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Regulatory Cybernetics: Adaptability and Probability in the Public Administration's Regulations

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Abstract

Dynamic perspectives from systems theory and cybernetics are used in this paper to introduce the self-adaptable legal regulation or individual decision-making based on Bayes networks. The latter, by using similar elements as systems theory or cybernetics can help decision-makers not only to quantify the evidential strengths of hypotheses but also to take the most probable decision. Nowadays legal science and the public administration with it that prepares the majority of draft legal rules, do not sufficiently address legal forms from which rules' content derives. The increasing speed of change and the consequent shortness of operative rules should force decision-makers to consider the new forms of legal norms and decisions that would still respect the objectivity and impartiality of decision-making.

Keywords:
Complexity, Regulation, Systems theory, Cybernetic, Bayes networks

> *Without changing our patterns of thought, we will not be able to solve the problems we created with our current patterns of thought.*
>
> —Albert Einstein

1. Introduction

The function of the law might be to produce *expectations* (Luhmann 2004), but due to the more and more complex environment, they are frequently unfulfilled. Nowadays courts increasingly demand decisions that go beyond the procedural rule of law towards a comprehensive duty of rational and consistent legislation (Meßer-

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schmidt and Oliver-Lalana 2016). Rationality as the universal promise of modernity also applies to the law (Grzeszick 2016), and thus the notions of legal consistency and coherence could be seen as the manifestations of "systemic" rationality (Meßerschmidt and Oliver-Lalana 2016), but there can be a problem here: consistency and coherence usually predispose the static environment, while a relation between a mean and a goal is not only static, linear and adversary, but also dynamic, layered, interdependent and thus complex, where a single line is replaced by numerous interactions, where the latter are interdependent and non-linear, where time lags are present between means and goals and where multiple iterations change the means, processes and goals to form a new entity that cannot be the same as it was at the start. A key premise here is that dynamic elements are not satisfactorily implemented in legal regulation as the purposeful system of formal goals. Every purpose-oriented system must by default be flexible, but the formation and implementation of rules is still mostly carried out through the classic legal tools of public administration, inspections, administrative and court procedures. These tools adapt too slowly to rapidly changing conditions in the environment. This paper aims to address the dynamic environment *vis-à-vis* rules' content and propose a solution that can be adaptable and known as well; for this, *adaptable* norms are proposed that change proportionately with situations. When the regulatory system is adaptive (when its environment is used according to legal goals), the ability to maintain expectations is *built into* the system as its element (one way to do this is an enactment of different rules or scenarios accommodated to different conditions/thresholds for the same situation). This paper's RQ hence goes one step beyond: *the meaning is based on systems/predispositions from which it is produced.*[2] Based on this, the research question is:

RQ: *How can legal control be established in a dynamic environment?*

To answer the RQ the literature on cybernetic and systems theory will be used; an answer can give useful directions for the administration of legal situations and systemic responses, through which control in a regulated environment can be established. Regarding the *research method*, qualitative research (theory description and extrapolation of elements) will be used from the field of complexity theory to present its element of emergence in order to point at the inevitably open, non-considered spaces (in our case of regulation) which make the static legal rules/decisions ineffective *per se*. This is further demonstrated with the present legal approaches in the dynamic environment in the third section, while the fourth section (compilation), based on the presented/extracted cybernetic and systemic elements, gives a foundation to present a platform that can address emergency and dynamism more effectively due to their basic ability to adapt. This is done in the fifth section, which combines the existing theory of complexity and systems to theorise the relationship

2 The examples of this claim are the geocentric *vs.* heliocentric models of the solar system, known as Kant's "Copernican Revolution" (1999).

among the dynamism, adaptability and legal structure, and based on them presents the mentioned platform (known as Bayes network, which includes the mentioned elements in its structure) on which a potential legal problem is solved, after which the conclusion follows.

2. The absence of emergence in legal regulation

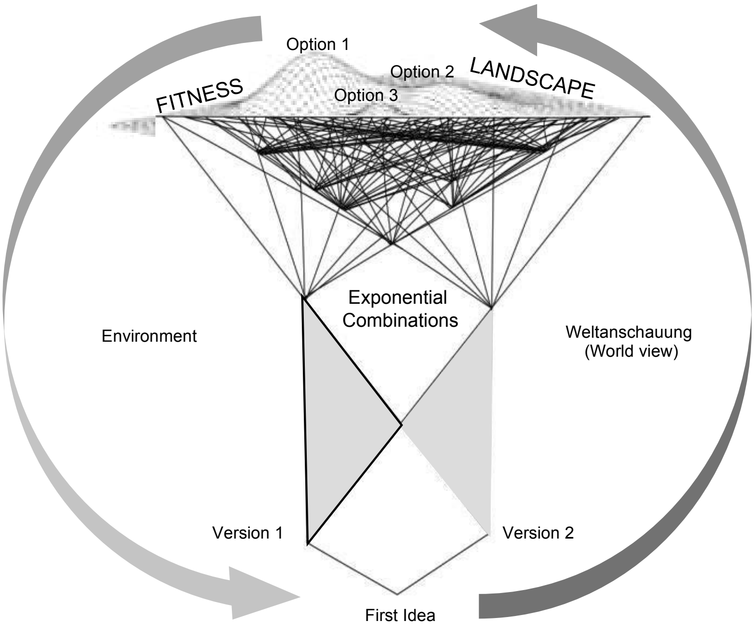
The problem of complexity (in regulation) strikes the public administration (PA) hardest because the vast majority of legislative proposals (above 90%) are initiated by the government in, e.g., Great Britain, Croatia, Finland, Hungary, Macedonia, Romania and Slovenia (Kasemets 2001). Dysfunctionality, legitimacy, efficiency etc. depends on the criteria and perspectives among which complexity theory – despite numerous works that emphasised the benefits of complex adaptive systems to the law-and-society system's behaviour (Ruhl 1996), organisations (Anderson 1999), public services (Haynes 2015), public administration (Kiel 2014; Koliba et al. 2010; Snellen and Klijn 2009), public-administration research (Klijn 2008), public decision-making (Gerrits 2012), political science and public policy (Cairney 2012; Morçöl 2012), public institutions and public policies (Room 2011; 2016) and governance systems (Teisman et al. 2009) – is still mainly present in theory, but absent in the practice of PA. The latter should be more at ease with complexity, law and flexibility (Rosenbloom et al. 2014); there is still a modest understanding of *interactions* in administrative decisions (Graaf et al. 2007; Herweijer 2007) and *a lack of understanding how decisions evolve in the dynamic environment*.

