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Evolutionary law and economics: theory and method

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ABSTRACT

The standard model of evolution in the economics of law, its important insights notwithstanding, lacks a good account of inheritance to go with analogues to variation and selection. The normative implication of the standard model, which is that self-organising and spontaneous orders will tend to efficiency, is also misplaced. Just as the association of evolution with progress, characteristic of the theory of legal evolution of a century ago, is now understood to be anachronistic, so it is time to discard outmoded notions linking judge-made law and common law legal reasoning with evolution to efficiency. Setting aside the unwarranted normative connotations of evolutionary models would release them to shape empirical research. Evolutionary theory informs methods, including leximetrics, time-series econometrics and machine learning, with the potential to throw light on the structural dynamics of legal change, and to resolve questions of law's coevolution with the economy which were raised but not resolved by the legal origins debate.

Keywords: evolutionary law and economics; legal evolution; game theory; systems theory; leximetrics; time series econometrics; machine learning; natural language processing.

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INTRODUCTION

The association of evolution with progress, which animated early attempts to apply Darwinian thinking to law, is no longer seen as tenable.[1] Its association with self-organisation[2] and spontaneous order,[3] on the other hand, continues to be influential. In contemporary law and economics, evolution is invoked to explain the pre-legal origins of social order.[4] It is a short step from there to the claim that the kinds of regulatory laws which are produced by the modern nation state are likely to be inefficient and distortionary.[5] A modified account would accept a role for law in ensuring societal coordination and cooperation, but distinguish between varieties of legal system according to their evolutionary content: hence judge-made law is to be preferred, on efficiency grounds, to statute;[6] private law is to be preferred to public law;[7] and, in the sense of legal origin, common law is to be preferred to civil law.[8] If it is hard to separate evolutionary theories of law from normative arguments about the content of legal rules, the field of legal evolution is perhaps little different in this respect from legal theory more generally, in which normative argument tends to be foregrounded. Finding an agreed basis for the study of law as a societal phenomenon remains an elusive project. Yet without such a grounding, the social scientific understanding of law cannot be expected to progress.

If, despite these difficulties, the idea of legal evolution is currently undergoing one of its periodic revivals, that is for good reason. It is not just in the physical and biological sciences but also in the social ones that evolutionary paradigms have been shown to have wide explanatory power. There has been an evolutionary turn in economics,

1 Peter Stein, *Legal Evolution: The Story of an Idea* (Cambridge University Press 1980) 124. Darwin himself seems to have thought that evolution was not purely progressive, writing: 'we are apt to look at progress as the normal rule in human society; but history refutes this': Charles Darwin, *The Descent of Man* vol I (Murray 1871) 166-167.

2 Niklas Luhmann, *Law as a Social System,* Klaus Ziegert (trans), Fatima Kastner, Richard Nobles, David Schiff and Rosamund Ziegert (eds) (Oxford University Press 2004).

3 F A Hayek, Law, *Legislation and Liberty: A New Statement of the Liberal Principles of Justice and Political Economy* (Routledge 1982).

4 Robert Ellickson, *Order without Law: How Neighbours Settle Disputes* (Harvard University Press 1994).

5 F A Hayek, The *Road to Serfdom* (Routledge & Kegan Paul 1945) and *The Constitution of Liberty* (University of Chicago Press 1959).

6 Paul Rubin, 'Why is the common law efficient?' (1977) 6 Journal of Legal Studies 51; George Priest, 'The common law process and the selection of efficient rules' (1977) 6 Journal of Legal Studies 65.

7 Hayek, *Law, Legislation and Liberty* (n 3 above).

8 Edward Glaeser and Andrei Shleifer, 'Legal origins' (2002) 117 Quarterly Journal of Economics 1193.

with evolutionary and epistemic approaches to game theory moving the field on from its mid-twentieth-century origins,[9] and a revival of interest in the role of institutions, including those of the legal system, in shaping long-run capitalist dynamics.[10] Meanwhile there is growing focus on the application to economic phenomena of theories of chaos and complexity, with their implications of self-reference and adaptation in the operation of markets and firms,[11] and a resurgence of interest in the discipline of cybernetics, which has assumed fresh relevance with the digitisation of social and economic life in all its various forms.[12] For these numerous reasons, it is timely to consider whether evolutionary concepts can help generate a descriptive or positive theory of law, of the kind which can aid understanding of its relationship to the economy.

This paper is intended as a step in that process. Section two below considers the standing and relevance of the mechanism, which for the sake of convenience can be referred to as the variation-selection-retention or 'VSR' algorithm, which lies at the core of the modern evolutionary synthesis in biology and is at the starting point of the extension of that synthesis to the social sciences.[13] The section will argue that, in order to make use of the VSR algorithm beyond biology, thought should be given to whether it represents a metaphor only, no matter how useful, for certain social and legal processes, or whether it can be regarded as having the somewhat different ontological status of being a constituent part of social, and legal, reality; a case will be made for the second of these two positions. The third section considers the implications of modelling based on the VSR algorithm for the empirical study of laws and legal systems in their economic context. Three sets of methods are considered: quantitative content analysis of legal texts ('leximetrics'); time series econometrics addressing the issue of causal inference; and the conjunction of machine learning with natural language processing which is opening up new possibilities for the analysis of legal texts. The final section concludes.

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9 Masahiko Aoki, *Toward a Comparative Institutional Analysis* (MIT Press 2001) and *Corporations in Evolving Diversity* (Oxford University Press 2011); Herbert Gintis, *The Bounds of Reason: Game Theory and the Unification of the Behavioural Sciences* (Princeton University Press 2009).

10 Geoffrey M Hodgson, *Conceptualising Capitalism: Institutions, Evolution, Future* (Chicago University Press 2015); Simon Deakin, David Gindis, Geoffrey M. Hodgson, Keinan Huang and Katharina Pistor, 'Legal institutionalism: capitalism and the constitutive role of law' (2017) 45 Journal of Comparative Economics 188.

11 Benoît Mandelbrot and Richard Hudson, *The (Mis)behaviour of Markets: A Fractal View of Risk, Ruin and Reward* (Profile Books 2008).

12 Thomas Rid, *Rise of the Machines: A Cybernetic History* (Norton 2008).

13 On the definition of the VSR mechanism or algorithm and its use beyond biology, see Donald Campbell, 'Variation and selective retention in socio-cultural evolution' in Herbert Barringer, George Blanksten and Raymond Mack (eds), *Social Change in Developing Areas: A Reinterpretation of Evolutionary Theory* (Schenkman 1965).

EVOLUTION IN LAW: FROM METAPHOR TO REALITY

In his article surveying the field of evolutionary law and economics, Georg Van Wangenheim identifies two uses of the term 'evolution'.[14] The first is associated with what he terms, following Daniel Dennett, 'Universal Darwinism'.[15] This, he suggests, is 'grounded on drawing analogies to Darwinian biological evolution and its three core elements – variation, replication and selection'.[16] The body of literature he is referring to 'adapt[s] the models established in biology to problems in the economy or ... in the legal sphere', with

> some adherents of this strand of evolutionary economics [restricting] arguments admissible in evolutionary economics to models based on the variation, replication, and selection of 'memes', which in analogy to genes in biology carry the relevant information determining the fitness of their carriers, phenotypes in biology, which replicate and are selected.[17]

The other use of evolution in law and economics refers, he suggests, to contributions which are 'less exclusive in their definition of evolution', only requiring for a theory to be evolutionary 'that it tackles the emergence of some kind of novelty and its dissemination within some environment'.[18]

According to Van Wangenheim, the VSR algorithm 'is a powerful tool to develop new ideas on, and explanations of, social and economic

14 Georg Van Wangenheim, 'Evolutionary law and economics' in Francesco Parisi (ed), *The Oxford Handbook of Law and Economics Vol 1: Methodology and Concepts* (Oxford University Press 2017).

15 Daniel Dennett, *Darwin's Dangerous Idea: Evolution and the Meanings of Life* (Penguin 1995). The term 'generalised Darwinism' has also been used in this context: Geoffrey M Hodgson and Thorbjørn Knudsen, *Darwin's Conjecture: The Search for General Principles of Social and Economic Evolution* (University of Chicago Press 2010). Since generalised Darwinism is an important idea in the context of economics (Geoffrey M Hodgson, *Evolutionary Economics: Its Nature and Future* (Cambridge University Press 2009)), management studies (Howard E Aldrich, Geoffrey M Hodgson, David L Hull, Thorbjørn Knudsen, Joel Mokyr and Viktor J Vanberg, 'In defence of generalized Darwinism' (2008) 18 Journal of Evolutionary Economics 577; Dermot Breslin, 'Reviewing a generalized Darwinist approach to studying socio-economic change' (2011) 13 International Journal of Management Reviews 218), information theory (Eric D Beinhocker, 'Evolution as computation: integrating self-organization with generalized Darwinism' (2011) 7 Journal of Institutional Economics 393) and the theory of social ontology (Jan Willem Stoelhorst, 'The explanatory logic and ontological commitments of generalized Darwinism' (2008) 15 Journal of Economic Methodology 343), its neglect by law and economics scholars, as noted by Van Wangenheim (n 14 above), is all the more striking.

