ON MATHEMATICAL PATTERNS IN THE WEB OF THE LAW INDICATING A QUASI-BIOLOGICAL EVOLUTION

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This research project aims to reveal a specific mathematical pattern in the development of the common law. Its starting point is a prediction inspired by modern complexity theory that in a case law system the frequency of more important and of less important decisions should follow a so-called "power law" distribution (which is closely related to Zipf's Law). This hypothesis is verified by analysing the case law of New Zealand.

For readers from the legal profession not acquainted with this kind of analysis, a brief introduction to Zipf's Law is provided. While the mechanisms behind this phenomenon are the subject of ongoing debate, this study is based on the theoretical model of complex systems known as notion of "self-organised criticality". It is inspired mainly by the work of the biologist Stuart Kauffman and can be regarded as an application of his ideas to the area of law.

To provoke further thought, some related concepts of the evolution of law are discussed. However, the substantive part of this study is the empirical analysis. The overall aim of the study is to shed some light on the question of how the law develops (or is developed).

Cet article s'intéresse aux raisons qui, en marge d'autres théories, pourraient par le truchement d'un raisonnement purement mathématique, expliquer les modalités d'évolution que la Common law.

Cette thèse a comme point de départ, le postulat énoncé par une branche des mathématiques modernes, celle dite de la complexité.

Sur ce fondement, l'auteur soutient que l'occurrence dans la Common law entre les décisions importantes et celles qui le sont moins, reposerait en fait sur une répartition obéissant à la théorie dite de la "power law distribution" laquelle se rapprochant à bien des égards de la loi de Zipf.

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Dans une étape préliminaire, l'article rappelle quels sont les principes qui gouvernent la loi de Zipf. Puis, tout en évitant de prendre part aux polémiques qui au sein de la communauté scientifique, accompagnent encore l'exacte détermination des différents mécanismes qui sous-tendent cette théorie, l'auteur entreprend l'étude de la jurisprudence néo-zélandaise au travers du prisme du modèle théorique des systèmes complexes connus sous le nom de "self-organised criticality". Ce modèle fortement inspiré par les travaux du biologiste Stuart Kauffman conduisent alors à considérer qu'il ne s'agit là que d'une simple transposition de ces théories dans le domaine du droit.

Pour compléter sa réflexion, l'auteur s'intéresse également à d'autres concepts, comme la théorie générale de l'évolution du droit, lesquels sont aussi susceptibles de s'appliquer à la Common law.

Toutefois l'argumentaire principal retenu par l'auteur repose, sur une analyse empirique du sujet. En effet, le but poursuivi est de présenter au lecteur de manière aussi schématique que possible, les principaux fondements de ces différentes théories.

Ce faisant, cet article n'a d'autre ambition que d'apporter dans un domaine qui s'inscrit à la frontière de la philosophie, de la sociologie juridique et enfin de la théorie du droit, quelques éclaircissements nécessaires pour la compréhension des modalités d'évolution de la loi.

> I like them to talk nonsense. Talking nonsense is the sole privilege mankind possesses over the other organisms. It's by talking nonsense that one gets to the truth! … Not one single truth has ever been arrived at without people first having talked a dozen reams of nonsense, even ten dozen reams of it, and that's an honourable thing in its own way; …
>
> Fyodor Dostoyevsky[1]

I INTRODUCTION

The idea for this research came while reading the book *At home in the universe* by Stuart Kauffman.[2] After developing some rather theoretical models of how certain biological systems evolve, Kauffman carried his ideas further, taking on empirical studies and even applying his methods of analysis to subjects beyond biology, for example different socioeconomic entities. Moreover, he succeeded in providing some evidence that many complex systems[3] share common

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1 Law student Razumikhin in Fyodor Dostoyevsky *Crime and Punishment* (Penguin Books, London 1991, Reissued 2003) 241.

2 Oxford University Press, New York, 1995. An earlier book of his is called *The Origins of Order* (Oxford University Press, New York, 1993). All the fundamental ideas are present. He had the same "suspicion" about the law (and many other human creations) that is presented as a hypothesis here. As far as is known it has not been tested yet, and Stuart Kauffman encouraged the author to do so in an email conversation.