Ends never reflect only beginnings but also new contents unknown at the beginning (the same holds for legal rules); all forms of complex adaptive systems as the "systems that involve many components that adapt or learn as they interact" (Holland 2006, 1) have a characteristic known as *emergence*: "[a]n emergent property is a global behaviour or structure which appears through interactions of a collection of elements, with no global controller responsible for the behaviour or organisation of these elements" (Feltz et al. 2006, 241). All is not only more than the sum of its parts, but the end – due to numerous combinations – *cannot be known in advance*. It emerges through interactions, by combinations that exponentially increase with additional parts or relations: 2 elements produce 4 combinations (as in any other combination of n^r or 2^2), 4 produce 16 combinations, etc. This is known as the butterfly effect, where tiny causes can have big effects (Lorenz 1963). If the idea of emergence is notoriously understood, it is still not built into the legal system. In complex matters final solutions are different from initial ones, while new problems emerge spontaneously during multiple relations in the time of problem-solving.

The concept of emergence can be helpful to describe the end of a decision-making process: a final decision is usually the result of numerous, intertwining combinations that interact between arguments and parts that were not included in the initial idea. The beginning and the end are only indirectly linked through the problem's exposure and the final solution; the latter reflects various arguments of several stakeholders who have adapted to the surroundings of other arguments and who have, in their "mutual conflicts", changed their content. Each solution is the result of several combinations, each solution has more than the beginning, and each solution represents the exponential result of the best result, which we do not know until it occurs. All the rest are, from the future's point of view, just (good/bad) predictions. A decision-maker should decide carefully on a particular path and constantly correct errors in terms of changes in the environment and according to predefined thresholds that require different reactions. The exponential function leads to the emergence of numerous (incomprehensive or chaotic) combinations that settle around the highest peaks (the same is true for popular ideas).[3] Figure 1 below visually presents this:

Figure 1

Decisions' complexity and (self) organisation



Source: own construction.

3 Although criminal codes have a large number of criminal offences, most of them in practice focus on violent crime, homicide, robbery, property crime and drug offences.

The "adaptive evolution" of a decision in a given context can be viewed as a "fitness landscape" or a hill-climbing process (in the law it is present as the prevailing legal rule with factual deviations among possible alternatives). The latter has emerged from Wright's shifting balance theory, which has presented the occurrence of genetic flow in small populations under environmental factors to understand evolution as a process of cumulative change that depends on a balance of conditions (Wright 1931). Based on this, Kauffman developed the theory of fitness landscape as "any well-defined property and its distribution across an ensemble" (S.A. Kauffman 1993, 37) to demonstrate the spontaneous emergence of order, i.e. the occurrence of self-organisation (in PA this is known as "that's the way we do things around here", or more formally as path-dependency as "a sequence of events narrowing the scope of action eventually resulting in a state of persistence or inertia"; Schreyögg and Sydow 2009, 4). Kauffman demonstrated that the spontaneous (natural) order exhibits itself as a consequence of autocatalytic reactions or the collective dynamics network.[4] The principle of self-organisation or equilibrium between competing combinations from evolutionary biology can also be used in social systems:

> *In collective decision making, fitness can be defined as 'the probability of an actor achieving its problem and solution definitions, that is, the actor's desired goal(s) as defined in its PSD [problem and solution definition]. An actor's ability to get closer to its goal depends on its position relative to other actors, not just on its own intentions or deliberate planning but also on what others connected to that actor do'* (Gerrits and Marks 2017, 75).

Adaptation normally progresses through small changes involving a local search in the space of possibilities (Jacob 1977); progress occurs by adaptive processes that gradually accumulate advantages *vis-à-vis* their competitors in the selected, context-dependent environment. A similar logic applies to legal decisions. If rules/regulators do not appropriately address changing contexts, situations will spontaneously – due to the very richness of interactions (Waldrop 1993) – regulate themselves towards their equilibrium (S. Kauffman 1996; Prigogine and Stengers 1984). In the field of decision-making also the fittest parts go towards equilibrium; through the latter they self-made "order for free": a decision-maker should not only be prepared (to stop the new order of things) at the time of a proposal but throughout the whole time in which the proposal obtains content in cooperation and later implementation with different stakeholders. Emergence and adaptation (self-regulation) are the inevitable facts of life, so it is worthwhile to see how they

4 In 1965, he programmed the N = 100 gene network (now known as the Kauffman/Boolean network), with each gene receiving K = 2 randomly chosen inputs from among 100. Such a network has 2^{100} states. "It turned out from numerical evidence that the median number of states on a state cycle was *the square root of N…* Self-organisation that confines patterns of model gene activities to tiny regions of the network's state space arises spontaneously in these networks. There is order for free" (S. A. Kauffman 2010, 110).

are present in the existing legal rules. The next section addresses this idea with the help of EU regulation (the latter was chosen due to its wide applicability in all EU member states).

