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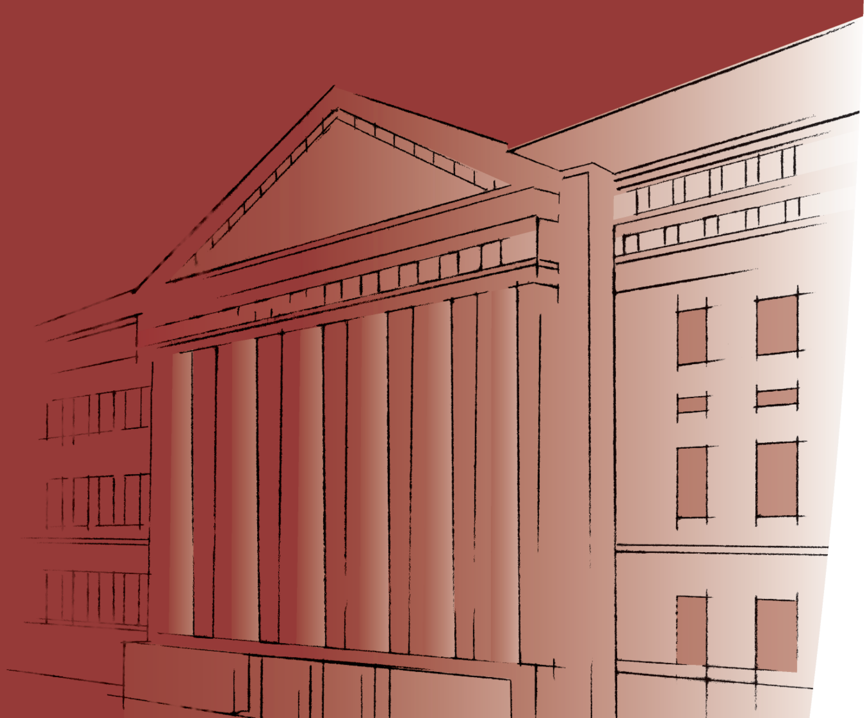
Normativity of scientific laws



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Normativity of scientific laws

UNIVERSITY OF TARTU
PRESS

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TABLE OF CONTENTS

LIST OF PUBLICATIONS

I. Mets, Ave, Rafaela Hillerbrand (2009). Epistemic uncertainties in climate predictions (poster). Conference “Philosophy for Science in Use”, Linköping 28.9.–2.10.2009

II. Mets, Ave, Piret Kuusk (2009). The constructive realist account of science and its application to Ilya Prigogine’s conception of laws of nature. *Foundations of Science* 14:3, 239–248

III. Mets, Ave (2009). Sotsiaalteaduste teaduslikkusest. Rein Taagepera *Making Social Sciences More Scientific: The Need For Predictive Models*. *Studia Philosophica Estonica* 2:1, 112–134

IV. Mets, Ave (2011). Measurement theory, nomological machine and measurement uncertainties (in classical physics). Conference EPSA11, Athens 5.–8.10.2011

V. Mets, Ave, Rafaela Hillerbrand (2011) Messtheorie und Messunsicherheiten (poster). Conference “Exploring Uncertainty”, Aachen 9.–11.10. 2011

VI. Mets, Ave (2012). Some limitations of universal international law from a philosophical point of view. *Law, Innovation and Technology* 4:1, 85–106

VII. Mets, Ave (2012). Measurement theory, nomological machine and measurement uncertainties. *Studia Philosophica Estonica* 5:2, 167–186

0. INTRODUCTION

Overview of the essence of the problem discussed. My dissertation deals with implicit and explicit normativity of ordering or finding order in the world. Order, lawfulness and regularity associate with epistemic security, that is, the possibility of knowing (the future) and of making plans. Hence the paper is about normativity of secure knowledge, or of feeling security as driving regulating and ordering. With 'scientific laws' in a narrow sense, often called 'laws of nature', I mean first of all mathematically expressed laws in contemporary empirical exact sciences. However, this is just the peak of what can be viewed and has been viewed as expressing order and regularity in nature (in portions of the surrounding world): their mathematical formulation rests on the attributes of corresponding phenomena or entities that have been quantified, rendered into numerical form or measurable; but (exact, rigorous, numerical) comparability – measurability – is not an all-or-nothing but rather a more-or-less potentiality of "attributes" (see Appendix 4). By contemplating their normativity or imperativeness, understanding laws of nature and evolution of this understanding (to be discussed in Chapter 2) are relevant, hence also other senses of those laws not (mathematically) expressed. So it is not merely about whether "nature" is inexorably compelling or not, or whether man needs epistemic security or not; rather it is also about what is regarded as nature and where the security is sought after.

When nature is the immediately surrounding world and wilderness, her particular (material) being is understood to constitute or belong to her "laws", then the knowledge and epistemic security – if such is to be achieved – stem from the man setting himself, his actions, according to or into accordance with the material natural environment. Striving towards epistemic economy – towards generality and concomitant abstractness – parallels neglecting individuality and material particularities in nature, forming nature to conform the general abstract knowledge, thus enforcing abstractifying both the notions of 'nature' and of 'laws of nature'. This is the inescapable approach of science, and being (made into) the epitome of correct, sometimes of true, knowledge of nature, this approach has expanded both to other cognitive practices aiming at scientificity, and to the everyday thinking and cognition. Acting in the world – including in the natural environment – man needs to employ the things and beings in the world, thus he changes the world according to his needs. When what is called laws of nature is taken as guidelines for this acting, the way of acting and of changing the world strongly depends on how the nature and laws of nature are understood. In the contemporary understanding, given by the (exact) sciences of nature, the world is thought to be acted upon in accordance with laws of nature – the laws formulated in those sciences; it is often neglected that it is, in fact or first of all, acted upon *into* accordance with those laws, particularly acting with the mediation of technology. In other words: laws of nature are usually taken to be purely descriptive – in contrast to legal laws which are explicitly normative by prescribing certain ways of conduct and action –

whereas their deep-rootedness in contemporary world picture and cognition guides human action on a deeper level, remaining unnoticed in their normativeness.

The technological mediation comes to determine ever more of human understanding of the nature and the world. It enables man to achieve his goals, thus setting nature into the role of providing resources to be arranged according to human discretion and control, used and exploited, thereby neglecting the nature's own being and dignity – as if what is were merely for and through man. It also broadens the possibilities of human action upon the nature, hence in a sense it seems to enhance human agency. However, the ever more technologically determined world also restricts naturalness of the life-world by intruding ever deeper and farther into the wilderness and narrowing its extent and perceivability; the nature (wilderness) recedes from the immediate cognition of everyday life. As mathematical-technical accountability and controllability of the world is strengthened, it comes to be taken for granted, forming a normal basic cognition of man and nature. By concentrating on the planned aspects and effects of his actions and neglecting multifariousness of beings and their relations, man thus claims ever more precise knowledge of the world and an ever more cunning skill to steer it. The unforeseen effects that arise out of this steering sooner prompt further technological means than revising the imperative of the ubiquitous (mathematical-technological) control and its generated world picture.

Formulation of the research question. I propose that laws of nature are not neutral with respect to human activity and thinking in the way as they are often thought to be so – namely as being purely descriptive, representing in human knowledge the way nature is and goes. This claim is not new (see references in footnote 1 and part 1.3.2); I think human agency, human understanding of nature, and the (human understanding of) laws of nature are mutually related and variously normative to one another, where the guiding aim is order enabling certainty in thinking and action. Thus I will consider laws expressing natural order (scientific laws) and laws expressing social order (legal laws). These two – nature and society – are the relevant fields for me to consider as: 1) they are *the* fields of laws, that is, the epitomes of law are mostly laws of nature and laws of society (legal norms); 2) nature and society are often regarded as contrasts, opposing counters, for 2a) nature is taken to be passive, as subject to human action, society as active, acting upon nature and other surrounding world, 2b) (due to 2a) laws of nature are taken to be descriptive, laws of society (legal norms) as prescriptive; the explicit normativity of legal laws offers a preliminary enframing for normativity of scientific laws; 3) as has been emphasized in several recent philosophical accounts of science[1], nature-related aspects and human-(and/or society-)related aspects should be accounted for together, if one looks for an adequate understanding of science; I assume this is

[1] Constructive realism: Vihalemm 1979, 1989, 1995, 2001, 2011, Rouse 1996, 2002, Stepin 1999a,b, 2005, Giere 1988, 2006, 2008, 2010.

necessary also for understanding law. (2b) is the immediate target of my study as I aim to show the normativity of laws of nature. Thus I will develop a comparative analysis of laws of nature or of sciences with legal laws, which depend on, or are ordered by, human decisions, and influence or order them. Such an analysis may comprise the following aspects:

A purely theoretical (formal-logical, linguistic – including semantic, or other) analysis may compare what are called 'laws', and the language of laws, in each of them[2], or the theoretical assumptions underlying such laws[3], or the relation of those laws to the (objective) reality (either on the side of their origin, or on the side of their purpose and function)[4]. A cognitive or phenomenological study is to show how scientific and legal systems, and the world imbued with and determined by them, is revealed subjectively, to individual consciousness (to the "self"), and how they affect the perception of self and its relation to the world[5]. A practical or historical approach would try to construe developments of scientific and legal systems in concrete historical, social-cultural and environmental circumstances as human and social actions and activities responding to those circumstances and their changes[6]. The levels of comparison may be the said laws[7], or the part (broadly construed) of the world they are to apply to[8], or the theories encompassing the laws[9], or meta-theories which study the scientific or legal theories (e.g. philosophies of science and of law)[10], or practices of law construction or formulation[11]. Finally, one can either compare these two areas as to their similarities and differences, for example in order to give an account for understanding one or another of their aspects with the help of the other (which seems to be most often the case); or one can consider relatedness, that is,

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[2] Dretske 1977, Dalla Chiara and Giuntini 2002, Haack 2008, Holmes 1899, 1897, Alchourrón and Bulygin 1971, Ross 1998, von Wright 1951, 1963, 1972, Kelsen 1976/1960, Dorato 2005, Hage and Verheij 1999

[3] Hart and Honoré 1973, Lunstroth 2009, Haack 2004, 2005, 2007, 2008, Holmes 1897, 1899, 1915, Alchourrón and Bulygin 1971, van Fraassen 1989, Laudan 2006

[4] Rundle 2004, Mumford 2000, 2004, Flanagan 2010, Beebee 2000, Landers 1990, Haack 1999, 2004, 2009, Holmes 1897, 1915, van Fraassen 1989, Dretske 1977, Ross 1998, Agassi 1966, 1973, Kelsen 1976/1960, Dalla Chiara and Giuntini 2002, von Wright 1951, Laudan 2006, Finnis 1980, Hage and Verheij 1999

[5] Finnis 1980, Mumford 2004, Haack 2004, Holmes 1915, Agassi 1995/96, Kelsen 1939/1940

[6] Ruby 1986, Lemons et al 1997, Haack 1999, 2008, Holmes 1899, Agassi 1982, Dorato 2005, Kelsen 1939/1940

[7] Austin 2001, Ruby 1986, Mumford 2000, Flanagan 2010, Dalla Chiara and Giuntini 2002, von Wright 1951, Alchourrón and Bulygin 1971, Dretske 1977, Dorato 2005

[8] Rundle 2004, Mumford 2000, 2004, Finnis 1980, Ruby 1986, Landers 1990, Holmes 1915, Dretske 1977, Ross 1998, von Wright 1963

[9] Hart and Honoré 1973, Finnis 1980, Haack 2004, 2007, 2008, Holmes 1899, Alchourrhón and Bulygin 1971, Kelsen 1976/1960, von Wright 1972

[10] Haack 2005, 2007, Holmes 1899

[11] Lemons et al 1997, Beebee 2000, Laudan 2006, Ruby 1986, Haack 1999, 2004, 2005, 2009, Holmes 1897, van Fraassen 1989, Agassi 1966, 1973, 1982, 1995/96

(mutual) influences or interdependence of legal or moral norms and scientific laws[12].

I see these aspects and levels to be interrelated and affecting each other, and I see also science and law affect each other in these various aspects, on various levels in several ways. The reputation of exact science stems from an image of it as of the true theory of the physical world; mathematics is thought to be the language of the nature. It is an image that all other sciences, including legal science, have tried to imitate, to strive towards. This presupposes well-defined concepts (mathematically defined, if possible), which correspond to determinate entities in objective reality (measurable, if possible). This image contributes to the perception that the world, its contents and their properties, are objectively clearly determinable, comparable, measurable, calculable. Well-formulated laws and norms are to enable interactions with the respective parts of the world and manipulation of them. Historically, as the notion of 'natural law' indicates, certain laws, moral or legal norms were perceived as being non-contingent, rather like laws of nature – laws of morals, of human reason or God (Austin 2001; Alchourrón and Bulygin (1971: 50–51): natural law postulates as the basic axioms of law as a deductive system on the example of Euclidian geometry, seen as the ideal science with a deductive system). Legal positivism opposed to treating human laws as naturally given, and treated them instead as arbitrary, as purely conventional. However, I would contend that although laws are not given objectively and independently of human mind, neither are they as arbitrary as it may appear according to positivism:

Both science and law are social practices. That is, they are carried out in human societies, have developed in social and natural circumstances, learning from them and shaping them. Neither is a mere theory, but rather a theory according to which certain activities are carried out and which is adjusted to the results of those activities. Thereby it is not that law applies to one part of the society and of the environment, and science to another part not overlapping with the first. Rather they apply to the same society and to the same environment, shaping them in different ways and aspects, but thereby changing the world from which either of them learns for its theory. Scientific research and development of theories change the understanding of the world, as the new knowledge created in those cognitive processes imbues common sense knowledge and becomes a basis for designing the world, including technical development. This changes social relations, natural and social environment, perception and understanding of the ways how human power can change the world, thus creating new possibilities and problems that must be (legally) regulated. Legal regulation, in order to be applicable and relevant to the new cognitive and technological situation, must use this very same scientific-technical language, thereby on the one hand crystallising it as a valid conceptual network, hence socially normative, on the other hand creating social-institutional science-making

[12] Lemons et al 1997, Haack 2005, Holmes 1899, 1915, Laudan 2006, Agassi 1966, 1973, 1982, 1995/96, von Wright 1963

structures, which on their part are based on the legal-political understanding of social relations [technocracy]. A third dimension, but related with the two previous ones, is the interdependence and mutual inspiration in universalisation or colonisation process for either frameworks: by claiming universal validity or truth, they pretend to be applicable independently of time and place; thereby legal-political power has enabled concrete manipulations of the world to prove scientific theories, and those on their part have empowered and credited the universal applicability and superiority of certain legal-political regimes (see Anghie 1999, Harding 2003, Lunstroth 2009). In Appendix 3 I consider the universality of laws – of laws of nature and of international law – arguing for fragmentation of laws (both natural and legal) and for corresponding locality-conditioned customised practice.

Arguments set forth for defence.

1. Scientific laws, or laws of nature as they are often called, are normative in a similar sense as legal laws are normative: they prescribe ways of acting and sanctions in case of non-conformity.
2. The aim of laws (scientific and legal) is achieving epistemic and practical certainty – simplicity and foreseeability (predictability) in actions upon the world.
3. Mathematicalness and mathematical laws are pragmatic in the sense that they provide the repose of mind due to the (illusory) simplicity in the complex, often irregular world.
4. The way the mathematical laws of nature gain validity operates through active human agency in restructuring the world according to those laws, or forcing the world to display regularities expressed with the laws. The aim of doing so lies, as said in argument 2. This is how scientific laws are normative, as said in argument 1.
5. The concept of nature depends on the concept of laws of nature; hence the more technical or abstract the concept of laws of nature, the more technical or abstract the concept of nature.
6. The world view is dependent on the concepts of nature and of laws of nature, and it is normative to human agency.

Description of methods. To a considerable extent, I work in the conceptual framework of constructive realism in various contexts, either applying it to concrete scientific attempts as case studies (Appendices 1 and 2); to law as one of my main issues, either as case study (Appendix 3) or in service of the comparison between scientific and legal laws, with the clarification of normativity of the former as one aim (Paragraph 1.3.2, Chapter 2, Appendix 3); or to serve more directly my main aim – explicating normativity of the basis of science and of its laws (Chapter 2, Appendix 4). Phenomenological approach to science and technology (by Martin Heidegger), and somewhat to law, will have a fundamentally important role, as I will compare and unite it with constructive realism in order to explicate cognitive aspects of natural and social order and trace their generation and normativities (Chapter 2, Appendix 3). To the latter end also historical accounts of aspects of science and technology will be engaged and used to explicate and clarify the phenomenological concepts (Chapter 2). To keep clear the meaning of ‘normativity’, a logical account of explicitly normative systems will be provided and expounded for comparison with not explicitly normative systems, together with some of its implications (abstractness or generality, causality, implicit normativity) (Chapter 1).

My attitude towards science, its theories and law-establishing practice as normative owes much to Joseph Rouse’s (1987, 1996, 2002) account of science as variously normative and his emphasis on practice in contrast to language, which he considers a substructure of practice, immersed in and interacting with it. Rouse’s naturalist account of normativity aims to take into equal account both (natural) science and its practice as well as the nature that the science is about, and to follow the principles of metaphysical naturalism that philosophy should impose no arbitrary constraints upon science nor invoke supernatural explanations about (the success of) scientific knowledge, and “that human beings and any other beings to whom (putative) norms might intelligibly apply are natural beings, embodied, causally intra-active, and historically and biologically evolved” (Rouse 2002: 2–4). For me the especially important aspects here are particularity and historicity of scientific practices and their carriers, their situatedness in particular cultural-technological-natural circumstances that make up their world. I see a parallel with Edgar Schein’s conception of the three levels of culture (the visible artefacts, the conscious espoused beliefs and values, and the unconscious basic underlying assumptions; see footnote 74) where Rouse’s normative networks are mainly on the underlying unconscious level (Rouse (1987: 62): “This field [of possibilities] remains hidden from us … as something so close to us and so obvious that we see right through it. We are unable to envisage concretely what an alternative to this field would be, and we are likewise unable to envisage the field itself as such.”). Their unconsciousness lies in the state of affairs that their normativity is usually not noticed, it is implicit in the practices, whereby the practices themselves and scientific language are usually not perceived as explicitly prescriptive (hence science and technology are usually considered (value-)neutral). This basic underlying level of culture and hence of (world-)cognition I perceive to be strongly shaped in the way as Martin Heidegger describes the essence of contemporary technology and science, and my main interest lies in articulating this way of cognition in a more detailed manner (Chapter 2). Thus my other major inspirations, particularly concerning what exactly science prescribes, how it shapes the being-together of man and the world, emanate from Heidegger’s philosophy of technology and Carolyn Merchant’s eco-philosophy, plus various other authors who either more or less explicitly state or implicitly follow the normativity or norms of science.

My contribution to solving the problem lies in 1) bringing the logic of explicitly normative systems to bear upon scientific regimes with the aim to clarify the normativity hidden in them; 2) the attempt to set legal regimes into the frameworks of practice-based philosophy of science and phenomenology of technology to uncover their analogous practical-technical approach to their object and the connectedness of techno-scientific and legal regimes in handling the world; 3) the tentative categorisation of aspects of implicit normativity of science; 3a) with critical analysis of classical physics (measurement theory), social science and the so-called post-non-classical science (by Ilya Prigogine) as illustrations of the aspects of normativity; 4) the historically based feminist-ecophilosophical interpretation of Heidegger's phenomenology of technology.

