurate.

Thirdly, CRAs cannot be expected to predict default rates without errors. Contrary to a standard assumption in finance, we do not live in a world of perfect foresight. It is illusory for the law to police incentives exclusively based on expected values and the underlying probabilities.[259] Our ability to predict the future is limited; so is CRAs' ability to commit to

[257] Cf Coffee, *Gatekeeper Failure and Reform: The Challenge of Fashioning Relevant Reforms* (n 254).
[258] Haar (n 250).
[259] On this point, Alessio M Pacces, *The Future in Law and Finance* (EIP 2013).

their predictions. Imposing on CRAs a strict liability rigidly dependent on the probabilities they estimate may discourage them from producing ratings in the first place. For this reason, CRAs are allowed to reduce their liability exposure by introducing a contractually determined parameter α, which is supposed to account for the uncertainty of the forecasting technology. Through this parameter, the CRAs will be able to prevent crushing liability stemming from the uncertainty of their models, while signaling to the market the degree of confidence in their own estimates.

4. Capped Strict Liability of CRAs: A Numerical Example

As explained in the previous section, imposing unlimited liability on CRAs is not an option. Because the default of any sufficiently large issuer could bankrupt a CRA almost instantly, no ratings would be provided under such regime. However, the characteristics of the market for ratings offer the opportunity to introduce strict liability with a cap on damages based only on objective factors. In the next section, it will be show with a formal model that this liability regime is sufficient to deter rating inflation. In this section, the intuition of the model with a simple numerical example is illustrated.

The main task performed by rating agencies is to classify and divide companies in clusters according to their probability of default.[260] To simplify, let us assume that a CRA perfectly knows this probability. If the liability cap is calculated by multiplying the price paid by the issuer times the inverse of the highest probability of default associated with the cluster in which the issuer is included, the liability of the rating agency will depend directly on the extent of rating inflation.

[260] Section 5.3 extends the reasoning to a slightly more detailed discussion of the activity performed by rating agencies.

To clarify the idea with a simple example, let us assume there are 100 firms, each one pays γ = 1 to the CRA for rating, and the cost of rating is zero. Let us also assume that the probability of a default (*Pr*) is equal to 0.01 for all the firms. If the rating agency correctly estimates the financial stability of the 100 firms, it will include all of them in the same cluster having – it is assumed – *Pr* = 0.01 as the upper bound. When only one firm effectively goes bankrupt the rating agency will be held liable for γ*1/*Pr* = 100 and will thus make zero profits. It is worth noting that the liability of the CRA is set to 100 independently of the damages stemming from bankruptcy, which could be much higher. However, if the rating agency systematically underestimates the probability of default (that is it inflates the rating), it will bear higher losses. For example, let us assume that all the firms are included in a higher cluster than their creditworthiness would grant, with an assigned probability of *Pr* = 0.005. In this case, if still only one firm goes bankrupt, the liability will be equal to 200, imposing on the CRA a loss of 100.

In this example, it is assumed that CRAs have perfect foresight, that ratings can be produced with zero profits, and that no reputational sanction is attached to rating inflation. In the mathematical model presented in the next section all these assumptions will be relaxed.

In concluding this section, it is worth noting that this liability rule compensates investors with a sum of money that is in no way related to the harm they have suffered. However, given that it is nearly impossible to prove CRAs' negligent behavior and the portion of the harm suffered by the investors that is attributable to their conduct, it is hard to determine how much harm rating agencies effectively cause to the market by producing inaccurate ratings. As suggested by Coffee,[261] the liability rule should therefore prioritize deterrence over compensation.

[261] Cf Coffee, *Gatekeeper Failure and Reform: The Challenge of Fashioning Relevant Reforms* (n 2544).

5. The Model

Let us define δ_j as a measure of rating inflation (or deflation). With regard to the *jth* cluster of creditworthiness, δ_j is defined as:

$$\delta_j = \frac{m_j - s_j}{m_j} - Pr_j \qquad \forall_j \in \mathrm{J}\,, \tag{4.1}$$

where the index j varies on the whole set J of rating classes, m is the number of firms included by the *nth* CRA in the *jth* class of rating, s_j represents the number of firms included in the *jth* cluster that did not go bankrupt, and Pr_j indicates the default rate for the letter grade associated to the *jth* cluster. In other words, $(m_j - s_j)/m_j$ denotes the ex-post probability of default, whereas Pr_j indicates the ex-ante prediction. Consequently, if CRAs predictions are confirmed ex-post:

$$\frac{m_j - s_j}{m_j} = Pr_j \;;\; \delta_j = 0 \qquad \forall_j \in \mathrm{J} \tag{4.2}$$

Conversely, we formally define rating inflation as:

$$\frac{m_j - s_j}{m_j} > Pr_j \;;\; \delta_j > 0 \qquad \forall_j \in \mathrm{J} \tag{4.3}$$

The overall level of rating inflation (or deflation) of the *nth* CRA is defined as:

$$\overline{\delta} = \sum_j \delta_j / J \qquad \forall_j \in \mathrm{J} \tag{4.4}$$

The parameter β denotes the difference between the rating assigned to the *ith* firm by the *nth* CRA and the rating potentially assigned to the *ith* by another CRAs. Hence, β measures the level of rating inflation of the *nth* CRA relative to its competitors.

In a perfect market the profits of the *nth* CRA can be described by the following equation:

$$\Pi_{n,j} = \sum_{j} \sum_{i=1}^{m_j} \gamma_{i,j} + R(\beta, \overline{\delta}) \qquad (4.5)$$

$\gamma_{i,j}$ is the fee collected from each firm net of given rating costs while $R(\beta, \overline{\delta})$ is the reputational effect of CRA's conduct.[262] $R(\beta, \overline{\delta})$ captures the impact of this conduct on future income. The reputational effect then depends on the two parameters defined above, namely β and $\overline{\delta}$.

In a perfect market investors will be able to detect any mistake in a CRA's predictions and to punish it with a reputational sanction $R(\beta, \overline{\delta}) < 0$ sufficient to make such mistakes unprofitable. In addition, because there is no market failure, regulation does not need to rely on ratings and there are no regulatory benefits from investing in rated assets. In other words, in a perfect market characterized by perfect foresight, no rating inflation could exist because reputational sanctions are sufficient to prevent opportunistic behavior, regardless of the paying scheme and the liability rule adopted. It follows that in this scenario no liability should be imposed on CRAs.

However two market failures have been identified, namely the existence of regulatory benefits attached to high ratings and the naivety of some investors. Despite being agnostic about the exact impact of each factor, the findings of the literature suggest that both *m* and $R(\beta, \overline{\delta})$ change their shape and their behavior because of them. In this case, the regulator confers an independent value upon high ratings and hence the reputational effect of rating inflation is altered. Under

[262] For the sake of simplicity it is assumed that CRAs only compete on the number of rated firm, not on the level of the fees. This assumption is without loss of generality, as our results would hold also for variable fees.

these circumstances it is plausible that conflicting reputational concerns arise. Frenkel[263] suggests that, especially in concentrated markets, rating agencies facing weak reputational constraints might find it profitable to be lenient and inflate ratings while inducing investors to believe that they are credible. In other words, not only the reputational sanctions might be softened by investors' lack of sophistication, but rating inflation might even be rewarded by institutional investors. As a result, given the existence of regulatory benefits and naïve investors, issuers will be attracted to high ratings regardless of their informative content, and hence *m* becomes dependent on β and on the size of the regulatory benefits. Equation (4.1) thus becomes:

$$\Pi_{n,j} = \sum_{j} \sum_{i=1}^{m(\beta,Rb)_j} \gamma_{i,j} + R\,(\beta, \overline{\delta}, \theta) \tag{4.6}$$

Where Rb denotes the regulatory benefits attached to high ratings and θ indicates the share (in value) of naïve investors. Higher values of β and $\overline{\delta}$ result in a higher reputational sanction for the CRA. At the same time, the reputational loss is lower if the value of θ is higher.

Being extremely simple, this description cannot capture the complex nuances that characterize the functioning of CRAs. However, this simple framework is sufficient to include the crucial point made by the literature: given the existing market failures and regulatory distortions, CRAs are able to increase their short-term profits by producing inflated ratings. Under the status quo, CRAs are de facto immune from liability. Therefore, the additional revenues from rating inflation can be larger than the reputational costs to be borne in the future, at least up to a certain level of rating inflation.

[263] Sivan Frenkel, *Repeated Interaction and Rating Inflation: A Model of Double Reputation* (Unpublished working paper, Hebrew University 2012).

Moreover, for individual CRAs, the number of firms to rate depends positively on the level of rating inflation. Because solid firms want to communicate their creditworthiness to the market, some issuers will want to be rated independently of rating inflation. However, another group of issuers will be interested in purchasing a rating *only if* rating inflation is above a certain threshold (for example allowing them to pass the investment grade threshold, which is a condition for investor to enjoy regulatory benefits). Inflating ratings is the only way to attract the issuers of the second group. If this behavior does not sufficiently harm the reputation of the *nth* CRA, rating inflation not only increases short-term profits, but becomes also necessary to survive in the market for ratings. Because the expected liability is nil and the reputational sanctions are not sufficient to support an equilibrium where $\overline{\delta} = 0$, CRAs that do not inflate their ratings will lose customers and short-term profits to their competitors without increasing their future revenues by the same or a higher amount. As a result, all CRAs will inflate ratings to the same extent and the equilibrium will be $\overline{\delta} > 0$ and $\beta = 0$.

Introducing the following liability regime can improve this equilibrium.

5.1. Capped Strict Liability under Simplifying Assumptions

Under the proposed strict liability rule, the liability of the *nth* CRA for any firm defaulting in the *jth* cluster will be equal to:

$$Ln_j = \sum_{i=1}^{m(\beta,Rb)_j - s_j} \gamma_{i,j} / Pr_j \qquad \forall_j \in J \tag{4.7}$$

The profits of the *nth* CRA are now equal to:

$$\Pi_{n,j} = \sum_{j} \sum_{i=1}^{m(\beta,Rb)_j} \gamma_{i,j} + R(\beta,\overline{\delta},\theta) - \sum_{j} \sum_{i=1}^{m(\beta,Rb)_j - s_j} \gamma_{i,j} \; / Pr_j \qquad (4.8)$$

For the sake of simplicity, let us assume that $R(\beta,\overline{\delta},\theta) = 0$. In other words, for the moment it is assumed that no reputational sanction is attached to inaccurate ratings.

We obtain for the *jth* cluster:

$$\Pi_{n,j} = \sum_{i=1}^{m(\beta,Rb)_j} \gamma_{i,j} - \sum_{i=1}^{m(\beta,Rb)_j - s_j} \gamma_{i,j} \; / Pr_j \qquad \forall_j \in \mathrm{J} \qquad (4.9)$$

The ratio $(m(\beta,Rb)_j - s_j)/(m(\beta,Rb)_j$ denotes the share of firms that effectively defaulted. If this ratio is equal to Pr_j then the CRA has correctly estimated the probability of default of the issuer and $\Pi_n = 0$. If the CRA has underestimated the probability of default, which is to say it has inflated the issuer's ratings, then $\Pi_n < 0$. $\Pi_n > 0$ only if $Pr_j > (m(\beta,Rb)_j - s_j)/(m(\beta,Rb)_j$. Hence, facing strict liability according to our model, CRAs will never have any incentive to inflate ratings. To the contrary, the optimal strategy for them would be to award always a probability of default equal to 1. This extreme case of rating deflation is purely theoretical, because obviously no issuer will ever be interested in purchasing such a rating. Actually, also because highly rated assets bring about regulatory benefits to regulated investors, issuers will have an interest to receive a rating that is as high as possible.