3. The best criteria so far in the EU regulation that addresses adaptability

The complex adaptive systems[5] (an ecosystem, the market or the law in its best version) can reveal various forms of adaptation and self-organisation, of which the market is the clearest example. In the field of competition, the EU has enacted extensive regulation (from the Single European Act of 1986 onwards), while to our knowledge the Directive 2006/123/EC of the European Parliament and of the Council of 12 December 2006 on services in the internal market (OJ L 376, 27 December 2006, 36–68) is a rare example that is, on the legislative level, focused on (adaptability, i.e.) the removal of barriers to further implement the freedom of establishment and the right to provide services (Articles 49–56 TFEU). A service activity should be subjected to authorisation by the competent authorities only if that decision satisfies the criteria of non-discrimination, necessity and proportionality ("the objective pursued cannot be attained using a less restrictive measure, in particular, because a posterior inspection would take place too late to be genuinely effective"; Article 9). Article 10(2) gives conditions for the granting of authorisation that preclude the arbitrariness of competent authorities: "[t]he criteria shall be: (a) non-discriminatory; (b) justified by an overriding reason relating to the public interest; (c) proportionate to that public interest objective; (d) clear and unambiguous; (e) objective; (f) made public in advance; (g) transparent and accessible." Despite the clearly written criteria, they are still of qualitative nature, which gives significant room for a decision maker's margin of assessment (developed by the ECtHR in *Greece v. the United Kingdom*, no. 176/56 of 14 December 1959) to decide in case-by-case matters. A step forward already occurred in case records and arguments *vis-à-vis* the public-interest goals, but in the rapidly changing environment, the criteria and cases to be decided should not only be managed in a more automated way but also a more objective one, irrespective of the existing composition of decision-makers or judges at the end of a decision line.

Although the OECD (2018) acknowledges (as the element of feedback from systems theory) the importance of *ex-post* evaluation of regulations, along with the importance of *ex-ante* evaluation of administrative burdens, these approaches are still on a qualitative level, where quality is "in the eyes of the beholder", not "in the eyes of the beheld". A demand to reduce regulatory burdens can be a part

5 Complex adaptive systems consist of "many interacting components, which undergo constant change, both autonomously and in interaction with their environment. The behaviour of such complex systems is typically unpredictable, yet exhibits various forms of adaptation and self-organization" (Heylighen 1999, 1).

of evidence-based management (Rousseau 2013), or it can fit into the "best evidence rule" (Fisher 2012) that helps to determine whether burdens are necessary, but we should not disregard *ex-post* looks for results *vis-à-vis ex-ante* rules without knowing/considering the causes, combinations and exponential relations that caused results. The features not included of the above-mentioned EU criteria are the connectivity, interaction, communication, feedback, combination, self-organisation and the exponential function between individual elements that are formally focused on the implementation, coordination, control, data collection, information and decision-making. Just as an organisation must address models of *actual-relational-exponential* operations to change them or to be effective, also rules "self-create" models of their surroundings to do the same. Having this in mind, changes to the above-mentioned criteria should be more efficiently sought as a reflection of the surroundings, without the need to decide in a case-by-case manner. This can be done, as was said, with general rules. Through them, countries require businesses and private individuals to conduct or avoid certain actions or require a provision of information on conduct.[6] The first should also be attentive to all accommodations and adaptations during the implementation phase. On a quest to address the question of how to form a more adaptable rule (its form), we will present a flexible, automatic method by which general rules can also reflect more quantitative elements. This will be done with the help of elements from cybernetics and systems theory.

4. Cybernetic and systemic elements

In addition to drafting the general legal rules, PAs could not only regularly monitor regulations' effects and take appropriate actions but also prepare them based on systemic (Luhmann 2013) and cybernetic theory (W. Ross Ashby 1960; Beer 1966; Wiener 1961; the theory of control mechanisms based on the concepts of information and feedback as part of a general system theory) that allows rules' *self-adaptations* according to formal goals *vis-à-vis* their embeddedness in the wider system dimensions. Even though cybernetics was recognised as the control and communication in the animal and the machine (Wiener 1961) almost 60 years ago, and despite its direct connection with the law and communication[7] it is still not present in legal regulation and control. The fact of its non-usability per se, parallel with the classic legal tools, confirms the regulators' predominant, classical use of intuitive feelings during the preparation of draft rules, despite the

6 When these obligations are proportionate to an intended goal and are composed of the usual costs of business and justified legal burdens (those address market failures), they are known as administrative costs (the harmful, reverse effects of administrative costs are known as administrative burdens). On the other hand, even administrative costs can cause unintended consequences when goals could be achieved more easily/innovatively.

7 Law is the ethical control applied to communication… Thus the problems of law are communicative and cybernetic – that is they are problems of orderly and repeatable control of certain critical situations (Wiener 1989, 104, 110).

known human cognitive fallacies (Gambrill 2012; Kahneman 2013; Tversky and Kahneman 1974), from which emanate unintended or harmful consequences (Merton 1936; Parrillo 2005; Sieber 1981). Systems theory and cybernetics thus use the notion of regulation similarly to the way it is used in the field of legal regulation[8]; the paper therefore further proceeds to extract elements from systems theory in order to apply them or to gain new perspectives in the field of regulation. There is always more than one way to look at a problem; sometimes it helps that problems from one field are evaluated by another one.