16 Van Wangenheim (n 14 above). What Van Wangenheim refers to as 'replication' can also be termed 'retention' or 'inheritance': see below, this section.

17 Ibid 162.

18 Ibid.

change, due to its very restrictiveness'; in other words, by virtue of its 'narrow frame', it 'forces the researcher to very clearly define: what varies, where variation comes from, how replication takes place, and which forces drive selection'.[19] However, Van Wangenheim's survey, published in 2017, found that 'within the literature sorting itself into [evolutionary law and economics], explicit Universal Darwinism only plays a minor role';[20] indeed, he cites only two papers, out of the more than one hundred in his survey, making use of it.

We may conclude from Van Wangenheim's article that the bulk of research in evolutionary law and economics actually makes little use of evolutionary concepts, preferring instead to see evolution as a synonym for 'change'. This is arguably a missed opportunity.[21] The issue is not whether evolutionary modelling and analysis can *only* proceed through the lens of the VSR algorithm; it is whether the full potential of the model for law and economics research is being realised.

Richard Dawkins has described evolution as the 'nonrandom survival of randomly varying coded information'.[22] This taut definition contains a number of elements. Variation or mutation in the most basic unit of evolution – in biology, the gene – is assumed by the definition to arise randomly, through copying 'errors'.[23] Whether or not mutation is entirely the result of error, it can be thought of as essentially stochastic.[24] The persistence or survival of particular genes, on the other hand, is neither random nor stochastic. Under conditions of scarcity, they are selected by reference to their fitness properties, or, more precisely, their implications for the fitness of their 'carriers' (plants or animals) in a given environment.[25] This process is 'blind'

19 Ibid.

20 Ibid.

21 It may also be an error, since change is only one aspect of evolutionary models; cf Richard Dawkins, *The Selfish Gene* 30th anniversary edn (Oxford University Press 2005) 12, referring to Darwinian selection as 'the survival of the stable'. It should be noted that, while Darwin was aware of the need for a mechanism of inheritance to complete his theory, he knew nothing of the concept of the gene, which came later; thus what is today thought of as the 'Darwinian' understanding of evolution is not exactly the same as Darwin's own.

22 Richard Dawkins, 'Man or God?' (*Wall Street Journal* 12 September 2001), written as part of a dialogue with the religious writer Karen Armstrong. Dawkins' theory of evolution is set out at greater length in *The Selfish Gene* (n 21 above), in particular chs 2–3.

23 Dawkins (n 21 above) 31–32.

24 G S Mani and B C Clarke, 'Mutational order: a major stochastic process in evolution' (1990) 240 Proceedings of the Royal Society B (Biological Science) 1297; R A Blythe and A J McKane, 'Stochastic models of evolution in genetics, ecology and linguistics' (2007) Journal of Statistical Mechanics: Theory and Experiment P07018.

25 Dawkins (n 21 above) 36.

rather than 'random';[26] it is structured, without being predetermined; but there is no teleology, and no convergence on an optimal end state.[27] The process is constrained in its outcomes, both externally and internally: by environmental conditions, including the degree of scarcity and the resulting degree of selective pressure, on the one hand;[28] and by the capacity of the gene to code the information needed to build the carrier (or more precisely, needed to instruct the proteins which build the plant or animal in question), on the other.[29]

Other elements of Dawkins' definition are notable. It is significant that he places such a high degree of emphasis on 'coded information' as the content of evolutionary units.[30] Evolution, in this view, requires the coding of information about the world into a form which permits its retention or inheritance over time.[31] This feature of evolution is underplayed in the law and economics literature, in favour of a focus on variation and selection. The Rubin–Priest model of legal 'evolution to

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26 Richard Dawkins, *The Blind Watchmaker* (Oxford University Press 1986) 3, referring to 'natural selection, the blind, unconscious, automatic process which Darwin discovered' and which 'has no purpose in mind … no vision, no foresight, no sight at all'.

27 Dawkins refers to the result of evolution as 'complexity' (ibid 10) echoing Charles Darwin's observations on diversity in the final lines of *The Origin of Species* (Murray 1859), referring to 'these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, [that] have all been produced by laws acting around us'. That neither complexity nor diversity imply teleology or optimality is emphasised by Uri Hasson, Samuel A Nastase and Ariel Goldstein, 'Direct fit to nature: an evolutionary perspective on biological and artificial neural networks' (2020) 105 Neuron 416, 424.

28 Dawkins (n 21 above) 36.

29 On genes informing the synthesis of proteins, see Richard Dawkins, *The Extended Phenotype: The Gene as the Unit of Selection* (Oxford University Press 1989). The level at which selection occurs in nature remains a highly contested issue in biology, and Dawkins's focus on the causative power of genes is by no means generally accepted. See George C Williams, *Adaptation and Natural Selection: A Critique of Some Current Evolutionary Thought* (Princeton University Press 1966); Benjamin Kerr and Peter Godfrey-Smith, 'Individualist and multi-level perspectives on selection in structured populations' (2002) 17 Biology and Philosophy 4; Pierrick Bourrat, 'From survivors to replicators: evolution by natural selection revisited' (2014) 29 Biology and Philosophy 4.

30 Cf Gérard Battail, 'Does information theory explain biological evolution?' (1997) 40 Europhysics Letters 343.

31 Richard Dawkins, 'Replicator selection and the extended phenotype' (1978) 47 Ethology 1; Richard Dawkins, 'Replicators and vehicles' (1982) King's College Sociobiology Group 45; Dawkins (n 29 above). The idea that genetic material is essentially a type of information continues to be the subject of much debate in biology: see, in particular, John Maynard Smith, 'The concept of information in biology' (2000) 56 Philosophy of Science 177; J A Winnie, 'Information and structure in molecular biology: comments on Maynard Smith' (2000) 56 Philosophy of Science 517.

efficiency' identifies litigation as a mechanism of selection which purges the law of inefficient (or wealth-destroying) rules. It is assumed that rules which have wealth-destroying effects are structurally more likely to be challenged in court, and so more likely to be selected out, leaving a residue of efficient (or wealth-maximising) rules.[32] The analysis has been widely credited with providing an explanation for the claim that the rules of private law in common law legal systems are consistent with allocative efficiency, and so promote economic growth.[33]

Mutation, in the Rubin–Priest account, is generated by what are assumed to be random variations in the way judges apply rules to the cases which come before them, as in the biological model. A process of variation plus selection, over sufficient iterations, is capable, it is argued, of generating rules which are optimally fitted to their environment, which are taken to mean Pareto-optimal or wealth maximising. However, it is only because the model omits to give systematic consideration to the role of inheritance or retention that it is able to predict evolution to efficiency; once account is taken of the need for some degree of continuity or inheritance in law, there is no guarantee that judge-made law will produce optimal results.[34] On the contrary, it is more plausible to believe that judge-made law will be characterised by 'frozen accidents', path dependencies and lock-in effects, of the kind associated with the non-teleological evolution which occurs in nature.[35]

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32 See Rubin (n 6 above) 51; Priest (n 6 above) 68.

33 Van Wangenheim (n 14 above) 5–6. See also Ben Depoorter and Paul Rubin, 'Judge-made law and the common law process' in Francesco Parisi (ed), *The Oxford Handbook of Law and Economics volume 3: Public Law and Legal Institutions* (Oxford University Press 2017), noting qualifications and refinements of the original hypothesis in the later literature.

34 Simon Deakin, 'Evolution for our time: a theory of legal memetics' (2002) 55 Current Legal Problems 1.

35 Mark Roe, 'Chaos and evolution in law and economics' (1996) 109 Harvard Law Review 641. On path dependence more generally, see Paul A David (1985) 'Clio and the Economics of QWERTY' (75) American Economic Review (Papers and Proceedings) 332; Brian W Arthur, 'Competing Technologies, increasing returns, and lock-in by historical events' (1985) 99 Economic Journal 116; Douglass C North, *Institutions, Institutional Change and Economic Performance* (Cambridge University Press 1990). The idea of path dependence has much in common with the biological concepts of exaptation and punctuated equilibrium (on which see Stephen Jay Gould, *The Structure of Evolutionary Theory* (Belknap Press 2002)), discussed in a legal context by Deakin, 'Evolution for our time' (n 34 above). See also 'shifting balance theory' (SBT) which explains how populations caught in suboptimal peaks in adaptive landscapes can traverse across regions of low fitness (adaptive valleys) and subsequently higher fitness peaks: Sewall Wright, 'The roles of mutation, inbreeding, crossbreeding and selection in evolution' (1932) 1 Proceedings of the Sixth International Congress on Genetics 356. Roe ('Chaos and evolution' this note above) discusses the relevance of this idea for law.