Issuers, CRAs and regulated investors have normally an information advantage compared to regulatory authorities and courts. The question is how to induce the market for ratings to reveal information efficiently. The proposed strategy is to create, by imposing an appropriate strict liability on CRAs, opposing interests for CRAs, issuers and investors. More specifically, the CRAs will prefer to supply lower ratings in order to reduce their expected liability, whereas issuers and regulated investors will prefer higher ratings. The ratings produced in such a market

are going to reflect valuable information about the creditworthiness of issuers and their bonds. In fact, this is the only way in which gains from trade can be generated after the profits from misrating are disallowed by a capped strict liability rule. This outcome will ultimately benefit financial regulators and the society at large.

In every market the opposing interests of sellers and buyers lead to an equilibrium price that, absent market failures, is considered optimal. To re-create such equilibrium in the market for ratings it must be ensured that issuers and regulated investors, on one side, and CRAs, on the other side, have opposite interests. This has also important dynamic implications. Under the status quo, increasing competition between CRAs would only worsen the problem of rating shopping.[264] This circumstance rules out the most straightforward strategy to improve the efficiency of ratings, namely increasing competition. Competition could again be valuable in the market for ratings after imposing strict liability on CRAs. In the presence of a capped strict liability regime more actual and potential competition between CRAs can be expected to lead to more innovation in forecasting techniques rather than to more rating inflation.[265]

5.2. Capped Strict Liability with Imperfect Foresight and Reputational Sanctions

Under the proposed liability rule, four different conditions have to be fulfilled for an efficient market for ratings to emerge: *(i)* $\Pi = 0$ is considered a satisfying equilibrium; (*ii*) rating agencies know the true probability of default; (*iii*) $R\left(\beta, \overline{\delta}, \theta\right) = 0$ and (*iv*) firms defaults are uncorrelated.

With respect to (*i*), to use γ as the relevant base for the liability rule implies that the profits of CRAs, given accurate ratings, are set to zero. They become negative only in the presence of

[264] Cf Becker and Milbourn (n 223); Bolton, Freixas and Shapiro (n 211).
[265] This point is discussed in more details below, in section 7.

rating inflation, which under the assumption of perfect foresight is sufficient to guarantee rating accuracy. The condition $\Pi = 0$ is reminiscent of the absence of economic profits under perfect competition and is not particularly restrictive. As mentioned in the previous section, this equilibrium cannot be improved by exaggerating the probability of default (rating deflation) because at some point this will drive the number of rated firms to zero. This scenario is not particularly interesting for policymaking; therefore, it is not explored in this chapter.

More importantly, even under ideal incentives, the CRAs will be prone to make mistakes, violating condition (*ii*). In fact, condition (*ii*) is never true – we do not live in a world of perfect foresight. In addition, the assumption *(iii)* – namely that R = 0 – should be relaxed too in order to take into account the effects of reputation and, more in general, all the factors affecting the future income of CRAs. Finally, condition (*iv)* concerns systemic risk as a source of crushing liability. This problem will be tackled in section 5.

To address (*ii*) and (*iii*) the parameter $0 < \alpha < 1$ is introduced. α limits the expected liability of CRAs. The profit of the *nth* CRA are now equal to:

$$\Pi_{n,j} = \sum_{j} \sum_{i=1}^{m(\beta,Rb)_j} \gamma_{i,j} + R\left(\beta, \overline{\delta}, \theta\right) - \sum_{j=} \sum_{i=1}^{m(\beta,Rb)_j - s_j} \gamma_{i,j} * \alpha / Pr_j \qquad (4.10)$$

Where α denotes the fraction of $\gamma_{i,j}$ that is considered to calculate the expected liability. The smaller α, the more mistakes CRAs are allowed to make without suffering losses (and the more economic profits they can make if their ratings are correct). In other words, this scenario lies between two extremes: a perfect market where ratings are efficiently policed by reputational concerns; and the stylized market described in section 4 in which $R\left(\beta, \overline{\delta}, \theta\right) = 0$ and rating agencies face liability whenever a rated issuer defaults. In the former case the optimal α (let that be α^*) is equal to 0, in the latter it is equal to 1. Because, as shown by the literature on

CRAs, the reputational sanction is neither optimal nor is it totally absent, α^* will lie between the two extremes.

Identifying such an optimal value might seem attractive, but this would be an almost impossible task. A benevolent and omniscient regulator could identify the optimal value of α for any transaction and at any moment in time. However, an omniscient regulator would also know the correct rating for any issuer and financial asset and thus the whole problem of accurate ratings would simply not arise. On the contrary, regulators neither possess unlimited information nor can they be expected to be always benevolent. It seems extremely difficult that a public authority can adequately manipulate α in order to guarantee that CRAs earn enough to stay in business without being tempted to inflate their ratings. In order to determine α^*, it would be necessary to know the value of the parameters $\beta, \overline{\delta}, \theta$, the shape of the functions $R(\beta, \overline{\delta}, \theta)$ and m, and the level of accuracy of the available forecasting technology.

In more qualitative terms, it is argued that the simultaneous presence of regulatory benefits, naïve investors, and imperfect forecasting techniques has affected the market for ratings in a very complex way. In our view, re-creating opposing interests between supply and demand for ratings is a better strategy than attempting to correct the above reasons for market failure via detailed regulations. Given the existing market failures no further assumptions about the shape of $R(\beta, \overline{\delta}, \theta)$ are made. Instead it is suggested to rely on market mechanisms to determine α, based on the market players' knowledge of the parameters determining the size of the reputational sanction $R(\beta, \overline{\delta}, \theta)$. Obviously, the higher is α, the more CRAs will be credible because they are punished if they inflate their ratings. However, the expected liability may be too high to sustain a market for ratings given the existing forecasting technology. A lower α, on the other hand, is good to keep CRAs in business, but might be insufficient to cope with the problem of rating inflation given the shape of $R(\beta, \overline{\delta}, \theta)$.

The alternative to choosing α by regulation is to let α be determined contractually. In this vein, CRAs are allowed to announce to the market (that is, to the investors) how much they are committing to a certain rating with their choice of α. This approach copes with an important shortcoming of imposing strict liability on CRAs. CRAs have often stated that their predictions are ordinal in nature, not cardinal. The proposed liability rule requires that all CRAs be compelled to publish the specific range of probability of default associated to a certain rating, and particularly to connect the upper bound of this range to their expected liability. In a sense, this implies forcing CRAs to produce ratings as a cardinal measure. Although this increases transparency, it would also place on CRAs a burden that they might be unwilling to bear. If the value of α is determined by a regulatory authority, there is the concrete risk that this burden becomes excessive. As it was mentioned, regulators are not omniscient. Neither are CRAs. Imposing on CRAs a given α means committing them to a given level of confidence in their own probability estimates. CRAs that find such a level of confidence excessive may simply decide to exit the market.

Conversely, if the rating agencies are allowed to decide how much to 'bet' on a certain rating, they will be able to take into account the unavoidable uncertainty surrounding predictions of the future and the possibility of mistakes or imperfection in their models. This solution has a number of advantages. Firstly, it introduces a commitment device to improve the functioning of the market for ratings. This device is a varying degree of liability exposure, which CRAs can choose freely so long as this choice allows them to produce ratings valued by investors. Secondly, because the CRAs know better than anybody else how accurate their forecasting models are in predicting future defaults, they can choose the level of commitment that is sufficient to keep them in the business thus preventing strict liability from becoming crushing.

The key feature of α is its contractibility. Being a commitment device supported by an enforceable strict liability rule, α can be as low as to keep CRAs in business and as high as to make ratings informative for investors including the naïve ones.[266] In other words, α allows contracting on unobservable parameters like the determinants of $R(\beta, \overline{\delta}, \theta)$ and the uncertainty of forecasting models. In the absence of regulatory distortions, competition in the provision of certification services to issuers will always make sure that α is the efficient outcome of the opposing interests of CRAs and investors. Moreover, because CRAs will compete on α, this mechanism also provides incentives to improve the forecasting technology over time. Only the presence of regulatory benefits from high ratings makes this market approach unviable, because such benefits could be so high as to offset all the negative determinants of $R(\beta, \overline{\delta}, \theta)$. When this is the case, the regulatory benefits can sustain a market for ratings also with α artificially low (or even zero).

If α is contractually determined, financial regulation cannot allow whatever rating to have regulatory relevance. More precisely, besides requiring a high rating for investors to enjoy regulatory benefits, regulation should also impose that α chosen by the CRA producing the rating is above a specific threshold. Under such arrangement, rating agencies would not merely claim that a firm deserves a high rating, but they would have to put their money where their mouth is in order to be credible. At the same time, by deciding exactly how much to expose themselves to liability, CRAs can prevent the risk that an excessively zealous regulator forces them to carry an excessive burden – at the end CRAs are not obliged to produce rating relevant to regulation. It is important to note that CRAs are not forced to adopt any particular value of α. In theory, they could simply decide to shield themselves from any liability claim if that was acceptable for issuers and investors. However, if CRAs want their ratings to have a regulatory

[266] It is assumed that no investor is so naïve to be unable to rank commitments to liability exposure based on $0 < \alpha < 1$.

value, they should be the first to show reliance in their own predictions by complying with a minimum value of α established by regulation

5.3 Extending the Model: Loss Given Default

In certain cases, especially for corporate bonds, ratings are not only an indicator of the probability of default, but also include an estimate of the loss given default (LGD).

In this section the model is adapted to take into account the LGD as well as any other quantitative aspect that CRAs might consider to produce a rating. Once again, for the sake of simplicity, let us refer to equation (4.5) under the assumption of perfect foresight. To take into account the LGD, equation (4.5) should be modified in the following way:

$$\Pi_{n,j} = \sum_{j} \sum_{i=1}^{m(\beta,Rb)_j} \gamma_{i,j} + R(\beta,\overline{\delta}) - \sum_{j} \sum_{i=1}^{m(\beta,Rb)_j - s_j} \gamma_{i,j} \ /Pr_j * LGD_{r\,i}/LGD_{p_i} \qquad (4.11)$$

LGD_r represents the LGD effectively observed whereas LGD_p represents the predicted LGD. Similarly to our previous discussion on the probability of default, if $LGD_r > LGD_p$ then the expected profits will decrease. If $LGD_r = LGD_p$ the expected profits will not be altered by liability. Lastly, for $LGD_r < LGD_p$, Π_n would theoretically increase, but as it was explained for the probability of default, a scenario in which CRAs systematically underestimate creditworthiness is not very realistic because, at some point, issuers will simply stop buying its ratings.

This simple extension shows that this liability rule could be applied, with an identical logic, to any quantitative factor employed by rating agencies for the production of their assessment.

6. Systemic Risk

To avoid that strict liability becomes crushing, it is necessary to protect CRAs from systemic risk, which may result in correlated defaults. Correlated defaults are problematic both because they undermine the ex-post accuracy of CRAs' estimates and because they are a risk that cannot be insured (or self-insured) by definition. Although the choice of α allows to take into account for the fallacies of forecasting models, a strict liability rule still makes CRAs residual risk bearer for the portion of damage compensation triggered by the default of a rated issuer or bond. Therefore, apart from the uninteresting case in which α is set to 0, it is important to make sure that CRAs do not face liability when defaults depend on systemic risk rather than on the individual circumstances of the issuer or of the bond that ratings are supposed to assess with a varying degree of precision (α).