Course of answering the research question and its evidence. In Chapter 1 (like in Appendix 3) a comparative analysis of science and law is elaborated. I propose a logical reconstruction, a conceptual framework (from Alchourrón and Bulygin 1971) of explicitly normative systems, to try applying it on scientific theory in order to identify possible analogous elements characteristic of normative systems (paragraph 1.1). The two kinds of systems (science and law) will be compared as to the legitimacy of the logical analogue: the roles of abstractness and concreteness (1.2) and the kind of implication presumed in the laws (between the elements of the laws), or the logical modality of the laws (1.3). Subparagraph 1.3.1 then scrutinises causality as an aspect of necessity usually implicated as the modality of natural laws, and its role in legal law will be regarded; subparagraph 1.3.2 broadens the notion of normativity from explicit to implicit kinds of prescriptiveness better suitable for scientific laws and scientific world picture. In my view the talk of law, lawfulness, regularity, or order, is driven by the human need or longing for certainty and the will to bring this certainty into the world, to have the world under control.[13] Thus Chapter 2, elaborating on the kinds of implicit normativity and hence of normativity of the basis of science (as does Appendix 4), analyses and criticises the meaning of regularity or order as to what it is that offers this certainty; additionally, human order-seeking and -bringing interaction with the world, with the nature, and some historical aspects of this interaction and of corresponding world picture or cognition will be undertaken. Paragraphs 2.1 and 2.2 give a historical-phenomenological account of the emergence of contemporary scientific-technological world cognition, 2.3 of scientific theory and scientific law. Subparagraphs 2.3.1 and 2.3.2 peer more deeply into the concept of law of nature, its historical variants and the concept of the nature or the world (and wilderness) in relation to the understandings of laws of nature. Paragraph 2.4 provides some examples to illustrate the approaches of the theoretical frameworks of Chapters 1 and 2.

The four articles underlying the current work (Appendices 1…4) contribute to the aim of the dissertation as follows:

Appendices 1 and 2 constitute case studies that paved the way for my argument (mathematical laws of nature as normative for the micro level of matter and fundamental human cognition, and for social sciences, correspondingly).

[13] Although Laudan (1984: 83–84) claims that science abandoned the ideal aim of epistemic security, this aim still seems to persist at least in the popular understanding of science and its role in society. Also Cartwright (2008, 1) finds that despite quantum indeterminacy and chaos the world is seen as governed by laws of which the success of science is evidence.

Appendix 1 “The constructive realist account of science and its application to Ilya Prigogine’s conception of laws of nature” (Mets, Kuusk 2009)[14] illustrates the perception that mathematics is a (or the) true language in which to describe and make sense of the world. Prigogine is a renowned scientist who has created considerable well mathematised theories of self-organising systems in chemistry and physics. In this paper we criticise his attempt to expand this mathematical approach to what he calls ‘*the* fundamental level of reality’, to the micro-level that he considers to be inherently fundamentally irreversible, self-organising, unstable, complex, and to the ‘fundamental level of human perception’, particularly time as a kind of basic “dimension” of human experience of life and the world. Our criticism mainly rests on the nature of exact scientific theories as idealised, abstract theories with particular aims and purposes, where the aims and purposes determine the required or allowed level of abstractness and closeness to empiria. Mathematics, “the language of science”, does not describe immediately the reality that a scientific theory is about, but rather defines models that can be used to manipulate the reality, as we argue on the basis of accounts of science by Nancy Cartwright, Rein Vihalemm and Ronald Giere. Hence it does not make much sense to try to describe the whole intricate material world with mathematical formulae, which are in any case too abstract and would become unmanageable and hence unusable if it should be adapted to describe the intricate elaboration of the world as Prigogine seems to have in mind. In addition, in the light of the discussion of measurement theory and practice in Appendix 4, a deficit of concrete references from mathematical formulae to empirically identifiable properties of material situations diminishes the applicability of Prigogine’s approach.

There is another aspect to Prigogine’s approach which deserves criticism in the perceptual and historical accounts of order to be developed in the following analysis: the will to mathematise the most intimate “dimension” of human being (*Dasein*) – time. He criticises the usual parametrisation of time, that is – that time is usually inserted into physical formulae as a parameter in the same way like parameters of space, as if time had the same characteristics, and most weirdly – as if one could move forwards and backwards in time like one can move in space. Thus he attempts to develop what he calls a ‘time operator’, which is to take into account the irreversibility of time. However, if this operator as a mathematical formula is to apply on concrete situations, it must be specified in relation to material settings of the world, which has not been done, so it can rather be viewed as pure mathematics than as physics (in Appendix 4 I consider the relation of mathematics to matter through measurement; Stepin 1999a,b, 2005 exposes conditions for mathematical formula to count as part of physical theory – material interpretability). The parametrising approach to time in classical physics takes time as something uniform, whereas this uniformity

[14] In this article the author suggested the problem investigated and performed the philosophical analysis, while the co-author complemented it taking into account the actual work in theoretical physics.

has been achieved through corresponding technologies resting on processes considered as regular, that is, as generating periodic physical (material) signs counting as time units which can be used in physical operations in science, technology and everyday life. On the other hand, looking at time not as the materially-spatially generated sequence of ticks, as axes of units, but rather as a flow of moments, as the fundamental sense of human experience of life, in the eco-feminist and Heidegger-inspired critique of science and technology to be considered later in this paper, such a formalisation of the most intimate perception may count as offensive, as a misrepresentational mathematical enframing superimposed on an inarticulable reality, thus setting it wrongly or blocking it. However, time operator could also be a concept applying to any dynamic system, purporting to describe its inherent time flow, not just the inexorable transience in human cognition. But what would this mean – what information would it give about this system, if related only to its inner self? A mathematical formula must be interpretable, it must make reference to some humanly reachable and intersubjective system, its variables and parameters to some measurement and unit systems and dimensions. This means their reference cannot be limited to just one operating unity, but must take reference to other material systems, including some etalon units and processes for ascribing numbers, if mathematics is to make any sense at all, if it is to help calculate (see Appendix 4 about the meaning of measurement for physical theory, and Tal 2011(2012) about measurement units and their materialisations).

Appendix 2 "On scientificity of social sciences. Rein Taagepera *Making Social Sciences More Scientific*" (Mets 2009) relates to normativity of scientific, mathematical approach in the field of social phenomena. Taagepera argues against the misuse of mathematics, or rather – of statistics, numerical methods – in social sciences, and for exact scientific, mathematical, quantifying and purpose-oriented methods. My analysis brings forth some specificities of social phenomena, like complexity, conscious "self-organisation" or self-determination, due to which the idealised approach fostered by Taagepera should be applied with due care. I also pose the question about scientificity and the meaning of mathematicalness in sciences: What is the core of scientificity, to be found in exact sciences, that other disciplines with the pretension of being scientific are to feature? This core seems often to be taken to be a numerical precision, whereas Taagepera takes it to be simple meaningful (that is, empirically interpretable) mathematics; precision in itself gives no understanding if the numbers cannot be interpreted, but understanding is *the* aim of science. He takes quantification of relations between variables to underlie a good scientific method. Normativity in his attitude towards primacy of theory- and mathematics-driven research is clearly manifested by his explication of the basis on science, namely in the second of the two motivating questions of scientific research: "What *is*?" and "How *should* it be on logical grounds?" (Taagepera 2008: 5). Implicitly, Taagepera's approach manifests normativity of exact scientific rationality – that exact quantification gives understanding and is thus to be sought if a human endeavour is to be useful in its aim.

Appendix 3 “Some limitations of universal international law from a philosophical point of view” (Mets 2012a), together with Chapter 1, constitutes the comparative analysis of science and law. Whereas Chapter 1 concentrates on the logical and linguistic aspects of laws in either practices, Appendix 3 draws parallels between scientific and legal regimes on theoretical and practical-social levels. It emphasises the primacy of practice, of the material actuality with respect to theory or conceptual understanding. The latter, however, is often regarded as clear and well defined, and as such providing a true understanding of the reality, and assumedly applicable universally independently of “local material idiosyncrasies” which are regarded as deviance from correctness and hence count for being rectified. I argue (among others with the help of historically founded criticisms of political and scientific colonialisms) against universality of laws and correspondingly of orders, both legal and scientific, and for locally customised theoretical and practical treatments of the world. I also question the notion of regularity which seems to be fundamental to a practice-based account of laws, namely regularity of operations or actions: for scientific laws, experimentation grounds the regular application or applicability of mathematical formulae in matter, thus laboratory operations are to build up a kind of system of regular processes; in law, it is the behaviour of politicians, lawyers, justices etc. that makes up a regularly functioning system that law can be based upon, like customary international law, for example (Tunkin 1961). The regularities in legal matters, that is in political and social processes or events, are questionable, as I contend there, for having too many “dimensions” to be interpreted in concrete situations which the particular legal enframing is applied to, and for the interpretations being too subjective. Here I must add another rather trivial source of the irregularity of social processes: their historicity. As I will discern, based on Mackie, broader, middle and narrower notions of causality, similar enframing should be taken into account here: talking about regularity, Tunkin seems to consider only the narrower notion of processes, which with a great deal of simplification could be taken to reiterate themselves. However, each time they appear in a new historical situation, the middle and broader contexts of those processes are always new, and the three levels being interdependent with each other, thus determine new meanings for the narrower sense of lawfulness or regularity. Peeter Müürsepp (2012) considers historicity a confounding regularity also in laboratory experiments in physical sciences. This accords with Joseph Rouse’s understanding of continuous recreation (re-establishment, redefinition) of research foci and stakes, or what matters in research, as practice and knowledge evolve and mutually determine each other.

Appendix 4 “Measurement theory, nomological machine and measurement uncertainties (in classical physics)” (Mets 2012b) together with Chapter 2 explore the basis of science and its conditioned world picture. Whereas Chapter 2 explores rather the meta-metalevel of science – the history of scientific practice and law, and of concomitant world cognition and its changing that underlie and have brought forth normative exact scientific world picture at all, Appendix 4 explores rather the metalevel of science – measurement as the basis of scientific practice and physical theory. It concerns the relation between mathematical laws of physics and the "noisy" material laboratory reality that they are to account for. I aim to show that neither fundamental nor phenomenological (numerical) laws describe the material actuality, as both simple mathematics as well as ascription of numbers are too idealised with respect to the fuzziness and intricateness of material world. I argue that using mathematics to account for matter is pragmatic, or goal- and activity-driven, and so are the notions of noise and (measurement) errors, and modelling or mathematisation of the latter, serving simple calculable conceptual and practical treatment of the world. This paper contributes to the understanding of the notion of regularity and its pragmaticalness: as the material world under study in physics laboratories, however isolated from external influences and best approximating the ideal of *ceteris paribus* conditions, still displays real deviances from the ideal mathematical formula that refers to or denotes it, that is from ideal regularities, the question of tolerance of such deviance and its meaning for the fundamental physical theory arises. Utterances from practicians to the effect that the simplest possible mathematics should guide the physicist in interpreting and processing empirical results testify of the normativity of mathematicalness and simplicity, or of what is understood as scientific rationality. This in its part contributes to the contemplation of world picture to be undertaken in the dissertation: scientific rationality means analyticity, quantifiability, simplicity, calculability. The imperative basing of scientific results on these principles is just a manifestation of the world picture that has formed in social practices.

1. WHAT ARE CALLED 'LAWS'? THE LANGUAGE AND LOGIC OF LAWS

There have been attempts to reduce legal system to a set of logically analysable sentences, similarly to logical positivist attempts of reducing scientific theories to propositions, linguistic entities (e.g. Haack 2007 refers to Langdell; Morgenthau 1940, Alchourrón and Bulygin 1971). At the dawn of contemporary science, legal science was regarded as a purely rational or formal science (Alchourrón and Bulygin 1971: 2) like mathematics and logic, with the difference of having import on material reality by guiding decision making (Oppenheim 1944; Haack 2007). In the positivist understanding, (legal or scientific) theory consists of well-defined concepts or terms with well defined relations between them (see also Holmes 1899), and such a system is allegedly, or in an ideal case, coherent, self-contained and sufficient through deduction for all possible (legal or scientific) cases (Morgenthau 1940). Theoretical sentences are logically analysable, hence their correctness – like the rationality of science – is a matter of logic (Haack 2007), and deducible from each other (in case of exact sciences – mathematically deducible). Felix Oppenheim and Susan Haack analyse the legal language logically. Both emphasise that logic is not the whole of law, practice being a necessary determining part of it; however, Oppenheim (1944: 143) regards the "law in action" or the empirical science of law to be just a 'particular branch of the study of "law in books"'.

1.1. Logical elements and properties of normative systems

Carlos E. Alchourrón and Eugenio Bulygin (1971) seek a purely logical reconstruction of a normative system, which has the following elements: Universe of Discourse (UD): which real world events – misdeeds – are aimed at by a law (elements of UD are actual, individual cases, happening in concrete space and time); Universe of Properties (UP): which legally relevant properties constitute the treatment of a certain kind of misdeed in written law; e.g. a certain kind of harm or good faith of a party in an event; Universe of Cases (UC): defined by the presence or absence of said properties (UC is a set of generic cases, which, together with UP, is used to determine appropriate UD or elements thereof); Universe of Actions (UA): which are the possible actions to be taken in case of said type of misdeed (actions are logically independent of each other (logical atomism) and from properties; they are equated with their effects/results, that is, with states of affairs to be reached through the actions); Universe of Solutions (US): provides Universes of Actions with deontic operators ('permitted', 'obligatory', 'prohibited', 'facultative'). Any normative system, including written law, is a system that correlates Universes of Cases with Universes of Solutions. It thus has elements of the form ($F \rightarrow G$), where F is an element of a Universe of Cases and G an element of a Universe of Solutions. Alchourrón and

Bulygin discern logical and empirical implications of a normative system: the properties in the Universe of Properties are required to be logically independent, but they may still be empirically dependent (e.g. causally); (hence, but also independently from the previous) even if a normative system has a logical or normative gap (i.e. some cases are not related to any solutions), it may be empirically complete if those cases do not occur in reality. A normative system is logically or normatively complete if it has no normative gaps, that is, it gives solutions to all possible cases (to all elements of a Universe of Cases). As to problems of application, they discern between gaps of knowledge (due to lack of empirical information about an individual case) and gaps of recognition (due to fuzziness of legal concepts), but they regard them as strictly independent of each other and independent of logical gaps. Axiological gaps – that prescriptively relevant properties are descriptively not relevant (that is, are not taken into account in the system) – are due to value decisions and can occur only if there are no normative gaps in the system (that is, if the system gives solutions to all cases, but in an undesirable way). Ideally, a normative system, like a deductive system in general, is complete (i.e. has no normative gaps), consistent (does not correlate any case with two or more contradictory solutions) and independent (there are no redundant solutions) (ibid: 5).

Let us notice some similarities between a normative system and a scientific theory: The Universe of Discourse for a scientific law is the cases which it can be applied to (e.g. the law of gravitation to massive bodies); the Universe of Properties are the quantities defined in a physical theory and used to define "laws of nature" (e.g. mass *m*, gravitational force *g*, time *t*, etc.); the Universe of Cases is the set of laws of physics (or of nature, as sometimes called) where the relations and (thereby) intensities of said properties (quantities) are defined. The Universe of Cases for laws of science are determined through experiments and measurements[15] of involved "independent" quantities, which at least theoretically have a numerically determinate, often continuous, scale – in contrast to the purely qualitative discrimination between presence and absence of a property in legal cases.[16] But regarding measurement as a process of comparison that always presupposes some contrasting background or different intensities of properties, legal and scientific cases look more similar on a certain level: they both select or define[17] a restricted number of properties or attributes from the

[15] Experiments are one of the testing methods of laws of sciences – perhaps the most secure ones for determining applicability of mathematical laws (of physics for example). Hence they serve to determine the material settings which count as the Universe of Discourse and make up the basis for the Universe of Cases for sciences. Experiments are "constructed out of measurements" (Baird 1964: 89); in Appendix 4 I consider the relation between measurement and experiment and theory of physics.

[16] Alchourrón and Bulygin mention that there are relevant properties in law which can have a continuous scale, e.g tax rates.

[17] Whether it is selection or definition is not a trivial matter and will be focused on later in this paper: 'selection' refers to the representational understanding of laws, 'definition' to the conventionalist understanding, either of which alone is insufficient.

complex entangled reality, which are regarded as relevant, and assign a value to them on some scale (either discrete, like the binary regarded by Alchourrón and Bulygin, or continuous or some other). Like in law, so also in science the theoretical (here importantly – mathematical) account of cases and properties depends on the empirical knowledge about the Universe of Discourse, but also determines what is regarded as such: For one thing, namely, the Universe of (scientific) Discourse is equated with the real world "events" in which the defined properties and their relations as formulated in laws of sciences are identified as essential[18]; for another – the mathematical formulation and the scale assigned to an attribute depend on the empirical basis, on the Universe of Discourse (empirical relational system) available for the abstraction (numerical relational system).[19] In this respect, the simple values 'present' and 'absent' of properties occur also in scientific cases: the "purer" the phenomenon[20] to be studied or modelled, the more properties are absent; the closer the model is to come to the real material situation, the more properties are to be included (like magnetic force to gravitational phenomena, or friction and resistance of the medium of oscillation).[21] Alchourrón and Bulygin (1971: 170) draw a parallel between the logical functioning of scientific and normative systems that I here present in tabular form (ibid: 170; logical denotations added):

	Explaining (science)	Justifying (normative)	[logical denotation]
Description of:	Phenomenon	solution	[G]
deduced from:	scientific system	normative system	
-consisting of:	general laws	general norms	[$(F\rightarrow G)$]
and from:	antecedent conditions	a case	[F]
Uses	predicting future phenomena	guiding future actions	[$(x)(Fx\rightarrow Gx)$]
	explaining past facts	justifying past actions	[$(x)(Fx\rightarrow Gx)$]

At first sight, there seem to be no clear correspondent to the Universe of Actions, and hence also to Universe of Solutions, in science, in the way as there is in law. This corresponds to what Oppenheim, Haack and several other authors allege: science is said to be normatively neutral, that is, making no prescriptions as to treating the concrete real world systems. However, looking back in the history of science, or of some disciplines that now are considered as scientific – medicine and mathematics, for example, at their dawn (Ritter 1997a,b) in

18 That is, the phenomena studied in exact sciences are precisely those that can be mathematised, that is, dissected into measurable attributes, those (re)combined in mathematical formulae; see e.g. Vihalemm 1995, 2001.

19 The first hints to natural-historical (natural scientific) approach, the latter to phi-scientific approach (see Vihalemm 1989, 1995; those are also discussed in Appendix 1, and will be considered later in this paper).

20 I write 'pure' in quotation marks because I consider phenomena and hence their purity dependent on theory, not as something inherent in nature and directly read out of her. See also Rouse (2002).