Evolution in nature 'is a blind-fitting process by which organisms become adapted to their environment'.[36] It depends on over-production in order to generate a sufficiently high level of mutation to trigger selection. Variation takes multiple forms in addition to genetic mutation, including gene regulation and expression, and genetic drift. Inheritance via vertical transmission between parent and offspring is not a given but depends on the combinatorial power of the genetic code. Selection occurs via forces which include not just 'natural' or environmental selection, but artefactual external force, and sex, kin, and group preferences. It can result in hugely diverse and complex structures, but only over extended periods of time which are far longer than the durations that can be ascribed to human institutions.[37]

If this model has a certain validity in its application to social phenomena, it would imply a processual understanding of evolution as a dynamic process of adjustment, with multiple mechanisms in play, and no unique equilibrium in view. Evolution in nature appears to produce 'order from noise', but this is a misleading metaphor. Biological evolution occurs through recursive iterations between genes, phenotypes and environments; there is order in the genetic code and the phenotypes it generates, only because the external environment is also structured.[38] Thus the 'solutions' it produces are '*mistakenly* interpreted in terms of elegant design principles' (emphasis added); they are the result of 'the interdigitation of "mindless" optimisation processes and the structure of the world'.[39]

In so far as it is appropriate to speak of 'optimisation' of outcomes, the solutions arrived at are likely to be specific to local environmental niches, and so incapable of being scaled up or readily applied to other contexts. Evolution consists of 'ever-changing, blind, *local* processes by which species change over time to fit their shifting *local* environment' (emphasis added).[40] It is also backward-looking: it can only adjust to new observations by putting them in the context of past ones.

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36 Hasson et al (n 27 above) 424.

37 Ibid, concluding that given the high error rate required for variation as well as the length of time needed for selection to take effect, evolution through blind variation, selection and retention is both 'costly and inefficient' as a mode of resource allocation.

38 While there may be a degree of randomness in genetic variation, the world as such is not random: 'it is structured according to laws of physics, biology, sociology, and the mind reflects this structure': Hasson et al (n 27 above) 426. For discussion of the similar idea of organism-environment interactions and context dependence in economics, see Sidney G Winter, 'Economic "natural selection" and the theory of the firm' (1964) 4 Yale Economic Essays 225.

39 Ibid 417.

40 Ibid.

This understanding of evolution may not predict 'evolution to efficiency'. However, bringing inheritance back into the model alongside variation and selection may actually be a good fit for what we know about the dynamics of legal change. Numerous studies of, and theorisations around, legal reasoning have pointed to inheritance-like mechanisms in legal language and decision-making, above all those associated with the way common law courts make use of the doctrine of precedent to combine 'at once stability and change' in the way they develop the law.[41]

Another reason for thinking about law in terms of the inheritance function of coded information is the bridge which can then build to systems theory, and the related fields of cybernetics and complexity theory. Niklas Luhmann's work is a fundamental point of reference in this respect, and it is here that we find developed the idea that legal concepts code information into a form, delimited and defined by juridical language, which permits their stabilisation or retention over time. Thus 'concepts are stored experiences taken from cases',[42] by virtue of which it becomes possible for 'distinctions [to] be stored and made available for a great number of decisions'.[43] Concepts 'compound information'[44] and operate as 'historical artefacts, auxiliary tools for the retrieving of past experiences'.[45]

It is through concepts, moreover, that 'the legal system has built up a highly sensitive reception and transmission station for economic news'.[46] While the separation of the economic and legal systems: 'prevents the automatic reception of the economic approach into the legal system (despite all the theories of "economic analysis of law")',[47] it is precisely the autonomy of law and its self-referentiality ('autopoiesis') that enables it to perform the function, essential for economic coordination, of stabilising expectations. In order for economic exchange to occur, 'law has to fulfil its own function, not that of the economy, effectively'; law 'must not belong to the type of goods or services that can be bought in the economic system, since 'otherwise there would be a vicious circle in the use of money, and the conditions which make money transactions possible would have

41 Karl Llewellyn, *The Bramble Bush* (Oceana 1930) 71.

42 Luhmann (n 2 above) 346. On the significance of the distinction between concepts and rules, with concepts characterised as hierarchically organised linguistic categories defined by varying degrees of abstraction, see Deakin, 'Evolution for our time' (n 34 above).

43 Luhmann (n 2 above) 340.

44 Ibid.

45 Ibid.

46 Ibid 390.

47 Ibid 400.

to be transacted and paid for in their own right'.[48] For transactions to occur in the economy, 'it must be possible to ascertain and, over the course of time, to remain able to ascertain, who the owner is before and after the transaction, and who is not'; through legal coding, the form which in the economy is called 'exchange' acquires 'a legal name, namely "contract"'.[49]

The idea that shared information or 'common knowledge' is at the root of societal coordination is also found in evolutionary and epistemic game theory. These branches of game theory model strategic interactions of boundedly rational agents in uncertain environments. The evolutionary strand points to the role of observation and learning in generating a basis for cooperation and coordination among inherently self-interested agents.[50] The epistemic strand points to the importance of beliefs in framing preferences, and of common knowledge or shared cognition in providing a basis for coordinated action.[51] The 'Bayesian' updating of beliefs in response to signals from the environment means that parties' preferences come to reflect the structure of their world.

An insight of this group of models is that rational behaviour, in itself, is incapable of generating stable outcomes; it is *common knowledge of rationality* which produces stable states, 'Nash equilibria', and this is

48 Ibid 391.

49 Ibid 393.

50 The origins of evolutionary game theory can be found in biology and may be traced back to R A Fisher, T*he Genetic Theory of Natural Selection* (Oxford University Press 1930) and later to John Maynard Smith, *Evolution and the Theory of Games* (Cambridge University Press 1982). Dawkins applies Maynard Smith's concept of the evolutionarily stable strategy to his theory of gene-centred evolution in *The Selfish Gene* (n 20 above) ch 5. The translation of these ideas into political science and economics since the 1980s can be seen in Robert Axelrod, *The Evolution of Cooperation* (Basic Books 1984); H Peyton Young, *Individual Strategy and Social Structure: An Evolutionary Theory* (Princeton University Press 1998); Aoki, *Toward a Comparative Institutional Analysis* and *Corporations in Evolving Diversity* (n 9 above); and Gintis, *The Bounds of Reason* (n 9 above). On the distinction between evolutionary and classical game theory, see Herbert Gintis, 'Classical versus evolutionary game theory' (2002) 7 Journal of Consciousness Studies 308, and for a recent overview of the field, J McKenzie Alexander, 'Evolutionary game theory' in Edward Zalta (ed), *The Stanford Encyclopedia of Philosophy* summer edn (Stanford University Press 2021).

51 The theory of epistemic games is derived initially from David Lewis, *Convention: A Philosophical Study* (Harvard University Press 1969) and then from the mathematical formalisations presented by Robert Aumann, 'Correlated equilibrium as an expression of Bayesian rationality' (1987) 55 Econometrica 1; 'Backward induction and common knowledge of rationality' (1995) 8 Games and Economic Behavior 6; and, with Adam Brandenberger, 'Epistemic conditions for Nash equilibrium' (1995) 63 Econometrica 1161. See, generally, Eric Pacuit and Olivier Roy, 'Epistemic foundations of game theory' in Zalta (ed) (n 50 above).

so regardless of whether the outcomes are welfare-maximising or in some way sub-optimal. According to this interpretation, the 'mutual defection' outcome in the one-shot or finitely played prisoner's dilemma game is not, as is sometimes supposed, the unique and inevitable outcome of each agent calculating that they are better off defecting than cooperating, whatever the other one decides.[52] This outcome only works where agents have a 'high degree of intersubjective belief consistency',[53] and there is nothing in static game theoretical models to guarantee this. Instead, the sub-optimal outcome of mutual defection is dependent on the knowledge, common to both parties, that defection is the expected strategy in the environment in which they find themselves. This explanation directs attention to the features of the environment which frame the parties' interactions, and to the mechanisms through which knowledge of those features comes to be widely shared. It is not possible then to speak of 'rationality' in exclusively psychological terms: rationality is situated and contextual, a reflection of the social environment.

A core concept here is that of a 'correlated equilibrium', first proposed in a formal model by Robert Aumann,[54] and subsequently developed into a theory of the cultural and institutional framing of cooperation by Herbert Gintis[55] and Masahiko Aoki.[56] A correlated equilibrium is a variant of an original Nash equilibrium, with the difference that each player chooses a best response to the other *assuming the other observes an event or instruction which informs their likely behaviour*. The 'event' is variously referred to as a 'choreographer' or 'correlating device'. Examples of correlated equilibria given by Gintis include the hawk–dove game played with the property strategy, which implies 'always play hawk if you are the incumbent, but not otherwise',[57] and the traffic intersection game with a convention, 'east–west goes first, north–south waits'.[58] Adapting the idea to a legal example, the

52 Aumann and Brandenberger (n 51 above).

53 Gintis, *The Bounds of Reason* (n 9 above) 41.

54 Aumann (n 51 above).

55 Gintis, *The Bounds of Reason* (n 9 above); see also his *Game Theory Evolving* (Princeton University Press 2009).

56 Aoki, *Toward a Comparative Institutional Analysis* and *Corporations in Evolving Diversity* (n 9 above) and (n 50 above); see also Masahiko Aoki, 'Endogenising Institutions and Institutional Change' (2007) 3 Journal of Institutional Economics 1; and 'Institutions as cognitive media between strategic interactions and individual beliefs' (2011) 79 Journal of Economic Behavior and Organization 20; and for an extension of Aoki's framework, Frank Hindrix and Francesco Guala, 'Institutions, rules and equilbiria: a unified theory' (2015) 11 Journal of Institutional Economics 459.