The problem of emergence can be addressed by systems theory. Systems are not only a collection of things or people that relate to each other but "[i]n fact, most systems of interest in decision making may often consist of abstract things and their relationships" (Daellenbach 1996, 28)28. A system *per se* cannot be divided into independent parts without the loss of its essential functions and by its default should be attentive to the whole vis-à-vis its parts. In the system, the rules of interaction collectively have a given purpose or are purposeful, i.e. "strive towards some state of balance" (Daellenbach 1996, 5)5 – that is the same as equilibrium in complexity – and/or "can select both means and ends in two or more environments" (Ackoff 1999, 21). Decision-makers must not blind their eyes to the fact that such concepts are not present either in the field of law. With the cybernetic/systemic approach, the regulatory and administrative decision-making can be more rational when the legal rule's *structure* (parameters, attributes and criteria) is primarily addressed as the essential condition for successful regulation; the rule's optimal semantic/linguistic precision is, as the derivation of the first, of secondary importance. This can be done when the below-given cybernetic directions/elements are applied. As this also holds true for the legal system, the latter should not disregard the below-given elements (if decision-makers aim at the successful legislation/regulation), extracted from the cybernetic and systems theory.

A system has components. The system is the organised whole, consisting of the interconnected and interdependent parts, components and subsystems. The general scheme of an open system is made from the following parts: 1. input, matter, energy and information; 2. a transformation process as the process by which input quantities change into the output of the system; 3. output is the result of the transformation process; 4. the environment – an open system is surrounded by an environment from which it receives input resources and to which it gives back outputs; 5. feedback – to maintain a current situation, a constant feedback flow from the output to the input is needed; the feedback is the necessary communication channel for

8 Administrators often address future oughts by using the notions of the "system", "whole" or "complete" without the inclusion of system elements or anticipation that the system self-moves according to its positive and negative feedback loops (Meadows 2008). The system's parts interconnect in numerous ways, relations and exponential combinations, and they are present even where a regulator's due care is present. "If [regulation is] left alone, it will regulate itself" (Vickers 1995, 43); this is not only a warning but up to a point an inevitable fact – the (legal) system is always more open (to other elements) than legal norms at the time of their enactment.

the control mechanism; 6. the control mechanism compares the values of the actual output with goal values and gives an initiative for necessary changes to maintain the system in a stable and/or more preferable state; 7. a boundary of the system is determined by frames that separate it from the environment.

Limit the flow of diverse data. According to Ashby, a complex (assembled) problem can be administrated only with the same or a similar measure of complexity, known as requisite variety (William Ross Ashby 1957). A decision that addresses numerous people can be manageable only with the cooperation of all people. This is usually not possible in the reality of complex life, so Ashby's idea of requisite variety needs "regulation that blocks the flow of variety … an essential feature of the good regulator is that it blocks the flow of variety from disturbances to essential variables" (William Ross Ashby 1957, 199, 201). A homeostatic loop of a regulator's amplifiers (from a regulator to a system) and filters (from the system to the regulator) is inserted to deal with an interesting part of the environment. If this is not done, the system self-regulates towards its equilibrium. Reality is too complex to be fully addressed; combinations exponentially increase when new parts are added, new interconnections and new patterns emerge, so representativeness (a sample size) must be established. To prevent disruptions, a good regulator limits the flow of diverse data to only some, essential, manageable criteria that address the observed surroundings.

Reality can be represented in a (black box) model. For analysis and design, a physical system or the real environment should be replaced by a simpler representation, by a *model* to gain a better insight into the environment. In the study of a physical or regulatory system, one may use *several* or many different models (Page 2018), depending not only on the problem being studied but on the perspectives by which something is recognised as a problem, i.e. the theoretical considerations, experiments, costs and calibration/precision requirements. The model ignores many attributes of the physical system and retains only qualities considered crucial to the problem under study. Robustness and/or stability is an important concern not only in system design but in the design of all dynamic systems (Callier and Desoer 2012; Willems 1970). A regulatory system is a nonlinear, complex and dynamic system with input-output stability, among which is placed a "black box" which – with the unknown things and combinations – transforms one or more inputs into one or more outputs. Deviations can be estimated by calculating the effect on system performance due to changes in design parameters and exogenous disturbances.

Feedback loops. Things self-regulate if a regulator does not regulate them (Vickers 1995). Even when the regulator does this, all things do not converge into a wanted state; the regulator's goal is to estimate a region to which things/motions/actions largely converge and to find proper nudges to push them towards a wanted position. This is done with the help of a feedback loop as the nonlinear or non-stationary system element. "Control of a machine on the basis of its *actual* performance rather than its *expected* performance is known as *feedback,* and … when the information which proceeds backward from the performance is able to change the general method and pattern of performance, we have a process called learning" (Wiener 1989, 24, 61). The feedback loop should respond and accommodate values automatically; its internal autonomy is not jeopardised because the system reproduces itself through its operations (the combinations and values of internal parameters change if this change is based on pre-written codes or scripts – i.e. rules – as alternative scenarios in the face of changed values). In this way, "the *expectation of disappointment*, which is the core reason for communicating expectations in a normative style" (Luhmann 2004, 241) could also be smaller. The feedback is the most important element of the system since it allows the latter to adapt to a wanted position by making concrete decisions; dynamic balance exists with the continuous input data and the acceptability of outputs (results) for the environment (humans). Maintaining the state and adjusting activities through feedback and decision-making according to the final goals of the system represent a *sine qua non* of each adaptation in nonlinear systems (the cyclicality of events is present due to the growth and expansion, regression and recession). Controlling the tendency toward disorganisation and/or the process by which living beings resist the general stream of decay is known as homeostasis. If a homeostatic system is made, there is no need to have strong legal enforcement to realign input-output relations. There would be less need to maintain a feedback loop "manually" through public administration or court adjudications or general legislation when a situation demands so. This commitment should be engraved *in* the system.

Quid pro quo resemblance. The decision-maker should consider that: a) only diversity can address diversity; a complex (assembled) problem can be administrated only with the same or a similar measure of complexity (Ashby's requisite variety) (William Ross Ashby 1957); b) the regulator must be a model of a regulated area/thing (Conant-Ashby theorem) (Beer 1994); c) any decision is as good as its regulator. The administration of development requires the continuous monitoring, control and evaluation of effects because the main purpose of the first is to ensure the effectiveness and efficiency of implemented measures in a managed field. For good governance, planning, monitoring and impact assessment, timely responses to deviations are needed, which means that the fundamental elements of the system are present in decision-making.