21 These matters are discussed in more detail in Appendix 4.

Babylonia and Egypt, Universes of Actions and of Solutions seem to have their counterparts.[22] Some examples to illustrate: “If a man is covered with a rash [element of the Universe of Cases]: gradually mix malt flour into oil, apply, and he will recover; if he has not yet recovered, apply warm *simtum* and he will recover [elements of the Universe of Actions]” (Ritter 1997a: 52, quotation from a Paleo-Babylonian text)[23]; for the mathematical exercise “I added the surface and my side of the square: 45” the solution goes: “You pose 1, the *wasitum*. You divide the half of 1 (: 30). You multiply 30 and 30 (: 15). You add 15 to 45: 1. 1 is the square root (of) it. You subtract the 30, that you multiplied, from 1 (: 30). 30 is the side of the square (ibid: 54, quotation from a Paleo-Babylonian text)”;[24] and a mathematical exercise from Egypt (Ritter 1997b: 68): “An example for making a round granary of 9 (and of) 10.” “You subtract 1/9 of 9: 1. Remains: 8. Multiply 8 by 8; it will be 64. You multiply 64 by 10; it will be 640. Add to it its half; it will be 960. Its quantity in *khar*.” “You take 1/20 of 960: 48. Enclosing it in 100-quadruple-*heqat*; wheat: 48 *heqat*.” There are clearly cases (elements of Universes of Cases) in the mathematical texts, although as aims of actions and not as their incentives, and actions prescribed in given cases; that is, cases and actions are correlated with each other, thus the examples above can be regarded as elements of Universes of Solutions. (Already in the Egyptian texts of mathematics, the explicit descriptions of actions to be taken were left out, so that only tables of numbers, standing for the series of mathematical operations to be performed, were left (Ritter 1997b gives several examples), thus grounding the later abstracting-theorising approach by Greek mathematicians. See also Stepin (1999a: 28–31) about Egyptian and Greek mathematics.) The Greek pre-runners of some contemporary sciences hint to Universe of Actions as well: economics (*oikonomia*) and astronomy (*astronomia*) referred to sets of rules for treating or observing corresponding parts of the world (household, celestial bodies) (Ruby 1986). This accords with Rein Vihalemm’s understanding of laws of exact sciences that he calls laws of nature: according to his conception of phi-science (1995, 2011 etc.), laws in those sciences do not tell us what the world itself is like, but rather what can be done with it and what cannot and in this sense guide the material ordering of the world with the aim to achieve accordance with the mathematics. However, the case for the analogues of Universe of Actions is dubious: What I call elements of a Universe of Cases in the mathematical examples may in fact be elements of Universe of Actions – as actions are by Alchourrón and Bulygin equated with their consequences, and the exercises here which solutions are given to are exactly the consequences of those actions presented as elements of a Universe of Actions, or stages of solving the exercises. According to the Aristotle’s four causes conception, we are given *causa finalis*. The same is actions in Universe

[22] Their social reputation resembled that of nowadays as well (Ritter 1997a).
[23] Translations from French by A.M.
[24] Babylonians used a sexagesimal system of arithmetic.

of Actions of explicitly normative systems like law if understood as the consequences or effects of those acts, hence as wishful final states.

As to the logical properties of both scientific and normative systems as allegedly deductive systems, Alchourrón and Bulygin (1971: 171–173) draw some explicit comparisons. Completeness and consistency are rational ideals for both empirical sciences as well as in normative systems: in the former, completeness means that the theory should be able to (causally) explain all phenomena in its scope (related to determinism), in the latter that it must be able to give a solution to each case.[25] Consistency in science, particularly mathematical science is also linked to determinism: mathematically possible different solutions mean indeterminacy in interpretation of the formula (an example of this are bifurcations in deterministic chaos). Alchourrón and Bulygin point out four main differences between scientific and normative systems: science explains empirical facts, normative systems explain or justify solutions; general laws of science are descriptive, those of normative systems prescriptive; in science, antecedent conditions "cause" the effect (regarding the formula $(F \rightarrow G)$ – F causes G, however "cause" is meant here), in normative sciences no case causes its solution; the "empirical conditions of adequacy" in science is truth, in normative systems it is validity, which can be and often is a matter of convention – that truth never is.[26]

In this "purely" logical account, Universe of Discourse is in a sense out of the logic: as a linguistic account of law or norms (norms as linguistic entities) lend themselves more easily to logical analysis or reconstruction than a metaphysical account would (norms as ideal entities, as thought-formations or meanings) (ibid: 5),[27] the Universe of Discourse, whose elements are understood as particular material states of affairs, is trivially non-linguistic on this level of reasoning (meta-level with respect to legal norms).[28] As Alchourrón and Bulygin take into account what legal scientists really do – deal with actual concrete cases, determine their subsumption under appropriate legal acts – the Universe of Discourse in their account should probably be understood as these concrete cases. However, their approach – pure logic – is supposed to be – and they contend it to be – universal, applicable to more than just the current, actual world, rather to 'the actual world plus its extrapolation', 'the actual world plus all similar cases'. In logic, Universe (or Domain) of Discourse is understood as the set of entities over which the variables of a formula may range, hence $\{x\}$ such that $(x)(Fx \rightarrow Gx)$. The x here, an element of a Universe of Discourse, a

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[25] Alchourrón and Bulygin emphasise that actually no legal scientist is interested in completeness or other logical features of the whole normative system, e.g. the whole legal code of a state, but rather just a narrow field of law concerning particular field of cases.

[26] However, conventionality and changeability of basic conventions come in degrees.

[27] This seems to be trivial – as logic stems from logos, which is sometimes translated as 'word'.

[28] There are of course norms that have language or language use as their object or touch upon it, like those about free speech, that is, language (use) constitutes some Universe of Discourses.

possible extrapolation of cases dealt thus far, is possibly "not yet there", hence it is something ideal. It is to be recognised according to – as it is defined through – Universes of Properties and Universes of Cases. But how are those reached? Alchourrón and Bulygin do not discuss this, they state the possible plurality of sources of basic sentences in law (natural law, sovereign or other; ibid: 59–60). This issue has to do with the notion of regularity to be discussed later: How regularly do or must actual, material x-s with exact properties F (and G) occur – so that it would make sense to talk about abstract properties F (and G) to be found in a Universe of Discourse or defining a Universe of Discourse? What roles do they play in theories (scientific and legal)? I will next consider the abstract and material planes of reasoning in law from the point of view of logic; particularly, relations between Universe of Discourse and Universe of Properties/Universe of Cases will be addressed.

1.2. Levels of reasoning – referents of logical elements

There are at least two aspects to the question of levels of referents of laws (abstractness or universality or generality and individuality or concreteness or particularity of laws) or the logical form of laws: 1) The "purely" logical aspect of whether laws refer to particulars or to universals, that is, whether the correct logical formulation is $(x)(Fx \rightarrow Gx)$ – there are presumed to exist particulars x that have properties F and G, or $(F \rightarrow G)$ – the existence of corresponding particulars is not presumed, only the possibility of their existence, that is, there are properties F and G and sometimes they get embodied by some particulars (the question of empiricism and realism of abstract or theoretical entities, e.g. properties);[29] 2) The import of concrete, particular actuality to theory: does the "logical" difference between $(x)(Fx \rightarrow Gx)$ and $(F \rightarrow G)$ make a difference in law-making, in theory of law (or of science)? Does it make a difference in the specification of F and G, and in the relation of x to F and G? Dretske concerns the first aspect, Oppenheim the second.[30]

Fred Dretske's (1977) logical analysis of laws (of nature) touches upon the form of legal norms, or particular legal statutes or regulations, with reference to their way of regulating. Namely legal regulations, like scientific laws, set relations between abstract (Platonic[31]) features, not between concrete objects or

[29] Is 'x' also an abstract entity? 'x' as a reference to an idealised, abstracted individual? This probably depends on the context: in applications, e.g. judicial or engineering reasoning, it is a concrete individual, on juridical or theoretical level it is a general abstract individual.

[30] Those aspects are not independent of each other. For example, if one considers the elements of Universe of Cases F as composed of elements of Universes of Properties f_i: $F=f_1+f_2+...$, then if actual, particular x can affect F, then F can change in time as the practice of law or accordingly science advances: $F_1=f_1+f_2+...$ becomes $F_{1.1}=f_{1.1}+f_{2.1}+...$ Also Alchourrón and Bulygin point this out.

[31] Dretske says (1977: 267–268): if there are laws of nature, they are definite relationships between universal (Platonic) properties; and: it is nowadays too "expensive" to hold that there are no laws of nature.

individuals: hence, not the form "$(x)(Fx \rightarrow Gx)$", but rather "F-ness$\rightarrow$$G$-ness", where F and G are universal properties or quantities, and the meaning of '$\rightarrow$' ('equals' or 'yields' or other) depends on the particular law (also E.J. Lowe (see Mumford 2000) regards both legal and natural laws as pertaining to 'sortal terms').[32] Although laws, "[i]n both the legal and the natural context", do tell how an individual falling under them is to behave – as "the modality at level n is generated by the set of relationships existing between the entities at level n + 1 (Dretske 1977: 265)" (a diamond is to have a certain refractive index, the President of the United States is to consult the Parliament on certain issues) – it is only in the aspect of the required property that an individual comes to be relevant for a theory. Any other of her properties, even if co-extensional with those included in the law-statement, is irrelevant to the law. Hence law is not a universal truth which would depend on statements about concrete particulars: "Laws eschew reference to the *things* that have length, charge, capacity, internal energy, momentum, spin, and velocity in order to talk about these *quantities themselves* and to describe *their* relationship to each other (ibid: 263; emphases added)." Similarly the laws that define relations between government branches are not about the particular individuals, but about those governmental offices, and set constraints upon individuals only as long as they occupy those offices. By deeming no references to concrete individuals and events to be a part of the language of laws, Dretske leaves the Universe of Discourse out of the scientific language (like Oppenheim, to be considered next), but also out of legal language.[33] The relationships defined by the law are themselves not necessary or obligatory – they could as well be (redefined) differently just like laws of thermodynamics are formulated in many different ways[34] – they are so only for the individuals and objects occupying the "offices".

Felix Oppenheim's focus is more on the logic of functioning or application of law, hence he sees interpretation as the process of applying theoretical terms to empiria more important.[35,36] He considers interpretation to be defining the

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[32] The first formulation $(x)(Fx \rightarrow Gx)$ enters as a supporter of counterfactuals, and in this role is the indirect linkage between law and concrete individuals or objects.

[33] There is Universe of Discourse in Dretske's account in the sense that the account does have a possible reference to material reality – the institutions of President and Parliament – but Dretske deems the material reality rather irrelevant to the logical form and interpretation of legal statutes, and of 'laws of nature', respectively.

[34] However, Dretske here fails to take into account that different formulations of laws of physics arise from different "levels of reasoning", or dividing the part of material world into different sets of discernible properties. However, when this is fixed, the relation between these properties is believed not to depend on human power; whereas designing government offices and their functions is humanly, or socially, determined.

[35] The most frequent form of deduction in law is syllogistic – deriving a prescriptive consequence for a concrete crime from two basic sentences, one of which is a statement of fact, the other a prescriptive statement of legal consequence: person p has committed an act a which falls under the definition of crime c, hence p must be punished as settled for crimes of said type (Oppenheim 1944: 148).

extension of legal terms or of laws (or of terms that appear in laws) and thereby creating new basic sentences in the legal language – as in his account law has two kinds of basic sentences: theoretical, given in legal norms, and empirical, stating concrete particular facts. He claims scientific and legal languages to differ from each other in that the former contains no reference to concrete individuals and events in the world; the main form of deduction should accordingly differ in science, as being only between theoretical, not concrete, sentences and statements of laws. But there seems to be confusion about levels of reasoning here, or rather about the nature of the practice considered, which I will address more thoroughly later: law is seen as a plainly down-to-earth and solution-driven domain of human activity, hence in mutual interaction with the part of the material world it is about; science is seen as mainly a theory, as a conceptual system with the aim of providing true reflection of the world in linguistic or mathematical signs. However, as I will argue, on-going interaction with the concrete material world, that is – practice, is essential in both of those domains (see also Stepin 1999a,b, 2005, Rouse 1996, 2002; in Appendix 3 I briefly discuss definitions' relation to actuality pertaining generally to both science and law).

Dretske's understanding of legal language thus differs from that of Oppenheim, as in Oppenheim's analysis, empirical terms referring to concrete persons and events – that is, Universe of Discourse – are a basic or primitive element of the legal language. Thereby Dretske's understanding seems to illustrate Martin Heidegger's (1959b) account of science: in contemporary mathematical science, it is not concrete objects but rather the abstract features that are important; object, objectness, is abstracted from scientific understanding and cognition, the object of cognition is the network or entanglement (*Gewirk*) of abstract properties (particularly quantities in exact sciences). Heidegger (1959a) contends that man comes to see himself in the same scientific enframing – he abstracts himself from concrete cognition, from concrete personness, and reduces himself to his abstract, enumerable and quantifiable properties. Dretske's understanding of legal regulations corresponds to this contention of Heidegger. In Dretske's conception, seeing the (social) world through the enframing of a legal theory, or the theoretical framework of legal terms or concepts, means that one sees just the abstract offices (like the governmental ones) and their abstracted relations that are defined through their functions, and concrete persons or collectives come forth only when, and as much as, they fall under the definition.

Both Dretske and Oppenheim, and also Langdell and positivist theory of law presuppose well defined concepts, but Dretske's account applies to explicitly

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[36] This difference from Dretske may also or primarily be due to the different fields of law they consider: Dretske's field is designing law, one that determines and designs its object like engineering science (although he likens it with no engineering science but rather with "pure" "descriptive" science), Oppenheim's field is the "objective", "human-independent" world that happens itself, so the treatment of it must be based on an adequate description and understanding of it – like natural sciences are understood to provide adequate description of nature in the form of laws of nature.

purposefully man-made or designed world: to political order (public law), whereas Oppenheim and Alchourrón and Bulygin analyse law pertaining to (seemingly) emerging, in a sense self-organising world (like criminal law). What is common in both cases is that the defining function of law applies to the human activity to be regulated by the laws; what is different is that in Dretske's case also the entities themselves are explicitly constructed (government institutions) on the basis of definition, in Oppenheim's case entities are to be found or to happen in the (social) world and to be interpreted in the judicial process on the basis of a legal theory.[37] However, Oppenheim does not deem a definition to be once and for all settled (nor does Dretske) and unambiguously applicable to all cases; rather, he regards the interpretation of particular cases as basic sentences of the legal language, which thus create new definitions by modifying the extensions of legal concepts, or bringing new concepts into the legal language. By this he brings the factual, down-to-earth aspect of law to bear on the legal language in two ways: Explicitly as one of his main points he claims the validity of legal sentences to depend on actual, activity-driven conditions in a way that scientific sentences do not, as the latter only need to be syntactically and semantically correct, but not stated by official authorities, hence not valid but only true. Less explicitly, and perhaps unwillingly, he makes the "law in books" fundamentally dependent on the "law in action", as he says the process of interpretation creates the basic sentences of legal language. Thereby Oppenheim (seemingly inconspicuously) confounds declarative and constructive functions of basic sentences: a sentence referring to an individual, e.g. "Smith has committed a grand larceny", is at once a statement of fact, hence it has a truth value, and at the same time it is an interpretation, hence a definition in Oppenheim's account, and hence it has no truth value. I think this confusion hints to the practical confoundedness, or interdependence, of statements of fact and of interpretations, or rather the dependence of what is believed to be empirical on the theoretical and "pre- or quasi-theoretical" background beliefs (see also Agassi 1956 for this issue). Similarly in science, shifts of concepts take place, even if in popular and sometimes philosophical thinking (positivist, realist[38] and Popperian accounts of science) notions seem to be fixed and ideas to have recurred, for example, when talking about the "come-back" of the corpuscular theory of light[39] or the atomic view of matter[40]. Development of (scientific) apparatus opens up new cognitive possibilities, thus providing new views onto

[37] Cases are implicitly constructed – certain happenings or constellations, states of art, are constructed as cases on the basis of legal understanding or theory, of effective legal codes.

[38] As pointed out by Rouse (1996: 16) and discussed and criticised by Laudan (1984: Ch. 5), particularly what he calls 'Convergent Epistemological Realism'.

[39] See for example Agassi 1956 on the non-identity of the earlier and later corpuscular theories of light.

[40] See for example van Melsen 1957 about the changing of the concept of atom.

natural and designed worlds, changing extensions of concepts and interconceptual relations, and opening prospects for novel theories.[41]

What role do the logical elements – Universes – have in this matter? Is the reasoning carried out on the level of those Universes? Or concrete individuals and events? In legislation and theoretical science it is the general, abstract level (Universe of Properties, Universe of Cases, or *F*-ness and *G*-ness), in application (judicial, engineering) the individual level of x, elements of a Universe of Discourse – it is for them that there is any theory at all – for treating the real world somehow, either in science or in law. What are the relations of all those Universes to the actual material reality – in law and in science? The on-going practice changes both of them, their "basic sentences" or "basic definitions", hence the whole theory. Besides the question "is Universe of Discourse the actual material world?" we have the question "what is the relation between Universe of Discourse and Universe of Cases?" to solve. The latter guides identification of actual events as belonging to the Universe of Discourse of one or another law. At the same time, as Oppenheim asserts (and I agree), those actual events, having been identified as belonging to a Universe of Discourse, change this Universe of Discourse, its extension trivially and through this also its intension. How so? It brings in new situations: even if the narrower specification of a case fits the definition of the Universe of Discourse (Universe of Cases) exactly, its broader context brings in new specifications, new relations, new individual properties – and hence new ways for abstracting and idealising, but also possible new relevant properties which will have to be included in Universe of Properties and Universe of Cases.

Abstraction and generalisation is necessary for the possibility to predict what happens in cases that have not (yet) been observed; without this ability, science would be useless and even impossible (Feynman 1965: 76–77, 164–166, Stepin 1999a: 23, Taagepera 2008: 25, 63, Wallace 1997: 56–57). Similarly in law: the importance of logic and purely logical deductive clarity attributed to law serves to create the feeling of certainty: "The process of analogy, discrimination, and deduction are in which [lawyers] are most at home. […] And the logical method and form flatter that longing for certainty and for repose which is in every human mind (Holmes 1897: 998)." Alchourrón and Bulygin (1971: 170) can be interpreted as saying to the same effect: "Both activities, causal explanation and normative justification, arise from one and the same need in man – his need, as a rational being, to give a rational account of things, whether it is an explanation of the phenomena of the world or a justification of his own actions." Prediction has been regarded as an essential task of science that rests on the immutable regularities stated by the laws of nature that sciences carve out of apparently

[41] Hanzel (2008: 280, 287, 294) explicates the conceptual difference between earlier and later (contemporary) versions of laws on the basis of idealisations that were available at the time of their formulation, that is, what kinds of (theoretical) conceptions (e.g. gravitational force) belonged to the kit of science of the time. Laudan (1984: 128–129) explicates why two succeeding theories about the same phenomenon cannot be equal (they normally have different ontologies).

chaotic reality. Holmes (1897, 1915) and Ross (1998) attribute this task also to legal regulations – bodies of dogma and terms used in them, and in the judicial process of courts.[42] Like in scientific theories there are theoretical terms (like 'force') whose main function is to connect the theory into a compact body of predictive use, so in legal doctrines there are theoretical terms (like 'rights' and 'duties') that serve to predict the outcomes of certain deeds. Ross contends the meanings of such terms to be empty, as there is nothing in the material reality corresponding to them, so they cannot be applied isolated from their function, which is to guide practical decisions. Also Holmes takes the factual decision process of courts to constitute law – analogously to Oppenheim's account of the continuous redefinition of basic legal sentences, which steadily shifts the Universes of Discourse and of Cases and their mutual relation. I contend that this longing for certainty and repose uttered by Holmes is present also in science, or is even the essence of mathematical treatment of the world, and prevails in the popular and political image of exact sciences. It looms behind the search for an all-unifying fundamental mathematical theory, or a finite set of fundamental (covering) laws which all others would be deducible from, and the ever-expanding coverage with mathematical laws of worldly phenomena.[43] At the same time, ever more areas of practical social life, and also of the non-human world (like territories, aquatories, outer space) are covered by legal laws. These tendencies relate to the above-mentioned claims to universality, on the one hand, and logical certainty and clarity of categorical boundaries like Alchourrón and Bulygin present them and Morgenthau criticises, on the other hand.