57 Gintis, *The Bounds of Reason* (n 9 above) 135.

58 Ibid 136.

'good faith game' can be understood as a correlated equilibrium of an original version of an offer and acceptance game played according to the rules of the 'battle of forms'. The addition of the correlating device – here, a legal rule which penalises opportunistic bargaining strategies – shifts outcomes from a sub-optimal Nash equilibrium involving mutual defection (in the battle of forms game, both parties seeking to impose their terms on the other in the hope that they will fire the 'last shot') to one of mutually beneficial cooperation (in the good faith game, bargaining to an outcome which maximises the joint contractual product).[59]

Consistently with the underlying methodology of epistemic and evolutionary games, the coordinating device is not simply posited, but is described in information-theoretic terms. Following the signal of the correlating device is a best response provided players have a given 'common prior'. More formally, a correlating device is an event [N] that specifies a particular environment [E] to all agents. With 'symmetric reasoning', all agents treat [N] as the basis for the belief that they are in a given environment [E]. An environment [E] can be said to be norm-governed if there is a norm [N(E)], which could be legal or social, specifying certain strategic behaviour [S]. If each agent is confident that other players associate [N] with [E], following [S] must be the common best response. Put another way, the correlating device or norm [N(E)] *is* the common knowledge on which agents draw to coordinate their actions.[60]

Gintis invokes the idea of culture to explain common knowledge: cooperation and coordination is possible because human societies contain 'cultural systems that provide natural occurrences that serve as symbolic cues for higher-order beliefs and expectations'. The parties' common priors 'are the product of common culture'. Thus it is not observation or experience alone which makes complex cooperation possible, but the existence of mechanisms of 'cultural transmission', which provide the means by which information can be retained and accessed.[61]

While Gintis says little about institutions in general or law in particular, Aoki builds on the idea of correlated equilibrium to construct a theory of public institutions, which include law. In his approach, an institution can be defined not so much as the rules of the game as the 'equilibrium outcome' of those rules; in game theoretical

59 Simon Deakin, 'Legal evolution: integrating economic and systemic approaches' (2011) 7 Review of Law and Economics 659.

60 Gintis, *The Bounds of Reason* (n 9 above) 138. See also Aoki, *Corporations in Evolving Diversity* (n 9 above) 127.

61 Gintis, *The Bounds of Reason* (n 9 above) 140-141; Aoki, *Corporations in Evolving Diversity* (n 9 above) 131.

terms, the play of a game, rather than the game form.[62] As he puts it, this view understands institutions as quasi-endogenous to their context: institutions 'may be identified with salient properties of recursive states of play such that every player takes them for granted and believes it beneficial to adapt to them'. Rules are therefore both 'systems of action' and 'shared cognitive categories'.[63]

Similarly to Luhmann, albeit from a wholly different (indeed, inverted) starting point,[64] Aoki arrives at the view that legal rules are defined by their cognitive content. Laws are 'equilibrium public indicators'[65] which convey to agents information on the environment that they are in and enable them to predict with confidence that all other agents know it. This makes it possible for agents to 'reason symmetrically', the condition for a correlated equilibrium. More precisely, he suggests, legal rules are 'summary representations of recursive states of play' in society. They embody knowledge about the past as well as directing behaviour: they 'can be regarded as representing something to be believed to prevail and to happen (and thus self-enforcing) from players' experiences'.[66] Law, then, is a form of 'historically accumulated common knowledge'.[67]

Combining game theory and systems theory therefore allows us to develop a more fully rounded account of legal evolution. The inheritance or retention function is performed by legal concepts, which code information from law's external context ('exchange', 'wrong') into juridical forms ('contract', 'tort') which the law can then process in its own terms.[68] Without some degree of distinctiveness to legal language,

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62 Aoki, 'Endogenising institutions and institutional change' (n 56 above).

63 Aoki, *Corporations in Evolving Diversity* (n 9 above) 120.

64 Aoki adopts an approach rooted in the modelling of individuals' strategic behaviour, in contrast to Luhmann's social systems theory, in which the individual agent barely features as a unit of analysis. It should, however, be borne in mind that the game theoretical approach adopted by Aoki and Gintis marks a departure from methodological individualism, in seeking to understand rational action in its social context; on the need to move beyond an account in which institutions are seen as reducible to individual interactions, see Gintis, *The Bounds of Reason* (n 9 above), at 223: 'Complexity theory is needed because human society is a complex adaptive system with emergent properties that cannot now be, and perhaps never will be, fully explained starting with more basic units of analysis. The hypothetico-deductive methods of game theory and the rational actor model, and even gene-culture coevolutionary theory, must therefore be complemented by the work of behavioural scientists who deal with society in more macrolevel, interpretive terms.'

65 Aoki, *Corporations in Evolving Diversity* (n 9 above) 127.

66 Ibid 128.

67 Ibid 131.

68 Simon Deakin, 'Juridical ontology: the evolution of legal form' (2015) 40 Historisches Sozialforschung 170.

there is a limit to the effectiveness with which external information can be internally processed; thus the maintenance of a linguistic boundary between law and its economic or social context (of the kind represented in doctrinal terms by the distinction between 'law' and 'facts') is not an accidental feature of legal reasoning so much as its essential precondition.

The variation function is observable in the trial-and-error process through which legal rules are applied and tested to disputes and conflicts as they arise. It is not necessary to posit entirely random decision-making, and it is unrealistic to do so, given the way in which concepts enable learning from past experiences to be activated when addressing novel questions. The open-textured quality of legal language, and the contestability of legal interpretation in 'hard' cases, may be expected to generate a range of possible outcomes at the point where the law is called on to adjust to a new event in its environment.

The selection function can be observed in the litigation process which drives the development of case law, but can be present in the formulation of statutory rules, which are shaped by interest-group lobbying and collective deliberation. Any contrast between 'spontaneous' case law, on the one hand, and 'purposive' or 'directed' legislation, on the other, can only be a matter of degree.[69] The contestation of interests is present in both contexts, with repeat players able to exercise resources and power to their advantage unless checked by rules of procedure (for example, legal aid and conditional fees in the case of litigation, registration of interests and curbs on the commercialisation of political influence in the case of legislation). Just as there is more than one type of selection in nature, so it is possible to envisage multiple mechanisms in the social realm, which may alternatively substitute for or complement each other, depending on circumstances.[70]

This is an understanding of legal evolution, then, which stresses the cognitive content of the law and dynamic, processual and experimental character of legal change. The idea of evolution is not being used simply as metaphor; as Luhmann suggests, reference to the VSR algorithm in this context 'should not be taken as an argument by analogy but as a pointer to a general evolutionary theory, which can have many different applications'.[71] The model does not generate any *a priori* reason for

69 Simon Deakin, 'Law as evolution: evolution as social order' in Stephan Grundmann and Jan Thiessen (eds), *Recht und Sozialtheorie Im Rechtsvergleich* (Mohr-Siebeck 2015).

70 Deakin, 'Evolution for our time' (n 34 above) 38.

71 Luhmann (n 2 above) 231. If the use of the VSR algorithm in the context of the social sciences is seen this way, that is, as a specific application of a wider general theory of evolution, some of the problems in treating biological processes as *directly* informing social ones, as envisaged by sociobiology and evolutionary psychology, can be avoided: see Deakin, 'Evolution for our time' (n 34 above).

favouring judge-made law over statute, private law over public law, or the common law over the civil law. Nor does it offer us any reason for believing that the law tends inevitably to efficiency, however precisely that term is understood. What it does offer is a positive or descriptive theory which we can use to generate predictions or claims on the law–economy relation which are capable of being empirically tested. This is one in which the legal and economic systems are autonomous from, while at the same time endogenous to, each other: they co-evolve, mutually adjusting to each other's existence, in a way which denies any ontological priority of one over the other.

EVOLUTIONARY EMPIRICS: ISSUES OF MEASUREMENT AND INFERENCE

If law and the economy are understood as quasi-endogenous to each other's mode of operation, the precise nature of their relationship in any particular market setting (labour, financial, product or other markets, as the case may be) or historical period (industrialisation being not a continuous process but one characterised by phases and cycles of technological development) is left open to empirical inquiry. The feasibility of empirical study in this area is, however, conditioned upon the plausibility of the techniques involved. We will consider three sets of methodological issues concerning, respectively, 'leximetric' approaches to the measurement of legal phenomena; econometric approaches to statistical association and causal inference in the analysis of legal and economic data series; and the use of machine learning and natural language processing to study the long-run dynamics of legal and economic change.