3 For an introduction to the theory of complex systems and a definition of the term as used hereinafter, see John L Casti and Anders Karlqvist (eds) *Complexity, Language, and Life: Mathematical Approaches*

attributes and may be governed by the same principles. For example, patterns revealed in the development of new machines and technologies (which development is obviously human-driven) were found to be exactly the same as in the evolutionary dynamics of some "natural" systems (namely organisms and species). If Kauffman is right in this, it seems to make no difference whether a complex system is at its most basic level dependent on human decisions or on something else (for example a creature's chances of survival and procreation). The same patterns of development should occur in either case. Such systems would seem to be somehow "self-organised" rather than anything else.

Although similar statements about the law have been made before by sociologists and philosophers,[4] the issue is still disturbing. It should be so to anyone occupied with legal work. How much power do judges and parliamentarians possess over the law? Can it be true that they base their decisions on strict legal reasoning while at the same time unknowingly fulfilling some kind of higher-ranking plan? Are the decisions actually in some way "demanded" or determined by the legal system itself? Who is in control – the human being or the web of law itself?

The following study may reveal some objective truth about this matter, not just philosophical speculations. Be it lack of imagination, or simply lack of careful reasoning – there has always been some sympathy felt for the doubting Thomas when it comes to accepting unproven claims of social theory.[5] That is the fascinating point about Kauffman's research: he offers something tangible. The common law can be examined for the same signs of order, the same non-coincidental mathematical patterns that he observed in natural systems.

II SYNOPSIS OF THE UNDERLYING THEORY

A Paradigms in Social Evolution: the Ant versus the Ant-Hill

The following illustrations offer some ideas as to conceptions that might or might not be corroborated depending on the outcome of the empirical analysis undertaken later. The concepts

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(Springer-Verlag, Berlin, 1986) XI. For an attempt at applying complexity theory to the law see J B Ruhl "The Fitness of Law: Using Complexity Theory to Describe the Evolution of Law and Society and Its Practical Meaning for Democracy" (1996) 49 Vand L Rev 1407.

4 The examples of Friedrich von Hayek and Niklas Luhmann are discussed below. As far as the application of biological evolution to the law is concerned, this idea seems much older. See for instance Albert G Keller "Law in Evolution" (1919) 28 Yale LJ 769. This field of research has flourished ever since, for a recent contribution and crossover to philosophy see Hutchinson *Evolution and the Common Law* (Cambridge University Press, Cambridge 2005).

5 Keller described similar concerns about some of his contemporaries who rejected Spencer's sophisticated and original concept of social evolution purely for lack of evidence, while at the same time Darwin's challenging yet intellectually unpretentious concept of biological evolution found ever more followers mainly because he had something to show (Keller above n 4, 772).

outlined are all based on an understanding of the law as a social system that is not significantly influenced or even cannot be influenced in its evolution by the creatures it governs.

Following this line of thought, one exponent that comes to mind was Austrian-English economist Friedrich von Hayek. Most of his ideas about society originated from a close scrutiny of the mechanisms of the free market. However he expressly stated his discoveries of evolutionary processes to be equally manifest in the fields of morality and law, and all other systems of rules that characterise society.[6] In fact, he believed that all social institutions, customs and norms had grown in an evolutionary way strikingly similar to Darwin's theory, persisting where they proved useful and fading out where they were not.[7] The most challenging conclusion of his was that society in the course of this evolution had inevitably come to a point of complexity far too great to be grasped by the human mind, a complexity thus exclusively governed by its own principles.[8] To many contemporaries, this seemed an unsavoury way of describing the relationship between the individual and society. It turned the prevalent sociologic paradigm upside down, much like Karl Marx did with the philosophical paradigm of Friedrich Hegel that was widely believed to explain society very well at that time.[9] In Hayek's own words: "[…] how basic are some of the differences which distinguish my present philosophy from that which is predominant in our generation. I rather expect you to revolt against most of what I have said. I only hope that you will very seriously reflect upon it."[10]

Maybe things have changed since Hayek's statement, and indeed his views and related ways of thinking have infiltrated many a legal scholar's mind in the meantime. The now popular economic analysis of law seems closely related, as it is based on the presumption that legal rules emerged in response to economic exigencies arising from the principle of wealth maximisation, and on the further implication that their creators rarely recognise their own rules as serving this purpose. However, what is worth noting is that this approach still attributes some influence to individual human decision-making – some power to change or improve the whole system. Otherwise economic analysis would be a waste of resources measured by its own standards. Yet it cannot be said with certainty that this would not have been consistent with Hayek's views, as he himself constantly suggested ways of improving society, or avoiding improper forms to organise it.

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6 Friedrich von Hayek *Knowledge, Evolution and Society* (Butler & Tanner, London 1983) 56.