1.3. Modality of laws

As Dretske's logical form of laws '*F*-ness→*G*-ness' indicates, laws can be regarded as 'linking two elements [*F* and *G* or *F*-ness and *G*-ness] with each other' – as Hans Kelsen (1976) expresses it, likening legally defined order to causality in laws of nature in the sense that both kinds of laws say which effect (*G*) follows which conditions (*F*) (in law, both *F* and *G* are determined by the legal regime). Difference between them, according to Kelsen, is in the modality of this relationship: for laws of nature the relation ('→', 'implies') *is (necessarily)* so, independently of any act of will, for judicial order the relation *must be* so[44], as settled through an act of will of a legal authority (hence a more accurate formulation, in Dretske's terms, would be '(*x*) (*Fx must* imply *Gx*)' – as

[42] Also Haack (2009: 19) addresses the predictive function of law ("law-as-prediction"), and criticises it on the basis that each new legal case or situation is different from the past, so laws are not applied as a strict logical system of drawing conclusions, but rather adapted to each occasion. The changeability of (legal) states of affairs due to occurring events is included in the logical account of law as a dynamic system by Hage and Verheij (1999).

[43] See Appendices for different fields of this striving.

[44] Some reckon 'ought to' as more appropriate in legal vocabulary. Dretske uses 'must' for both legal and scientific laws. Kelsen uses the word '*soll*', which is better translated as 'ought'.

the modality of the stated relation between abstract properties or offices applies only to the level of individuals (x)).[45] This difference is emphasised by many writers on the topic (Beebee 2000, Haack 2007, Rundle 2004, Mumford 2000, 2004) and in various formulations: laws of nature (or scientific laws) describe, whereas legal norms prescribe; legal norms can be obeyed or disobeyed, laws of nature cannot be disobeyed and in this sense they also cannot be obeyed or consciously followed; necessary A implies A, obligatory A does not imply A (von Wright 1951, Dalla Chiara and Giuntini 2002). This implies the different relations of legal norms and laws of nature (or laws of science; Universes of Cases) to the world that they are to apply to (Universe of Discourse), or of the theoretical part of law or science correspondingly, with the material reality: laws of nature are thought of as describing how the world is and behaves as a non-conscious, non-sensible reality; legal norms and rules are regarded as prescribing ways of behaviour, in this sense designing, or intending to design, the world that is consciously and sensibly to obey them. Hence statements of law 'F-ness→G-ness' belong to different Universes depending on whether they are legal or scientific: in law, the F belongs to a Universe of Cases and G to a Universe of Solutions (law explicitly prescribes policies); in science, the whole formula belongs to a Universe of Cases, linking elements of a Universe of Properties (F, G) with each other (laws seem explicitly to describe the reality)[46].

Kelsen (1976) links the modal difference of legal norms and laws of nature (obligation vs necessity) also to the origin of laws: legal laws are an act of will by an authority, whereas there is no such authority nor act for laws of nature.[47] To many, the notion of law is intimately related to a law-giver (Beebee 2000, Austin 2001) and/or conscious following of or governing according to law (Finnis 1980, Beebee 2000, Mumford 2000, 2004, Flanagan 2010). So they say that using the word 'law' to denote regularities or necessities of nature, or formulations of (natural) regularities in sciences ('laws of nature' or 'laws of science' accordingly) is metaphorical, because there is no law-giver, no conscious following of those laws, and no purposeful governing of nature according to those laws. This conclusion rests on the representational understanding of laws of nature or of science, according to which laws of nature as natural and physical sciences formulate them are descriptive, describing essential and inherent features of the world (also Haack 2007, Dretske 1977). The analogy draws from the written or potentially formulable rules that are followed by the subjects of the rules (human beings or objects in objective material reality correspondingly). This view implicitly lies on the assumption that

[45] In Alchourrón's and Bulygin's formulation, modality equals deontic denominators, hence there can be 'obliges', 'prohibits' etc instead of 'ought'; or should the G itself be read as an element of Universe of Solutions (as I did claim earlier)? But then the '→' is already on the meta-level – the value-decision level – and (F→G) is a hypothesis of relevance if '→' is 'ought'; it will be a thesis of relevance if '→' is 'is' or 'implies'.

[46] Or rather they construct mathematical images of reality in the form of phenomena, that is, they describe models of reality.

[47] The view of laws of nature as divine legislation will be addressed in the next chapter.

scientific laws and theories are objective in the sense of pertaining to human-independent reality, free of normative and value-laden premises; as well as the assumption that legal norms and systems are only or primarily a matter of convention, hence contingent and changeable at any time, in contrast to laws of nature which because of their descriptive character are unchangeable (and to be expressed by scientific laws).

For normative systems like law, Universes of Actions and of Solutions are what constitute the explicit normativity of legal norms: they explicitly state what is to be done or which end state is to be reached in certain circumstances. Besides the historical (seeming) normativity of this kind in science illustrated above (paragraph 1.1), there are contemporary accounts which state it more or less explicitly: for example Nancy Cartwright's (1999) notion of nomological machine as a law-producing setting, and Rein Vihalemm's notion of phi-science cited in paragraph 1.1 (also Appendices 1, 2 and 3). To use Dretske's formulation, a law '*F*-ness→*G*-ness' generates "physical" or "nomic" necessity of relations between concrete individuals, laws "tell us what *would* happen **if we did such-and-such** and what *could not* happen **whatever we did** (Dretske 1977: 264; italics in original, bold added)." These accounts construe laws of nature (scientific laws) as built upon human activities, upon the ways how human practice orders and arranges the material world.[48]

1.3.1. Causality

Let us look closer at 'causality' as what the necessity in scientific laws is often taken to be, and which is often used in various different meanings.

Collingwood (1937–1938) considers three understandings of causation: I. The original meaning as *causa* or *aition* consists of efficient cause (the current state of affairs) and final cause (the state of affairs to be brought about) and pertains to intended actions of conscious beings: those can be caused by another conscious being's influence, or may be self-caused. According to this understanding, it is rather the legal norms, not laws of nature, which are causal, as motivating conscious human action. II. Natural scientific notion of causation, which is a contingent process, depending on *conditiones sine quibus non* and on (man) turning it on and off – cause itself in this sense (*aition* – blame, accusation) is a condition that can be humanly manipulated.[49] This causation is, to Collingwood's mind, only metaphorically so: making things of "inorganic nature" behave in the way that man likes, thwarting them behaving as they

[48] Dretske's aberrance from the popular understanding of scientific laws manifests itself also in his explicit statement that on the abstract level, laws could be formulated differently than they are – supporting his view that necessity holds only on the level of particulars due to abstract level of laws, not on the abstract level. Also Ronald Giere (2006) advocates the pluralistic view of laws, but he grounds it concretely on sciences and the plurality of their research levels.

[49] Collingwood adopts a Baconian or Aristotelian notion of natural science as practical, manipulating science.

themselves like (ibid: 96). III. Mathematical or theoretical causality of theoretical science; that is, theory or a mathematical model states an allegedly causal relation which is necessary (apodictic), for being mathematical, and non-spatio-temporal. Those called laws of nature in my context and considered as causal by Kelsen (and Taagepera), belong to this category. Collingwood regards this notion of causation as anthropomorphic – stemming from an animistic theory: the neo-Platonic theology.

Heidegger (1959a, 2003), criticising the contemporary instrumental understanding of technology and correspondingly of causation, considers and explicates this word '*aition*' ('debt') in its original Greek understanding as fourfold (*causa formalis*, *causa materialis*, *causa efficiens* and *causa finalis*), where causing should rather be understood as occasioning (*veranlassen*), which pertains to both conscious action (bringing something forth, Collingwood's II meaning and perhaps also I meaning) as well as to spontaneous happening in living nature, *physis* or "the arising of something out of itself" (coming forth) – which is even the highest form of bringing-forth as *physis* inherently has its own "irruption belonging to bringing forth" (Heidegger 2003: 254). I will consider some issues contiguous with the historical meanings of causality in Chapter 2. Let us next consider the notion and role of causality in law and in science as nowadays understood (which is what Heidegger and Collingwood criticise), and its relation to norms and laws and to the conditions mentioned by Kelsen.

H.L.A. Hart and Tony Honoré (1973) concentrate on causality in law. Their notion of cause stems partly from that of J.S. Mill which has four main features (ibid: 20): 1) "invariable sequence of events in nature", referring to empirical regularities [$(x)(Fx \rightarrow Gx)$], 2) causal events and states (F) are complex, not simple [$F=(F_1F_2F_{3\ldots})$], 3) distinction between scientific notion of causality (entire set of causal conditions is sufficient [$F_1 \ldots F_n \ldots \rightarrow G$]) and legal notion of causality (one of the causal conditions is selected [$F_i \rightarrow$G]), and 4) one and the same event may in different circumstances have different causes [in C_1, $F_1 \rightarrow$G; in C_2, $F_2 \rightarrow$G; …]. Hart and Honoré have three criticisms against Mill's notion of cause (ibid: 20–23): 1) causation is usually not understood as invariable sequence, but also statements about singular sequences of events are legitimately regarded as causal. Nancy Cartwright (1989) likewise emphasises the fundamentality of singular causations: there must be a (at least one) concrete causation in the material world in order to state a general causal relation (also Mackie (1980: 80, 122) mentions this). In addition, superfluity of the requirement of material regularity is supported by Cartwright's claim that there are not enough regularities in the world [for exact sciences like physics] (Cartwright 1999: 71); all the less can there be real regularities in such complex domains that law, politics and applied sciences, like environmental and climate science, are engaged with.[50] 2) One must differentiate between causes and

[50] However, whether something appears as regular, depends on the deviation tolerance established for the asserted regularity (measurement uncertainties in laboratory practice are an example; see e.g. Appendix 4 about this), similarity with the "standard" is conventional.

reasons (in Collingwood's account – causes improperly or metaphorically called so, and real causes) – the latter is often the relevant notion in law (here particularly the requirement of regularity breaks down, as the same influence may incite different conscious effects on different individuals or on different occasions). 3) Mill considers mainly scientific causal inquiry, which is explanatory; in law, causal inquiries are rather attributive – searching for the strength of causal link between a defendant's act and the effected harm. The last criticism pertains to two main differences that Hart and Honoré draw between law and science: Firstly, that science is interested in general causality, or regularity of general features, and concrete causal relations are merely a tool for finding those, whereas law seeks for concrete causal chains and applies general causal relations for this end. Secondly – which is analogous to Mill's third feature – that in sciences there is no sharp distinction between causes and merely enabling circumstances – as in reality, things are more complex and there are no clearly separate elements of a set of conditions which cause an effect and other elements that do not cause it, it is rather the whole situation in which an effect occurs; in law (and in history and common sense thinking) such concrete causes as sequences of events are singled out of complex circumstances that are said to have caused an effect. I would add a fourth criticism that not only causal states and events F are complex, but also effect states and events G are complex $[F_1 \ldots F_n \ldots \rightarrow G_1 \ldots G_m \ldots]$.[51] Usually it remains unnoticed because it is just a particular state or event whose causes are of interest. But it is not some causal chain that is isolated from the rest of the world, rather it is related to many other things and processes not in immediate focus, but which may manifest themselves in other spatiotemporal or contextual circumstances. Hart and Honoré's third criticism and Mill's 3rd feature of causality point to the solution-driven purposes more immediately perceivable for common sense of either kind of investigations: in law, truth must be settled once and for all in a sensibly short time, in science, the pursuit of truth is an on-going process (Haack 1999, Laudan 2006).

The causalities meant by Hart and Honoré in law and in science are of the same kind of occasioning: the kind happening in the "human-independent" world to be described in technical terms in order to bring it under a theory (a law or norm); it is not likening the formulae to each other as to their modalities 'necessity vs. obligation', where F and G belonged to different Universes according to the formula's belonging either to the field of law or that of science. To make it clearer, let me make substitutions in the formula $[F_1 \ldots F_n \ldots \rightarrow G_1 \ldots G_m \ldots]$: F_i (i=1,..., n, ...) -> $F_{1.i}$ (i=1,..., n, ...) and G_j (j=1,..., m, ...) -> $F_{2.j}$ (j=1,..., m, ...); then the logical formula for a legal norm will look like this: $([F_{1.i} \rightarrow F_{2.j}] \rightarrow G)$, where the first '→' stands for causing in the contemporary

Thus regularities for non-exact-scientific domains may be more loosely defined for allowing reasonably economic treatment of them in terms of corresponding theories or normative systems.

51 Also Kelsen (1939/1940: 107) points out that both "causes" and "effects" are complex and not clearly separable from each other and from the general situation.

"scientific" sense and the second '→' stands for the correlating of an element of a Universe of Cases ($F_{2.j}$ or [$F_{1.i}$→$F_{2.j}$]) with an element of a Universe of Solutions (G).

Let me now clarify the misunderstanding about causality in contemporary science, or the interpretation of F, G and '→' in Dretske's formulation. Some reckon associational or covering-law relations in scientific laws as causal, for example $f=ma$ and functions for different forces f, deducible from this (e.g. Taagepera 2008; Feynman 1965: 53);[52] this is what Hart and Honoré seem to have in mind. However, on this mathematical-theoretical level – in mathematically formulated laws of physics for example – there is no causality at all like already claimed by Collingwood, but rather an interrelation of singled-out attributes that are regarded as essential in a phenomenon.[53,54,55] Such an interrelation holds in certain circumstances, called *ceteris paribus* or *ceteris neglectis* conditions. Causality may enter this game in material experiments, where the conditions for a phenomenon to occur are created with the help of a concrete apparatus – then the effects of the apparatus and of other circumstances that may be present in the situation materially cause the phenomenon to occur. This corresponds to Mill's first feature of causality – that the notion entails invariant sequence of events – that involves three important aspects that also Hume had pointed to: materiality (empiricalness), succession (temporal order), and regularity, the first two of which are relevant here. Thus the "scientific" notion of causality resembles that of Hume and Mill in that there can be a causal relation only between material events or 'objects' which are clearly discernible from each other and appear in temporal order (Mackie 1980: 30, 32). Associational laws considered by Taagepera, in contrast, hold between simultaneous attributes of one and the same 'object' or set of objects, and they characterise abstract (theoretical) properties and relations of a system.[56] This mathematically expressed relation of measured attributes and their dependence on other possible circumstances is what matters to theory, not some concrete

52 The force function is even better to be interpreted as the definition of the concept of force, rather than an associational law, as Poincaré has argued (Ayer 1998: 813).

53 This was pointed out to the author by Piret Kuusk in personal communication; causality, as she says, is in physical theories always related to time and enters only the heuristic or "narrative" part of physics, but not its abstract theory or mathematical laws associating quantities with each other. See also Gasking (1955).

54 In field theory, and thus in modern fundamental physics, there are no causes at all (Rafaela Hillerbrand in personal communication).

55 However, Hanzel (2008) considers those (associational) laws as causal (he calls them 'laws of manifestations' in comparison with what I would call, on Cartwright's example, phenomenological laws ('laws of appearance'), as the latter describe phenomena purely on the basis of their empirical appearance, the former on the basis of the causal forces or factors (capacities) behind the empirical phenomenon that bring it about.

56 The confusion with succession and simultaneity is present already in Mackie's formulation of causality (1980: 63): he claims for some purposes the form '[In circumstances *C*] each [*F*] is followed by [*G*]' to be legitimately replaceable by '[In circumstances *C*] each [*F*] is [*G*]'.

causal chain that brings it about (also Stepin 1999a: Ch. 2; 2005: Ch. 2; Ladyman and Ross 2007: 121). In applied science and technology, where concrete material things and their evolution in time play an essential role, (concrete) causality is a more substantial element of reasoning. But on this level scientific reasoning resembles the level of concrete happenings that interest judicial reasoning. Examples can be taken from environmental and risk evaluation where effects of concrete (possible) activities and objects are of interest. In contrast, the theoretical part of law, like a scientific theory, deals with idealised categories and relations more similar to natural sciences.[57]

Mill's listed 2nd and 4th features of causality – complexity of causal events or states, and plurality of possible causes for an effect – yield what Mackie calls inus conditions[58] (Mackie 1980: Ch. 2). This should be understood in the frames of his activity-driven distinction between causal field, conditions and cause: Causal field is the normal background conditions (*ceteris paribus* conditions) which are taken as a self-evident part of normal human activity and not considered a part of the cause (even though science may deem it an important cause or condition, like presence of oxygen for fire). Conditions are the various non-self-evident or non-everyday states or events, which are together necessary for the effect to occur. Cause is one of those necessary conditions that strike normal human experience as conspicuous, that occurs differently from normal state of affairs in the particular situation (ibid). Mill's 3rd feature of causality, Hart and Honoré's 3rd criticism to Mill, and the two differences between scientific and legal notions of causality that they draw (general vs concrete causality, and enabling circumstances vs concrete causal chains), pertain to this dissection of causation. That science deals with general "causality" has to do firstly with the plurality of scientific disciplines that study the world from different aspects and on different levels, thus bringing forth different ways in which things can behave and relate to each other. Secondly, (theoretical) science is not interested in contingent "idiosyncratic" circumstances, but universal properties and generalised, unhistorical relations, like Heidegger, Dretske and Holmes describe.[59] In judicial and various applied scientific inquiries like environmental and climate science for policy making, it is the concrete idiosyncratic circumstances and events that matter, and theoretical science is often of help for advising about (physically) possible processes and (causal) scenarios, or possible sets of inus conditions for a particular effect.

As Hart and Honoré argue, causal relations are essential for determining which paragraph of a given legal code should be applied in a given case, hence

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[57] Hence the interpretation for bringing unclear concrete material occurrences under the clear concepts of theory by comparing "how like or unlike the standard clear case the present debatable case is (Hart and Honoré 1973: 87)", is essential both in law and in science.

[58] insufficient but non-redundant parts of unnecessary but sufficient conditions

[59] Local, incidental or contingent circumstances may be seen as occurring in the form of initial and boundary conditions, but even as such they are generalised, not related to concrete circumstances but to generalised properties and their relations – as a quantity can be treated as variable in one research, as parameter in another.

real causal relations are a constituent element of Universes of Cases, hence they are to be considered as elements of Universe of Properties, or of the *F*-ness in legal norms, or the conditions determined by the legal regime that Kelsen mentions (1976: 80). This means that they must be formulated in terms concordant with legal theory, or the latter must concord with the relevant perception and understanding of the world. For example, environmental and climate laws must use the conceptual frameworks of corresponding sciences, and those sciences, on their part, must carry their research out in a way that would be usable for legal policies aiming at those parts of the world. That is, their outcomes must indicate humanly manageable properties. According to the manipulational account of causality in practical science (Collingwood 1937–1938), and if causal relations are as fundamental in science as Cartwright contends[60] (1989), the outcome of scientific research being about humanly manageable is trivial: (exact) scientific practice itself is engaged with numerically exact manipulation of the "inanimate" world, bringing material settings, and procedures on them, into accordance with mathematical laws of nature in controllable ways. But also scientific mathematical theories themselves purport to causal systems, like in Cartwright's example from econometrics (Cartwright 1989: Ch. 1) (or in environmental and climate models). Often the purported "systems" are not directly controllable in all their parts and details, particularly the Cases (mathematical laws) often cannot be tested in laboratory situations, or cannot be tested for all of the possible values of their constituent Properties (Collingwood's theoretical causality, causal relation which has not been empirically confirmed, hence belief in it rests exclusively upon theory). For Cartwright, such causality makes sense because she regards capacities of things or their properties as the most fundamental measurable and calculable features underlying causes. In applied sciences, inferences about the material world are often drawn from the calculations of those mathematical ideal models, hence the models are taken as representing, or as functioning in the same way as, the real world properties and their (causal) relations, or the Universe of Discourse. This theoretical causality Collingwood recognises to be perceived as necessary because of its mathematicalness or apodicity, in contrast to the manipulational causality which is perceived as contingent because it is material.