A probable future. As in the case of an environment's complexity, the reality is replaced by a simpler representation; in the legal field, the reality is represented by a legal model. The usual way in science is to find a model's properties, capabilities and limitations, while in the second case, a proposed legal rule – after its enactment – is usually directly applied *without* testing, even though rules regulate *pro futuro* cases where in the time of enactment there are no causal relations known; they are hard to establish even for past or present states (Carnap 1966; Cziko 2000). Statistical models can be used for the past (adjudication, the testing of hypotheses, explanation), which indicates the strength of the relationship (in-sample strength-of-fit) or for the future (prediction), in which the accuracy of out-of-measurable-sample predictive power can be estimated. For the first methods, regression analysis (the coefficient of determination or R^2) and structural equation models (Chi-Squared, Akaike information criterion) can be used, while for the second, predictive analytic tools can be utilised (all statistical models, machine-learning and data-mining algorithms that can produce predictions, like the k-nearest neighbour algorithm, random forest, decision tree learning (CART), Monte Carlo method or Bayesian networks; Nielsen and Jensen 2007; Pearl 2009; Shmueli et al. 2017). A further step from sampling towards better future decisions is the so-called field of business analytics or data mining. The study of these questions is the task of systems theory that uses mathematical and other tools that give predictive power to a model, so the merits of various model alternatives may be ranked before investing resources to build the most successful or highly predictive alternative. And the same also applies for the legal field, for which a system's elements should be given and interconnected in the first place (the communications, model, system, feedback, adaptation, black box, stability, responsiveness, autopoiesis, input-output relations, predictions, homeostasis) to represent the legal system as responsive, without adjusting it manually, i.e. by implementing rules one by one, usually after a violation has occurred.

Law and probability. At first sight, the principle of legal certainty contravenes probability. Among lawyers, Kelsen made a clear distinction between the principle of causality ("If *a* is, then *b* is or will be") (*sein*) and the principle of imputation ("If *a* is, then *b* ought to be") (*sollen*), the first being part of natural (descriptive) science while the second of normative science (the normative connection between two facts) that addresses conditioned human behaviour dependent on "a legal authority (that is, by a legal norm created by an act of will)" (Kelsen 2005, 77). On the other hand, a simple mathematical rule shows two parts (2^n) always have four combinations, so there must be something more than sole authority. The normative element of ought also includes uncertainty – and with that also the applicability of probabilistic methods to tasks that require reasoning under uncertainty (Pearl 2014) – because legal actions are conditioned on the actions of other facts (be they persons or things).[9] In *Philosophical Foundations of Physics*, Carnap has, even for the natural sciences, demonstrated causality "is not a thing that causes an event, but a process…[in which] certain processes or events cause other processes or events" (Carnap 1966, 192). A state where each consequence is also a cause that together with other causes contributes to the later multilevel and intertwined consequences is more and more complex and not all relevant facts can be known, so causal relation means solely potential predictability. Legal accountability is possible only in

9 Additionally, Bayes' theorem (it explains the probability of an event based on prior knowledge of conditions that might be connected to the event) shows that there is more than just authority: the probability (P) of truth (T) given authority (A) = $P(A|T)\ P(T)/P(A)$. Because $T + A = 1$, there is never only authority without truth (even in the most autocratic countries that need it for the efficient administration of the country).

cases where sufficient regularity in causal relations can be established to be able on this basis to predict consequences with high probability. A model's value increases proportionately with a higher level of prediction, and this stands for the legal principle of certainty.

Interactions. A solution to a problem should not be treated independently from other aspects of the problem, or a system's performance cannot be evaluated from the standpoint of its part: it is the product of the interactions of *all* parts. Among the additional elements are the administration of uncertain information and quantitative methods that address the former. They both address intuition's shortcomings; their content is separated from the cybernetic elements because they can be studied distinctly (in the view of the adaptive and more reliable regulatory model, they are additional elements that must be built into the model).

Quantitative methods. In past decades, there was significant interest in the assessment of probability, risk analysis and related similar methods that address uncertainty. Decision-makers should prefer quantitative methods because "[t]he major advantage [*vis-à-vis* qualitative language] … is that quantitative concepts permit us to formulate quantitative laws. Such laws are enormously more powerful, both as ways to explain phenomena and as means for predicting new phenomena" (Carnap 1966, 106). A legal system to predict optimal general rules and/or decisions should, therefore, have its origin in the quantitatively assessed probability that deals with uncertainties (a classical way is to use intuition based on experiences) in a more objective manner. By this way, it could be inferred with a higher probability whether a proposed legal rule is effective.

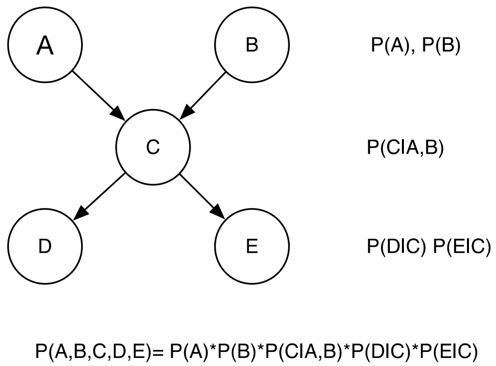
5. Bayes networks

The needed adaptability of legal rules in the complex and dynamic environment should exhibit the basic elements of systems theory, which were presented in the previous section. Although regulation has elements of adaptability[10], it is still far from the needed level. Given the absence of an appropriate method in the law other fields have been checked whether they incorporate cybernetic and systemic elements in their domain, as presented in the previous section. A field that can exhibit the needed adaptation and the mentioned elements was found in the field of probability, in Bayes (belief) networks (BN). Pearl (2009; 2014) found that the problem of storing and processing uncertain information (and general legal rules that address the uncertain future clearly fit into this frame) could be solved by using