Unfortunately, there is no unique way to cope with this problem. As it will be shown,[267] rating structured finance products differs from rating traditional corporate bonds precisely because of their different exposure to systemic risk. As it will be shown, corporate bonds are rather insensitive to fluctuations of economic output in the short term. This offers a straightforward way to deal with systemic risk: the strict liability of CRAs should be limited to the short term. However, structured finance products are very different from corporate bonds in this respect because their defaults can be highly correlated also in the short term. To be sure, contrary to traditional corporate bonds whose credit risk mainly depends on firm-specific characteristics, structured finance products behave like economic catastrophe bonds[268] concentrating defaults in the worst states of the economy as a whole. This extreme sensitivity of structured finance to

[267] Cf Coval, Jurek and Stafford (n 212); Matthew D Rablen, 'Divergence in Credit Ratings' (2013) 10 FRL 12.
[268] Cf Coval, Jurek and Stafford (n 212).

systemic risk is a problem that cannot be ameliorated limiting the CRAs' liability to the short term. Therefore, this approach is effective only for corporate bonds. As far as structured finance products are concerned, addressing systemic risk requires a modification of our strict liability regime. The two approaches are presented in turn.

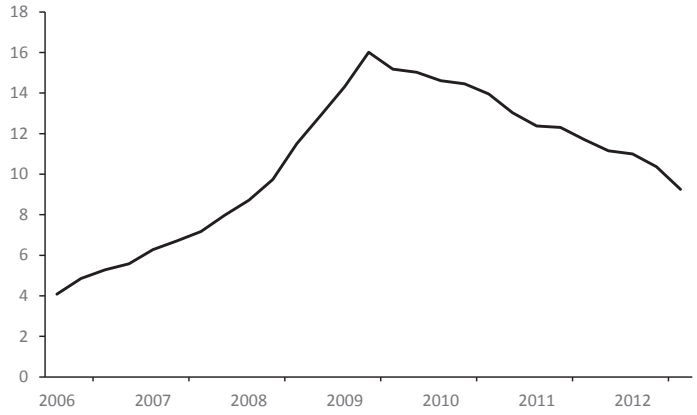
6.1. Short-Term Liability for Rating Corporate Bonds

Predictions can be medium-to-long term or short term. In this context, three months are considered to be a typical short-term horizon, because this is usually the timeframe (the so-called 'watchlist') in which CRAs review their assessment and decide whether to maintain or downgrade a certain rating.[269] The rating of corporate bonds mainly depends on the probability that their issuers – typically business enterprises – go bankrupt.[270] While medium-to-long term predictions in this respect seem to be greatly affected by systemic risk, short-term predictions present this problem in an attenuated form. If the focus is a sufficiently short time horizon, there is no reason to expect that the correlation between business issuers going bankrupt will be significantly positive. This seems to hold true even in times of aggregate economic distress. For instance, the data from the Quarterly U.S. Business Bankruptcies show that even during a crisis as violent as the global financial crisis, bankruptcies have taken a certain time to propagate.

Figure 1 illustrates this well. It can be noticed that, although the increase in the frequency of bankruptcies between 2006 and 2009 was significant, the short-term fluctuations were not particularly violent.

Figure 1: Bankruptcies of business firms in the U.S. (in thousands)

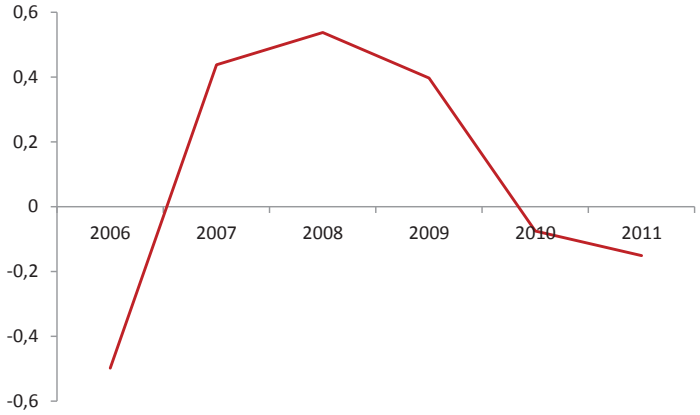
[269] Cf Cristina E Bannier and Christian W Hirsch, 'The Economic Function of Credit Rating Agencies–What does the Watchlist Tell us?' (2010) 34 JBF 3037.
[270] For simplicity I do not include another important determinant, namely the Loss Given Default. See section 5.3.



Source: American Bankruptcy Institute (www.abiworld.org)

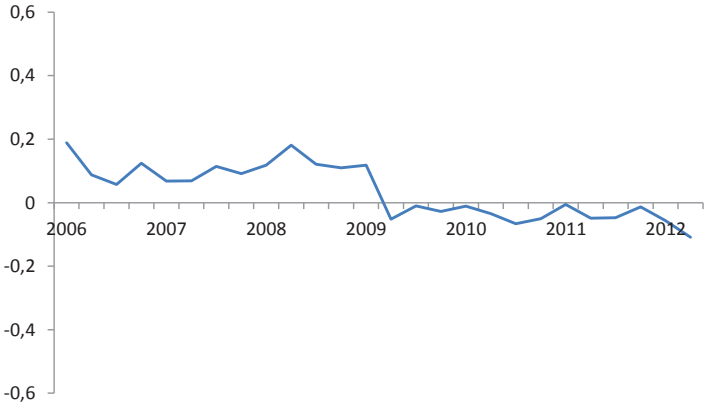
The point is illustrated even more clearly by the contrast between Figure 2 and Figure 3. By looking at a period of one calendar year, the percent change in the number of bankruptcies is dramatic, reaching peaks of 44% and 54% respectively in 2007 and 2008. On the contrary, by considering a shorter horizon, for instance a quarter, the percent changes are much smaller. These changes are often below the ten percent threshold, and are never above 19%. Without pretense to discuss thoroughly the impact of systemic crises on bankruptcy rates, it should be emphasized that these data suggest that firm defaults can be indeed correlated; but economic crises, however severe, do not spread instantly across issuers.

Figure 2: Yearly Percent Change in Bankruptcies of Business Firms in the U.S.



Source: American Bankruptcy Institute (www.abiworld.org)

Figure 3: Quarterly Percent Change in Bankruptcies of Business Firms in the U.S.



Source: American Bankruptcy Institute (www.abiworld.org)

Based on this observation, the strict liability faced by CRAs rating corporate bonds should have an expiration date. Rating agencies would be strictly liable only if the issuer goes bankrupt

shortly after the rating has been issued or confirmed. If the definition of short term coincides with the typical interval in which CRAs review their ratings, CRAs will have the opportunity to revise their ratings when changed circumstances call for a different assessment. If an aggregate shock takes longer than three months to alter the frequency of defaults, CRAs will avoid liability just by adjusting their ratings to the new environment when the revisions come due. At the same time, liability cannot be avoided simply by downgrading firms that suddenly turn out to be riskier than originally foreseen. Once a rating is given or is confirmed, it will commit the CRA for three months in a proportion corresponding to the choice of α. After the expiration date, the standard negligence rule could be put back in place, which is another way to say that CRAs would face no liability, as is currently the case.

6.2. Postponed Liability for Rating Structured Finance Products

Although limiting liability to the short term offers CRAs an effective protection against systemic risk in the case of corporate bonds, this solution may not be sufficient for structured finance and, more in general, whenever defaults can be positively correlated also in the short term. Under these circumstances, the liability of CRAs simply needs to be excluded if defaults depend on systemic risk. In order to achieve this result, it is necessary to depart from the traditional deterministic tort law approach and exploit the law of large numbers. In this perspective, it is possible to imagine an incentive scheme grounded on the same model presented in the previous section, with the modifications below.

This system would work as follows. A public authority records the rating issued by the CRAs, the fees they receive, and the actual frequency of defaults of each structured finance product. Using α/Pr as a multiplier, the regulator calculates the potential liability that each CRA has to face for each default. CRAs should still be allowed to choose α as in the strict liability regime

designed before. However, CRAs will not be asked to pay damage compensation whenever a structured finance asset defaults. Only after a certain time interval, say one year, the public authority will verify the overall accuracy of a CRA's predictions, which, in turn, will determine whether the CRA in question is to face liability for the assets that defaulted in the previous year. For example, let us consider the cluster BBB- (Baa3 using Fitch scale). The historical, annualized range of probability of default associated with this cluster is 0.025 - 0.032.[271] If, during the time interval considered, less than 0.032 of the assets included in the cluster have defaulted, then no compensation will be due. Conversely, liability will be triggered if the quality of ratings has been below the relevant threshold. In other words, the payment will be due only if more than 0.032 of the assets included in the cluster BBB- has defaulted.

Postponing the imposition of the monetary sanction allows making liability conditional on the failure of CRAs to predict default over a sufficiently large number of observations. This approach has two advantages in coping with systemic risk. Firstly, if the predictions of rating agencies turn out not to be inflated over the relevant timeframe, their profits will not be affected by the defaults occurring within their range of predictions because they will simply face no liability for those defaults. Compared to the strict liability solution, this mechanism tempers the over-deterrence stemming from the uninsurability of systemic risk. However, CRAs would still be liable to pay damages when the frequency of default in a given time interval exceeds the highest probability of default in the relevant class of rating. This effect is desirable to police rating inflation; but it also leaves CRAs exposed to systemic risk, particularly in those scenarios of 'economic catastrophe' where structured finance assets tend to experience extraordinary rates of defaults. Financial crises are a case in point.

[271] This example is based on Fitch's historical (annualized) default experience. Cf Coval, Jurek and Stafford (n 212).

Fortunately, postponing the imposition of liability has a second advantage in coping with systemic risk. The timeframe for assessing the accuracy of CRAs' prediction could be made long enough to absorb the violent fluctuations in the default of structured finance products depending on a financial crisis. Obviously, for this purpose, the length of the interval is crucial. Whereas a one-year period could be sufficient to assess the accuracy of CRAs' ratings of structured finance in normal times, this might be just too short a time to compensate the sudden spikes in defaults coming along with a financial crisis. For this reason, it is advocated the introduction of a double layer of protection for the rating of structured finance products. At a first stage the ex-ante predictions of rating agency are compared with the ex-post default rates during the year in question. As stated above, if the predictions are accurate over one year, no liability will be imposed on rating agencies. Conversely, if the CRA has underestimated the number of defaults over one year, the public authority could decide *on an exceptional basis* to impose liability on the additional condition that ratings were inflated also over a longer time horizon. Importantly, in order to protect CRAs from systemic risk, the relevant timeframe can be extended backward, not forward. If, because of a financial crisis, structured finance products have experienced extraordinary rates of defaults in a year, it will take many years before the situation returns to normality and even longer before the shock can be absorbed by the data.

Let us illustrate this solution with a simple numerical example. Assume that, for instance over the past five years, a rating agency has predicted for a given class of structured finance products the expected number of defaults (ED) indicated in the table below. Let also the actual number of defaults (ND) be as reported in the following table.