7 Eamonn Butler "Foreword" in Hayek above n 6, 7.

8 Hayek above n 6, 56: "[I]t was not man's intelligence which created society, but cultural evolution which created man's intelligence. Our brain does not manufacture intelligence; our brain is merely an apparatus for absorbing and learning a traditional way of thinking, a tradition both of interpretations of the world, and of rules of conduct which we have learned to follow."

9 Marx changed from dialectical idealism to dialectical materialism by swapping the roles of *Bewußtsein* (consciousness) and *Sein* (matter). The similarity to Hayek is astounding: in both cases, social reality was subdued by the intellect.

10 Hayek above n 6, 56.

More radical scholars have come to deny even such possibilities. Under the label "theory of social systems" sociologists, led by Niklas Luhmann, depicted a society completely detached from (though, of course, dependent on the existence of) human beings.[11] Their message is: If you want to create a suitable model of a social system – say the law, forget about the people. All they might do is to irritate the system in its operations, without being able to foresee the consequences. Indeed one claim cannot be easily dismissed: the "system" of society that was born many thousands of years ago was hardly wilfully established – it arose spontaneously out of the chaotic thronging actions[12] of individuals. Adepts of the theory of social systems argue that the same independence characterises its development ever since. It is the system itself that responds and adapts to the individuals' behaviour (experiencing it as a mere disturbance), thus procreating itself in an organic, self-controlled way. This way is basically explained by Darwin's concept of variation/selection/stabilization (of the system's elements, ie communications)[13], though slightly amplified and generalised.[14] Special emphasis is given to the proclamation of a clear, impenetrable line that separates a social system from its environment, and our place – according to this view – is decidedly in the latter (ie, outside of society). The process of self-procreation, of re-combining elements of the system, for example of elements of the law to create new law, has become known as "autopoiesis".[15] Interestingly enough, this was another borrowing from biology.[16]

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11 For an introduction to Luhmann's theory see Klaus A Ziegert "The Thick Description of Law" in Reza Banakar and Max Travers (eds) *An Introduction to Law and Social Theory* (Hart Publishing, Oxford, 2002) 55.

12 The notion of "actions" is used only to give a more intuitive, comprehensible illustration. It is rather imprecise in this context. In fact, in the 20th century many sociologists (including Luhmann) turned away from regarding "actions" as being the basic element of society, and claimed "communications" to be its true fabric. Thus, society came into being by evolution working on communications, rather than on actions.

13 According to this theory, a social system consists of communications using a specific binary code. The system of law, for example, would be the system of all statements that describe something as "lawful" or as "unlawful".

14 Niklas Luhmann *Law as a Social System* (Oxford University Press, Oxford, 2004) 230. Focussing on communications as a "basic element" of society is an elegant way to provide a basis for Darwin-like evolution. However, if this bold reductionist premise is rejected in favour of a more "common sense" view on society, it is far more difficult to find suitable analogies to biological evolution. For a discussion of the problems arising see C R Hallpike *The Principles of Social Evolution* (Clarendon Press, Oxford, 1986) 33.

15 See Arthur J Jacobson "Autopoietic Law: The New Science of Niklas Luhmann" (1989) 87 Mich L Rev 1647.

16 The term was coined by Humberto Maturana to explain some of his findings in experiments with the nervous system of doves. Showing boards of different colour to these birds, he expected to find new signals running through their visual nerves whenever a new colour was presented. This did not happen. He concluded the nervous system to be "closed", unable to incorporate new impulses from outside, but instead to simply produce reactions "of its own", and in this way reaffirming the difference between itself (the old signals and the new ones derived from these) and its environment (everything else). Later he named this process of self-creation by self-reference "autopoiesis". For an early description of the concept see

Legal scholars rarely go as far as this, but the idea of a quasi-biological evolution of law has found considerable support over the last century, which is not confined to experts of law and economics.[17] Looking back even further, statements by some of the greatest legal scholars of the 19th century (like Friedrich Carl von Savigny[18] and Oliver Wendell Holmes[19]) indicate that they already – intuitively – conceived the law as having a life of its own and following its own constraints in the struggle to develop the best rules.[20] While speculations about an evolutionary nature of the law therefore have a long tradition, empirical evidence is still missing.[21] Yet, taking account of modern complexity theory, there is a certain starting point for empirical studies of the evolution of law that suggests itself and is explored here.

Francisco J Varela, Humberto R Maturana and R Uribe, "Autopoiesis: The organization of living systems, its characterization and a model" (1974) 5 Biosystems 187.