10 The usual ways by which the law is accommodated to a current situation are done by the canons of interpretation (Sutherland 1891; Scalia and Garner 2012), legal principles (Dworkin 1978; Braithwaite 2002; Black 2008)"plainCitation":"(Dworkin 1978; Braithwaite 2002; Black 2008, legal experiments (Pontier 2001; Engel 2013) or sunset clauses (Breyer et al. 2006). There is usually no quality-control means established that uses diagram rules or statistics (as inductive reasoning) and probability in sampling techniques to determine a level of risk.

conditional independence presented in directed acyclic graphs (no feedback loops from a variable back to itself – do not equate them with a system's overall feedback that connects the system's results with an initial problem) that represent only the most significant variables in the system and causal links between nodes. By encoding probabilities and the conditional independence relations among them, the d-separation algorithm is used to better understand and model complicated problems, i.e. to upgrade numerical to graphical representations to be able to compute relevant conditional independence relations in graphs (seen in conditional probability tables). Pearl named the whole method Bayes network; it represents a way of modelling the causal structure of systems that determines predictions that could be tested without conducting experiments (in multivariate systems that contain more than two variables for which a simpler Bayes rule could apply). The d-separation criterion determines which variables are independent in a Bayes net and permits us to display induced and non-transitive dependencies. It assumes that each node is conditionally independent of its non-descendants *given* its parents (a node is conditionally dependent only on its parents).[11] BN and a method to calculate all probabilities given their parents are presented in the below-given Figure 2:

Figure 2
Bayes network



Source: own construction.

11 BN in general represents joint distribution as $P(y_1, \ldots, y_n) = \prod_{i=1}^{n} P(y_i|\text{Parents}(Y_i))$, where Parents($y_i$) denotes immediate predecessors of Y_i in the graph, so joint distribution is fully defined by graph plus $P(y_i|\text{Parents}(Yi))$.

The system's components are represented in BN with a set of nodes and causal links, the limitation of diverse data is made by conditional probability tables[12], the feedback loop can be seen by constant adjustments of conditional probabilities that can be at the same time viewed as the black-box model, and a probable future is addressed with probabilities *per se* (decision-making under uncertainty). In addressing uncertainties with a large number of factors, the Bayes approach can thus be used, which establishes a network of connections between causes/factors and effects/decisions. With the calculation of probability for the individual causes, effects and their combinations, the established model enables the evaluation of common preferences in the decision-making of involved stakeholders. Probabilities can be constantly changed due to changes in the environment.[13] The most widespread formalism for the establishment of probable cause-and-effect models are BN and their upgrade for the support of decision-making, decision diagrams or influence diagrams (Howard and Abbas 2015; Nielsen and Jensen 2007). BN are used to conceptualise and simulate a system that contains uncertain consequences through the incomplete understanding or insufficient knowledge of a system in a graphical model with a probabilistic structure (Pearl 2014). BN are "also applicable as a tool to assist decision-making in natural resources management, where issues are complicated and data are insufficient and uncertain" (Keshtkar et al. 2013, 49). BN enable the treatment of uncertainty and stochastic decisions; on the other hand, they enable the integration of a large number of heterogeneous factors, which is a clear advantage over the naive approaches of the direct use of the Bayes theorem (Carrier 2012). BN enable a simple graphic presentation of a complex network of connections between factors and decisions, thus bringing complex decision-making processes closer to stakeholders. Because of these advantages, the influence di-

12 To construct an adequate representation of probabilistic knowledge for all inferred judgments, we must define a joint distribution function $P(x_1, \ldots, x_n)$ on all propositions and their combinations. While useful for maintaining consistency and proving mathematical theorems, this view of probability theory is inadequate for representing human reasoning; the elementary building blocks of human knowledge are not entries in a joint-distribution table. Rather, they are low-order marginal and conditional probabilities defined over small clusters of propositions. Another problem with purely numerical representations of probabilistic information is their lack of psychological meaningfulness. The numerical representation can produce coherent probability measures for all propositional sentences, but this often leads to computations that a human reasoner would not use (Pearl 2014, 78). Numbers confirm this: a conditional probability table for Boolean x_i with k Boolean parents has 2^k rows for combinations of parent values. If each variable has no more than k parents, the complete network requires at most ($n * 2^k$) numbers. This is a lot less because it grows linearly (not exponentially) with n (the number of nodes), vs. (2^n) for the full joint distribution. For 5 n the first with 2 parents has 10 variables and the second $2^5 - 1 = 31$. To fully describe the network, only 10 values are needed instead of 31.

13 The addition of new probabilities based on past experience is similar to the concept of stigmergy, which describes "a mechanism of coordination used by insects. The principle is that work performed by an agent leaves a trace in the environment that stimulates the performance of subsequent work – by the same or other agents. This mediation via the environment ensures that tasks are executed in the right order, without any need for planning, control, or direct interaction between the agents" (Heylighen 2016, 4).

agrams can be used for modelling decision-making processes in various fields, and the legal one is no exception.

Example of Bayes Network. For the sake of simplicity and a gradual transition to the proposed arrangement, suppose we saw an increase in the number of requests for the relocation of a post (P=yes) and that mobbing as the cause is excluded (M=no). We are, for example, interested in the probability that the reason for relocation is a new office location (L); then we are interested in P(L|M=no, P=yes). If we want to find out what is the most likely cause for this, we must calculate P(B|M=no, P=yes) and compare both probability distributions of possible causes with the observed state. In this case, we will refresh the belief for two variables, L and B. We are interested in how the conditional probability of the new location will change at a given condition change P(L|M=no, B, R, P=yes). Graphically, our interest is illustrated (with added probabilities) in Figure 3.