Year	*1*	*2*	*3*	*4*	*5*	∑
ED	10	9	8	7	6	40
ND	9	8	7	6	10	40

Only in the fifth year the rating agency has underestimated the number of defaults. Therefore, under the normal rule, the CRA should be liable to pay a compensation based on the α/Pr multiplier. However, the public authority might exceptionally determine that a spike from 6 to 10 defaults from one year to another is a consequence of systemic risk and hence it might extend the assessment interval. For example, regulation may provide that in such situations the assessment interval could be extended up to the average maturity of the structured finance products in question. Let us assume, as in the numerical example, that the average maturity is five years, the latter becomes the relevant timeframe to determine whether the CRA is liable. As the example shows, over a five-year period ED is equal to ND (40 defaults) and therefore, despite the spike in the number of defaults in the fifth year, the CRA will face no liability.

This solution would reward the CRAs who were more conservative in their ratings the years preceding a financial crisis, as those CRAs could count on historical frequencies of default below the maximum PD associated with the relevant letter grade. This effect is countercyclical, namely it counters, however little, the formation of asset bubbles without standing in the way of a recovery of credit.[272] Although this solution ultimately relies on the ex-post discretion of public authorities to cope with systemic risk – which it is assumed to be unpredictable – it is

[272] The countercyclical property of our solution is especially relevant given that ratings quality has been shown to be lower during booms Heski Bar-Isaac and Joel Shapiro, 'Ratings Quality Over the Business Cycle' (2013) 108 JFE 62.

worth noting that this discretion is essentially limited to the declaration of a status of financial crisis; all of the other consequences on CRAs' liability should be predetermined by regulation.

7. The Virtues of Capped Strict Liability

It is worthwhile to briefly highlight the benefits of the approach presented in this chapter. In the first place, the liability rule proposed connects CRAs' expected profits to the quality of their ratings, thus inducing them to put their money where their mouth is. In fact, by tying the expected liability to the rating assigned (and to the level of commitment accepted), the CRAs' profits will depend on the quality of their predictions. It follows that the problem of rating shopping is addressed implicitly, as any CRA that produces overoptimistic ratings to attract more issuers will be forced to face higher liability.

Secondly, this proposal introduces a damage cap based on objective factors. The cap has the important virtue to prevent over-deterrence of rating activity. At the same time, this approach eliminates almost any discretion on the side of regulators and courts. The only exception is the declaration of financial crisis status necessary to offer CRAs rating structured finance products a second layer of protection against systemic risk. Otherwise, the rule advocated in this chapter carries sizeable savings in terms of administrative costs. There will be no need to scrutinize the behavior of CRAs or to establish complex standards of care in order to prevent them from producing inflated ratings. Moreover, courts will not have to quantify the portion of damages attributable to the conduct of CRAs. Determining that an issuer or a bond have defaulted and multiplying the price by the probability of default associated with a given rating are (quasi-) automatic and (quasi-) costless tasks. The risk of litigation errors, frivolous litigation, and opportunistic settlements usually created by strict liability will all be ruled out.

Finally, the incentive scheme described above ties the income earned by CRAs to the quality of their forecasting techniques, thus creating the right incentives also from a dynamic perspective. To understand this point, let us assume that three rating agencies exist: A, B, and C. A and B have developed state-of-the-art forecasting models; thus they are able to assess with greater accuracy than C the issuer's probability of default. Let us also assume that firms are divided in two groups, X and Y, which respectively have a low and a high probability of default. Under these assumptions C will not be able to distinguish between X and Y and will therefore be forced to assign an average probability of default. Good issuers, however, could obtain better ratings from A and B because these rating agencies are able to better assess their creditworthiness. As a consequence, issuers belonging to the cluster X will switch to the two CRAs that are able to assign them the rating they deserve. The more good firms switch to A and B, the higher will be the average level of risk of the pool of firms rated by C. In the end, all the good firms that have a low probability of default will be rated by A and B, and the firms with a high probability of default will be indifferent between A, B and C. As in the real world, the probability of default of rated firms approaches a continuous function, the only competitive equilibrium is one where every firm opt for A or B, unless they are so risky to be indifferent between A, B, and C. In this case, however, the rating would have hardly any added value for the issuer and C would have to exit the market for ratings.

An identical reasoning applies to the parameter α when CRAs choose freely how much to expose themselves to liability. In fact, CRAs that can offer predictions which are more accurate will be able to determine with higher precision when they can expose themselves to a higher liability. It is obvious that good firms will have every incentive to hire the CRA that can adopt a higher value of α, both because this implies a higher commitment to rating accuracy and because a relatively high α should be a precondition for ratings to deliver regulatory benefits.

For analogy with the mechanism described above, a high α will emerge as a result of CRAs' competition on the quality of forecasting techniques.

8. Conclusion

There has been an enormous debate both at the political and at the academic level on how to induce CRAs' to produce accurate ratings. In this chapter, it has been argued that tying liability to the probabilistic prediction offered by the CRA and exploiting the law of large numbers allows developing a framework that gives CRAs the correct incentives. More precisely, it has been proposed the introduction of an expiring, capped strict liability rule with a contractual component. A damage cap based on objective factors is introduced in order to avoid crushing liability, whereas the expiration date is needed to shield CRAs from systemic risk whenever – as in the case of corporate bonds – defaults are largely uncorrelated in the short term. Furthermore, CRAs are allowed to determine contractually at what level they want to commit to their predictions. Importantly, no liability is imposed on them, unless they want their ratings to have regulatory relevance. Finally, in order to protect CRAs from systemic risk also when defaults can be correlated in the short term (as in the case of structured finance), a departure from the traditional deterministic tort law approach is proposed. By delaying the compensation until after few defaults have occurred, CRAs may be punished only when their predictions are proven to be inaccurate by the law of large numbers.

V. The Indeterminacy Principle of Tort Law and Economics

1. Introduction

At a first glance, the law and economics movement seems to be the answer to the indeterminacy of predictions. Every law and economics textbook contains in one form or another the proof of what Dari-Mattiacci called the two fundamental theorems of tort law and economics.[273] The first, the efficiency-equivalence theorem, states that under the classic assumptions any negligence rule gives both parties efficient incentives with respect to care.[274] The second, the activity level theorem, asserts that under the classic assumptions no negligence rule gives both parties efficient incentives with respect to activity level.[275] In other words, the classic model of tort law and economics promises to offer a very precise description of parties' behavior, at least under strong simplifying assumptions.

Nevertheless, despite the prominent place that these theorems occupy in the tort law and economics arena, much confusion surrounds their real meaning. In this chapter, I attempt to shed some light on the real informative content that they carry. More precisely, I will show that even under the classic assumptions the only possible statement is that the party who is not the residual loss bearer will take optimal care.[276] Or better, because no information can be derived on the behavior of the party who is not the residual bearer, even the extremely simplified world described by the economists is dominated by an indeterminacy principle.

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[273] Cf Cooter and Ulen (n 229); Steven Shavell, *Economic Analysis of Accident Law* (HUP 1987); Mitchell A Polinsky, *An Introduction to Law and Economics* (Little Brown 2007). The definition first appeared in Giuseppe Dari-Mattiacci, *Tort Law and Economics* (n 55).

[274] The classic assumptions are: (*i*) parties are rational and utility maximizing (*ii*) perfectly informed about the legal rules, (*iii*) risk neutral, (*iv*) there are no administrative costs (*v*) and compensation is perfect. Cf Shavell, *Strict Liability versus Negligence* (n 49).

[275] Cf Shavell, *Strict Liability versus Negligence* (n 49).

[276] The residual loss bearer is the party that will bear the losses deriving from accidents in which neither of the two parties have been negligent.

First, I show that the two fundamental theorems cannot hold at the same time. The two fundamental theorems can coexist only if parties' behavior is determined through a two-step procedure; first, the parties determine their respective care levels and only later decide their activity level.[277] Implicit in this approach is the assumption that care and activity level are independent goods, instead of being (imperfect) substitutes.[278] Once this implicit assumption is relaxed, the classic model can no longer offer *any* information on the behavior of the residual loss bearer (indeterminacy principle).

Second, in contrast with the received wisdom, I show that under the standard assumptions the traditional negligence rules generally do not allow reaching a second-best outcome. More precisely, building on the literature on loss sharing between non-negligent parties,[279] I show that under the traditional assumptions there can be infinite rules leading to a higher social welfare than negligence and strict liability with a defense of contributory negligence.[280]

Given the little informative content of the traditional model, in the second part of this chapter I suggest integrating its study with the concept of optimal space of uniform standards. That is to say, the optimal area in which standards should be uniform considering the following factors: (*i*) characteristics of the environment, (*ii*) similarity of preferences and characteristics of individuals, (*iii*) uniformity of activity level across space and (*iv*) uniformity of activity level over time.[281] Combining the concept of optimal space of uniform standards, with the framework

[277] Cf Jacob Nussim, and Avraham D. Tabbach, 'A revised model of unilateral accidents' (2009) 29 IRLE 169. They note how this approach is extremely common and used, for example by Shavell, *Economic Analysis of Accident Law* (n 273) 22 and Steven Shavell, *Foundations of Economic Analysis of Law* (HUP 2004) 195.
[278] This approach is far from extinct. In a recent paper, Dari-Mattiacci et al. adopt the mirror image of this assumption. They assume that one party's care level cannot affect other party's activity level. Cf Giuseppe Dari-Mattiacci, Bruno Lovat and Francesco Parisi 'Loss Sharing between Nonnegligent parties' (2014) 170 JITE 571. It is however apparent that this assumption does not necessarily hold. If all drivers in a certain city become ruthless it is very likely that pedestrians will lower their activity level, and not only adopt more care.
[279] Cf Dari-Mattiacci, Lovat and Parisi (n 278).
[280] With infinite rules, I mean that there can be infinite criteria for sharing losses among the parties leading to higher welfare than negligence and strict liability with a defense of contributory negligence. This is, after all, a relevant dimension under which negligence rules can be differentiated.
[281] The literature generally focuses on (*ii*).

of the classic model it is possible to draw some normative implications. For example, when the optimal space of uniform standards is small, rules in which courts do not dictate parties' behavior (i.e. strict liability) tend to be superior. Conversely, when the optimal space of uniform standards is large, it might be better to opt for rules in which the court set due care levels for both parties (i.e. negligence with a defense of contributory negligence).

2. The Classic Model

To justify the claims presented in the introduction to this chapter, I will reproduce the proof offered by the classic literature.[282]

Tort law and economics scholars usually divide accidents into unilateral and bilateral. In the former case only the injurer is able to take precautions affecting either the probability of the accident or the size of the potential losses. In a bilateral setting also the victim can affect the likelihood of the accident and/or the magnitude of the expected losses. Because the theorems are mostly relevant in bilateral settings, unilateral accidents will not be discussed.

Following the classic literature, it will be assumed that parties are risk neutral, that there are no administrative costs, and that compensation is perfect. Moreover, in order to behave as predicted by the model, parties are assumed to be perfectly informed about the legal rules, rational, and utility maximizing.[283] Lastly, the activity level has to be intended in its literal meaning, yet within the framework of the classic model it could be defined more conveniently in a different way. As Shavell[284] suggested, 'care' is the set of precautionary measures included in the negligence criterion and 'activity level' is the residual set of precautionary measures not

[282] Steven Shavell, 'The Optimal Use Of Nonmonetary Sanctions as a Deterrent' (1987) 77 AER 584.
[283] Cf Shavell, *Strict Liability versus Negligence* (n 49).
[284] Ibidem.

included in the negligence criterion.[285] This alternative definition will be discussed in section 3.