17 See for example Donald Elliott "The Evolutionary Tradition in Jurisprudence" (1985) 85 Col L Rev 38; G Priest "The Common Law Process and the Selection of Efficient Rules" (1977) 6 J Leg Stud 65; P Rubin "Why is the Common Law Efficient?" (1977) 6 J Leg Stud 51; J Goodman "An Economic Theory of the Evolution of the Common Law" 7 J Led Stud 393; William Landes and Richard Posner "Adjudication as a Private Good" (1979) 18 J Leg Stud 235; R Nelson and S Winter *An Evolutionary Theory of Economic Change* (Harvard University Press, Cambridge, 1982); G v Wangenheim "The Evolution of Judge-Made Law" (1993) 23 Int Rev L & Econ 183; D Whitman "Evolution of the Common Law and the Emergence of Compromise" (2000) 29 J Leg Stud 2753; Kenton K Yee "Common Law Efficiency under Haphazard Adjudication" (2005) <http://ssrn.com/>.

18 Friedrich Carl von Savigny *Vom Beruf unser Zeit für Gesetzgebung und Rechtswissenschaft* (1814) 13: "All law … is first developed by custom and conventional morality, next by jurisprudence, – everywhere, therefore, by internal silently-operating powers, not by the arbitrary will of a law-giver". These lines were not written in a civil law context in the sense of codified law. On the contrary, in the quoted work Savigny defended the non-codification of the law. However, it is suggested here that the proposed evolutionary structure of the law does not only apply to the web of the common law, but equally to the network of judgments in civil law countries, although the proof of this statement must be left to further studies.

19 Oliver Wendell Homes *The Common Law* (1881) 1: "The life of the law has not been logic: it has been experience. The felt necessities of the time … have had a good deal more to do than the syllogism in determining the rules by which men should be governed." In evolutionary terms, the "felt necessities" represent the struggle of more or less "fit" rules for survival as opposed to a development of the law according to the preferences of the judges.

20 The work of Sir Henry Maine must also be mentioned as an early description of the evolution of law. However, as Elliott observes (above n 17, at 45): "[…] Maine had not assimilated the Darwinian concept of evolutionary change as variation as in the distribution of characteristics within populations. Maine still thought in terms of the iron laws of the machine, or the inflexible stages of development in embryology, which were the model for Herbert Spencer's theory of evolution, not Darwin's."

21 See Yee, above n 17, 22, also claims that the common law has not yet been examined for Zipf's Law. He speculates that the data given in Montgomery N Kosma "Measuring the Influence of Supreme Court Justices" (1998) 27 J Legal Stud 333 might show a Zipf distribution, but states that it is impossible to be sure without analysing the raw data.

B A Hint from Maths: the Omnipresence of Zipf's Law in the World

The key to this project lies in a startling discovery made by the linguist George Zipf in the first half of the twentieth century.[22] Studying the structure of the English language, he found that, in a corpus of natural language utterances, the frequency of the n-th most frequent word is roughly proportional to 1/n. Thus, the most frequent word occurs about twice as often as the second most frequent word, and about three times as often as the third most frequent word, and so on. The statement has since been verified in many studies,[23] and it is astounding how close the actual frequencies of words come to those predicted by what has become known as "Zipf's law". Even more surprising is the fact that, in a more generalised form,[24] the same distribution was found in many other manifestations of collective human behaviour, like city sizes, wealth distribution etc.[25] As will be shown later, Zipfian distributions are also present in data derived from the common law.

The interpretation of this mysterious discovery is not an easy task, but it is widely believed that it is deeply connected to the way the observed systems evolve. To explain why, it must first be noted that observing Zipf's law is indeed unexpected. While the general fact that there are, for example, some huge cities, then many smaller ones, then countless villages etc. does not come as a surprise, the fact that the distribution of city sizes according to their frequency in real life follows Zipf's law so closely is puzzling. The same applies to word frequencies, and so on. Given the absence of an almighty intelligence that controls the development of these phenomena, the question arises where this order comes from. It is tempting to assume that some higher-level laws of complexity are at work, (at least partly) superseding the individual low-level decisions of the individuals involved. Yet, the issue is still highly controversial.

A trivial explanation that suggests itself would be that a Zipfian distribution is simply characteristic for a certain class of randomly created complex systems, and its existence in real life therefore not telling at all. Not long ago, it has been proposed that even randomly created texts show a Zipfian distribution of word sizes (in this context, word size means the relative frequency of a word).[26] If this was true, it would render the work of many researchers in the field of complex

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22 George K Zipf *Human Behaviour and the Principle of Least Effort* (Addison Wesley, Cambridge, 1949).