We need to calculate the following two terms:

P(L=yes|M=no, B, R, P=yes) = $\frac{P(L=yes,M=no,B,R,P=yes)}{P(M=no,B,R,P=yes)}$ and

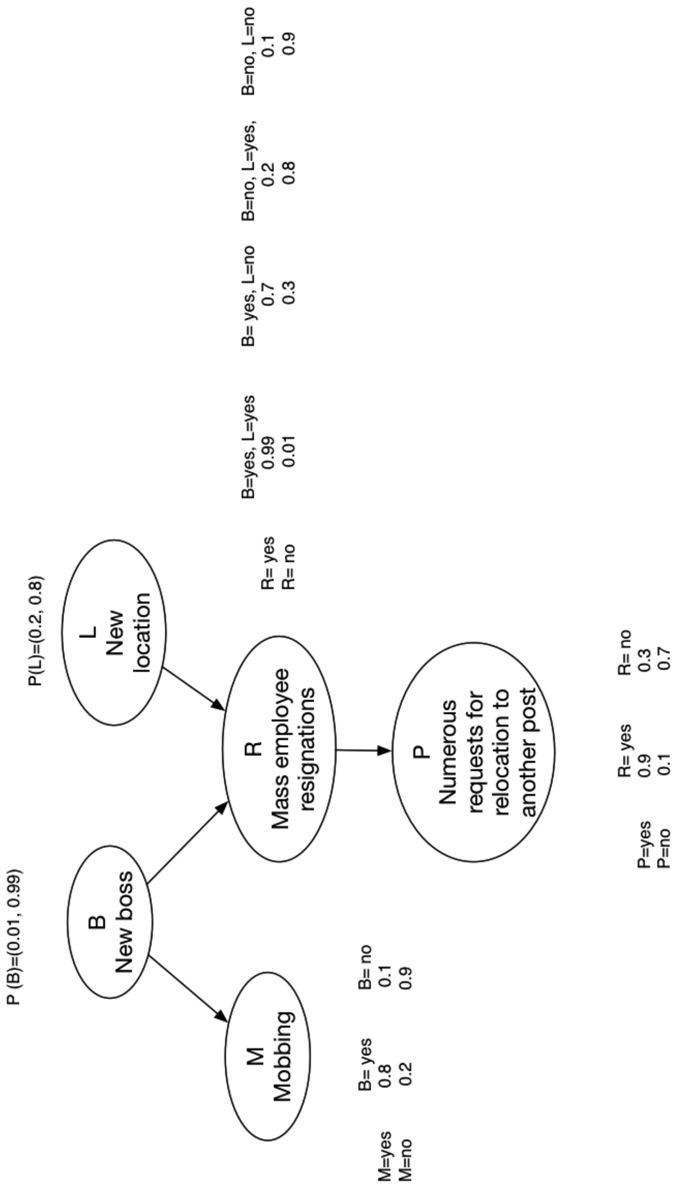
P(L=no|M=no, B, R, P=yes) = $\frac{P(L=no,M=no,B,R,P=yes)}{P(M=no,B,R,P=yes)}$.

It is enough to calculate the counters in fractions and then to norm the obtained probabilities. The calculation for the first of them is shown, since the course is the same for both:

P(L=yes, M=no, B, R, P=yes) =
= ∑ P(L=yes) P(B) P(M=no|B) P(R|L=yes, B) P(P=yes|R)=
=P(L=yes) P (B=yes) P(M=no|B=yes) P(R=yes|L=yes, B=yes) P(P=yes|R=yes) +
+ P(L=yes) P(B=yes) P(M=no|B=yes) P(R=no|L=yes, B=yes) P(P=yes|R=no) +
+ P(L =yes) P(B=no) P (M=no|B=no) P(R=yes|L=yes, B=no) P(P=yes|R=yes) +
+ P(L=yes) P(B=no) P(M=no|B=no) P(R=no|L=yes, B=no) P(P=yes|R=no)=
=0.0003564 + 0.0000012 + 0.032076 + 0.042768 =
=0.0752016.

Similarly, another counter is calculated, and it is 0.25776. After standardising the meters, the conditioned probabilities are calculated: P(L|M=no, P=yes) ≐ (0.23, 0.77) and that is P(B|M=no, P=yes) ≐ (0.005, 0.995). Given the new perceived facts, it is more probable the cause for the created situation is a *new location*, not a new boss. The probability for the first variable P has increased, while for the second M has decreased. The likelihood of the variables remained the same in the network, while conditional probabilities changed with the changed results. If a problem is presented as BN, probabilities can be calculated for any kind of problem. A result can be later transferred into a relevant legal norm or can be a cause of its change. Initial evidence could be, for example, as in Figure 4 below, a high number of road casualties. Testable variables are in the grey pattern,

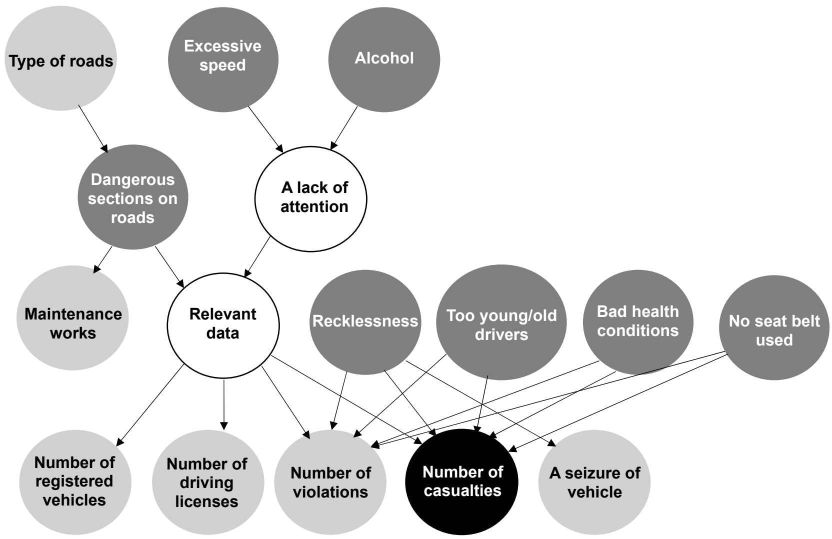
Figure 3
BN – the relocation of the post



Source: own construction.