Measuring legal phenomena: 'leximetrics'

The term 'leximetrics' has entered general use in empirical legal research over the past decade. It can be applied in a general sense to refer to all statistical uses of or approaches to law[72] or, somewhat more specifically and usefully for present purposes, to a method of generating machine-readable data concerning legal norms through content analysis of legal texts.[73] In this second and more precise sense, leximetrics involves the translation of textual material into

72 Robert Cooter and Thomas Ginsburg, 'Leximetrics: why the same laws are longer in some countries than others' U Illinois Law & Economics Research Paper No LE03-012.

73 Priya Lele and Mathias Siems, 'Shareholder protection: a leximetric approach' (2007) 7 Journal of Corporate Law Studies 17.

quantitative form as indicators and indices.[74] Because the method can be used to construct legal time series based on texts (cases and statutes) which are sequentially ordered, it can be put to use in testing claims about law's evolutionary properties and the dynamic nature of the law–economy relation. As with any other such method, however, its relevance is dependent in practice on there being a high degree of fit between the question which is addressed and the way in which the data being used to address it have been constructed.

Among the first attempts to develop indicators specific to law were those of international agencies, including the Organisation for Economic Co-operation and Development (OECD)[75] and the World Bank.[76] Perhaps because of their semi-official nature, they quickly gained a certain standing among researchers as well as policymakers. Over time the input of researchers has become more evident, and there has been a certain degree of cross-fertilisation between the university-based and agency-based modes of index production.[77] Indices have proliferated, as have econometric studies making use of them.[78]

Leximetric datasets are sometimes said to be 'synthetic',[79] but in this respect they are not fundamentally different from other data sources which are widely used in the social sciences. Growth studies use definitions of national income and output which ultimately rest on theories of how far trade is a synonym for wellbeing.[80] The statistical

74 Zoe Adams, Parisa Bastani, Louise Bishop and Simon Deakin, 'The CBR-LRI dataset: methods, properties and potential of leximetric coding of labour laws' (2017) 33 International Journal of Comparative Labour Law and Industrial Relations 59.

75 The OECD Employment Protection Indicators date back in their original form to the early 1990s. See David Grubb and William Wells, 'Employment regulations and patterns of work in EC countries' OECD Economic Studies Working Paper No 21 (1993), and for the latest version of the indicators, OECD Indicators of Employment Protection.

76 The World Bank's *Doing Business Reports* have published a number of indicators of the business environment since their first appearance in 2004. See now World Bank, Business Enabling Environment. In September 2021 the World Bank announced that it was discontinuing the Doing Business indicators because of concerns over 'data irregularities': 'World Bank to Discontinue Doing Business Report' (16 September 2021).

77 Thus, the World Bank financed some of the indices constructed by La Porta et al, and the International Labour Organization part-funded the Cambridge CBR-LRI index of labour regulation.

78 For a recent study containing an overview of the leximetric literature, see Jonathan Hardman, 'Articles of association in UK private companies: an empirical leximetric study' (2022) European Business Organization Law Review 517.

79 OECD and European Commission, *Handbook on Constructing Composite Indicators: Methodology and User Guide* (OECD 2008).

80 Diane Coyle, *GDP: A Brief but Affectionate History* (Princeton University Press 2015).

category 'unemployment' measures not the absence of 'work ' as such, but rather that of 'employment', an exchange relation of a particular kind with a distinct historical origin and lineage.[81] In all such cases, in order to interpret a given data series, it is relevant to examine the theoretical priors which went into its construction, and to consider how far those priors determine the form it takes.

An unavoidable prior in the construction of any dataset is that the data contained in it represent an external reality which would exist even if it were not being studied.[82] For some, this is a contentious step. Rejecting the possibility of 'objective empirical knowledge' in favour of a 'postmodern, constructivist social epistemology, according to which there is no "reality" to be discovered', this view holds that law should be seen as 'an epistemic subject that creates its own reality'.[83] A 'science of law' which purports to take legal phenomena as its object is similarly self-referential: 'science does not discover any outside facts: it produces facts'.[84]

Does leximetric method really create its object? There is no doubt that leximetrics creates leximetric data. Without leximetric techniques to make them, the *datasets* would not exist, and the 'facts' they contain are indeed constructs. However, it is a different matter to claim that the underlying *laws* would not exist but for the attempt to study them.

It is possible that, over time, through feedback effects, indices may influence the content of these laws. This is demonstrably the case with the indices developed by the World Bank, which were reported in 2008 to have influenced 'dozens' of law reform initiatives since the early 2000s.[85] Legal indices, as representations of the world, can influence that world, albeit with a lag. This type of reflexivity may well be a feature of all systems of representation. However, to say that representational systems operate in a relationship of feedback with their environment

81 Robert Salais, Bénédicte Reynaud and Nicolas Bavarez, *L'Invention du chômage* (Presses universitaires de France 1999).

82 Simon Deakin, 'The use of quantitative methods in labour law research: a defence and reformulation' (2018) 27 Social and Legal Studies 456.

83 Ioannis Kampourakis, 'Empiricism, constructivism and grand theory in sociological approaches to law' (2020) 21 German Law Journal 1411, 1416.

84 Ibid, quoting Gunther Teubner, 'How the law thinks: towards a constructivist epistemology of law' (1983) 23 Law and Society Review 727, 743.

85 Rafael La Porta, Florencio Lopez-de-Silanes and Andrei Shleifer, 'The economic consequences of legal origin' (2008) 46 Journal of Economic Literature 285, 325.

is one thing; to say that they create that environment *de novo* is a different thing.[86]

It is relevant to note that empirically minded social scientists engaged in the making of datasets expressly refer to the identification of a 'construct' as one of the first steps in this process,[87] and give the term 'construct validity'[88] to the process of ascertaining whether a particular construct is workable in its own terms. There need be no disagreement between 'realist' and 'hermeneutic' approaches on the active role played by the researcher in the creation of data. 'Data' do not exist in a natural state, and so are not simply observed; data are arrived at by processing observations according to categories which must pre-exist those observations, even if they are capable of being updated in response to them.

Where the disagreement comes is in the possibility of validation through the experimentalist methods of all empirically orientated science disciplines, including the social sciences: hypothesis identification, empirical observation, and provisional resolution of claims. If this is the founding dogma of empirical legal research, it no more arbitrary as a starting point than the converse proposition, seemingly associated with 'societal constitutionalism', that such a position is impossible.

Nor should it be thought that an empirically driven, social-scientific approach is incompatible with a systemic understanding of society, or with the methodology it implies. Science, as one social sub-system among many, observes other systems through its own discursive techniques. In doing so, science 'does not simply duplicate the view of the [system] it observes'; rather, 'the system being observed is covered over with a procedure of reproducing and increasing its complexity that is impossible for it' to achieve in its own terms.[89] Leximetric categories are no doubt among those 'conceptual abstractions that do

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86 Thus, rather than saying that there is no social reality awaiting discovery, as opposed to multiple epistemes or cognitive frames of reference, it may be better to say that discursive systems such as law and science are part of the reality that they seek to represent, and with which they reflexively interact. Law does not entirely create its own reality, since its discursive categories reflect, if incompletely, the social referents to which they relate, and with which they may be expected to co-evolve: Simon Deakin and Frank Wilkinson, *The Law of the Labour Market: Industrialization, Employment, and Legal Evolution* (Oxford University Press 2005) 6, 14–17. On the claim that it is a 'fallacy' to conclude, from the existence of multiple forms of knowledge, that there is no single, invariant social reality to which they relate, see Roy Bhaskar, *A Realist Theory of Science* (Verso 1975).

87 Deakin, 'Quantitative methods in labour law research' (n 82 above) 461.

88 OECD and European Commission (n 75 above).

89 Niklas Luhmann, *Social Systems*, John Bednarz (trans and ed), 'Introduction' by Dirk Baecker (Stanford University Press 1995) 56.

not do justice to the observed system's concrete knowledge of its milieu or to its ongoing self-experience', but it is precisely 'on the basis of such reductions – and this is what justifies it – [that] more complexity becomes visible than is accessible to the observed system itself'. It is the 'technique of scientific observation and analysis, the functional method', which produces new knowledge, in so far as it 'allows its object to appear more complex than it is for itself'.[90]

Nor is it the case that the empirical study of law is ultimately reducible to 'the currents of logical empiricism and positivism in social sciences',[91] if those are taken to mean a research agenda which identifies social reality with directly observable and mathematically tractable event regularities. Leximetrics may be, in part, a quantitative research method, but its use alongside other methods, including qualitative data collection through interviews and field work, and historical archival research, far from being ruled out, is more likely to generate meaningful results than reliance on any one method.[92] Nor is a leximetric approach in itself incompatible with an understanding of social reality as layered or structured, of the kind associated with critical realist and social-ontological approaches to law.[93]

The association of empirical socio-legal research with positivism rests on the belief that there exists a deep 'epistemological divide between socio-legal studies and societal constitutionalism' which 'corresponds to the epistemological and ontological divide between positivism, empiricism, and rationalism on the one hand, and constructivism on the other hand'. That there is such a divide is one of the few areas of common ground between positivists and interpretivists, who insist not just on the unique correctness of their own respective positions, but on the impossibility of transcending their limits. The result is the all-too-familiar division of the social sciences into competing and mutually incompatible sub-disciplines, a result which may be regarded favourably as a contribution to pluralism or, less so, as a contribution to the fragmentation, verging on disintegration, of the social sciences, a process which incidentally leaves little space for any social scientific approach to law to flourish and encourages those who are sceptical of what it can achieve.