23 See Henry Kucera, Nelson Francis *Computational Analysis of Present-Day American English* (Brown University Press, Providence, 1967), known today as the *Brown Corpus*.

24 The generalised form is $y \sim r^{-b}$ where y is the frequency of the word and r its rank in the frequency table. In natural language, b is close to unity, which leads to the simple form of Zipf's law with $y \sim 1/r$.

25 Like the popularity of given names, word frequencies, city sizes, or incomes. Data collected through internet servers also shows that the phenomenon occurs in several aspects of that network: number of visits to a page, number of pages within a site, number of links to a page. See Lada A Adamic, "Zipf, Power-laws, and Pareto – a ranking tutorial" <http://www.hpl.hp.com/research/idl/papers/ranking/ranking.html>.

26 Wentian Li "Random Texts Exhibit Zipf's-Law-Like Word Frequency Distributions" (1992) IEEE Transactions on Information Theory 38, 1842.

systems in the last decades pointless. This position, conceiving Zipf's Law as a trivial statistical regularity with no need for explanation, has indeed gained some support in recent years.[27] However, a more recent study maintains that the previous findings about random texts where flawed and that Zipf's Law is still to be seen as a unique feature of natural language related to its origin and evolution.[28]

Nevertheless, the reader should not be misled by claims that the enthusiasm fuelling the innumerous research projects in Zipf's tradition, like the present one dealing with the common law, is necessarily justified. The true implications of the observed Zipfian distributions is subject of an ongoing debate, and only time will show the outcome. Due to the limited scope of this paper, the interested reader is referred to the literature for further criticism.[29] This paper will briefly present the current predominating view of complex systems that display Zipf-Law-like distributions, which is based on the theoretical model of networks described by the notion of "self-organised criticality". It is submitted that this model applies to the common law, and that the presence of Zipf distributions in the common law therefore is meaningful. It indicates that the speculations about a "self-organised" evolution of the law expressed by all of the above-mentioned scholars are meritorious.

C "Self-organised Criticality" in Biology and Physics

Assuming that Zipf distributions are not "trivial statistical regularities", the only conclusion that remains is that the existence of this pattern in apparently rather different systems indicates structural analogies. It has been suggested that these common structural features in human-made phenomena might be reflections of a similar structure of the human brain – ie, we would have a certain way of organising our own matters because of certain inner restrictions of the mind. However, Zipf's Law has also been found in many natural (biological and physical) systems.[30] The origin of this order must therefore be different. Scientists like Stuart Kauffman believe that the common structural features are in turn the result of a principally similar evolution. If this is true, and the same principles are at work in the development of both physical/biological processes as well as in manifestations of collective human behaviour, then society too obeys nothing other than "laws of nature". Human will would at best have limited possibilities – in fact it would be quite out of the game.

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27 MA Nowak, JB Plotkin and VA Jansen "The evolution of syntactic communication" (2000) Nature 404, 495-498.

28 Ramon Ferrer i Cancho and Richard V Solé "Zipf's Law and Random Texts" (2002) Advances in Complex Systems 5, 1.

29 See especially the sceptical article of Evelyn Fox Keller "Revisiting 'scale-free' networks" (2005) BioEssays 27, 1060.

30 The biological phenomena include the extinction of species (see Kauffman *The Origins of Order* above n 2, 276, for a plot from a simulated environment). In physics, phase transitions have been at the focus of study. A more colourful example is the distribution of earthquake magnitudes, which is also Zipfian.

The studies on Zipf's Law in biology and physics have focused on network-like complex systems.[31] For such systems, a common evolutionary model has been proposed, based upon the idea of "self-organised criticality". These systems are especially characterised by a power-law distribution of changes in the network, which is in fact the same thing as Zipf's Law, but seen from a different angle:[32]

(1) Smaller events (effecting a small change in the network) occur much more often than big ones.

(2) The distribution of events is not contingent, it follows a so-called "power-law". This means the probability that an event is of a certain size **x** is just an inverse power of **x**:

$$\mathbf{P[X=x] \sim x^{-k}}$$

An easy test for this is to plot the frequency of events against their size using logarithmic scales, which should result in a straight line running from the upper left to the lower right corner.