In bilateral settings both the victim and the injurer can affect the likelihood of an accident; thus adequate incentives to both parties have to be provided. A rule of strict liability without a defense cannot achieve this result. As the victim will be compensated for all her losses she will have no incentives to take care. Conversely, the injurer will be forced to internalize all the losses she causes and will thus take optimal care and engage in the activity optimally.[286]

A better result can be obtained under a rule of strict liability with a defense of contributory negligence; the victim will now be induced to take optimal care to avoid being held liable (recall that it was assumed due care to be set at the optimal level). Given that the victim will take due care, the injurer will have to bear all the losses and will therefore take optimal care too.

The social optimum cannot be reached if the activity level is taken into account. Because the victim will be entirely compensated for all the losses she suffered, she will compare her private marginal benefit (PMB) from engaging in the activity with her private marginal cost (PMC), instead of taking into account the social marginal cost (SMC). As a result, she will engage in the activity too often. Conversely, being the residual loss bearer, the injurer will be induced to internalize every loss she causes; she will therefore compare the marginal benefits from the activity with the SMC and engage in the activity optimally.

Symmetrically, under a negligence rule the injurer will take due care but she will engage excessively in the activity because she will be able to escape liability for all the losses. The victim is now the residual loss bearer and hence she will engage in the activity optimally. From these considerations it is possible to infer that any negligence rule will induce both parties to

[285] Cf also Giuseppe Dari-Mattiacci, 'The Optimal Scope of Negligence' (2005) 1 RLE 331.
[286] Strict liability is usually considered the dominant rule in unilateral settings since the incentives given to the victim are irrelevant.

take optimal care (efficiency equivalence theorem) but no negligence rule can induce both parties to adopt the optimal activity level (activity level theorem).

An obvious postulate is that the behavior of the residual loss bearer will depend on the behavior of its counterpart; as the party who is not the residual loss bearer will have an excessive activity level, the residual loss bearer will not behave as she would have, had her counterpart engaged in the activity optimally. This is due to the fact that injurers and victims play what is usually defined as a non-cooperative game; each player acts independently but their payoffs depend on the strategies of the other players.[287] It would be illogical to imply that an excessive activity level of one of the parties would not affect the behavior of its counterpart.

2.1 The Mathematical Model (Trying to Apply the Theorems)

The income equivalent of total welfare in a non-market bilateral situation can be described as follows:[288]

$$W(x, y, s, t) = A(x, y) + H(s, t) - ytl(x, s) \qquad (5.1)$$

- W is the total welfare;
- x is the level of precaution adopted by the injurer;
- y is the activity level of the injurer;
- $A(x, y)$ is the income equivalent of the utility to an injurer of engaging in his activity at level *y* exercising care x;

[287] John Nash, 'Non-cooperative Games' (1951) 54 Annals of Math 286.
[288] The model presented in this section closely follows Shavell, *Strict Liability versus Negligence* (n 49). This model implies a linear relationship between the activity levels and the harm. More recent formulations of the classic model have abandoned this assumption. The proof offered holds also if the more general model is adopted.

- s are the precautions adopted by the victim;
- t is victim's activity level;
- $H(s,t)$ is the income equivalent of the utility to a victim of engaging in his activity at level t exercising care s;
- $l\ (x,s)$ are the expected accident losses per victim per unit of injurer activity and of victim activity.

I define *univocally* the optimal level of precautions and activity (denoted by x^*, y^*, s^* and t^*) that maximize the function W.

For any given level of precautions x, A is a strictly increasing function of y until it reaches its maximum, to become strictly decreasing afterwards. Specifically, for any x, $A_y(x,y)>0$ for $y<y(x)$ and $A_y(x, y)<0$ for $y>y(x)$. $y(x)$ is uniquely defined by either $A_y(x,y)=0$ or, if this never holds, $y(x)=0$. $H(s, t)$ has analogous properties. Under a rule of strict liability with a defense of contributory negligence the victim will have to set $s=s^*$ but she will not take into account the term $ytl(x, s)$ when determining her activity level, hence $t>t^*$. Conversely, the injurer faces the problem of maximizing W, given s and t chosen by the victim;[289] for the two fundamental theorems to hold (under the definition of optimality adopted) the injurer should adopt $x=x^*$ and $y\leq y^*$.

A symmetrical reasoning applies to a negligence rule. The injurer will choose $x=x^*$ and $y>y^*$ and the victim should respond by choosing $s=s^*$ and $t\leq t^*$.

3. A Puzzling Hidden Assumption

[289] H is now a constant so to maximize W is the same as maximizing $A(x,y)- ytL(x,s^*)$.

In the previous section, in line with the prevailing literature,[290] I determined the care levels and the activity levels of the parties through a two-step procedure. First, I identified the care levels of the parties and then I derived their activity levels. Nevertheless, it is intuitive that the two problems are strongly interrelated. To put it differently:

> 'in contrast to the common result in the literature, the socially optimal behavior of injurers [and victims] cannot be determined in two steps: first by finding the level of care that minimizes total accident costs incurred each time injurers [and victims] engage in the activity; and then by raising the level of activity as long as the marginal utility for injurers exceeds the increment to total accident costs.'[291]

Let us refer to the familiar example of drivers (injurers) and pedestrians (victims). The traditional two-step procedure implicitly assumes that pedestrians will always answer to an excessive number of cars only by walking less, because the parties have already determined their respective care levels when they decide how much to engage in the activity. In fact, if the parties determine their care and activity levels in two different moments, the choice of the former is not affected by the behavior in terms of the latter. That is, even if injurers will have an excessive activity level, the victims will still take optimal care but they will walk less miles. However, this is not necessarily true.

Let us move to a typical city where drivers and pedestrians have to coexist and where a rule of strict liability with a defense is in place. As pedestrians are not the residual loss bearers, they will adopt optimal care but will have an excessive activity level. Drivers can decide to react in different ways to victims' behavior: (*i*) they can adopt optimal care but drive fewer miles. (*ii*) They can drive just as much as they used to, but at a lower speed (or taking more care). In other

[290] E.g. Shavell, *Foundations of Economic Analysis of Law* (n 277) 194.
[291] Nussim and Tabbach (n 277). As the authors suggest, this approach is very common in the mainstream literature.

words, under the classic assumptions a rule of strict liability with a defense might lead the injurer to engage in the activity optimally, but to adopt excessive care. (*iii*) Drivers might simply decide to take a longer route in order to avoid the city center packed with pedestrians. They would drive more miles while adopting a lower care level than the one they would have adopted in the city center. In this case, under the classic assumptions, a rule of strict liability with a defense leads the injurer to engage in the activity excessively, yet to take less than optimal care. It is incorrect to rule out the second and the third possibility implying that to adopt optimal care and to lower the activity level is always the best reaction.

This conclusion is reinforced if the broader definition of activity level advocated by Shavell[292] and Dari-Mattiacci[293] is adopted. In fact, it should be implicitly assumed that every time the victim adopts a low level of unobservable precautions (an excessive 'activity level'), the injurer's best response is always to increase the level of unobservable precautions (to lower the 'activity level'). Why this should be the case is a puzzle that is very likely to not be solved, especially considering that the set of precautions that victims and injurers have at their disposal might be completely different. To imply some sort of parallelism between their sets of observable and unobservable precautions appears to be illogic.

Informally, this example shows that parties do not necessarily adopt optimal care, unless it is assumed that the observable precautions and unobservable precautions are independent goods. Such an assumption offers a strongly distorted representation of reality and – as it will be shown in the following section – it contradicts the mathematical model used to demonstrate the two theorems.

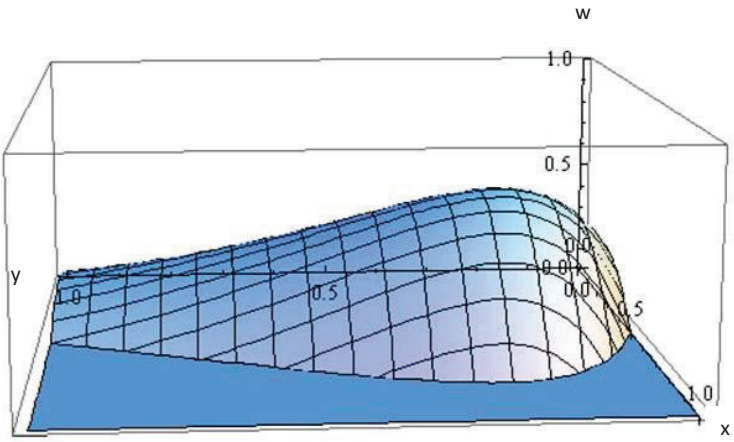
[292] Cf Shavell, *Strict Liability versus Negligence* (n 49).
[293] Cf Dari-Mattiacci (n 285).

3.1 A moving maximum

In this section, I will show that the two theorems only hold under the very restrictive assumption that care and activity level are independent goods. Total welfare in a non-market bilateral situation can be described by (5.1):

$$W(x, y, s, t) = A(x, y) + H(s, t) - ytl(x, s) \qquad (5.1)$$

The behavior of a function that respects the assumptions imposed by the seminal article of Shavell – for given values of *s* and *t* – is shown in the following figure



Let us assume that *t* and *s* have been chosen optimally by the victim; the global maximum will be identified by a certain pair *x*, *y*. In other words, given *s** and *t**, the maximum welfare will be reached for *x**, *y**. As soon as there is a departure from *t**, the function *H(s,t)* will no longer assume its optimal value; because *s* and *t* appear also in the term *ytl*(*x*,*s*) a departure from *t** is not a linear transformation and hence it will inevitably change the shape of the curve too. The global maximum will no longer be in *x**. The Injurer will no longer take 'optimal care'.

Let us now focus on a negligence rule. The injurer will set x equal to x^*, but she will not take into account the term $ytl(x,s)$ when determining her activity level y, hence $y > y^*$. On the other hand, the victim has to maximize W, given the care level and the activity level chosen by the injurer. The curve has now a different shape from the original one given y^*, therefore it cannot be claimed that the victim will adopt the optimal care level s^* and a suboptimal activity level.

3.2 Redefining what is Optimal: A Cure Worse than the Disease

I defined *univocally* the optimal care level and the optimal activity level (denoted by x^*, y^*, s^* and t^*) as the levels of precaution and the levels of activity that maximize (5.1). It is possible to offer a cure to the fundamental theorems, yet this probably creates more problems than it solves. The first theorem would formally be valid if 'optimal' is defined as any behavior that maximizes the welfare function faced by an agent. I will label this 'private-optimum'. On the one hand, this definition is redundant, because it is already embedded in the concept of economic rationality that economic agents maximize their own utility function. On the other hand, this 'cure' introduces ambiguity in the terminology and weakens even the most basic normative implications that follow from the classic model. Also, note that if we focus on private optimums parties not only adopt optimal care, but also an optimal activity level. Therefore, under this definition of optimality it is the second theorem that becomes false.

Let us assume that a negligence rule is in place and that total welfare is still described by (5.1).

Once again, the value of x, y, s and t that maximize (5.1) are x^*, y^*, s^* and t^*. The injurer will now adopt a care level equal to x^* and an activity level $y_n > y^*$ that maximizes the function $A(x^*,y)$.