1.3.2. Implicit normativity

The systems that Alchourrón and Bulygin call normative are that on logical grounds – due to containing explicit prescriptions for actions. As they advocate analyticity and clarity of concepts through clear and strict definitions of technical terms, their concept of 'normative' may also be regarded as technical, being limited to 'explicitly prescriptive' in this logical sense, to sentences telling

[60] Cartwright regards causal laws in science more fundamental than associational laws, the latter being built upon the former; causal laws, on their part, rest upon (causal) capacities of things or their properties.

what is to be done. However, there are also less technical concepts of 'normativity' applied in the contexts of science and law. I will present some accounts of normativity of laws or in science, and thereafter my own classification of aspects of normativity in and of science.

Ernest J. Lowe explicitly claims natural laws (nomological generalisations, or dispositional claims about sorts or kinds that he considers natural laws to be; Lowe 1989: 35 and 2009: 34) to be normative, whereas he seems to hold two different senses of normativity. The first is a similar sense in which judicial and moral laws are normative – prescribing how a normal individual of the type targeted by the law is to be (Lowe 1980; 1982; 1987a; 1989: 147–148). He exemplifies both natural sciences' kinds of laws (and respective natural kinds) like "Ravens are black" (ravens) as well as exact sciences' kinds of laws like "Electrons have the charge –1" (electron) (Lowe 1980, 1982). In (1987a: 273) he expresses the view thus: "According to the normative account of laws, a statement of natural law (a 'nomological' statement) characteristically implies that normal or typical individuals or exemplars of some recognizable natural kind possess a certain dispositional property, that is, are disposed to behave or appear in a certain way (usually in certain specifiable conditions)." He also considers the notions 'permit' and 'obligate', that usually pertain to moral and judicial laws, in the context of natural laws: if the latter are to be logically similar to the former – and that they must be if pretending to legitimately be called 'laws' – then 'not permitted that *p*' does not imply 'obligatorily not-*p*' and 'obligatorily *p*' does not imply '*p*' (ibid), contrasting to the account of modal difference between natural and legal laws enunciated by the many philosophers, presented in 1.3.1;[61] or again "an exception to a putative law is permissible provided that it does not constitute an instance of another, incompatible law (ibid: 275)". These equalisations of natural law with legal and moral norms and laws leave it unclear what exactly Lowe means by 'natural law': if it is to be normative to its object *x* in the same sense as judicial law is to the subject of law, that is, obligatory, then it should be something that nature "prescribes" (in the metaphorical sense of the word) to itself, or just what nature is like[62] – as nature cannot spontaneously, from out of itself, follow human prescriptions (in the literal sense of the word 'prescription'); however, conceding natural laws to be incompatible with each other rather refers to the concept of natural law as statements formulated in sciences that can be

[61] This normative account of laws of nature resemble what Joseph Needham (1951b: 225) reports about medieval understanding of natural laws as laws prescribed by God, that in Europe, transgressing those laws was considered possible to the extent that anomalously behaving animals or things were litigated and punished for transgressing the laws that God had prescribed them; whereas, in contrast, in China, no transgressing of natural laws was considered possible – in whatever ways nature is (behaving), it is natural and according to its laws (one could say – man had no arrogance to pretend to know all and everything about the Universe, to be in a state to judge its ways).

[62] This view rests on the belief in lawfulness of nature, and specifically in the governing role of natural laws, which is not self-evident; this view is criticised by Mumford (2004).

inconsistent just as it is possible to formulate inconsistent statements[63], for example when not sufficiently qualified (that is, if their conditions of application or "validity" are not pronounced to the extent as to make explicit their compatibility)[64]. Stephen Mumford (2000) rebuts Lowe's normative account of natural laws on the basis of two differences between legal and natural laws: 1) The origin and status of laws – who should be the prescriber of norms in case of natural laws? God as prescriber is subject to scepticism; empirically discovered laws are rather descriptions than prescriptions. 2) For legal norms, there is a gap between *norm* (the written law or norm) and normal (what is practiced normally or in most cases, considered normal in the society). There can be no such gap for natural laws.

The second sense of normativity in Lowe's account pertains to human conduct and attitude towards the objects that laws refer to. This sense can also be seen as a reinterpretation of Lowe's first notion of normativity as restrictions to human attitude towards the world: men (e.g. scientists) applying the laws are to consider as objects of those laws, that is, as the Universe of Discourse of those laws, those sorts, and derivatively individuals, that accord with the specification of the law. For example, the law "Ravens are black" is to be applied to normal or typical ravens, whereas e.g. albino ravens are to be considered as non-typical with respect to this law (although they may be typical with respect to a law about the underlying causes of albinism; Lowe 1980; 1982; 1989: 198–199). He more explicitly pronounces this interpretation in relation to laws of "advanced sciences" in (1989: 149 and 174–175): as there are not even perfectly normal individuals in the real world (that is, corresponding to all the normal traits of its specified sort or kind), still less perfectly ideal individuals that the advanced sciences deal with, laws and terms of those sciences are theoretical, ideal, and hence normative by excluding any abnormal individuals from the Universe of Discourse of the science (for example, there can be no proton with charge other than +1, or with any other attribute different from that of an "ideal proton"). This kind of normativity resembles that included in Rein Vihalemm's concept of phi-science (physics-like science), which itself defines its object according to what in the world corresponds (can be made to correspond) to the mathematical descriptions of exact sciences, and it only "sees" that part of the world that lets itself be subsumed to mathematical description (Vihalemm 1995, 2011 and others). Lowe explains the purpose of this setting of norms (Lowe 1989: 175): "the idealizing tendency of scientific theory-construction is just a response to the perfectionist urge to refuse to allow abnormality to enter the most fundamental description of nature, but still involves an implicit

[63] As Cartwright and Giere explicate the forming models in sciences, correspondingly models of engineering or applied sciences and representational models (Cartwright 1983: 104–106; Giere 2010: 272). However, it may be questionable if this notion of inconsistency can apply to laws as generalisations that Lowe takes them to be.

[64] This criticism rests on the assumption that nature cannot be incompatible with itself; however, I'm not in the position to evaluate the credibility or even meaning(fulness) of this assumption.

recognition of the normative character of nomic generalizations." This discords with Vihalemm's understanding according to which there could not even be any of those theoretical entities involved in the "advanced science" unless as the constructed (not generalised!) idealisations. But it concords with my claim (parallel to that of Holmes) that the idealisation (be it generalisation or construction) aims to expunge abnormality – and with this, uncertainty – from our understandings and handlings of the world.

Anthony M. Tinker, Barbara D. Merino and Merilyn Dale Neimark (1982) argue against the claimed objectivity and independence of positivist (realist) accounting theories (theories that presume the existence of a human- and theory-independent reality that is the same for all), intending to show value-ladenness of supposedly descriptive, empirical theories, as contrasted with normative theories. On the basis of the historical development of the concept of 'value' in economics, and in contrast with alternative value theories (classical value theory vs marginalist value theory) that have differing underlying assumptions about the basic phenomena of the field[65], they show the determining role of pre-analytic values in economic and accounting theories which are usually claimed to be value-free, historically descriptive and hence non-normative. Due to the ban to formulate economic theories in normative form, and their claim to objectivity by restricting their scope of (causal) relations taken into account in the theory and factors claimed to make up the values of goods, those theories are believed to reflect objective facts. However, they do actually determine the description of the world by accountants, thus also handling of the world by corporations and politicians on the basis of financial statements, and are therefore prescriptive and create the very "facts" they "describe", ignoring other facts of society that are related to and more or less directly dependent on the concept of value in economics.[66] Thus, as Tinker et al note, marginalist value theory, by restricting its scope or the concept of value, does so at the cost of socially ideological idealisations; hence "this separation of theorizing into descriptive, positive and normative is designed to create an illusion of impartiality and independence to support normative policy type decisions (ibid: 172)".

The discussion by Tinker et al can be taken to exemplify Vyacheslav Stepin's (1999b) and Joseph Agassi's (1956) understanding of the prescriptive role of world picture. Stepin proposes the notions of scientific world picture and special scientific world pictures (linked to particular scientific disciplines) that, among their other functions, create a system of values that determines the character of world cognition and an active relation of man to the world, and

[65] e.g. that markets are effective; wealth endowments can be ignored; informational efficiency is an important indicator of economic well-being; utils can be added together; markets exhibit equilibrium-seeking properties (ibid: 170–171).

[66] "Since the ultimate object of economic activity is to reproduce the (real) means of subsistence, with stock prices merely "paper" intermediaries in this process, the linkage between stock prices and the production of real goods and services is critical and cannot be taken for granted (ibid: 171)."

prescribes the legitimate hypotheses, problems and solutions for scientific theorising and research. That is, they restrict the theory's underlying assumptions and hence the phenomena that make up the scope (Universe of Discourse) of the theory, but also its structure (Universe of Properties and Universe of Cases). In the case of economic theories, the Universe of Discourse is "reproduc[ing] the real means of subsistence", for value theories "the logic of exchange relations", whereas "accounting has provided the system for measuring and reporting reciprocity in exchange" (Tinker et al 1982: 174), or the "theory of measuring value". The marginalist theory of value restricts the logic of exchange to purely pecuniary, to monetary transactions, thus preserving some phenomena of preceding value theories, but expunging some other aspects ("the underlying processes") of those phenomena, that is, restricting the Universe of Properties and hence Universe of Cases. For example, in Marxist value theory, ""value" is ultimately a social relation because it is concerned with the exchange of the life experiences of people whose labor is bound-up in the products (ibid: 179)"; that is, (socially necessary) labour, society-at-large, and income distribution and other differences between social classes, are some properties that marginalist value theory expunged from accounting. The assumptions listed in footnote 62 may be regarded as stemming from the special scientific world picture underlying marginalist value theory; some further such assumptions might be (ibid: 190):

> that the primary (and perhaps sole) rationale for and objective of contemporary financial reporting is to serve the capital market; that competitive market forces can be relied upon to protect all interest groups (and that all interest groups are represented in the process); that members of each interest group are equally capable of processing information and discerning management's (homogeneous) utility function; that only government possesses coercive power; that all behavior is motivated by economic rationality; and that public interest arguments are always a sham to mask self-interest.

Larry Laudan (1984) focuses on cognitive values and methodological norms and rules in science, seeking to answer the question of achieving consensus about scientific theories among scientists. He sets out from the hierarchical view of science according to which dissent in science can appear on three interrelated levels (ibid: 23–25): facts or what there is in the world, meaning both observable and also unobservable and theoretical entities; methodology of science or rules concerning attributes of scientific theories, "principles of empirical support and of comparative theory assessment", from highly general to specific to particular scientific disciplines; and the basic cognitive aims (like truth or "conceptual economy" or "predictive accuracy" or "manipulative simplicity"; ibid: 48). Laudan argues on the basis of historical evidence that these three levels do not rigidly depend on each other, as there is no one-to-one relationship between them; or in other words: facts, methodologies and aims do not uniquely prescribe each other. Although aims and rules in science are often rather general and not uniquely interpretable, they are nonetheless prescriptive, as theories not complying with them are excluded (ibid: 85).

Vyacheslav Stepin (1999b) tackles similar issues about the complex forms and levels of norms and ideals in scientific inquiry. He discerns two types of norms and ideals in science (ibid: 31ff., 40ff.; translation by A.M.): a) the three basic forms of cognitive guidelines (for explanation and description, for demonstration and foundation (justification), for construction and organization) "that guide the process of reproducing the object and the varying shapes of scientific knowledge", corresponding to science as cognitive process; and b) social standards that determine the role and value of science for the society in a particular era, corresponding to science as a social institution. He emphasizes that the various ideals or characteristics of scientific knowledge (accuracy, empiricalness, simplicity etc.) pertain to different forms of norms in science, and they can change within time more or less according to their generality. The last point will be particularly relevant to my study. Stepin discerns three levels of ideals of science (ibid: 41ff.): I. those that differentiate it from all other forms of knowledge and do not change since Antiquity (the era when the first scientific disciplines in the contemporary sense were born): its difference from opinion, justification and demonstration, the requirement to discover the essence of things, not restricting itself to the appearance of phenomena; II. ideals of style of thinking determined for a particular historical era, e.g. difference between Ancient Babylonia and Egypt, and Greece, in organizing (mathematical) knowledge (see also paragraph 1.1 of this paper), or the medieval differentiation between correct knowledge (by observation) of practical import, and true knowledge, discovering the symbolic meaning of things; III. ideals, principles of particular scientific disciplines.

John Lemons, Kristin Shrader-Frechette and Carl Cranor (1997) discuss cases of science-based policy making, particularly environmental policies where the underlying scientific models are complex and over-laden with various sources of uncertainty. On the one hand, they show politics- and ideology-ladenness of applied research, where epistemological decisions must be met under economic pressure by restricting the number and values of variables (Universe of Properties) and time span taken into account in models. For example, in modelling Yucca Mountain as a possible nuclear waste repository, temperatures of air and soil, scenarios of climate change had to be limited and time span restricted inadequately relative to the expected lifetime of the repository, leaving out of consideration even the possibilities known to the sciences of that time. On the other hand, the resulting scenarios of nuclear waste evolution were considered as possible on the basis of epistemic standards of fundamental science – the standard of proof: 95 percent rule (that is, a scenario of causal links has a confidence level of, or is taken as true if its probability is, at least 0,95)[67] – which is inadequate for cases of high environmental and health

[67] Epistemic values of science, particularly the 95 percent rule, is also discussed by Laudan (2006) in legal context which resembles the policy decision context as both depending on

risks. Besides explicitly pointing at values influencing scientific research in application, Lemons' et al own text implicitly manifests the normativity of epistemic values and standards in science like theoretical and analytical simplicity, scientific rationality and certainty, quantifiability and measurability that should be met by natural sciences, as illustrated by the quote (ibid: 217, emphases added):

> In fact, ecology has *failed* to develop predictive laws because *ecological systems* are so inherently complicated that all the small and assumed insignificant *variables* can easily overwhelm the *ecological systems* and confound the *mathematical models*, as well as because of the fact that we simply do not understand much about the structure and functioning of ecosystems.

This considering the inability to provide certain predictions via mathematical models as failure hints to considering mathematicalness and certainty of numerical predictions as normative and as the ideal to be followed by sciences. In addition, their criticism of the modelling of Yucca Mountain only targets the restrictedness of geological-physical attributes, but not the restrictedness of the model merely on said attributes with no attention at all paid to, for example, biological or cultural contexts of the mountain[68].

Joseph Rouse (2002) argues for implicit normativity in scientific practices partly on similar grounds as Lowe argues for normativity of laws: as an alternative to the regularities-account; that is, scientific practices cannot be identified on the basis of regular procedures and activities (like natural laws cannot be identified on the basis of regular events and associations in nature), as there are no objective regularities, e.g. in following rules (Rouse 2002: 170). However, Rouse's normativity-account of scientific practice has a rather complicated shape – it has various "constituents" and 'intra-actions' to which he applies the words 'normative' or 'normativity', but what exactly those normativities consist in is rather unclearly articulated (unclearly in contrast to Alcourrón's and Bulygin's and other logical expositions of normativity). Among the various normative elements of scientific practice in this account are: the surrounding world: by engaging in a practice, one is "implicitly committed to on-going engagement with a surrounding world (ibid: 256)"; understanding of the self in relation to this surrounding world: "Who "we" are depends upon how our surroundings are configured. That, in turn, is a normative question: what are the phenomena (as repeatable patterns) to which our activities belong? (ibid: 332)"; other practices: scientific practice can only be identified "against a background of other practices (ibid: 170)"); inter- or intra-actions – particularly

finding out the ultimate truth about particular real world individuals (objects or "systems", persons, events).

68 Yucca Mountain has been a sacred site for local indigenous people since times immemorial; see Fowler et al 1991; http://www.umich.edu/~snre492/kendziuk.html

causal ones – with the world (people and things):[69] "[C]ausal interactions with objects acquire normative authority over what people say and do (ibid: 186)"; interactions with scientific-experimental apparatus (ibid: 286–287); and also that which in other accounts might be called laws of nature, or phenomena: "The repeatable pattern of a physical phenomenon is ... normative rather than simply regular (ibid: 280)". These elements cover several aspects, listed in the introduction, in which laws can be contemplated: the narrow notion of laws as expressing some kind of order or regularity in the world, their relation to the world, theories that encompass them, practices of formulating laws, (inter)-relatedness of law-formulating practices. Rouse regards them as tightly interdependent, particularly he sees (scientific) (linguistic) discourse as strongly dependent on practice and perception. Above all, his notion of normativity seems to mean the implicit guiding role of "what is at issue and at stake" in (scientific) practices, what is being aimed at, and that something is being aimed at;[70] this, on its part, is constantly changing as the world and perception of it is changed through material activities (practices).[71]

To clarify Rouse's notion of normativity, let us notice that in his account it is the practice or action (activity) that makes up the world and therefore also makes up science.[72] But this is exactly the element of a (logical) system that underlies its normativity – actions; and those actions being provided with deontic operators. So in Rouse's account, the fundamental constituent of life-world and of science is the Universes of Actions, and "what is at issue and at stake" determines the Universes of Solutions. The latter logically includes Universes of Cases and hence those of Properties, which are the logical, linguistic or theoretical parts of normative systems, in Rouse's account the discursive and hence in a sense secondary element of practices, as they rest on those. Universe of Discourse is on the one hand the perceived part of the world, on the other hand it must be regarded as the world acted upon. So Universes of Discourse and of Actions are the underlying elements of science as understood in Rouse's framework. However, it is also clear that all the Universes are subsumed to constant reconceptualisation and reestablishment, as issues and stakes change due to the constant explorative and conceptualising reconfiguration of the world in scientific and other actions (practices). This of course implies historical changing of (implicit) norms which complicates detecting concrete norms and by this demonstrating the normativity of practices like science. Rouse's normativity might be close to what Stepin and Agassi mean by the normativity

[69] Similarly to Cartwright, Rouse argues for the priority of causality, or causal intra-actions, in practices, including scientific practice (ibid: e.g. 259–260, 318).

[70] "Intentionality is … an inherently normative concept, at two levels: its use by an interpreter is governed by norms, and in using it, the interpreter ascribes rational normativity to what she interprets (ibid: 188)."

[71] "What is authoritative over and constitutive of human agency and meaning ... is not the independent objective natures of things, but the emergent configuration of a situation as having something at stake in its outcome (ibid: 257)."

[72] Thanks to Endla Lõhkivi for pointing this out to me.

or guiding task of world view or world picture, and also as the deepest level of Schein's partition of culture, which determines how the members of that culture perceive and think about their world (footnote 74).