D An Illustration of Self-organised Criticality: Bak's Sand Pile

One of the pioneers of self-organised systems, the late physicist Per Bak, used to illustrate his view of complex systems with the famous sand pile example. He asked to consider sand being continuously dropped on a tabletop. The sand has already piled up to the maximum extent – as much new sand as is dropped, that much slides down the edges of the table. Now if just one grain of sand is dropped at a time at a random location, what will happen? It turns out that, while the effect of every single dropping of grain in itself seems totally unpredictable, repeating the experiment reveals a pattern. Mostly the grain just falls down and stays, while it sometimes effects a small landslide, causing sand to slide over the edges, and very rarely the dropping of one grain of sand will trigger a big avalanche. As might have been guessed, the distribution has been shown to be of a power law nature. As Kauffman points out, such a system is in a "poised state", where it is "able to propagate perturbations – avalanches – on all possible length or size scales".[33] Bak would go on to describe what he called "self-organized criticality" – a mechanism by which an ordered system arises out of the chaotic individual movements of small particles, and Kauffman adds the idea that such a system can develop best when it is precisely at a state of delicate equilibrium between order and chaos, which is why those systems prefer such states.

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31 Sometimes the elements of these systems are themselves complex systems, for example if social systems are conceived as higher-level hierarchies made up of lower-level biological systems (in contrast to Luhmann's view explained above). This leads to interesting complications in the interaction between the evolutionary mechanisms on the different levels. See C Dyke *The Evolutionary Dynamics of Complex Systems* (Oxford University Press, Oxford, 1988) 50.

32 For an introduction to the mathematics of power-law and related distributions see Lada A Adamic above n 25.

33 Kauffman *The Origins of Order,* above n 2, 255.

E An Organic Conception of the Common Law

1 The hypothesis: judgments triggering avalanches in the common law

Whatever view is taken of this illustration of "self-organised criticality", the possible analogy to the common law should be obvious. Every new judgment adds to the common law like a grain of sand to the sand pile. The change of the law can be very small, as most of the judgments receive only few references. From time to time a judgment will trigger a big avalanche, dramatically changing the scope of the law in a certain area and being quoted as stating the new principle in many consecutive decisions.

2 References as measure for a judgment's influence

To search for a power law in the network of the common law, the judgments have to be assigned a rank. It seems natural to measure the importance of a judgment by the number of references it receives, and that offers precise numerical data that can easily be statistically analysed. It is a standard way of measuring the influence of opinions, proposed and applied by Landes and Posner three decades ago,[34] and well developed since. Effects that might influence or distort the data gained by using this method have been discussed at length in the literature,[35] they are unlikely to pose a significant problem for this analysis.

While the number of citations is an established approximation for the influence of a judgment, there is a much deeper point that makes it the appropriate measure here. The references themselves can be seen as the links between the elements of the common law network. Following the logic of the network model, the number of references therefore even loses the character of an approximation, and becomes the exact measure for the impact of a judgment on later judgments.[36]

If the hypothesis is true and the law evolves according to the same principles as the aforementioned systems, it can therefore be assumed that the probability of a judgment receiving a certain number of references should be a fixed inverse power of this number. This is what this paper aims to show.

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34 William Landes and Richard Posner "Legal Precedent: A Theoretical and Empirical Analysis" (1976) 19 J Law & Econ 249.

35 See Montgomery N Kosma "Measuring the Influence of Supreme Court Justices" (1998) 27 J Legal Stud 333, 338.

36 Arguably, judges will also take into account some judgments without making an explicit reference. The network therefore also contains invisible links. However, it seems reasonable to assume that their distributions follows the same law as that of the visible links (explicit references). Therefore, the network model does not have to be extended to include those thoughts of judges that go unexpressed, as it most likely would not affect the results.

III ANALYSIS OF THE COMMON LAW

A Concept of the Analysis

To search the Common Law for power law distributions requires:

(1) A sufficiently homogeneous set of judgments.[37]

For this purpose New Zealand Court of Appeal judgments of the period 1960-75 are analysed.

(2) A list of references to each of the judgments.

The lists provided by the "Lexis Nexis NZ CaseBase" database are relied upon.

(3) A mathematical analysis of the collected data.

This simply means plotting the number of references against the number of judgments on a log-log-scale chart, and comparing the result to a power law distribution (which would have the form of a straight line). As said above, this approach is equivalent to searching for Zipf's Law, but is a more appropriate method for the given data.