The victim has to maximize the function:

$$W(x, y, s, t) = A(x, y) + H(s, t) - ytl(x, s) \quad (5.2)$$

The victim will choose the values s_n and t_n that maximize (5.2). These values are 'optimal' given the behavior of the injurer but they are different from s^* and t^*.

Let us switch to a rule of strict liability with a defense of contributory negligence. In this case the victim will be induced to adopt a care level of s^* and the activity level $t_s > t^*$ that maximizes the function $H(s^*,t)$.

The injurer will now face the following function:

$$W(x, y, s, t) = A(x, y) + H(s, t) - ytl(x, s) \quad (5.3)$$

To maximize (5.3) she will choose the corresponding values x_s and y_s. These values are once again optimal given the behavior of the victim, but are different from x^* and y^*.

Although it is true that the level of care adopted under both rules is optimal (if we refer to private optimum), they are not equal nor are they necessarily equivalent in terms of welfare. Under a rule of negligence the parties will adopt the levels of care x^* and s_n, whereas under a rule of strict liability with a defense of contributory negligence they will adopt x_s and s^*. There is no sound reason to argue the equivalence of these pairs of care levels, even though they are both called 'optimal'.

Summarizing, if we focus – as we should on the social optimum the first theorem is false. Alternatively, defining as 'optimal' any behavior that maximizes the welfare function faced by an agent (i.e. private optimum), the first theorem would become true, yet the second theorem would be false. Under the latter definition of optimality, parties adopt both optimal care and optimal activity level. The two theorems cannot coexist, because they cannot be simultaneously valid.

As under different rules parties maximize different functions under different constraints, they will adopt different care levels depending on the existing rule. Moreover, these care levels will generally be different from the univocally defined x^* and s^* and hence will not be optimal. Alternatively, we can focus on private optimums, yet by doing so the fundamental theorems become tautological in the sense that they automatically follow from the assumption of agents' rationality. To put it differently, it is true that parties would adopt 'optimal' care (i.e. they will maximize their own utility function), yet it is not possible to draw any inference on the efficiency of their behavior in terms of overall social welfare.

Furthermore, it cannot be proven that $y_n > y_s$ or that $t_s > t_n$; the mathematical model confirms the qualitative intuition presented in section 3. Under a rule of strict liability with a defense of contributory negligence the activity level of the injurer might even be higher than under a rule of negligence.

These findings are summarized in the following tables:

Table 1:

	Strict Liability w/ a defense	Negligence
Care Level I	$x^?$	$x=x^*$
Activity Level I	$y^?$	$y>y^*$
Care Level V	$s=s^*$	$s^?$
Activity Level V	$t>t^*$	$t^?$

The notation $x^?$, $y^?$, $s^?$, and $t^?$ is used when from the classic model it cannot be inferred if the value of the variable will be higher, equal, or lower than the optimal value. As shown by Table

1, no information can be obtained on the behavior of the party who is not the residual loss bearer (indeterminacy principle).

In Table 2 the behavior of the parties under the different rules is compared.

Table 2:

	S.L. w/ a defense	Negligence	Comparison
Care Level I	$x^?$	$x = x^*$	?
Activity Level I	$y^?$	$y > y^*$	?
Care Level V	$s = s^*$	$s^?$	?
Activity Level V	$T > t^*$	$t^?$	?

Table 2 shows that the fundamental theorems carry a very small informational content. Even within the classic assumptions, it is not possible to compare the different rules under any dimension.

3.3. How Efficient are Traditional Negligence Rules?

It is generally stated that first best results are impossible to achieve,[294] yet a second best solution can be reached by choosing either for negligence or strict liability with a defense of contributory negligence. This optimistic conclusion is, however, not supported by the mathematical model.

Let us introduce a parameter $0 < \alpha < 1$ denoting how losses are allocated between non-negligent parties. Let us assume that for α=0 all the losses resulting from accidents in which

[294] Shavell, *Strict Liability versus Negligence* (n 49).

both parties have taken due care are borne by the injurer, whereas for α=1 all the losses are allocated on the victim. Therefore, under strict liability with a defense of contributory negligence α=0 and under a negligence rule α=1.

As α is a continuous variable, there exist an infinite number of criteria to allocate losses among non-negligent parties.[295] Each of these solutions (could) lead to a different pair of care levels and to a different level of social welfare. Whenever one of the traditional rules is chosen, there could be an infinite number of sharing criteria leading to a higher overall welfare. In fact, there can be *infinite* rules leading to a higher welfare than negligence and strict liability with a defense of contributory negligence.

Let us recall that under a negligence rule the injurer will maximize the function *A(x*,y)*. The reason is that under a negligence rule non-negligent injurers will not bear any loss, and hence the weight (α) of the term *ytl(x.s)* is equal to 0. As an example, let us now assume that α =0.1. The injurer will therefore adopt *x** and take the y_α that maximizes the following function:[296]

$$A(x^*, y) - 0.1 * ytl(x^*, y) \tag{5.4}$$

The victim will now maximize the following function:

$$W(x^*, y_{\alpha,}, s, t) = A(x^*, y_{\alpha,}) + H(s, t) - 0.9 * y_{\alpha,} tl(x^*, s) \tag{5.5}$$

Once again, the values s_α and t_α chosen by the victim are optimal given the behavior of the injurer, but are different from *s** and *t**. Notably, there is no way to rule out the possibility that this outcome is more efficient than the one reached under a negligence rule. As α can assume infinite values, there can be infinite rules that are better than negligence and strict liability with a defense of contributory negligence.[297]

[295] Dari-Mattiacci, Lovat and Parisi (n 278).
[296] Or the sake of simplicity, I assume that $\alpha = 0.1$ is not enough to undermine injurers' incentives to take optimal care.
[297] Cf Dari-Mattiacci, Lovat and Parisi (n 278).

Two additional points should be noted. First, although under the non-univocal definition of optimal behavior every negligence rule formally leads both parties to adopt the 'optimal' level of care, these optimums are not identical, nor can they be assumed to be equivalent from an efficiency point of view. In other words, even if we want to preserve the assertion that every single negligence rule leads both parties to adopt optimal precautions, we cannot save the label 'efficiency equivalence theorem'.[298] In contrast with a common result of the literature, the pairs of care level adopted under the various rules are not necessarily equally efficient.[299]

Second, the so-called 'lesser of two evil principle' – explained below – must also be reinterpreted accordingly.[300] It is common wisdom that:

> '[T]he preferred liability rule depends on whether it is more important to control the injurer's or the victim's activity level. If the injurer's activity level is of greater concern, then strict liability with a defense of contributory negligence should be used. If the victim's activity level is more important, then negligence is preferable.'[301]

Nevertheless, the choice of the optimal rule does not depend only on the deviation in terms of activity level (i.e. under a negligence rule the distance between y_n and y^*). It depends also on the departure of the behavior of the residual loss bearer from the one that maximizes W (i.e. under the same rule the distance between s_n *and* s^* and t_n and t^*). Unless new hypotheses are introduced, we cannot infer that larger departures in terms of activity level lead to a greater

[298] Giuseppe Dari-Mattiacci and Gerrit De Geest, 'The Filtering Effect of Sharing Rules' (2005) 34 JLS 207.
[299] Among the many authors that have embraced this syllogism cf Dari-Mattiacci. 'It follows that a negligence rule which makes the injurer pay only 1% of the accident cost in the case of both parties being negligent and lets the victim bears 99% of the loss is as efficient with respect to care as a 50-50 rule, as a 90-10, as a 75-35 and so forth' [note that the author refers also to the extreme cases of pure negligence and strict liability with a defense of contributory negligence]. Dari-Mattiacci (n 55).
[300] David Gilo and Ehud Guttel, Negligence and Insufficient Activity: The Missing Paradigm in Torts (2009) 108 MLR 277.
[301] Cf Polinsky (n 273).

welfare loss. In fact, even if the deviation in terms of activity level is larger under a certain rule, the related pair of 'optimal care levels' might be inferior.

It could be argued that the care level of the residual bearer departs from the optimum as a consequence of the deviation in terms of activity level of the counterpart, and thus the latter is relevant. However, it should also be admitted that the deviation in the activity level is a mere reflex of the due care level imposed by the courts. At a closer look, the 'lesser of two evil principle' simply means that we should control the variable that is more important to control.

Syllogistic thought is an irresistible temptation and it is indeed natural to think that (*i*) if all rules induce the parties to adopt the optimal level of care and (*ii*) if under every rule the party who is not the residual bearer has an excessive activity level (*iii*) then the only difference among different rules is the level of activity. On the contrary, the rules should be evaluated in terms of the deviation of the three variables that are not directly fixed by the courts (y, s and t under a negligence rule, and x, y and t under a rule of strict liability with a defense), but the model offers no guidance from this perspective. In other words, we are again back to where we started. No prediction can be made on the behavior of the parties.

4. Maximizing…Nothing

Despite its scarce informative content, the classic model can be an interesting starting point to study the many faces of heterogeneity. Heterogeneity exists under a number of dimensions, yet law and economics scholars generally focus only on some of them. In this section, I will argue that studying the main sources of heterogeneity jointly allows identifying the optimal space of uniform standards. This concept can be integrated into the framework of the classic model.

4.1 When?

A first dimension under which heterogeneity should be studied is time. Most of the models focus on the level of activity, yet not on *when* the activity is engaged. A simple numerical example is enough to show that the variable time should not be ignored. Let us assume to be in a city in which drivers (injurers) and pedestrians (victims) have to coexist. For the sake of simplicity, it will be assumed that in this city there are only 20 people. 10 of them are (only) drivers, whereas the other 10 are (only) pedestrians. It will also be assumed that accidents happen only between one driver and one pedestrian. Furthermore, it will be assumed that courts can observe the activity level and the care level of both parties.[302] When a certain regulation has to be introduced it generally has no expiration date. Affirming that the optimal activity level for drivers is 1000 miles is a meaningless statement, unless the relevant time interval during which the 1000 miles can be covered is defined. In other words, given the information available, the courts (or the legislator) have to maximize W over a certain time interval. For example, it could be said that the relevant time interval is a year; therefore, the courts have to identify the optimal number of miles that should be covered during this time interval. The courts will therefore define a negligence criterion that will induce parties to adopt the care levels x^* and s^*, and the activity levels y^*/per year and t^*/per year.[303]

The idea that maximizing the function (5.1) over the relevant time interval always implies that also the total welfare is maximized has never been questioned. Nevertheless, this idea is wrong. In the example, it was assumed that courts want to define how many miles pedestrians and drivers should cover every year. As they have all the relevant information on the precaution costs and on accident costs, they can maximize (5.1). Let us suppose that the optimal activity

[302] Here, I am departing from the traditional assumption that the activity level is not observable.
[303] The literal meanings of optimal care and activity level are being used. It has also been assumed that activity level is observable and is included in the negligence criterion.

level for pedestrians is 100 miles a year while adopting a care level of 10. It will also be assumed that for drivers it is optimal to drive 1000 miles a year and to adopt a care level of 20. Following the classic literature, these values are called 'optimal' as they maximize (5.1); however, it would be a very lucky coincidence if these values also maximize the total welfare over a year.