"broken, so fix it" variables are dark grey, while hidden variables (white) ensure sparse structure and reduce parameters. Given a country's road-casualties statistics, the probabilities of nodes can be calculated[14] and based on that the appropriate (regulative) measures can be applied:

Figure 4
BN for the problem of road casualties



Source: own construction.

6. Discussion

General legal rules are still used in a very static manner, while combinations among rules and facts still *de facto* emerge and further produce new combinations. A classic response to the question of rules' efficiency could state that decision-makers should test whether unintended/harmful consequences emanate from a lack of evidence-based management, from the bad public policies that *ex ante* do not balance different interests or *ex post* disregard the (changing) contexts of previously justified responses, etc. Although this is (intuitively) a good idea, it says nothing about the *form* of such methods. Legal rules could copy/follow the behaviour of adaptable systems, as humans are also such systems. The stability or adaptability of a system (i.e. in our case, legal control) is a property of the system as a *whole*, and includes *co-*

14 The MSBNx Bayesian Network Editor and Tool Kit can be used to calculate probability values within the BN (Microsoft Research 2019).

ordination[15] between parts. A legal system should be no loose conflux of events but a tight and knowable network of communications, consisting of much information that presents reality as a *network* (Beer 1986; Luhmann 2013). The latter could, due to its ever-present positive/negative feedback, allow the system's self-maintenance and self-adjustment to (pre-determined) formal goals. This kind of self-adaptation can be understood as systemic, as the regulatory cycle that self-learns. In this paper this goal is seen in *adaptable* norms that change proportionately with situations.

With a known joint distribution in BN, with the known BN's structure and its formulas, a final event's probability can be calculated, given the known/changed probabilities of each part in the network. The interactive version of BN is very useful to understand how the system's adaptability changes and to know further actions can be coordinated; in this manner, the Asia network is demonstrated on the website Bayes server (Bayes server 2018), where everyone can see how BN works in practice. BN is the example of complex adaptive systems that could be used in the legal science for the objective of prediction/verification of future/past events; results can then be used at legal drafting. BN can be used as a (computerised, applicative) tool to verify a formal decision and/or a citizens' decision, i.e. to (re) evaluate the latter in the light of BN's results (the latter are more relevant proportionately with the larger number of inputs). Legal control in complex adaptive systems (an ecosystem, the market or the law in its best version)[16] can be established when a pattern created by interconnections (between the system's, i.e. rule's, parts) can be changed, and not when rules' content is fully known in advance (even the case law demonstrates a rule's content cannot be fully known in advance because it always accommodates and applies to context). Given the structurally based BN regardless of its content the RQ from the introduction of this paper is "conditionally positively answered": *control can be established when the system's pattern, i.e. its results, can be revealed and changed when intentionally changed input values change the behaviour of the whole system*. This can be done by changing the input probabilities as input variables in BNs that accordingly give a different final result.

7. Conclusion

In the future, complexity will increase due to its inevitable element of the exponential function. The law is no exception, and although we could not predict what will happen, regulators and practitioners could more objectively predict what could

15 Science of PA is inevitably connected with coordination: "the development, if not the survival, of civilization depends on organization, coordination and the responsible and purposeful handling of human affairs; that is, on the science and practice of administration" (Thompson 2003, vi).

16 Complex adaptive systems consist of "many interacting components, which undergo constant change, both autonomously and in interaction with their environment. The behaviour of such complex systems is typically unpredictable, yet exhibits various forms of adaptation and self-organization" (Heylighen 1999, 1).

happen and prepare actions according to the result, provided that they are more attentive to the presented cybernetic and systemic elements. Although in the present time it cannot be known why something will happen, it is possible to know better *how* something happens, how changes can be spotted, and how the legal system and conditions in which it operates can be changed. BN is one approach that can be used in this manner. As the present forms of regulation BN can be good in proportion with the quality of data put into it, while the former better includes the elements of complex adaptive systems. In the rapidly changing environment, only *structure* can be known and its results accepted or rejected by the legislature with the change of a norm's content (e.g. when the norm's variations are known at its enactment as various legal scenarios, legal certainty is not endangered). A deeper insight into the process of forming rules in the complex environment that this paper presents emphasises the idea that it is not about rules but how they are *framed* and how they *interact*. In the future practitioners should be more focused on the *adaptability* of legal norms that could more effectively address the complex and dynamic environment (while legal certainty should not be endangered). The promulgation of a law in an official journal – as a necessary formal condition for legal validity – will probably be replaced in the future by online insight into the rule's content and/or its automatic transmission into our mobile devices. It is not about a rule's content but its *prepositions* and *relations*; it is about the distribution of belief in causal relations/links. In the future, legislators will probably discuss methods/algorithms from which rules' content derives. The principles of objectivity and impartiality could be placed at a higher level if paradoxically nobody knew – in a manner of Rawls's veil of ignorance – in advance the rules' final contents, as long as their *form* will be known. And this is something that the present forms of legal drafting cannot provide.

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