B Findings

The data collected from "LexisNexis NZ CaseBase" is given in Table 1. The majority of judgments received no references at all (30 per cent or 189 of a total 646) or were only mentioned once in follow-up jurisdictions (21 per cent or 137). This reciprocal relation between importance and frequency generally holds true throughout the other half of the judgments, up to two decisions account for more than 25 references (*Inland Revenue, Commissioner of v Walker* [1963] NZLR 290 and *McLaren Maycroft & Co v Fletcher Development Co Ltd* [1973] 2 NZLR 100).

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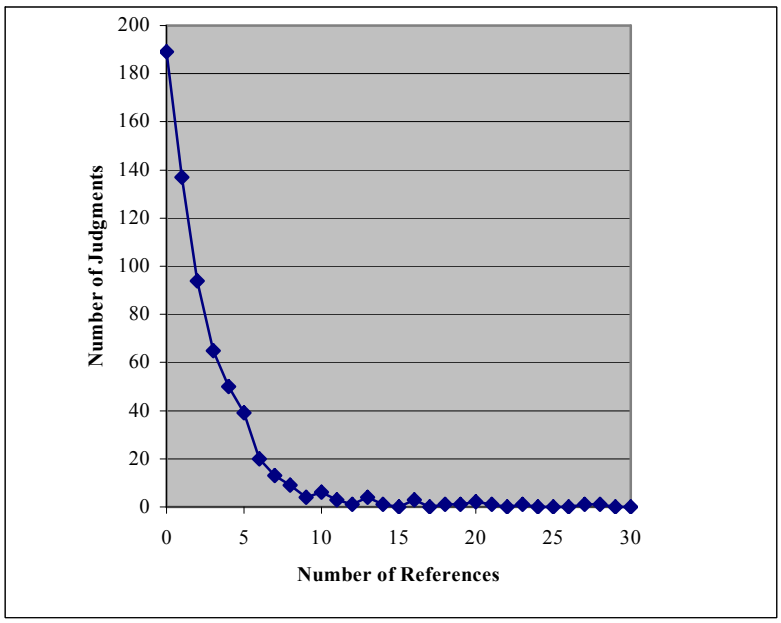
37 Of course the set can never be perfectly homogeneous. It would for example, be possible to differentiate between different fields of law, thus concentrating on a certain homogeneous subsection of the common law network. However, for the limited purpose of this study this is not necessary. As the results show, any remaining distorting effects seem to be either insignificant or self-neutralising.

Table 1

Number of References	Number of Judgments				
0	189	10	6	22	0
1	137	11	3	23	1
2	94	12	1	24	0
3	65	13	4	25	0
4	50	14	1	26	0
5	39	15	0	27	1
6	20	16	3	28	1
7	13	17	0	29	0
8	9	18	1	30	0
9	4	19	1	>30	0
		20	2		
		21	1		
				Total	**646**

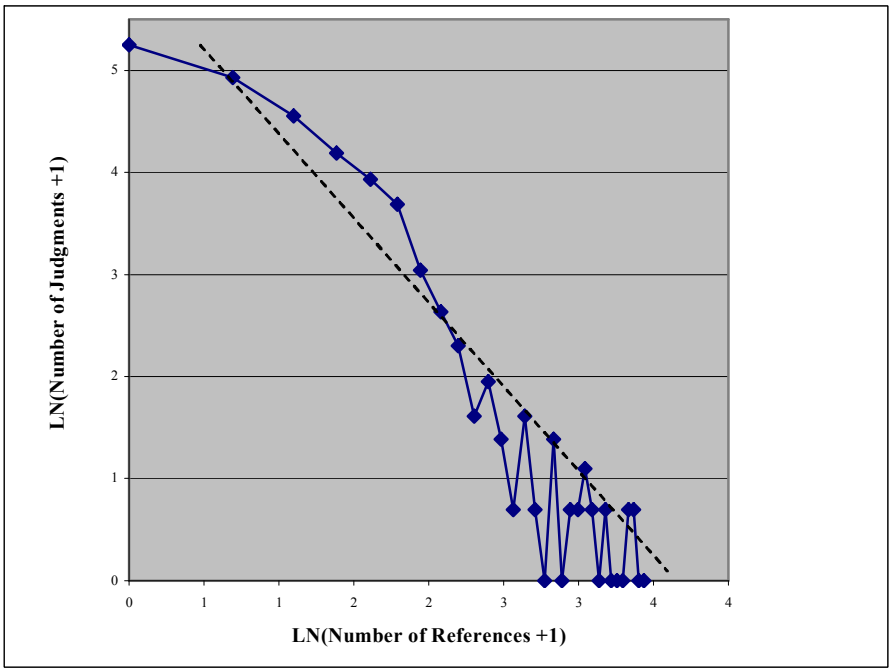
Plotting the contents of this table using an ordinary linear scale gives the following:

Table 2



The curve in Table 2 only gives a faint idea of an underlying mathematical law. Luckily – and as suspected in the outline of this study – the use of logarithmical scales produces a more illuminating chart.