To understand why let us assume that pedestrians only leave their apartments from January to June, whereas drivers use their cars only from July to December. As accidents by assumption only take place between one driver and one pedestrian, the optimal level of care for both parties is 0. Because drivers and pedestrians never share the streets, even the smallest precaution is inefficient. In other words, the value of the parameters that maximize (5.1) over a year do not maximize the sum of social welfare in the two semesters. Under these circumstances, maximizing (5.1) over a year is an empty exercise, as it is possible to achieve a better result by choosing any value of x and s smaller than x^* and s^*. Ideally total welfare is maximized for $x=0$ and $s=0$.

The example offered here is clearly oversimplified; however it shows that maximizing (5.1) is an empty exercise, unless it is assumed that injurers and victims are uniformly distributed over the relevant time interval. The mathematics behind it is trivial: since the relationship between the variables is not linear, to maximize (5.1) over a certain time interval does not imply that also the sum of the welfare in the fractions of that interval is maximized. In this case, if W is maximized over each semester better result is obtained than maximizing W over the year. In other words, *when* people engage in the activity is a crucial piece of information that is completely ignored by the classic model.

Abandoning our oversimplified example does not change the scenario.

Let us move to a real city and let us relax the assumption that accidents cannot happen between two drivers. Let us also relax the assumption that people walk and drive only six

months per year. It still seems plausible that the optimal level of precautions that drivers and pedestrians should adopt is heavily dependent on how crowded the streets are. As stated above, under a rule of strict liability with a defense the victim will have to set s equal to s^*. It was assumed that also the activity level is observable and hence $t = t^*$. The injurer will choose the combination of care level and activity level (x^*,y^*) that maximizes W, given the (optimal) behavior of the victims. If the number of victims is not constant during the year (e.g. there might be fewer pedestrians during winter due to the cold weather, whereas the summer breeze might offer an incentive to walk), also the optimal behavior of the injurer is bound to change accordingly. To prove this point mathematically it suffices to note that the combinations of x and y that maximize W change for different values of t. If during winter $t_w < t^*/2$ and during summer $t_s > t^*/2$ (with $t_s + t_w = t^*$), there will be a combination of x and y that is optimal for winter (x_w, y_w), and another combination that is optimal for summer (x_s , y_s). A better result in terms of welfare can be achieved if injurers adopt x_w, y_w during the winter and x_s ,y_s during the summer instead of x^* and y^* all over the year.

It might be suggested that the obvious solution is to adopt as the relevant time interval a season instead of a year; however, this would offer very little relief. In fact, it can be argued that the activity level of pedestrians is not the same during the entire winter, as it is very likely that there is a peak in the activity level of drivers and pedestrians during Christmas holidays. If this is the case, a week should be considered as the relevant time interval. Even doing so, the optimum will not be reached because people might be more likely to walk during the weekend than during weekdays. The answer could be further narrowing down the relevant time interval to a day. However, as people tend to walk more during the day than during the night also this solution would not be satisfying. If administrative costs are not considered, the relevant time interval should tend to zero, or at least be small enough to guarantee that the distribution of victims (injurers) is constant inside the interval.

Assuming that the activity level and the care level imposed by the court can change over time, equation (5.1) should be rewritten in the following way:

$$W(x, y, s, t) = \sum_{\tau=1}^{n} [\, A\tau(x, y) + H\tau\,(s, t) - \; ytl\tau(x, s)], \qquad (5.4)$$

where τ represents the time.

Conversely, if it is assumed that the courts have to define a single due care level and a single activity level for the whole period, (5.1) should be rewritten as follows:

$$W(x, y, s, t, \tau) = A(x, y, \tau) + H\,(s, t, \tau) - \; ytl(x, s, \tau) \qquad (5.5)$$

4.2 Where?

An identical line of reasoning applies with regards to *where* activities are engaged.[304] Unless it is assumed that the activity level is uniform across the relevant area as a whole, maximizing *W* in a certain area does not guarantee that the total welfare is maximized. For activities like driving, there are significant differences even between contiguous areas (two bordering roads can have a very different number of cars and pedestrians), hence the size of the optimal area should tend to zero. Once again, if the court can change the due care level depending on the area a negligence rule with a defense of comparative negligence has a comparative advantage. To the contrary, a strict liability rule is preferable whenever due care has to be uniform in areas that present different characteristics or where the parties have different activity levels.

[304] To demonstrate this point it suffices to replicate the proof offered with regards to when the activity is engaged. In fact, an average care level will over deter good drivers, while not being sufficient to prevent accidents caused by bad drivers. Assume that a speed limit is set at 50 km/h. Good drivers who could safely go at 60 km/h would be forced to reduce their driving speed (over deterrence), while bad drivers who should go at 40 km/h will be allowed to go faster than they should (under deterrence).

4.3 Who?

Lastly, the analysis can be extended to injurers' heterogeneity.[305] If the injurers are heterogeneous, any negligence standard defined having in mind the average injurer is bound to simultaneously over-deter some injurers and under-deter others. The same logic applies to victims in bilateral precaution contexts.

4.4 The optimal space of uniform standards

Combining the different sources of heterogeneity it is possible to study the optimal 'space' to impose uniform standards. In this vein, the optimal space of uniform standards depends on four variables: (*i*) characteristics of the environment, (*ii*) similarity of preferences and characteristics of individuals, (*iii*) uniformity of activity level across space and (*iv*) uniformity of activity level over time.

From a positive perspective, this framework can explain many features of legal systems. An example is the lower speed limit in proximity of schools, especially at certain times of the day.[306] First, court can discriminate among the different areas and times, as the information on where schools are located and the time of the day at which children enter and leave the school are publicly available. Second, courts can discriminate between the different kinds of victims, as it is easy to isolate the individuals who can only adopt a low level of care (i.e. the children). Nevertheless, discrimination is not perfect because it is not possible to tell if the children in some primary schools are more responsible than the children in another school are. Lastly,

[305] William M Landes and Richard A Posner, *The Economic Structure of Tort Law* (HUP 1987); Daniel L Rubinfeld, 'The Efficiency of Comparative Negligence' (1987) 16 JLS 375; Alfred Endres and Tim Friehe, 'The Reasonable Person Standard: Trading Off Static and Dynamic Efficiency' (2014) 37 EJLE 249.
[306] Cf Fernando Gomez and Juan-Josè Ganuza, 'Caution, Children Crossing: Heterogeneity of Victim Care and the Negligence Rule' (2005) 1 RLE 3.

courts cannot discriminate among injurers, because it is prohibitively costly to assess the skill of each driver.

5. Conclusions

> 'Under strict liability with the defense of contributory negligence both injurers and victims will be lead to take optimal care when they engage in their activities. Furthermore, since victims will take due care, injurers will pay for the accident losses they cause and thus …. will choose the correct level of activity given victims behavior.'[307]

The indeterminacy principle states that under the classic assumptions no inferences can be made about the behavior of the parties. It can only be stated that the party who is not the residual loss bearer will take optimal care, but this is something that was assumed by hypothesis.

As paradoxical as it may sound, the quoted passage and the indeterminacy principle are describing the results of the same model. Although the importance of simplified models should not be underestimated, the qualitative description of their results should be as precise as possible if the law and economics movement wants to be a bridge for scholars with different backgrounds. Even admitting that the equivalence between the indeterminacy principle and the two fundamental theorems has always been taken for granted by mathematical economists,[308] it is probably not as intuitive for legal scholars. At the same time by uncovering the veil and

[307] Cf Shavell, *Strict Liability versus Negligence* (n 49).

[308] This point is very dubious. As stated above, Nussim and Tabbach correctly note how the classic literature generally refers to a two-step procedure to determine parties care and activity levels; if both parties first define the respective care level and only at a second stage the activity levels are derived no identity would exist between the fundamental theorems and the indeterminacy principle. Cf Nussim and Tabbach (n 277).

exposing this identity, it is shown that even the over-simplified world described by the economists is dominated by the indeterminacy principle.

VI. Conclusions

1. Main findings

The goal of this thesis was to show that the role that probabilistic considerations play in the law should be enhanced.

The argument provided for this statement is grounded on a series of hierarchically ordered claims. At the base of this pyramid of arguments lies the idea that natural sciences and philosophy have long abandoned a strictly deterministic (in the Laplacian sense) view of the world. Quantum mechanics and chaos theory have demonstrated that perfect predictability is nothing more than a chimera, thus forcing scientists to acknowledge our limits. The works from Capra perfectly capture the new attitude of natural scientists.[309] Laplace's bold statements have been replaced by a quasi-mystic deference to the mysteries of nature. In this vein, philosophers of sciences have accepted chance as a radical ultimate, or at least as unavoidable at an epistemological level. Similarly, probabilistic theories of causation have started to gain momentum and are generally considered one of the most important innovations in the field of the philosophy of science.[310]

Although some influential legal scholars have recognized the change of perspective of natural scientists, they generally regarded this process as irrelevant to the study of the law.[311] Diametrically opposed to this position, the second claim that I have advanced is that legal scholars cannot remain deaf to the developments of other disciplines. The reason is twofold.

[309] Cf Capra (n 3).
[310] Cf Sosa and Tooley (n 73).
[311] Cf Wright, *Causation, Responsibility, Risk, Probability, Naked Statistics, and Proof: Pruning the Bramble Bush by Clarifying the Concepts* (n 38).

On the one hand, the meaning of the basic concepts of tort law (i.e. causation and harm) is dependent on our postulates on the nature of the world.[312] On the other hand, overlooking the philosophical debate on determinism hides the synergies between the traditional goals of tort law. With regards to the former issue, admitting the inherent limits of scientific knowledge forces us to redefine what should be considered the main asset of a victim. In fact, in a probabilistic world a statement of the kind 'I have been harmed because the injurer has been negligent' is incorrect. The only possible statements are in the following form 'because the injurer has been negligent, I had a greater chance of getting harmed'. In other words, the victim has never had an entitlement to not being harmed. He was entitled only to not being at the receiving end of conducts that increased the probability of being harmed. Similarly, postulating the validity of scientific determinism does not allow recognizing risk exposure as a form of harm.[313] To the contrary, once the existence of intrinsic limits in our capacity to make predictions is acknowledged, compensation for risk creation cannot be denied anymore.

On the other hand, although still possible, in a deterministic world it is harder to accommodate concepts like welfare maximization and corrective justice. Not surprisingly, these two goals have generally been perceived as mutually exclusive. To the contrary, I have suggested that accepting the inherently probabilistic nature of the world allows strengthening the claim that corrective justice and welfare maximization are necessary complements. In fact, once the conception of harm advocated in this thesis is adopted, non-Aristotelian versions of corrective justice are even harder to pursue. As importantly, to defend a pure concept of corrective justice in a probabilistic world, a legal scholar has to accept that the emergence of material harm is totally irrelevant to the law. Not many legal scholars would follow this path, and hence a mixed theory between corrective justice and deterrence seems more attractive.

[312] Cf Perry (n 94).
[313] Ibidem.

Once having established that (*i*) we live in a world that can be interpreted only in probabilistic terms and (*ii*) that legal philosophers and legal scholars cannot ignore this fact, it was possible to move to the third level of the pyramid.