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90 Ibid.

91 Kampourakis (n 83 above) 1416.

92 John Buchanan, Dominic Chai and Simon Deakin, 'Empirical analysis of legal institutions and institutional change: multiple-methods approaches and their application to corporate governance research' (2014) 10 Journal of Institutional Economics 1.

93 Simon Deakin, 'Tony Lawson's theory of the corporation: towards a social ontology of law' (2017) 41 Cambridge Journal of Economics 1505.

The techniques of construct validity which are applied in leximetric data coding, which have their origin in psychology, demonstrate how, in the practical context of empirical social science research, the division between empiricism and constructivism is breaking down. It is no accident that in the context of legal data coding, the word 'construct' is used to refer to a conceptual category which is intended to represent, but not to replicate, a prior empirical reality.[94] It is only in identifying the constructed or synthetic nature of a leximetric category that its value in knowledge creation can be adequately assessed. It matters, for example, that a given approach to leximetric coding might start from the basis that in benchmarking legal rules it is measuring 'costs', while another aims to measure the 'normative effect of a rule'.[95] It is also essential, when considering a leximetric index, to know why particular rules, and not others, were chosen as the basis for individual indicators; why exactly the scales contained in the indicators were chosen and how they map on to the dimensions of the phenomena to which they relate; and how indicators are weighted to produce an overall index.[96] In these various respects, to say that leximetric data are 'constructed' is not to concede their undue artificiality, but to accept the need for clarity and transparency in the coding process, without which no reliable evaluation of their knowledge content is possible.

There is a further sense in which leximetric coding elides the distinction between empiricism and interpretivism, and this is that it takes interpretation as its research object. Leximetric coding assumes that the legal texts which make up the primary source material for legal datasets have a sufficiently stable meaning for them to be consistently coded. The text is a signifier for the meaning of the norm in its legal and wider economic context; the legal text 'script-codes' a social practice. A legal rule or concept is, at one and the same time, a cognitive category, and a material one. Nor is there is any sense in which its cognitive dimension, the law, operates 'outside' reality. Legal concepts are themselves part of social reality.[97]

Statistical association and causal inference: time series econometrics

Leximetric data are produced for a specific purpose: their use in statistical analysis. Other uses, in particular the construction of league tables purporting to rank countries according to the intensity of regulatory regimes, are not just secondary to this purpose; they may

94 See Deakin, 'Quantitative Methods in Labour Law Research' (n 82 above) 462.

95 Ibid 463, discussing differences in this respect between the OECD Employment Protection Indicators and the CBR-LRI index of labour regulation.

96 Ibid 465.

97 Deakin, 'Juridical ontology' (n 68 above) 182.

be of questionable value when it is borne in mind that leximetric data are at best an incomplete representation of the state of the law in a given country. Text-based data coding produces what may be called a 'jural' account of the law (such as the normative content of statutes and cases), as opposed to the 'factual' account which can be inferred from evidence about the operation of the law in practice (such as numbers of minimum wage infractions, health and safety inspections, or labour court hearings). For this reason it is generally accepted that leximetric data need to be combined with data sources of other kinds when assessing the likely economic impact of a legal rule, or group of rules.[98] Despite this obvious qualification, country rankings based on unamended 'jural' measures not only continue to appear in official reports, but seem to have had, in a number of instances, a tangible influence on policy making.[99]

The use of leximetric data in statistical analysis, while essential if the potential of the data are to be realised, brings problems of its own. When data are arranged into time series, there is potential for regression analysis to find spurious correlations. This 'autocorrelation' is a function of the way in which time series are ordered as historical sequences; it can arise, in other words, as a matter of statistical representation, regardless of the underlying nature of the association between variables of interest.[100] But it is also possible for incorrect conclusions to be drawn from correlations which are otherwise genuine. As with the construction of data, statistical associations do not speak for themselves; they must always be interpreted. That there is a very high degree of correlation between two time series is not in itself evidence that the phenomena they represent are causally related.

Even if we can be confident that a statistical association is not a mathematical illusion and that it represents a real relationship between societal phenomena or events, it may not be possible to infer anything about the direction of causation. It has become standard to observe that 'causation does not equate to correlation', but the problem is more fundamental: statistical techniques are not well designed to deal with questions of causality. Econometric studies often have to posit a causal relation rather than setting out to prove one. While techniques exist for demonstrating that an event, such as the passage of a law, is more

98 Deakin, 'Quantitative Methods in Labour Law Research' (n 82 above) 469.

99 La Porta et al (n 85 above) 325.

100 The risks of spurious regressions in time series analysis have been known about virtually since the inception of the discipline of econometrics. See George Udny Yule, 'Why do we sometimes get nonsense correlations between time-series? A study in sampling and the nature of time-series' (1926) 89 Journal of the Royal Statistical Society 1. For discussion, see Deakin, 'Quantitative Methods in Labour Law Research' (n 82 above).

likely than not to have changed outcomes, these depend on statistical conventions rather than on the types of inference which are possible under conditions of controlled experiments. Randomised controlled trials (RCTs) of the kind which are used in an attempt to approximate experimental conditions are no exception to this principle: under certain tightly circumscribed conditions they can provide *greater* confidence than could otherwise be possible of the likely effects of a policy intervention, but all such studies are situated in time and space and how far they can be applied to other contexts is a matter of judgement.[101] To make this point is not to argue that statistical methods, including RCTs, have not advanced understanding of policy interventions. It is to argue that knowledge of the kind they produce should not be regarded as infallible but instead, in common with all social scientific knowledge, as provisional in the light of future studies and the refinement of techniques which they may make possible.

The kinds of questions raised in law and economics research, concerning the nature of the law–economy relation in general and the contribution of legal rules and systems to economic efficiency and growth in particular, are not necessarily well suited to being addressed through RCTs, which are in any event highly resource-intensive in addition to raising numerous ethical issues. Examination of the claims of legal origin theory has mostly proceeded through the use of statistical techniques which are understood to offer ways of testing for causation without recourse to trial data; these include the instrumental variable technique which was initially used by La Porta et al to show that legal rules were not necessarily endogenous to their context, but could operate as independent or causal variables. In their studies, 'legal origin', standing for the common law or civil law origin of a country's legal system was used as an instrument to clarify the direction of causation from legal rules to economic outcomes. To be effective, an 'instrument', in this sense, must be strictly exogenous both to the independent or causal variable, and the dependent or outcome one (or more precisely, to the error terms in the relevant regression model). Legal origin fitted this description because, in the case of nearly all countries, the adoption of common law or civil law legal 'infrastructure' was the result of a chance event, namely colonisation or conquest by one of or other of the 'origin' countries (Britain, France or Germany). However, La Porta et al came to modify their position, abandoning the use of legal origin as instrument in favour of treating

101 For discussion of RCTs in the medical and social sciences, see Angus Deaton and Nancy Cartwright, 'Understanding and misunderstanding randomized controlled trials' (2018) 210 Social Science and Medicine 2.

it as the principal exogenous cause of variations in the content of laws, and, ultimately, in economic performance across countries.[102]

So stated, the legal origin hypothesis is, in essence, a claim about legal evolution. For there to be an effect of such longevity and magnitude presupposes the presence of deep-rooted path dependences. Consistently with an evolutionary understanding, events at a particular point in time trigger trajectories of 'exaptation' and diversity across systems, rather than one of adaptation and convergence.[103] This is hard to square with the claim that there is a single efficient configuration of laws to which countries are all moving or to which they should seek to move; the early studies may have concluded that common law systems enjoyed superior economic performance, but the later emphasis on the lock-in effects of legal origin suggests, on the contrary, that there is limited scope for the alignment of laws across national systems or, at least, across the different legal 'families'. The empirical evidence, as it emerged, confirmed this suggestion: transplants are less effective across the civil law–common law divide.[104] Empirical analysis also cast doubt on the claim of the common law's supposed economic superiority.[105]

The initial legal origin studies relied on cross-sectional data on the content of laws, mostly drawn from a single year of observations. There is now a wide body of longitudinal data on which researchers can draw to test claims concerning the impact of law on economic performance. Econometric techniques have also been evolving to address the issue of serial correlation and the related risk of spurious regressions. Recognising that many historical data series are non-stationary, meaning that they are liable to depart from a pre-existing trend or path in response to an exogenous shock, the method of cointegration provides a way to overcome the serial correlation problem: where two non-stationary time series are linked by a common trend, they can be modelled as moving together over time, with the potential to converge in the long run.[106] By its nature, then, this technique is well suited to testing claims about the co-evolution of legal and economic phenomena. The related concept of Granger causality, which tests

102 See La Porta et al (n 85 above) 298–299, discussing reverse causality and the use of the instrumental variable technique.