Let us notice that there have been both different sources of normativity, or what is setting norms (laws formulated in sciences, scientific practice – theoretical, experimental and applied, social and political considerations and practices, the underlying fundamental or scientific world picture or scientific theory), as well as different directions of normativity touched upon:

- norms set upon science: underlying assumptions determining the scope and basic terms of a fundamental discipline (Stepin, Tinker et al, Agassi) or of models in applied research (Lemons et al); epistemic (Laudan, Stepin) and practical (Rouse, Stepin) ideals and norms guiding and shaping scientific inquiry;[73]
- norms set by science: upon the way of seeing and handling the world (Tinker et al), upon policy decisions and their underlying knowledge standards

[73] Particularly widespread is the topic of value normativity or value-ladenness of theories. Studies dedicated to the latter show how particular underlying implicit value judgements affect science making, first of all practical applied science and scientific modelling for science-based policies, but also scientific theories (e.g. Lemons et al.1997 about environmental modelling for policy making; Tinker et al 1982 about ideologicalness of accounting theories; the joint article with Rafaela Hillerbrand to be based on the current work will deal with normativity and value-(and politics-)ladenness of particularly climate science). Agassi says to this end (1956 Part II: 381): "It is always possible to argue that a scientific theory which contradicts the metaphysical view which we now defend, is only tentative, an approximation to the truth, that a better scientific theory will supersede it which will conform with the metaphysics which we are defending." Indeed the same seems to hold about environmental policies, contemporary politics and international legislation, as Lemons et al (1997: 214) recognise on the basis of their study: "This historical analysis of environmental change … demonstrates the evolution of scientific paradigms over time and how humans have constructed knowledge to satisfy their needs and wants within certain political economic systems." Peter Newell states explicitly (2003: 60, 61, referring to Scoones 2002) that global economic and political powers, the capitalist market system, shape science, prescribe scientific rationality and soundness, and presumption of universality. In Alchourrón's and Bulygin's (1971: 103–107) logical account, values are external to the normative system as a purely logical system, but an important issue in legal theory related to axiological gaps, as they determine which properties ought to be relevant (prescriptive relevance) and hence to be included in a Universe of Properties (to be descriptively relevant). An axiological gap therefore occurs between a normative system, e.g. a legal act, and value judgements if the former does not take into account some properties that ought to be taken into account in a decision according to a hypothesis of relevance. To this effect, they say (ibid: 103): "To say that a property is relevant in the prescriptive meaning is to say that a certain state of affairs ought to be or should be the case, i.e. that a case and its complementary ought to have different normative status." In those inquiries into the value-ladenness of science it is often the tension between descriptive and prescriptive relevance of properties that is addressed: on ideological, economic, political grounds, scientists are prescribed by policy makers which entities to take into account in modelling the real world phenomena, which variables to include in their models of research, which domains of those variables, etc.

(Lemons et al), upon scientific practice itself – science reproducing its own practices (Stepin, Rouse).

These are certainly not independent from each other: as science can be said to be world picture-, value-, politics- and ideology-laden, so are politics, epistemic and moral values and law world-picture laden, which on its part is strongly related to science. I present in the following some aspects of how science itself (implicitly) exhibits normativity upon (other) portions of the life-world. Those aspects pretend neither to completeness nor exclusiveness, but are to clarify and illustrate what I mean by implicit normativity of science. Thereafter I will briefly consider them in case of law (explicitly normative systems) and relations between explicit and implicit normativities.

1) Conceptual normativity hints to linguistic treatment of the world, or how something is expressed in language. I discern two modes: general and particular. a) The general analytic way of seeing the world, which is both superimposed and presumed by the scientific thinking, means dividing the world into some kinds of well defined elementary particles or attributes, which, when composed, like in conglomerates of atoms, mathematical formula, or generally systems, make up the world (the concepts of Universe of Properties, Universe of Cases, Universe of Actions as atomic, independent, exclusive and comprehensive exemplify this general fundamental scientific-analytical attitude). Arie Rip (2009: 408, 416) links such a (conceptual) treatment with engineering thinking, where atomic, elementary parts, into which the world is divided, can be manipulated in controlled ways as building blocks. b) The particular way of correct thinking or talking or writing about the world (concrete elements of Universes of Properties and Universes of Cases), or perceiving it (concrete elements of Universes of Discourses): with which words, which conceptual networks, or which is the true description of the (human-independent) world; the examples of complex functional scientific concepts, shaping common sense understanding, might be: gene, species, climate, greenhouse gases, electricity, gravitational force; (from Tinker et al 1982: 176) capital, rent, profit, wage. The general meaning of conceptual normativity is enwombed in Vyacheslav Stepin's (1999b, 2005) conception of world picture or world view and philosophical foundations of science, in Edgar Schein's (2010) analysis of culture as the deepest of the three levels of culture[74], and possibly in Martin Heidegger's (1959a) notion of *Gestell* (see also Seubold 1986); the particular conceptual normativity is enwombed in Stepin's conception of (special) scientific world pictures (Heideg-

[74] Schein (2010: 23–33 and Part Two) discerns three levels of culture: the upper level of artefacts and observable behaviour which are manifest but difficult to interpret, the middle level of 'espoused beliefs and values' which are relatively conscious, and the deepest level of 'basic underlying assumptions' which are unconscious and taken for granted, only become aware of in contact with different cultures, where the underlying deepest levels come to conflict. Schein specifies as some features of 'culture' that it creates stability and certainty, it is a "coercive [hence normative!] background structure that influences us in multiple ways" (ibid: 3), including how we perceive and think and feel about things (ibid: 28).

ger 1959b brings those forth as well), and possibly (partly) in Lowe's kind of normativity (normal sorts) as I reinterpret it. I will inspect world picture as a guideline, hence as normative, in more detail in chapter 2.

2) Epistemic normativity again has two modes: theoretical or mathematical and practical. a) Mathematical accountability, closely related to the requirement of conceptual clarity; the norm here is accountability and measurability, or mathematical clarity where ever possible (conceptual clarity in non-phi-sciences), which implies in principle, if not in practice, determinism – as mathematics is a priori unique and universal, independent of particular material idiosyncrasies.[75] Cognitive aims and values in science, shared goals constraining permissible rules, analysed by Laudan (1984: e.g. 36, 48) and by Stepin (1999b), and Lowe's notion of normal sorts illustrate and expound this kind of normativity. Also the notions of (measurement) errors and noise evidence of the normativity of mathematical theories (or models or laws) of science: a datum, a measurement result can only be said to exhibit an error or noise if there is a norm that says what an error- or noise-free datum should look like. b) Laboratory experimentation to this end. What should be done with the world, or how should the world be arranged and ordered in laboratory, so that the laws formulated in the sciences would apply to it. I call this aspect 'epistemic' because the aim of laboratory experiment is to ensure knowledge about how a mathematical model and the material situation relate to each other, and namely that they display a required resemblance. Nomological machines (Cartwright 1999, discussed in Appendix 4) are material settings displaying the regularities expressed in mathematical laws, so they approximate the epistemic certainty closest. This aspect pertains to the method how "laws of nature" are reached: they are not read out of nature but constructed mathematically and experimentally. Martin Heidegger's view of science as working or manipulating and refining the real to secure it for pursued aims expresses this active role of theory and observation in securing knowledge (Heidegger 1977: 166–168; 1959b: 55–56). This view contravenes, in principle, both the inductivist and the representational understandings of law formation in science (or the naïver versions of them); particularly – mathematical laws build upon, and abstract from, the formal properties of experimentation and measurement procedures (Vihalemm 1979, Suppes and Zinnes 1962). In laboratories, causal chains of events are enacted which lead to constellations or settings of matter which enable measurement of theoretically prescribed attributes of interest. The Universe of Discourse is determined in laboratories: if a part of the world can be treated as a composition of measurable and calculable Properties, or of simpler Cases which can be treated in this way, it belongs to the Universe of Discourse. For example, climate models have as their components simpler models of phenomena studied

[75] Probabilistic laws can be understood as deterministic in the sense that a particular probability is necessary; however, laws so called (in physics) are based on particular frequencies in statistical collectives, hence they are statistical not probabilistic, that is, based on idiosyncratic empirical data not on apodictically true (mathematical) theory. (Probabilistic models are abducted/inducted versions of empirical frequencies?)

in laboratories, like convection or properties of atmospheric gases. Scientific practice is collective and historical or developmental (evolutionary).[76] Mathematical theory guides laboratory activities – design of experiments, interpretation of results (Agassi 1956). Historical or developmental means: Due to the historically long practice and in a sense accumulative process, some of the theoretical knowledge becomes basic knowledge, often implicit and tacit, in the (laboratory) practice of physics, and is not questioned anymore (tests for a putative mathematical law are designed and run only until the mathematical formulation and test results are made to coincide, or the final shape and limits of the law settled, or the "phenomenon is stabilised"). Collective means: The normativity of laboratory physics is implicit in the 'paradigm'; one learns already at the university what a 'correct' problem looks like, how to treat it, what a solution ought to look like (one talks about 'well defined' problems, variables and solutions). The correct formulation namely corresponds to the conceptual clarity of a scientific theory. Experimental practice serves to render unclear material settings to networks of well-defined quantities with sufficiently well determinable scales and magnitudes. Mathematical-experimental clarity and accountability of matter, reached by exact sciences, has been the ideal and norm of scientificity, the epistemic *Leitbild* to be followed by other sciences and by practical designing of the world,[77] thus underlying the next kind of normativity:

3) Practical normativity has a narrower mode and a broader mode. a) The narrower mode is engineering: applying exact scientific knowledge to design appliances – technology in narrower sense – used in everyday life or (industrial) production. It is in a sense somewhere between epistemic and practical normativity: it goes on in laboratories, being developed and tested there, but is applied outside laboratory and gets its task also from outside. b) The broader mode means social and technical practices and policies, including science teaching: How it is correct to treat the world (for example, technical requirements for buildings, conservation of species, climate regulation).[78] The narrower, scientific-institutional ordering habits are expanded similarly outside laboratory, when science is applied to real world problems, in policy making, rule creation for practical handling (also Rouse 1987: Ch. 1 and 101). In order to be compatible with engineering approach, the real world is divided into problems of different disciplinary bearing,[79] which consist of interconnected, practically identifiable and measurable attributes, relevant for the aim, some of which are

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[76] Rouse (2002) proposes implicit normativity in laboratory practices. See also Laudan 1984, Stepin 1999a,b, 2005.

[77] as illustrated by the Appendices here

[78] Appendix 3 touches upon this aspect of normativity with an example from climate science.

[79] Also Heidegger (e.g. 1959b) emphasises and expounds this. An example of this division into disciplinary competencies is the case of value and accountancy theory by Tinker et al (1982), where all other aspects (like societal) but monetary are delegated to other scientific disciplines.

considered humanly manipulable, others as dependent on those. The ways how to scientifically treat the world depend on how the world is scientifically understood, and also the other way around – understanding and hence conceptualising the world depend on how it is perceived, which on its part depends on the techniques of discrimination and manipulation of the world, that is – on technology. So all these aspects of normativity are related to each other.

A brief contemplation might suggest that there really are just two kinds of normativity: theoretical (conceptual, mathematical, epistemic) and practical (laboratory, engineering, policy making). I point out epistemic normativity, keeping in mind my general target in this work: mathematicalness, analyticity, calculability or predictability – that hint to regularities, order or simplicity of some kind – in the sense that something lets itself be known in advance, be calculated, and thus provides certain peace of mind or repose, as e.g. Holmes expresses it (see 1.2).

The general and particular conceptual normativities of legal systems have been briefly hinted to above and are manifested in legal statutes, acts etc.; the broader practical normativity of law is straightforward in judicial, and sometimes in political, actions and activities: it is the explicit normativity instantiated in normative systems, their Universes of Solutions. What about epistemic and narrower practical normativities? Some epistemic goals directing law or judicial practice come from science, particularly where science is to advice legislation or courts about possible real world happenings, connections etc., like Laudan (2006) or Haack (2004) consider, or like in science-based policies (climate, environmental and other). But this is epistemic normativity of science. Partly it pertains to law itself: as law is to enable orderly, accountable, secure life in the society, applying it must be accountable and predictable. Hence scientific certainty is sometimes normative to the broader practice of law. But the education and insider-practice and scholarship of law, similarly to scientific education and laboratories-institutes, that Rouse has described as exercising implicitly normative practices, can be regarded analogously as securing predictable and accountable practice of legislation and jurisdiction.

2. THE ORDERED WORLD AND ORIGINS OF NORMATIVITY

The last paragraphs of the first chapter already considerably diverted from the narrow conception of laws as linguistic formulations or formal entities. In this chapter I turn to the broader context of laws – to world picture as a guideline driving ordering the world theoretically and practically, and to historical contexts of laws, normativity and world picture (or world cognition). My particular interest lies in the fundamental level of world cognition (or Schein's basic assumptions of culture) that guide more generally the experience or cognition of the world and treating it in social practices.[80] The aspects of normativity listed in the previous chapter will bear on the disquisition as follows: 1a general conceptual normativity means the normativity of world picture or world view or cognition and will particularly be addressed in paragraphs 2.3.1 and 2.3.2, and its relation to broader practical normativity (3b) in 2.1 and 2.2; 1b particular conceptual normativity specifies and illustrates with some examples the general conceptual normativity; broader practical normativity (3b) is the supporter and reproducer of the world view as it designs and creates the world immediately surrounding human life and perception; this will be in focus in parts 2.1 and 2.2; theoretical and practical epistemic normativities (2a and 2b) represent the ideal manifestation or peak and standard or reference model of the world-picture-driven treatments of the world. Particularly the latter, 2a,b, and their corresponding world cognition will be historico-phenomenologically traced and grounded (especially in paragraph 2.3).

I will start by introducing my interpretations of Heidegger's core notions of the essence of contemporary technology (Heidegger 1959a).[81] According to his words (Heidegger 2003: 259) contemporary technology applies contemporary science and is based on it, but its essence holds sway within science. Hence this basing (of technology by science) must be understood more broadly than applying theory – rather as general conditions for the arising of such practices like contemporary science and technology. Reflecting world views as strongly dependent on human relations with the surrounding world, including technology, will thus be essential for understanding normativity in contemporary mathematical-empirical science: the anthropological view of technology (technology as human activity) emphasises and specifies the activity-related side of science and its laws (Universes of Actions); technology as the (or a)

[80] Stepin (1999b, 2005) discusses something like this under the name of 'philosophical foundations of science'.

[81] Thanks to Prof. Ülo Matjus for many patient explications on Heidegger's philosophy. However, I have not fully taken over his interpretation (as little as I understood it), but keep to large extent to my own (mis)understandings and (mis)interpretations that were disapproved by him – as it is not specifically Heidegger's philosophy in my focus but my own understanding of contemporary world view and its normativity, and how reading Heidegger has helped me understand and conceptualise these on a certain plane.

practical side of science and as human everyday coping with the world essentially determines human cognition and conception of the world (as mediated by technology); and technology broadly understood as a means for an end (the instrumental view of technology), a corollary to the manipulational account of causation (as a basis of scientific experiment and thereby of empiricalness of science), is changing, creating or designing the world (or trying to do so) according to human needs and visions of it.[82] On the basis of historical moments in the evolution of the concept of law and its place in society and science, I will track the essence of science, or scientific world cognition, that Heidegger's conceptions have suggested to me.

As for Heidegger (1959a) one of the foci is the difference between ancient and contemporary technology, understanding this will be relevant for the historical approach taken here. The main characteristics of contemporary technology that discerns it from the ancient one is said to be *Gestell*[83] – enframing – which is the ontological (not ontic) structure of the contemporary world (Seubold 1986: 111), challenging man to regard the world or nature as a *Bestand*[84] – standing-reserve, hence constitutes the basis of the normativity 1a. What exactly this nature of technology as *Gestell* and world as *Bestand* might mean, I will discuss in this chapter. The word '*Bestand*' has three important aspects: firstly as 'standing', it means something stable, brought to (still)stand and thus secured in its state; secondly as 'reserve' or 'inventory', it is something that can be expressed in quantitative terms – something measurable and calculable, and, thirdly, as such staying at human disposal and discretion.[85] Which of those meanings is the core of contemporary world cognition, discerning it from the earlier world cognitions, and thus corresponding to the essence of contemporary technology, will be addressed in the following contemplations.

Cognition – world cognition and human self-cognition – is to a considerable extent constituted through human (material) relation to the immediate surroundings, including nature and the Earth. Thus for understanding Heidegger's distinction between ancient and contemporary technology, and thereby the fundamental world view related conditions of contemporary science, I will trace the evolvement of this relation in some historical moments of material practices, particularly mining as an intimately Earth-bound practice[86] and as an almost iconic figurative illustration to Heidegger's understanding of truth as unconcealment – *Unverborgenheit*. Also scientists of the age draw parallels between

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[82] Heidegger regards the anthropological and instrumental views of technology as correct but not getting at the essence of it, thus incomplete. For me they are important as expressing the active, activity-related, and normative roles of technology and science.

[83] *Gestell* – base frame; frame; framework; mount; rack; shelf; stage; stand; support

[84] *Bestand* – inventory; population; stock; asset; book of business; constancy; continuance; crop; stability; supplies

[85] Glazebrook's interpretation of *Gestell* also hints at this aspect: "a way of revealing things that sets them up as a standing reserve of resources available for human disposal" (Glazebrook 2000: 113).

[86] Heidegger's own example of agriculture (e.g. in 1959a) is of course equally Earth-bound.

scientific inquiry and mining: William Gilbert imagines scientific experiment as "penetrat[ing] the inner parts of the earth", whereas he regards Earth as "our common mother" (Henry 2001: 115; quoting Gilbert's *De Magnete*); Robert Boyle likens experimental learning to "dig[ging] in the quarries for materials towards so useful a structure, as a solid body of natural philosophy" (Agassi 1956 Part II: 99 and 181, quoting Boyle's *Proemial Essay*). In a sense, 'world' – *Welt, wer-alds* – is itself to be understood as unconcealment, as what has come to light, to be known: it is something *for* man and *through* him, his (life)time and being together with other humans, times and places filled with people that offer maintenance and stand and thereby security – in contrast to wilderness (*Wildnis*) that is perceived as dangerous (Grimm and Grimm 1966, referring to the possible Christian origin of the word 'world'). Wilderness or desert is dangerous because it is unknown, it is concealed from man and his comprehension and insubordinate to his administration.[87] Being and truth or unconcealment (*aletheia*) are the same (Heidegger 1999: 135–136). Being is limiting the brought-to-the-fore or the brought-to-still-stand[88], that happens in coming out of concealment (*Verborgenheit*), in quarrel that weighs up the counters (Heidegger 1999: 151, and 1966: 87).[89] Mining could on this ground be seen as an activity that opens up the Earth as dark, opaque and concealed, bringing it to light and making it thus a part of the world, of human cognition. Man broadens the world, his understanding, by pushing the limits of world ever further into wilderness – bringing ever more of the wilderness forth into light and to still-stand, subsuming it thus under his understanding and administration.

Understanding what and how 'world' is in human cognition is to inform about the possibility of 'laws' in the world and in nature, and the particular meaning and change of 'laws of nature'. The narrow exact scientific concept might be seen as the peak and perfection of this notion, like the exact sciences themselves can be seen as the peak and perfection of epistemic certainty. So after contemplations on the man-Earth (or man-nature) relations I go on

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[87] Also in Baltic languages the word 'world' – '*pasaule*' (lv) and '*pasaulis*' (lt), literally 'under-sun' – refers to something lighted; the Estonian '*maailm*', literally 'Earth-heaven', refers to the being-together of the dark and opaque Earth and the light and transparent heaven (or sky or atmosphere or weather). Hear http://heli.er.ee/helid/970321.mp3 (in Estonian); Metsmägi et al. 2012: 91.