From this perspective, in this thesis I have advocated that whenever the law speaks a different language from the one used in other sciences it creates practical problems that cannot be solved within the traditional framework. The endless debate on causation in toxic cases and medical malpractice is a prominent example. Whenever courts decide to speak a non-probabilistic language and to adopt a dichotomic view of causation, it becomes impossible to correctly interpret the probabilistic evidence produced by scientific studies. In turn, this creates relevant problems in terms of both corrective justice and efficiency. For example, it would be both inefficient and 'unjust' to never hold a doctor that constantly makes the same mistake liable, because it reduces patients' chances of recovering only marginally. Furthermore, I have argued that postulating the existence of the deterministic demon creates problems stretching way beyond the analysis of causation. A deterministic mindset often prevents us from contemplating probabilistic solutions. From this perspective, Credit Rating Agencies are a perfect example. Both the legal and the economic literature have not sufficiently appreciated that ratings are inherently probabilistic and therefore their regulation has to be framed exclusively in probabilistic terms. In chapter IV, I have shown that complex regulation and sophisticated economic studies are not necessary to provide Credit Rating Agencies with correct incentives to issue accurate ratings. More precisely, the introduction of an expiring, capped strict liability rule with a contractual component has been advocated. A damage cap based on the probabilistic predictions offered by CRAs should be introduced to avoid crushing liability. Furthermore, to shield CRAs from systemic risk – in the case of corporate bonds - an expiration date is needed. Lastly, in order to protect CRAs from systemic risk also when defaults are correlated in the short term (i.e. structured finance), the traditional deterministic tort law approach should be

abandoned. By delaying the compensation until after few defaults have occurred, CRAs may be punished only when their predictions are proven to be inaccurate by the law of large numbers.

However, credit rating agencies only provide one example of the possible benefits derived by a deeper understanding of the role that probabilistic considerations should be playing in the law. In the next section, I will hint to another possible area of research.

The tip of the pyramid is represented by the idea that once the demon is defeated there is no way to bring it back to life.

In fact, although at a first glance the law and economics movement seems to be the answer to the indeterminacy of predictions, even the most basic of the models developed by this strand of research is dominated by an indeterminacy principle. As shown in chapter V, the traditional tort law and economics model cannot inform about the actual behavior of injurers and victims. The only possible statement is that the party who is not the residual loss bearer will take optimal care. However, this is an assumption introduced by law and economics scholars and not a conclusion derived from the model.

In conclusion, if all these claims are accepted, then it will be worthwhile investigating the role that probabilistic considerations can play within the law.

2. Future Research

Grounding the law on a more modern conception of the world inevitably raises many questions and opens several avenues for future research both at a theoretical and at a practical level. With regards to the former, having established that a Laplacian version of determinism cannot be adopted, not every kind of determinism can be ruled out *a priori*. There are several kinds of

determinism that 'crop up in physics'.[314] It is therefore interesting to explore how these forms of determinism can inform causal investigation in the law.

Secondly, it has been argued that, in a probabilistic world, risk exposure constitutes a form of harm. It is, however, important to investigate whether this statement can be accepted *tout court*, or some limitations have to be introduced. At a first glance, it seems that besides limiting the number of cases being brought to the court, there is no sound reason to limit the scope of compensation for risk exposure.

Lastly, it is important to analyze whether the relationship between corrective justice and deterrence changes again once the role of more sophisticated forms of determinism is understood (or once the boundaries of compensation for risk exposure are defined). In fact, deterrence and corrective justice can be considered mutually exclusive in a Laplacian world, whereas they become necessary complements in a probabilistic world. It is therefore interesting to investigate their relation under more sophisticated forms of determinism that have not been falsified yet.

Adopting a probabilistic view of the world is far from being a mere philosophical whim. Other strands of research can investigate the practical consequences of such a move. A paradigmatic example was the case of credit rating agencies (CRAs). On the one hand, a pure probabilistic liability regime has been shown to support the production of accurate ratings (as accurate as allowed by the available forecasting technology) and, on the other hand, it has been shown that it could pierce the shield of the First Amendment to the Constitution of the United States (Freedom of Speech). In this vein, it is interesting to investigate if a similar approach can be extended to other areas.

[314] Cf Earman (n 5).

Another area that would be worth exploring is environmental regulation. In fact, although causal uncertainty has been acknowledged by the literature on environmental disasters[315], it has generally been perceived as dichotomist in nature. Either an accident is characterized by causal uncertainty[316] or it is not[317]. On the contrary, the degree of causal uncertainty associated with an environmental disaster increases with the distance from the accident (in time and in space) of its negative effects. More precisely, it seems that for every single accident the degree of causal uncertainty is a continuous function depending on the distance of its effects (both in time and in space). Therefore, a formal model should be developed to understand if under the assumption of continuity of causal uncertainty criminal sanctions, tort law, and regulation are necessary complements. In the proximity of an accident it is relatively easy to identify the causal link between the conduct and the harm. As for this kind of harms it is often possible to meet a high standard of proof, criminal sanctions and liability are an effective mean to induce injurers to internalize these externalities. The more we depart from the accident (both in time and in space), the harder it becomes to identify the causal link beyond any reasonable doubt, which is the typical standard of proof in criminal law. Here the burden of proof required to impose criminal sanctions cannot be met, whereas tort law remains effective. However, departing even further from the accident, even a preponderance of evidence becomes hard to achieve. As preponderance of evidence is required to hold an alleged plaintiff liable, also liability would becoming ineffective. Consequently, *ex post* liability has to be complemented by *ex ante* regulation, as the latter does not require proving any causal relationship with the harm.

[315] Michael G. Faure 'The complementary roles of liability, regulation and insurance in safety management: theory and practice.' (2014) 17 JRR 689.
[316] Eberhard Feess, Gerd Muehlheusser, and Ansgar Wohlschlegel. 'Environmental liability under uncertain causation' (2009) 28 EJLE 133.
[317] Klaas van't Veld and Jason F. Shogren. 'Environmental federalism and environmental liability' (2012) 63 JEEM 105.

This framework could easily be extended to other areas of tort law (i.e. toxic cases and medical malpractice).

To summarize, a theoretical shift from Laplacian determinism to a more modern conception of the universe has been advocated. The consequences of such shift are pervasive and call into question many established dogmas. In this thesis, I have attempted to discuss some of these issues, yet much work remains to be done.

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Table of Cases

Summary

Despite the findings of natural scientists and philosophers, the law of torts is still clinging on a strictly deterministic (in the Laplacian sense) idea of the world. Probabilistic considerations are not alien to the legal world, yet they are generally regarded as *ad hoc* exceptions to handle particularly complex cases. From this perspective, this thesis advocates the need for a theoretical shift. A probabilistic approach to reality should become the norm, whereas determinism should only be considered a heuristic tool when confronted with prima facie deterministic cases.

In Chapter II it is shown that a strictly deterministic concept of causation is inadequate to face the intricacies characterizing modern litigation. In fact, the deterministic version of the 'but for' test necessarily creates frictions with the kind of evidence produced by modern science. The introduction of a purely probabilistic concept of causality is advocated and a distinction is drawn between the ex-ante and the ex-post probabilistic approach to causation. The former seems to be a better approach for lagged torts, whereas the latter is more appropriate to handle instant torts. Also, it is shown that in a probabilistic world the very concept of harm assumes a different meaning.

Building on the new definition of harm introduced in Chapter II, in Chapter III it is suggested that the debate on the goals of tort law should be reconsidered. In a probabilistic world welfare maximization and corrective justice are not mutually exclusive, but must be regarded as necessary complements.

In Chapter IV, it is argued that the problems created by a deterministic mindset stretch way beyond the analysis of causation. In fact, a Laplacian (deterministic) view of the world often prevents us from contemplating probabilistic solutions even when deterministic options have failed. From this perspective, Credit Rating Agencies (CRAs) are a perfect example. Both the legal and the economic literature have advanced solutions to improve CRAs incentives to issue accurate ratings. Yet, in most cases, the proposed solutions did not exploit the probabilistic nature of ratings, thus they were not framed exclusively in probabilistic terms. To the contrary, by designing a simple and legally workable strict liability rule it is possible to tie CRAs profits to the quality of their probabilistic predictions.

In Chapter V, it is investigated whether the law and economics movement can be considered the answer to the indeterminacy of predictions haunting other sciences. Not surprisingly, the answer to this question is no. Even the extremely simplified world of tort law and economics is dominated by an indeterminacy principle.

Samenvatting

Ondanks de bevindingen van natuurwetenschappers en filosofen, houdt het onrechtmatigedaadsrecht nog steeds vast aan een strikt deterministisch (in de Laplaciaanse betekenis) wereldbeeld. Hoewel probabilistische overwegingen de juridische wereld niet vreemd zijn, worden zij over het algemeen beschouwd als ad-hocuitzonderingen om bijzonder complexe zaken te benaderen. Vanuit dit perspectief bepleit dit proefschrift de noodzaak van een verschuiving in de theorie. Een probabilistische benadering van de werkelijkheid zou de norm moeten worden, terwijl determinisme slechts zou moeten worden beschouwd als een heuristisch instrument bij prima facie deterministische casussen.

In hoofdstuk II wordt aangetoond dat een strikt deterministische opvatting van causaliteit niet toereikend is met het oog op de complexiteit die kenmerkend is voor de moderne procesvoering. De deterministische versie van de *condicio sine qua non*-test resulteert onvermijdelijk in fricties met het door de moderne wetenschap gegenereerde bewijsmateriaal. De introductie van een zuiver probabilistische opvatting van causaliteit wordt verdedigd en er wordt onderscheid gemaakt tussen de ex-ante en de ex-post probabilistische benadering van causaliteit. De eerste lijkt een betere benadering te zijn voor situaties waarin de schade niet direct volgt op de onrechtmatige daad ('lagged torts'), terwijl de laatste meer geschikt is voor sitauties waarin dat wel het geval is ('instant torts'). Ook wordt aangetoond dat het begrip 'schade' als zodanig in een probabilistische wereld een andere betekenis aanneemt.

Voortbordurend op de nieuwe definitie van schade die in hoofdstuk II wordt gegeven, wordt in hoofdstuk III gesuggereerd dat het debat over de doelstellingen van het onrechtmatigedaadsrecht moet worden heroverwogen. In een probabilistische wereld sluiten welvaartsmaximalisatie en corrigerende rechtvaardigheid elkaar niet uit, maar moeten zij worden beschouwd als elkaars noodzakelijke complementen.

In hoofdstuk IV wordt gesteld dat de problemen die door een deterministische denkrichting ontstaan, veel verder reiken dan de analyse van causaliteit. In feite worden wij er door een Laplaciaans (deterministisch) wereldbeeld vaak van weerhouden probabilistische oplossingen te overwegen, zelfs wanneer de deterministische opties mislukt zijn. In dit kader zijn Credit Rating Agencies (CRAs) een perfect voorbeeld. Zowel de juridische als de economische literatuur biedt geavanceerde oplossingen ter verbetering van de prikkels voor CRAs om nauwkeurige ratings uit te geven. Maar meestal werd met de voorgestelde oplossingen niet de probabilistische aard van de ratings benut, waardoor zij niet uitsluitend in probabilistische termen werden ingekaderd. Door daarentegen een eenvoudige en juridisch werkbare risicoaansprakelijkheidsregeling te creëren, is het mogelijk de winsten van CRAs te koppelen aan de kwaliteit van hun probabilistische voorspellingen.

In hoofdstuk V wordt onderzocht of de rechtseconomische beweging als het antwoord kan worden gezien op de onbepaaldheid van voorspellingen die andere wetenschappen kwelt. Het is geen verrassing dat het antwoord op deze vraag negatief is. Zelfs de extreem vereenvoudigde wereld van het economische analyse van het onrechtmatigedaadsrecht wordt gedomineerd door het onzekerheidsprincipe.