103 On 'exaptation' in a legal context, see Deakin, 'Evolution for our time' (n 34 above) 10.

104 Daniel Berkowitz, Katharina Pistor and Jean-François Richard, 'Economic development, legality and the transplant effect' (2003) 47 European Economic Review 165.

105 See La Porta et al (n 85 above) 309: 'Legal Origins Theory does not say that common law always works better for the economy.'

106 Robert F Engle and C W J Granger, 'Co-integration and error correction: representation, estimation and testing' (1987) 55 Econometrica 251.

for the historical precedence of one variable over another by adding lagged values of the assumed independent variable to the regression equation,[107] can be used to test for the direction of causation between the economy and law.

Building on these techniques, vector autoregression (VAR) and vector error correction (VEC) models have been widely used in conjunction with leximetric time series to clarify aspects of the legal origin hypothesis. These studies show that changes to the content of legal rules are frequently endogenous to changes in economic conditions. Thus, stricter worker protection laws, rather than causing higher unemployment, may in reality be endogenous to the economic cycle: legislatures may respond to the threat of joblessness by making it more difficult for firms to dismiss workers.[108] The opposite is also possible if a recession reduces workers' bargaining power and hence their political leverage, but which effect is observed in any given country case is an empirical question, not one that can be answered *a priori*. Similarly, laws strengthening shareholders' rights may be an endogenous response to a rise in investor power and influence. This is not to say that law which is endogenous to the economy in this sense cannot also operate as independent variable with potential causal effects for the economy: it is plausible that laws passed in response to an external economic change will influence the economy in their turn, and empirical studies suggest that this is indeed the case.[109]

What these findings imply is that just as law does not respond to economic change in a linear fashion, nor do laws take automatic effect in the economy. Rather, laws can become adapted over time to particular economic and industrial phenomena, though coevolution and mutual reinforcement. If this process is specific to particular national contexts, coevolution of law and the economy *within* a country can lead to diversity and divergence *across* countries. Thus, the correlation observed in the legal origin studies between shareholder protection laws and dispersed ownership is best understood as a result of an extended coevolutionary process, involving mutual causation and the emergence over time of institutional complementarities.

The further correlation of these trends with common law legal origin is best explained by similar interdependencies: it is because

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107 C W J Granger, 'Investigating causal relations by econometric models and cross-spectral methods' (1969) 37 Econometrica 324.

108 Simon Deakin and Prabirjit Sarkar, 'Indian labour law and its impact on unemployment, 1970–2006: a leximetric study' (2011) 49 Indian Journal of Labour Economics 211.

109 Simon Deakin, Prabirjit Sarkar and Mathias Siems, 'Is there a relationship between shareholder protection and stock market development?' (2018) 3 Journal of Law, Finance and Accounting 115.

England was a common law system, and also, during the period of its initial industrialisation, one characterised by a relatively high degree of shareholder protection coupled with liquid financial markets and dispersed ownership, that a structural association between legal origin, the content of laws and related features of financial markets was established. When English law was transplanted to British colonies, the common law served as a carrier of shareholder-friendly company laws and capital markets characterised by a high degree of liquidity. But the appearance of legal origin as the ultimate, exogenous cause of legal and financial development is just that: an appearance. It is possible for civil law origin systems to develop strong regimes for shareholder protection, in response, for example, to investor pressure, and for these laws in turn to have tangible effects on firms' capital structure and performance. If, thanks to path dependencies and lock-in effects, legal origin has an independent causal influence on economic growth, it is likely to be a relatively weak one, and less significant in practice than the content (for example, pro-shareholder or otherwise) of the relevant legal rules.

Machine learning and natural language processing

Machine learning (ML) is a set of computational techniques for transforming informational inputs into outputs using algorithmic modelling.[110] An algorithm in this context refers to a mathematical model prescribing a series of instructions for optimising a given function. The distinctiveness of ML is that the algorithms are designed to self-adjust in response to new data.[111] This can involve, for example, the parameters of a function being adjusted in order to achieve a better fit with the goal being optimised, a form of error correction known as 'backpropagation'.[112] Thus, an ML algorithm is endogenous to the data it is processing; in effect, it evolves through recursive iterations with its context.

In the case of 'supervised learning', the programmer defines the goal or output (commonly known as the 'ground truth'), which the model then optimises through recursion; with 'unsupervised learning', the ground truth is not defined in advance but is allowed to emerge on the

110 David Spiegelhalter, *The Art of Statistics: Learning from Data* (Pelican 2019) 144.

111 David Lehr and Paul Ohm, 'Playing with the data: what legal scholars should learn about machine learning' (2017) 51 UC Davis Law Review 655; Christopher Markou and Simon Deakin, 'Ex machina lex: the limits of legal computability' in Simon Deakin and Christopher Markou (eds), *Is Law Computable? Critical Perspectives on Law and Artificial Intelligence* (Hart 2020).

112 David Rumelhart, Geoffrey Hinton and Ronald Williams, 'Learning representations by back-propagating errors' (1989) 323 Nature 533.

basis of the clustering of variables with a high degree of self-similarity or proximity.[113] It is possible to combine the two approaches, for example by using unsupervised learning to identify an implicit or latent structure to the data, which is then used as the basis for the ground truth in a supervised-learning approach, enabling the dataset to be refined and its predictive capacity enhanced.

The value of ML as a tool for analysing legal texts depends in addition on the potential for using techniques of natural language processing (NLP), including lexical analysis, machine translation and information retrieval, to process texts at scale.[114] The premise of NLP is that natural language is a symbolic system for representing semantics. Text is, at one and the same time, a physical signal and a symbolic expression of meaning. NLP applications use mathematical modelling to identify latent or hidden linguistic structures which can be used to translate, predict and generate text.

The combination of NLP techniques with the subset of ML applications associated with 'deep learning' (DL)[115] has particular significance for legal (and law and economics) research. DL approaches make use of 'artificial neural networks' or ANNs, computational models which seek to replicate what is understood to be the process by which learning occurs through the human brain.[116] Learning in ANNs is modelled in terms of the interaction between an 'input layer' ('neurons') through which information is received, a 'hidden layer' of equations which transform inputs into outputs, and a set of vectors ('synapses') linking neurons together, with the result that the outputs from one form the input to another. The vectors or synapses are 'weighted' to reflect their relative importance in the overall model. The weights are adjusted over the course of successive iterations, enabling the model to 'learn'. DL applications are characterised by multiple 'hidden' layers, making it possible to model high-level 'concepts' out of lower-level representations. It is these techniques which are largely responsible for the recent advances in speech recognition and machine translation that have greatly extended the practical usefulness of NLP techniques and brought them to wide attention.

ML techniques should make it possible to improve the quality of leximetric datasets and to expand the range of questions which they

113 On the distinction between supervised and unsupervised learning, see Jürgen Schmidhüber, 'Deep learning in neural networks: an overview' (2014) arXiv:1404.7828.

114 Madeleine Bates, 'Models of natural language understanding' (1993) 92 Proceedings of the National Academy of Sciences 9977.

115 Yann LeCun, Yoshua Bengio and Geoffrey Hinton, 'Deep learning' (2015) 521 Nature 436.

116 Schmidhüber (n 113 above); Hasson et al (n 27 above).

are used to address. Topic modelling (TM), a type of statistical model for discovering abstract 'topics' from bodies of text, is proving useful in data-mining texts in order to discover latent or hidden semantic structure;[117] it has been used to model presidential speeches,[118] classify historical Hebrew texts,[119] and to identify trends in sociological abstracts.[120] Instead of requiring a human interlocutor to create or 'hand code' a taxonomy, TM allows corpuses to taxonomise themselves using the immanent structure of the underlying texts. This type of application could be used as a robustness test for 'hand-coded' leximetric data, although whether it could replace it entirely is an open question, given the multidimensional nature of the judgements involved in legal-coding process.[121]

In practice, there remain significant obstacles to the effective use of ML in the legal sphere. DL applications of the kind which may be needed to code data at scale are heavily resource-intensive. Facial recognition models of the kind currently being developed use deep convolutional ANNs with millions of parameters. The function they are seeking to optimise is a physical feature of human physiognomy which is assumed to be highly correlated with an individual's identity, the latter signifying not just a biological category but also an institutional (legal) one. To get any kind of reliable result, there has to be not just a training set of the right size (one such model requires over 200 million facial images and 8 million individual identities) but also a clearly defined objective function, learning rule, and network architecture.[122] A language model of the kind used to predict word strings and sentence

117 D J Carter, James Brown and Adel Rahmani, 'Reading the High Court at a distance: topic modelling the legal subject matter and judicial activity of the High Court of Australia, 1903–2015' (2016) 39 University of New South Wales Law Journal 4; D J Carter and Adel Rahmani, 'Proximity and neighbourhood: using topic modelling to read the development of law in the High Court of Australia' (2019) 45 Monash University Law Review 785; Pedro Henrique Luz De Araujo and Teófilo De Campos, 'Topic modelling Brazilian Supreme Court lawsuits' (2020) 334 Legal Knowledge and Information Systems 113; Arthur Dyevre and Nicholas Lampach, 'Issue attention on international courts: evidence from the European Court of Justice' (2020) 16 Review of International Organizations 793–815.