[88] "Ergrenzung des zum Stand Gebrachten"

[89] Pelseneer (1949: 23) reports about "primitive" peoples that the appearance of things was essential, notional for them, so that changing it could turn everything upside down; due to this they did everything exactly as their ancestors had done. This reminds of Heidegger's notion of truth as what is in the fore and hence unconcealed from the sight, and that this brings stand or certainty. Also Archimedes' physics conforms to Heidegger's truth concept by having "directly evident and evidently logical" basic notions (weight, density, geometrical form), differently from that of Galilei, although being just as mathematical (Gorelik 2012a; it is, however, questionable to what extent those properties really are "directly evident and evidently logical"). One could see (remains of) this attitude still in the requirement in classical physics (Stepin 1999a: 321) that mathematical models reflect a pre-existing pictorial idea that was based on the world picture.

considering particularly the nature of contemporary science as *Gewirk* (fabric), on the basis of Heidegger 1959b, and technology as *Gestell* (enframing), and interpret them in various historical and cultural contexts or mind-sets in which some concept of 'laws of nature' has appeared. Thus I will try to bring forth some issues about the abstractness and concreteness of the notion.

2.1. The relation of (technical) cognition to mining: an eco-philosophical analysis

In this and the next section I consider some changes in the mental-spiritual side of world cognition arising from human practical treatment of nature, which underlie contemporary science. For this I gather together Carolyn Merchant's account of the beginnings of contemporary industry and science in eco-feminist terms (Merchant 2003), and Martin Heidegger's original (German) phenomenology of technology in his "Die Frage nach der Technik" (Heidegger 1959a).[90] I especially dare emphasise Heidegger's expressions in relation to mountains and mining for two reasons: Firstly, there is a remarkably important role – important with relation to the content and meaning – for words whose stem – *berg* – would be translated as 'mountain', and to words relating to mining, at that sometimes in meanings in which they are usually not understood anymore, even though they could be so understood some centuries ago; there are other possibilities to express the same meanings in German (nowadays), thence why I opine that his choice is not "random". Secondly – and why I think this expression is purposeful – the historical link between science and technology that Heidegger refers to, as it seems to me and as I will show on the basis of Merchant's eco-feminist account of technical development, is influenced by the relation of humans to nature, or man to Earth, evolvement of this relation and its reflection in mental-spiritual and activity-related world. Also Seubold (1986: 35–36) finds the essence of technology to be inherently related to the relation of man and Earth: as technology mediates man and Earth, helping man to make the Earth usable and to process her for himself, then more technical methods engender a father-from-Earth disposition in man. Hence I try to bring forth one break point that introduced such a difference between contemporary and ancient technology.

In order to better understand the words related to the stem '*berg*' (e.g. '*bergen*', '*verbergen*', '*entbergen*', '*Gebirge*'), let us look into their history. '*Berg*' and '*bergen*' stem from the hypothetical indogermanic parent language and can be related to each other, whereas Grimm and Grimm (1966) claim '*berg*' to stem from '*bergen*'. '*Bergen*' means etymologically 'keep, maintain, preserve' (e.g. grain, foodstuff) (Kluge 1989) and 'bring into a firm place (e.g. into a tower), bring to a mountain, to rescue' (Grimm and Grimm 1966, Auberle 2001, Paul 1992); '*berg*' means 'high, rising higher of the plane, raised', and

[90] As will be clear, the German original is decisive for my account.

also ‘sublime, exalted’. Mountains were seen as firm, secure places, as rescue – from which ‘*Burg*’ with the same meaning stems, also ‘rescue for the truth from appearing’[91] (Grimm and Grimm 1966: 1503, 1505), that originates from warfare – from hiding troops behind mountains to conceal one’s military might from the enemy, to face him unexpectedly, to bring him into (still)stand (Auberle 2001). Here one can notice associations that appear between these two meanings – ‘mountain’ and ‘maintain’ – as relevant in current context. Firstly, as will come forth in Merchant’s explications about understanding Earth as the nourishing mother, the Earth keeps or maintains her fruits (e.g. metals and ores), keeps them firmly ripening and ripened in her womb – in mountains, as the first mining activities took place in mountains (Kluge 1989: 75, entry word ‘*Bergbau*’ – ‘mining’). Secondly, when gathering and maintaining crops and other reserves, those were gathered into heaps, that liken mountains according to their shape, and that were also called like this – ‘*berg*’ (Grimm and Grimm 1966), and conceal and keep that what is in and behind them. And thirdly, keeping the truth in concealment, in secrecy, behind the mountain, harmonises with Heidegger’s understanding of truth as *aletheia*, and facing the enemy to bring him to still-stand from behind a mountain with his understanding of being as quarrel, as mutual bringing into limits with the brought-to-the-fore, bringing to still-stand and to appearance.[92]

Heidegger describes technology as bringing forth the truth, bringing it out of concealment – or appearing from behind a mountain[93] (Heidegger 1959a: 19). Together with episteme, it is a way of cognition (*Erkennen*): understanding, capturing something; “cognition gives explanation [or opening or making available or outcrop] (*Aufschluss*) (ibid: 21).” Technology (*techne*) brings being forth through a work – it is knowledge or skill to set being into a work, to bring it to (still)stand through a work (Heidegger 1999: 204; 1966: 122), or make it understandable, cognisable and available. As unconcealment is always accompanied by concealment (*Verborgenheit*), the truth or unconcealed always tends to conceal itself again, to hide itself behind the mountain or maintain itself heaped in a repository (store room), thus bringing man to the way of unconcealing it again and again, to set himself according to the concealed to bring it to light. Thus man and truth mutually bound and limit each other.[94] Taking into account Heidegger’s understanding of thinking as a way that discloses different views before “getting there” and gathers[95] the views together,

91 ‘hinter dem berge halten’

92 This conception of truth as quarrel probably has its roots in Ancient Greek conception of the ground (*arche*) of being as lying in the mutual countering and balancing between love and strife (Kelsen 1939/1940: 90).

93 Entbergen, “aus Verborgenheit her in die Unverborgenheit vor”.

94 This sounds similar to Anaximenes’ saying: come to know the starry sky, and you will come to know yourself (De Crescenzo 2007 Part 1: Ch. 5), if starry sky is a part of φύσις, that meant being for Greeks (Glazebrook 2000: 99), which means, as I have gathered from Heidegger, truth as *aletheia*.

95 legein, lesen

and of what is traditionally called *causa efficiens*, that it is what gathers the other three "causes" (debts or occasionings – *causa materialis*, *causa formalis*, *causa finalis*) together in thinking, sets them into the fore in imagination, to bring them into sight in reality as a complete (technical) thing, I see here the following association. This *causa efficiens*, for example the silversmith, is on a way of technical thinking which takes him forth between mountains and discloses different views to him of what he intends to bring forth. This way can also already be that of producing, where the initially imagined thing changes, for example due to contingent factors, or because this way (the material, form, or other) discloses (*entbirgt*) itself differently than initially thought: the thing can appear once this way, once another way (Heidegger 1959a: 21). The silversmith must adapt to the situation, for example change the direction on the way (switch to another raw material if this turns out to be poor, or other).

Contemporary technology also brings forth, but not from behind a mountain, rather from within a mountain – it extracts and unearths (*herausfördern*, *zutage fördern*). It does not seek different views, does not adapt to nature, but forces a mountain to open itself (*erschliessen*), it exposes nature (*herausstellen*). It thus does not let nature guide it, rather guides itself through nature and secures this guiding with an enframing (rack/stand) (*Gestell*) in mine shafts and other necessary constructions (material enframing), which enable to securely and optimally unearth and process the content of a mountain. The mountain (the bowels of Earth) thus becomes for man a strike, a reserve (of natural resources), which is opened (*aufschliessen*) and an important parameter of which is now the stand or supply of its stock (*Bestand*) – as it must pay off the efforts of setting the enframing. At the same time this enframing closes up previous production, which ran on the ways of thinking, of gathering, both by dump-hills (*Berg*) as well as by mining constructions (*verbauen*).

Carolyn Merchant (2004) describes on the basis of several sources (she quotes both Antique authors like Ovid, Seneca, as well as Renaissance and contemporary authors like Paracelsus, McLuhan, Valentine) antique understanding of the Earth as a nurturing mother, from whom everything on her has been born, both animate and inanimate and also that what is in her are fruits of her womb and entrails, ripening in her. The Earth was imagined as a human-like organism, which has a circulation system (streams, seas) and several functions characteristic to organisms (breathing, perspiration, metabolism). Mining "natural resources" (minerals, ores) was imagined as cutting open the womb or entrails of mother Earth. The Earth bestows on her surface what she wants to allow man to use, and keeps in herself what she does not want to allow man to use.[96] Such an understanding entails as well a moral attitude: the Earth as a mother, as the bearer, nurturer and keeper of life is sacred, she must be

[96] This material consideration and treatment parallels mental consideration, held for example by Socrates (who can be regarded as a shaman; De Crescenzo 2007 Part 2: Ch. 1) that one should rather involve in ethics as human affairs than in physics, because Gods hide from humans what they do not want him to know (Pelseneer 1949: 40).

honoured; mining metals and minerals out of her is violation of her sacredness (that she avenges, for example in the form of earthquakes), hence inadmissible, immoral activity.

Such an attitude still endured during the Renaissance, but growing interests of the mining industry in the conditions of commercial revolution in the 16th century imposed creating of a new conception of the Earth and of nature. So Merchant describes, basing on Adams, Agricola and others, the conflict of old and new conceptions. The new conceptions aimed to suggest that the Earth is in fact not a benevolent nurturing mother, but a wicked stepmother, who conceals from man resources useful for him, and that the damage resulting from mining (like environmental pollution and destruction) enables these to be exploited advantageously (one can, for example, cultivate fields on areas where forest have been cut down for metal smelting, and construction materials lost in the form of wood can be indemnified by the income from mining). Also the moral decline that the new conception brought with it spoke in favour of the old view: metals evoked greed and lust, drive brutality and violence, polluting human soul like mining pollutes Earth's womb. At the same time, mining activity was regarded as changing the Earth: she was not a nurturing mother anymore, but bore indiscriminately monsters into life and receives passively their violence (ibid: 424–425; Merchant refers to Spenser 1758). By strengthening of new values (growth of human well-being with exploitation of natural resources) contrariness toward technical study and exploration of the Earth decreased.

Although Merchant recognizes that mining of resources had been, from time to time, carried through with weaker moral sanctions already earlier, the dominant attitude was, however, honouring the Earth as an organism. Consequently, this activity and processing of metals were regarded with greater attentiveness: they were bound with special rites of purity, special power was assigned to smith-work and -tools. Celts, for example[97], honoured as sacred the sites where they extracted rocks or ores from inside the Earth, bound them with spirits or gods of the Earth and donated the gods and the Earth for their gifts.[98] This could be compared to Heidegger's 'way of thinking': the attention that was focused on opening the Earth's womb for human well-being and on exploiting her riches to create things is like a way of thinking, where senses must be pure and notice that which is concealed (in the mountain), the bringing forth of it, and things from it.[99] In contrast to this, the commercial turn brought along a disposition

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[97] The example told by Frank Suttner on an excursion concerning sacred sites of Aachen in spring 2012.

[98] This exemplifies Heidegger's conception of *Ding*, '*thing*', as a gathering site for the Fourfold (*Geviert*) – Earth and Sky, Mortals and Divinities: the Earth, or places, particularly the mining sites were for Celts such kinds of 'things', gathering sites, not plain reserves of resources. Furthermore, this thankfulness towards those sites evinces of "personification" of the Earth – she may have her own *telos*, but nonetheless she is so generous as to donate to humans from the fruits of her womb.

[99] Things were dealt with concernfully; Glazebrook (2000: 109) includes "the context of equipmentality and [things'] involvement" into the constitutions of things in concernful

according to which Earth must be profitable in the form of richness, glory, technical or military success. A conceptual change took place: Earth and what was born from her were not an animate organism anymore, but they were to be taken account of in the key of expenses and incomes – they were to be measured and calculated; that is, Earth and Earth's womb had turned into a stock, a standing-reserve, which was to be profited from and the supply of which was to be monitored.[100] In accordance with this, mining, setting of landscape and nature or rebuilding it (or even obstructing (*verbauen*) it) became admissible in such a way that profitable resources could be extracted. This at once closes the previous ways of thinking, as they cannot be commercially evaluated (or rather are not profitable).

Technology as cognition of the world thus indeed seems to have changed: previous technology focused on concrete thingness and interlocking of things with the overall entirety of nature and society, things gathered in them steps, each of which brought to them in their own way – or rather, the taker of those steps gathered them into a thing; or by exploring what is, that what unconceals itself disposes the exploring mind and thereby shapes (or limits) it, which on its part shapes the way the explorer's mind shapes the path of exploration and thus the world – what and how will be unconcealed (Heidegger 2003: 258 (1977b: 19)):

> That which primordially unfolds the mountains into mountain ranges and pervades them in their folded contiguity is the gathering that we call *Gebirg* [mountain chain].
> That original gathering from which unfold the ways in which we have feelings of one kind or another we name *Gemüt* [disposition].[101]

It can also be understood thus: wandering the length and breadth (*durchziehen*) of mountains, views open to the wanderer (thinker, craftsman, smith), mountain range opens itself, displays its details (*entfaltet*) and sets the disposition of the wanderer. Contemporary technology, by contrast, generalises things into abstract relations between reserve/supply parts which are detached from their original context and environment and which have no own *causa finalis*, the relation of cognition is not anymore the relation between a human being as *arche* and a thing's coming into being, but rather something like the relation between a storekeeper and stand/supply of stock.

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dealings, contrasting it to the theoretical attitude, where "such involvement does not belong to beings."

[100] Glazebrook (2000: 113) expresses a similar understanding of the meaning of technological *Gestell*: nature is set upon "to unlock and expose its energy for stockpiling."

[101] "Was die Berge ursprünglich zu Bergzügen entfaltet und sie in ihrem gefalteten Beisammen durchzieht, ist das Versammelnde, das wir Gebirg nennen.

Wir nennen jenes ursprünglich Versammelnde, daraus sich die Weisen entfalten, nach denen uns so und so zumute ist, das Gemüt." (Heidegger 1959a: 27)

2.2. Contemporary science and technology as ways of studying nature: an eco-feminist approach

The preconditions, described in the previous section, for relations between cognition of nature and the Earth and applying technology, arising from social practices, guide the way to examining relations between technology and scientific theory. One of the conditions for the arising of such practices like contemporary science and technology is a change in attitude towards nature and the Earth as treated in the previous section, where she comes to be regarded as something that can be divided into reserve parts and arranged as an order (*bestellen*). In this section I consider more closely the acting of science and technology as bringers forth of nature in the form, corresponding to the enframing, of division into parts. Here too I use ideas from Merchant to concretise the relationship between man and nature, appearing in the practices of science and technology. Whereas in the previous part the guiding idea was the Earth and nature as the mother whose child man is, then here nature appears as a female and man is imaged as a male who tries to seduce her.

Heidegger discerns ways in which that what a mountain conceals from view is brought into unconcealment, or how cognition of it is built up. He regards previous technology as an activity which helps nature to appear such as she would not appear by herself, gathering her capacities into an aimed thing. Contemporary technology is regarded as challenging nature, ordering (*Bestellung*) her to appear in a given enframing. While in mining, Earth is ordered in such a way that natural resources are quarried and delivered as a stock, then in technology, nature is ordered in such a way that she appears as a composition of (standing-)reserves of forces. According to Heidegger, nature herself requires such ordering from man by constantly concealing herself from him (2003: 257 (1977b: 19)):

> Thus when man, investigating, observing, pursues nature as an area of his own conceiving, he has already been claimed by a way of revealing that challenges him to approach nature as an object of research, until even the object disappears into the objectlessness of standing-reserve.[102]

This can also be understood thus: man is after (*nachstellt*) nature as his study area and lays into her (*angeht*) as into an adversary, into an object, and regulates her. As such, technology is ruling the nature, harnessing, enframing her; nature as an adversary is reduced to a composition of controllable forces.

A similar attacking and tracing, challenging enframing is applied in science (Heidegger 1959a: 29): physics sets nature in an experiment in order to study if and how she answers to such a setting. In an experiment, physics gathers forces

[102] "Wenn also der Mensch forschend, betrachtend der Natur als einem Bezirk seines Vorstellens nachstellt, dann ist er bereits von einer Weise der Entbergung beansprucht, die ihn herausfordert, der Natur als einen Gegenstand der Forschung anzugehen, bis auch der Gegenstand in das Gegenstandlose des Bestandes verschwindet." (Heidegger 1959a: 26)

into a certain stock, it regulates them appropriately. Forces must be calculable. As in contemporary technology concrete thingness is not essential (a thing with its occasioning ("causal") relations in the entirety of being), neither are concrete occasioning relations and material singularity essential in physics, rather it fades out into a provoked appearing of supplies, deploying one after another or simultaneously (ibid: 30). By this, (technological) science, particularly experimentation as the activity of bringing nature into the (mathematical) form of the scientific enframing, does violence to nature, making beings observable as what they are (Glazebrook 1998). As Trish Glazebrook (2000) says – modern science deprives nature of its *causa finalis*, of its own end, to superimpose human-determined ends upon her (that will be achieved through technology, technical treatment of nature).[103]

But just like in mining, so also in technology and scientific experiment, not everything that occurs (occurring truth, unconcealment) depends solely on man, is in his power (Heidegger 2003: 257 (1977b: 18)):

> Since man drives technology forward, he takes part in ordering as a way of revealing. But the unconcealment itself, within which ordering unfolds, is never a human handiwork, anymore than is the realm man traverses every time he as a subject relates to an object.[104]

Here one can surmise an allusion to the stand that man is the measure of all things: man takes himself to refer to nature ("he as a subject relates to an object"); that is, man measures everything on the basis of himself (in his enframing) and he builds an imagination as if he himself had created the nature set in this way. But Heidegger points out that exactly this stand, which stems from the delusion that nature has entirely the form of the enframing (a non-corporeal composition of abstract forces), is the greatest danger to human nature.

Here Heidegger's vocabulary allows once again to see associations with Merchant's treatment of attitudes towards nature and science in the dawn of contemporary science. When it was for man already morally admissible to invade into mother Earth, into nature, in order to get at metals and minerals concealed in her, then the human power and rule over nature had been instituted. Merchant refers mainly to Bacon as the advocate and expander of the new moral attitude from technical to scientific activities (Merchant 2003): man was the ruler of nature, until he fell into the original sin, in which woman was guilty, and was cast out of the garden of Eden, thus lost his dominion over

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[103] John Lunstroth (2009) says: in 11th–19th centuries, nature was claimed to have no moral, no essence.

[104] "Indem der Mensch die Technik betreibt, nimmt er am Bestellen als einer Weise des Entbergens teil. Allein die Unverborgenheit selbst, innerhalb deren sich das Bestellen entfaltet, ist niemals ein menschliches Gemächte, so wenig wie der Bereich, den der Mensch jederzeit schon durchgeht, wenn er als Subjekt sich auf ein Objekt bezieht." (Heidegger 1959a: 26)

nature. Science's task is to re-establish this dominion, and this is only possible by invading into her womb like into a mine and shaping her like on an anvil. Nature is imaged as a woman and re-establishing power over her as (violently) seducing her, penetrating her dark plots and caves, to uncover her secrets; contemporary science was to help get to know nature, to then exploit this knowledge in harnessing her to serve man, to "conquer and subdue" her, even rape and torture her like under inquisition. In scientific experiment, with the help of mechanical arts, human knowledge must help him harness his dominion over nature, dissect her and shape the nature through man's hand.[105]

Merchant calls this approach sexual imagination. Her interpretation can be not agreed with, like Alan Soble (2003) who claims that Bacon's allegories have been misinterpreted. However, the allegories of gender and sexuality obviously had an important impact on society at those times in deprecating femininity and boosting masculinity into ground principles of science and technology (Scharff and Dusek 2003: 414). In this light, Heidegger's treatment of being after (*nachstellen*) and organising nature and laying into her (*angehen*) seem to fit well with the masculine understanding of science that traces nature as a female being and tries to conquer her. Both practical handling of nature and the Earth (mining, producing), as well as theoretical examination, is forcing her to open herself through a stand or enframing (mechanical arts), to disclose her secrets.[106] That what is disclosed appears for sciences in an abstracted form as a reserve, that can be subdued to human will, that is, calculate and exploit to reveal new secrets by further shaping nature.