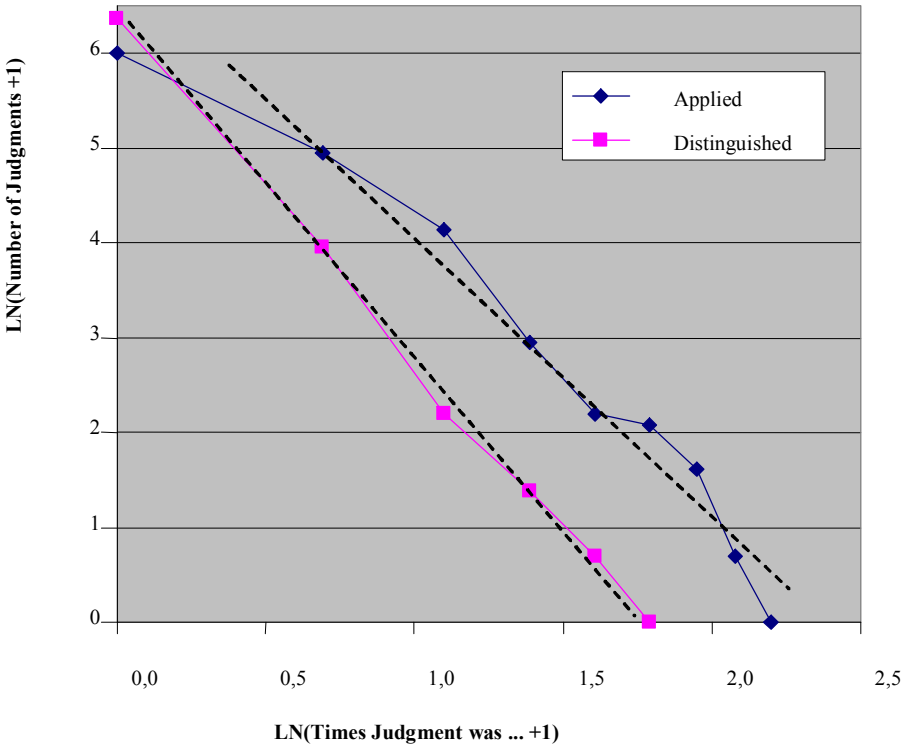
Table 3



The dashed line has been added and marks a "perfect" power-law distribution.[38] If the data is split up, taking into account different types of references (for example only explicit appliances of the ratio decidendi), some of the resulting charts are even closer to this "perfection".

38 Compare these to the strikingly similar power law charts in Kauffman *The Origins of Order* above n 2, 265, and to those on page 267 which he finds not to show a power law (as said on page 264). The zigzag effect on the right occurs due to the limited number of samples and the randomness that accordingly increases with their importance.

Table 4



These references are different from mere discussions of earlier cases. By being applied or distinguished, a case has a definite influence on a later case – the weaving of the web goes on. It is therefore of particular interest that, while the curve giving the overall distribution of references (see Table 3) is slightly convex, these references can safely be said to follow a power-law distribution.[39]

39 The fact that the overall distribution might only be almost following a power-law does not preclude the conclusion that it clearly follows a certain mathematical distribution. Moreover, it is generally understood that most of the discussed natural distributions are of this type but, simplifying, are said to follow a power law. For mathematical models that promise greater accuracy see Jean Laherrere and D Sornette, "Stretched exponential distributions in Nature and Economy: 'Fat tails' with characteristic scales" (1998) B2 European Physical Journals 525, and Lada A Adamic, above n 25, providing further references.

IV CONCLUSION

The hypothesis was that the Common Law is yet another evolutionary phenomenon showing a power-law distribution. At least the mathematical part of this statement has been proven.

Although this is not proof that the Common Law is a "self-organising" system, the philosophical implications can hardly be overestimated. Further deliberation is left to the reader. For those who are used to the everyday understanding of the law as a human creation. it seems worthwhile to reconsider less "philanthropic" and more organic theories like that of von Hayek or Luhmann.