118 Michal Ovádek, '"Popular tribunes" and their agendas: topic modelling Slovak Presidents' speeches 1993–2020' (2020) East European Politics 214–238.

119 Chaya Liebeskind and Shmuel Liebeskind, 'Deep learning for period classification of historical Hebrew texts' (2020) Journal of Data Mining and Digital Humanities,

120 Giuseppe Giordan, Chantal Saint-Blancat and Stefano Sbalchiero, 'Exploring the history of American sociology through topic modelling' in Arjuna Tuzzi (ed), *Tracing the Life Cycle of Ideas in the Humanities and Social Sciences* (Springer 2018).

121 Deakin, 'Quantitative Methods in Labour Law Research' (n 82 above).

122 Hasson et al (n 27 above) 420.

structures requires 48 layers, 1.5 billion parameters, 8 million documents, and 40 gigabytes of text. This model can predict words based on preceding words, but does not even closely approach standard human capabilities to 'accumulate and integrate broadly distributed multimodal information over hours, days and years'.[123]

There are other problems with the use of ANNs to predict legal text. The issue of algorithmic 'bias' is not an accidental feature of the method, but intrinsic to its approach: an evolutionary model of the world reproduces the features of that world, including gender and racial bias. Since the early 1990s, models in computational linguistics based on the idea of 'distributed representation' have sought to represent words in a text as points in abstract vector space; words nearer to each other in that space are assumed be 'related' in a 'morphosemantic' or evolutionary sense. The hypothesis here is that words will tend to be found near words that are 'similar' to themselves, and that these similarities can be captured numerically. Today's models use ANNs to transform ('embed') a word into a set (or 'vector') of numbers that represent its 'coordinates' in that space. The coordinates of the word representations are adjusted so that the model can be 'trained' to guess the 'correct' word by nudging it towards (incentivising) a particular guess, and away (disincentivising) from a different one. After each guess (or iteration), another phrase is selected at random and the process is repeated until a 'correct' result, as defined, is arrived at. The word-embedding approach is capable of capturing a huge amount of real-world information and can mimic features of human cognition such as analogical reasoning and grammatical inference. It is also highly effective at capturing real-world biases: for example, associating the binary man:women with gendered stereotypes such as carpentry:sewing, or architect:interior designer, or doctor:nurse. One way to deal with this problem is to find the axis that captured the concept of gender and delete it. However, the problem with this is that not at all associations of the concept of gender are based on stereotyping; the challenge, as one research team put it, is 'to reduce gender biases in the word embedding while preserving the useful properties of the embedding',[124] but this remains work in progress.

The language models used by the growing number of LegalTech applications which have achieved a level of linguistic fluency employ techniques based on the word-embedding approach. They adopt a system-internal representation of 'law' on the basis of the word

123 Ibid 421.

124 Tolga Bulukbasi, Kai-Wei Change, James Zou, Venkatesh Saligrama and Adam Kalai, 'Man is to computer programmer as women is to homemaker? Debiasing word embeddings' (2016) Cornell University: Computer Science – Computation and Language arXiv:1607.06520 [cs.CL].

embeddings that comprise a given corpus. In principle they should be capable of replicating the kind of localised 'interpolations' which ANNs, in common with other evolutionary models, are designed to achieve. This process is of a qualitatively different order from the 'extrapolation' which occurs when a decision maker, such as a judge, generates a new meaning by synthesising existing concepts into a new one applicable to today's case.[125] For this reason, current legal-focused ML applications are in danger of 'freezing' in yesterday's legal solutions.[126]

If the use of ML in resource allocation and case prediction is likely to remain problematic, there are other, more constructive uses of ML. ML applications are in a line of descent from evolutionary models of the kind first developed in cybernetics and time-series econometrics. As such, they are well designed for use in identifying the long-run structural dynamics of legal and economic change. The ANNs used in ML applications are simplified models of the process of synaptic network connection which has been observed in the human brain. This form of 'neural computation' is similar to the 'direct fitting' which characterises evolution in nature: it 'relies on over-parameterised optimisation algorithms to increase predictive power (generalisation) without explicitly modelling the underlying generative structure of the world'.[127] This is also a good description of the kind of legal evolution which depends on trial-and-error learning to arrive at a provisional understanding of its context. Just as evolution in nature has allowed self-organising, well-adapted models of the world to be produced without prior design, the juridical analogues of variation, selection and retention enable legal systems to adjust to changing economic and political environments, in the process contributing to societal diversity and complexity. It is this dynamic process which ML applications should be well placed to model and explain.[128]

CONCLUSION

We have argued for a model of legal evolution which could usefully shape research into the structural dynamics of the law–economy relation, and help identify and resolve questions concerning the relationship between law and economic performance. Evolution, in our understanding, is

125 On the distinction between interpolation and extrapolation in this context, see Hasson et al (n 27 above); Simon Deakin and Christopher Markou, 'Evolutionary interpretation: law and machine learning' (2020 forthcoming) Journal of Cross-disciplinary Research in Computational Law.

126 Mireille Hildrebrandt, 'Code-driven law: freezing the future and scaling the past' in Deakin and Markou (eds) (n 111 above).

127 Hasson et al (n 27) 418.

128 Deakin and Markou, 'Evolutionary interpretation' (n 125 above).

a process of mutual adjustment between, and coevolution of, three elements: system, environment and code. Its principal resource is information, which is generated from the environment via selection and embedded in the code through inheritance or retention. The inter-temporal transmission of information results in variation in the characteristics of systems, and the cycle begins again.

The mechanism of variation, selection and retention can be observed not just in nature but in human culture and institutions, including legal ones. The process is blind or undirected, but is not random. The forms it produces are ordered representations of an ordered world. It can be expected to produce complexity and diversity, given enough time. One of its other results is stability, which can become stasis. There is no guarantee that it will produce optimal allocations. It may generate equilibrium solutions within a local design space but these may not be translatable to other contexts or more generally scalable. Because it is undirected and can only progress through recursive error correction, it is costly in terms of the resources generated and the necessary error rate.

It is not possible to ascribe purpose to evolution in nature; stability, diversity and complexity are by-products, not goals, of the evolutionary process. In a similar way, cultural or institutional evolution may produce stable designs with certain complex properties, and generate diverse institutional forms, but these cannot be said to be its objective or in any sense its predetermined outcomes. Since the outcomes of evolution are to a high degree indeterminate, it cannot be expected to have any particular normative content, whether that is described in terms of allocative efficiency or a given theory or idea of justice.

In the light of the above, it would seem that elevating evolution, as a blind, undirected or automatic process, above individual or collective agency as a mode of resource allocation, is a category error. Widening the space for evolution is to prioritise a process which is 'mindless' over others which enable human beings to apply the higher-order cognitive capacities which are one of the by-products of their biological evolution. Cultural or institutional evolution may have bequeathed similarly useful by-products in the social realm, but this type of evolution could be as much a barrier to overcome as a decision-making aid.

If evolution is not a model for human decision-making, evolutionary models may, nonetheless, help us to understand what is at stake in the operation of law as a mode of human governance. Law occupies a particular cognitive space, as a means by which a society's various modes of operation are recorded, retained, and diffused. To perform this task, law draws on the combinatorial power of human language, and, in the era of writing, on the stabilising properties of text. As a mode of representation, law is endogenous to its context, while also

maintaining its separation from it. Law's boundary with the economy and politics, while limiting its capacity to influence outcomes beyond that boundary, is the condition for the effectiveness of its own operations.

In its contemporary form, which has coevolved with the rise of the market economy, law is the publicly instituted expression of norms of behaviour which, among other things, guide economic exchange. This type of state-organised law is not beyond or outside the processes of cultural and institutional evolution which affect all social systems; the legal system, in Dennett's terminology, is a 'crane', not a 'skyhook'. The principal task of evolutionary law and economics should be to explain how the legal system, in its modern instantiation, has come to exist, and how it operates with respect to the economic and political systems, among others. It may be possible to provide a pre-legal understanding of the type of localised social order which operates between the ranchers of Shasta County or in the dense trading networks characteristic of Chinese *guanxi*, but these accounts do not explain the principal feature of a modern market economy, which is that most exchange takes place at scale and between strangers. Attention could usefully be redirected to the question of how the legal system structures that kind of trade.

With the digitisation of text, legal systems are operating within new technological parameters, with results which are difficult to predict. One immediate effect of the rise of machine learning and natural language processing is to provide researchers with new tools for modelling the law–economy relation. Machine learning relies on computational algorithms which are, by their nature, evolutionary. Thus they are in principle well suited to analysing the long-run dynamics of legal and economic change. Precisely because they model learning as a 'mindless' process of direct-fitting between system and environment, they may not be well suited to modelling decision-making by human agents, whether they be judges or law-makers.

The claim that computational algorithms should replace human decision-makers in the legal sphere as elsewhere is a direct line of descent from earlier claims for the general efficacy of evolution as a principle of institutional design. As before, this is to translate a descriptive model into a normative space. Evolution as method is one thing, evolution as norm entirely another.