In both treatments there are two further aspects important: firstly, that man has been forced or challenged by nature to examine her provocatively, compellingly[107], and secondly, that what appears in the course of examination is

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[105] Also Heisenberg likens scientific-technical research and the brought-forth thereby to cutting open a human body (for example in a surgical operation) – both can incite estranging (Heisenberg 1955: 14).

[106] As Laudan (1984: 58) reports, the prominent attitude in the 18. century science towards observability fostered that "science should limit itself to those observational "laws which nature reveals to us"" (Bailly, quoted from Prevot 1805), that can be understood, not only as a prohibition to make up hypotheses, but also as remains of the taboo in respect to the Earth, of nature, a prohibition from invading and possibly blocking her inner self.

[107] As Prof. Matjus explained, *Gestell* is not a human doing, something that he makes up and imposes upon nature; rather man is challenged by nature into *Gestell*, he already finds himself inexorably forced in it that he cannot get out of. *Gestell* is normative in the sense that man must act according to it. In the following I will try to open to some extent what this means that man is forced into *Gestell*. However, if it is understood in the sense that man is forced into the technical-social situation that he is born into and that he has come into in his everyday doings, as I understood Prof. Matjus, then this is not so much different from any earlier (ancient) human situation, as in any era, one was born into a certain technical-social situation that determines one's ways of thinking and perception and sets one's dispositions, so the inexorability of this situation cannot in this sense differentiate contemporary technology from ancient technology. Rather it may be that in contemporary situation, technology is everywhere, the world (nature) itself is defined in technical terms (expressed as impossibility of understanding the world unless one can model or measure or manipulate

only partly in human power. The first can be gathered in Merchant's presentation of the story of the garden of Eden: female-nature lured male-man into a state where he does not dominate nature anymore, but is rather dominated by her, in Heidegger's words – man is in unconcealment for nature; and the other aspect follows from the requirement that, in order to dominate nature, one must know her, her secrets, because only by knowing nature, by harnessing her own laws, it is possible to dominate over her. Even if man rules nature technically – and in Bacon's understanding just then – nature discloses herself – and just herself, not something created by man, not human power (*Gemächte*). In such a feministic context we should also ask about the last mentioned word – *Gemächte* – if Heidegger has used purposefully exactly this word? In Estonian translation there is 'power' in this place, which could also be '*Macht*' in German, in English translation there is 'handiwork', that is '*Handwerk*' or '*Geschöpf*'. That Heidegger has willingly chosen a word related to (male) reproductive potency to express human capacities, is also suspected by Johannes Fritsche, who analyses the use of gender notions '*Geschlecht*' and '*Gemächte*' in Heidegger's works (Fritsche 1999: 188–194). Merchant's discussion allows to surmise that the image of sexual dominion and potency has indeed, more or less consciously, shaped the essence of contemporary science and technology, and one may speculate that Heidegger has also perceived the nature of technology and its aimed effect in this way. This would be in good accordance with his attitude towards contemporary technology, while he explicitly and acutely expresses what implicitly resides in techno-scientific worldview – the male dominance and suppression of female – and thereby denies the legitimacy of this worldview.

2.3. Interpreting Heidegger's conception of enframing as the essence of contemporary science and technology

In this section I consider more closely what is this stand, enframing, which determines the way how contemporary science and technology examine nature and reveal truth. This is to specify the exact science's nature as epistemic *Leitbild* setting norms to other sciences (normativities 2a,b) and broader (everyday) material-practical handling of the world (normativity 3b). I focus on physics as the science which Heidegger himself in 1959a,b mostly focusses on and which is commonly understood to underlie (a considerable portion of) contemporary technology. In order to sharpen Heidegger's distinction between earlier and contemporary technology and cognition, I accommodate his analysis into the context of science practice and the notion of phi-science coined by Rein Vihalemm. As measurement has a fundamental role in exact sciences, particularly in applying them on empiria in the form of experiment and technology –

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it; e.g. Bacon, Kepler and others, referred to in Hand 2004: 4–5; Feynman 1965: 58; Heidegger 1959b: 58, quoting Max Planck), whence one has an ever scanter possibility to come to nature without human-technical mediation.

which also Heidegger has drawn attention to – I touch cursorily upon the nature of measurement in the context of exact sciences (Appendix 4 gives a more thorough account of measurement).

The most important notions that characterise contemporary technology in Heidegger's thinking are enframing (*Gestell*) and (standing-)reserve (*Bestand*) introduced in previous paragraphs. The former conditions the latter (Heidegger 2003: 258): "We now name the challenging claim that gathers man with a view to ordering the self-revealing as standing-reserve: *Ge-stell*."[108] Heidegger says that the enframing is not technical: devices and people working on them belong to the enframing as parts of it and its arrangers, but enframing in itself is something else: it is a destining way of revealing, that originates from the forth-bringing revealing (*poiesis*), but sets it wrongly or blocks it (*verstellt*) (Heidegger 2003: 262). As the essence of technology, enframing is what endures (ibid). The enframing seems to appear as the way how man perceives the world or how the world or being appears to him, how he limits it: it is the way for man to come to see and handle the world as a standing-reserve.

What is it then, that Heidegger calls enframing? To clarify this, I consider what he says about science as nowadays the basis and pathfinder of technology. Just as it holds about contemporary technology, it also holds about contemporary physics that its essence is not determined by the use of devices (ibid; emphasis added):

> Modern physics is not experimental physics because it applies apparatus to the questioning of nature. The reverse is true. Because physics, indeed already pure theory, sets nature up to exhibit itself as a *coherence of forces calculable in advance*, it orders its experiments precisely for the purpose of asking whether and how nature reports itself when set up in this way.[109]

First I consider, what coherence of forces means. In the example of hydroelectric power plant (Heidegger 1959a: 2003) such a coherence emerges thus: stream as a natural object is harnessed as a source of pressure – it is reduced to "pressure" (or "energy") as one of its properties, and water turbine as a technical object is harnessed to transmit this force – it is reduced to "pressure" and "torque" as its properties. This means that things lose their thingness and objectness, they are abstracted into acting forces. It is the same in an experiment: when for testing a law of physics the conditions are staged in which that what the correspondent equation says should take place, it is not the concrete apparatus to bring forth those conditions that is important, but only its certain

[108] "Wir nennen jetzt jenen herausfordernden Anspruch, der den Menschen dahin versammelt, das Sichentbergende als Bestand zu bestellen – das *Ge-stell*." (Heidegger 1959a: 27)

[109] "Die neuzeitliche Physik ist nicht deshalb Experimentalphysik, weil sie Apparaturen zur Befragung der Natur ansetzt, sondern umgekehrt: weil die Physik und zwar schon als reine Theorie die Natur daraufhin stellt, sich als einen vorausberechenbaren Zusammenhang von Kräften darzustellen, deshalb wird das Experiment bestellt, nämlich zur Befragung, ob sich die so gestellte Natur und wie sie sich meldet." (Heidegger 1959a: 29)

properties (e.g. which ensure reliability of its readings). This law of physics, which is necessarily in a mathematical form, gathers as such certain "forces", which are theoretically (mathematically) defined. Nature is reduced to well defined dimensions and quantities (see also Appendix 4), and those are joined in a mathematical formula, according to which an experimental enframing is designed. Heidegger images physical theory as a fabric (1959b: 56): science sets the real or actual (*das Wirkliche*) so that it appears as fabric (*Gewirk*), or as a foreseeable outcome of applied causes that are joined and estimated in a network. Indeed, in physics, elements (quantities) are joined by definitions and deductions, they make up something like a web or fabric, and combining those quantities with each other enables to foresee possible experimental outcomes.

Second, what does calculable in advance mean? Of course, physics theory is necessarily mathematical and comprises calculation and prediction. "The methodology, characterized by entrapping securing, that belongs to all theory of the real, is a reckoning-up (Heidegger 1977c: 170)[110]", that is, it is mathematically defined, what of nature and how is brought forward, nature is been after mathematically. The non-perceivable (non-visualisable) essence of contemporary physics stems from its (theoretical-mathematical) enframing that requires that nature be adjustable as a composition of supplies. Also when applied to objects, it is necessary for science: that nature reports herself as a system of information, ensurable by calculation. Causality is not anymore occasioning, bringing forth, but "is shrinking into a reporting – a reporting challenged forth – of standing-reserves that must be guaranteed either simultaneously or in sequence (Heidegger 2003: 259)". It is measurement as the procedure of assigning numbers to objects or properties on a measuring scale (e.g. Hand 1999) that brings nature forth as mathematical and calculable, shrinks her into compositions of variables: in contemporary science as theory, what is important is the method of observation, which in physics is measuring, measurability (Heidegger 1959b: 58).

I will compare Heidegger's treatment with a contemporary constructive-realist account of science by Rein Vihalemm (e.g. Vihalemm 1989, 1995). Phi-sciences (physics-like sciences) are built on constructive-hypothetico-deductive method of study: 1) they construct their study domain mathematically, that is, their theory consists of mathematically defined models and the world ("nature") is studied according to how it corresponds to mathematical constructions of the theory; 2) on the basis of those mathematical constructions hypotheses are built up that are tested in an experiment or observation; 3) idealised laws, abstracted mathematico-experimentally, are deducible from each other mathematically. Those sciences adjust the world to their cognition, and their laws instruct by which experiment or observation is it possible to see the world in this way. The method of non-phi-sciences, in contrast, which originates from natural history, is classifying-descriptive-historical: they divide the studied world into classes

[110] "Das nachstellend-sicherstellende Verfahren aller Theorie des Wirklichen ist ein Berechnen." (Heidegger 1959b: 58)

according to their detailed descriptions, where also historical development of what is studied must be taken into account. Those sciences adjust their cognition to the world – they must notice all details and phenomena as a whole in order to adequately describe it. However, the models of phi-sciences are not merely mathematical constructions, but derived and tested in real experiments.[111] Experiment is the practical activity of science through which it brings the world forth in its specific way, achieves its peculiar world cognition corresponding to its mathematical (unique, apodictic) kernel (Vihalemm 1979: 44–50, 171–186, 191–198).[112,113]

On this background of practice-based understanding, let us again look at Heidegger's account of the essence of science[114]. We notice that the first feature of phi-science – being mathematically constructive – and the abstracting and idealising practice of phi-science correspond to the most important elements of his account: the first, correspondingly, to the calculating and measuring stand and enframing, and the second to supply (standing-reserve), reducing things to their few properties the stand (intensity) of which is measurable. In this same ideality, mathematicalness, is also concealed this enduring, this dwelling, which is to constitute the essence of contemporary technology: namely the uniqueness, universality and necessity of mathematics constitute the enduring kernel (enframing) of phi-science, that also ensures the endurance of its practice – reproducibility of experiment or of experimental results. Also the essence of contemporary technology should be understood in the same way: if it is based on phi-sciences, its composition is mathematically determined and calculated, functions (like transmission, transformation etc. of forces) and end outcome (like availability of electricity to end user) are important, they can be realised with different concrete apparatus, so the concrete apparatus is unimportant.

2.3.1. *Gewirk* and *Gestell*, abstraction and matter

In the last paragraph, I interpreted Heidegger's notion of *Gewirk* as the contemporary "laws of nature" (or scientific laws). As Heidegger notices, mathe-

[111] Empirical interpretations are essential to physics as empirical science: the mathematical formulae would be pure mathematics and no physics if they had no empirical interpretations (Stepin 1999a: 60–66, 207, 220–232; 1999b; Feynman 1965: 55)

[112] Heisenberg (1955: 45) expresses a similar conception about the characteristic link of contemporary science to world cognition and practice with a quote from Freyer: "I believe for handling; I handle for understanding ('Credo, ut agam; ago, ut intellegam – Ich glaube, um zu handeln; ich handle, um einzusehen')

[113] In Appendices 2, 3 and 4, I criticise the inattentive expansion of this abstracting and idealising approach and taking it for the provider of the essential knowledge about the world (particularly taking as unimportant the properties abstracted off and the following inattentiveness about them).

[114] A considerable portion of the comparison of practice-based approach to science and my interpretations of Heidegger's phenomenology is given in part I of Appendix 3.

matical science is believed to be a true description of reality or actuality[115], so the reality, the world itself that is represented with the theory, appears as a fabric (of well defined attributes). However, seeing the world as a fabric (of laws) is not at all new. In China, the inexorable order of nature that no-one and nothing can bypass is called with words stemming from silk processing: disentangling threads, weaving and forming the selvage of the fabric or web (Needham 1951b: 206–207). The world was recognized as a web or a pattern, of which all that there is are its nodes, or beings and things and their relationships make up this ordered, patterned web (ibid: 208). This web, the order of the world, is normative in the sense that man must conform to it in order not to bring peril (ibid: 207). As in (Confucian) China, human laws were required to conform to laws of nature, man was regarded as a part of nature, of the web, not somehow separate from it as an observer and manipulator of the world as of an object. Human deeds were understood as happenings in this web and if they did not conform, the natural order or pattern was disturbed (ibid: 199–200).

This interrelatedness of what we nowadays discern into human or social and natural spheres is not unique to the Chinese. Jean Pelseneer (1949: Ch. I) reports about popular beliefs from various peoples about interrelations between occurrences in the world that were regarded as interdependent, without discriminations (as nowadays held) between different kinds of occurrences, including discriminations between human and natural affairs. "Man tends to confound himself with nature", or there is no nature for him (ibid: 20).[116] Everything could cause anything, everything was considered possible and everything was mystical for the primitive peoples (ibid: 30). One can hear in this description a kind of interwovenness of the world and wilderness, or rather the absence of the world (as distinct human times and places) and equally of wilderness, as all is yet concealed, limits have not yet been drawn. Pelseneer understands this also as absence of laws and of nature – miracle was the most natural thing, there was no understanding of law of nature (ibid: 60; Bodde 1979: 142, points out the transition of emphasis in conceiving of nature from miracles or inordinate occurrences to orderly or normal occurrences in Europe in the 16th Century as contrasted to China in 4th–3rd Centuries B.C.). This seems to contrast with the Chinese understandings, where "nature" was assumed to have "its" laws, its order. However, the contrast pales somewhat when 'law of nature' is considered with its theoretical connotation that Pelseneer may have held: the Chinese

[115] Lovitt (Heidegger 1977c) and Glazebrook (1998, 2000) translate the word '*Wirklichkeit*' as 'reality'. I prefer 'actuality' as it retains the association 'act' – 'actuality' as is Heidegger's '*wirken*' – '*Wirklichkeit*', which I think is important for the change of the notion of fault or debt, or the rising of the notion of cause from it, that Heidegger (e.g. 1977a) also emphasises in relation to the genesis of the (contemporary) world picture.

[116] Hägerström (1953: 154–156) reports about law or morals of primitive peoples that they did not discern whether the feeling of conative impulse – that something "must/ ought to be done" – was conditioned naturally or socially. Stepin (1999a: 313) states that the stringent distinction between humans as spirited, sensuous beings, and the rest of the world is characteristic to the technogenous societies, not to traditional ones.

(Taoists) did not consider nature to be comprehensible for man with reason and theory (Needham 1951b: 225, 226, 229; Sivin 1985: 46), hence fixing laws of nature in humanly logical or mathematical language may have been regarded as arrogant and unreasonable, like Taoist and other Chinese (except Legalist) understandings of human laws was that writing them down is unreasonable (although partly for other reasons than hold for laws of nature; Needham 1951b: 198–199, 212–213; Bodde 1963: 382).

Although both Bodde (1963: 375, 394) and Peerenboom (1990: 314–315) emphasise the indiscrimination of nature and society by the Chinese in general (Bodde says that natural and social orders were fused by the Chinese and correspondingly both nature and man are subject to the same fixed laws *tse*; Bodde 1957: 719), they (as well as Needham) talk about distinctive laws concerning natural and social orders in Chinese society, and of corresponding words for 'law' (*li* and *fa* correspondingly for natural and social laws), which refers to distinction between human (social) and natural worlds. Particularly they saw natural order as immutable and unchanging, social order as changing – that is (one reason) why Taoists regarded it unreasonable to fix human laws in writing – and the requirement to harmonise human laws or social order to natural laws or natural order. This seems to evince of them having brought the being to the fore and to still-stand and made natural regularities into a more or less knowable and reliable notion, enabling the grounding of human laws on natural laws. Thus it renders my interpretation of this cognitive stand as concealment or not-yet-being-limited in Heideggerian sense dubious. It is still possible to argue that seeing those spheres as mutually impacting each other in possibly unforeseeable and deep- and far-reaching ways mingles those spheres indissolubly into each other and confuses their limits, and in this sense they do not limit each other. And on the other hand, for two spheres to limit each other, they must first be discerned and discriminated, which may have not been so in those ancient communities, as cited authors report, and it is only our contemporary thinking that makes the distinction (which I cannot avoid) and extrapolates it or its negation to bygone times.

Also causality has been likened to fabric: Heidegger's notion '*Gewirk*' (reality as seen through contemporary scientific theory) is meant as "surveyable series of related causes (Heidegger 1977b: 168)"[117]: actuality becomes pursuable and looked over in its acting. Cartwright (1989: 166–167) talks about "fabric of causal concepts". Let us notice the difference with the attitudes described in the last two sections: whereas the focus seems to be on causing or occasioning in both contexts, then earlier it was the things (or beings) and their (causal) relations themselves that make up a fabric, here it is concepts –

[117] "Die Wissenschaft stellt das Wirkliche. Sie stellt es darauf hin, daß sich das Wirkliche jeweils als Gewirk, d.h. in den übersehbaren Folgen von angesetzten Ursachen darstellt. So wird das Wirkliche in seinen Folgen verfolgbar und übersehbar" (Heidegger 1959b: 56).

something of human (theoretical) origin.[118] Holmes (1987: 997) reflects upon the (scientific, quantitative) causality-thinking in law: "The postulate on which we think about the universe is that there is a fixed quantitative relation between every phenomenon and its antecedents and consequents."[119] Like in Chinese 'world as web' there is assumed certainty and fixity in the notion of cause. However, laws of nature *li* for the Chinese were not something that man could look over or survey, and grasp into and fix in a theory and mathematics; and it is not something that man sets, let alone sets upon, the real: the order of nature is in nature herself, not arranged in her by man.[120] For contemporary science as a theory of actuality, reality brings itself forth as an object, that is, something clearly delimited from the subject (man) and standing opposite to him, and science, responding to this, reclaims actuality into objectness (*Gegenständigkeit*) (Heidegger 1959b: 48). By this, man as a subject limits himself from nature as an object, delimits reality as a sphere of research activity, of observation and control. Objectness of actuality is secured by arranging and processing it and prior determining of the possible framing of questions (ibid: 56–57; Glazebrook 1998). This attitude for the administration of causes and concomitant principles of causality may stem from the historical origin of this concept that Kelsen (1939/1940) reports: it comes from the principle of retribution or reward that was at first strictly social, hence humanly-socially determined, and only later (by Pre-Socratics) carried over to the natural realm.[121]

In contemporary physical theory, as argued above (paragraph 1.3.1), there are no causes. Causality works in time, but there is no time, so the fabric of the world becomes timeless. Theory as described by Taagepera (2008: Ch. 5; see also Appendix 2) as interlocking web of concepts (variables), where concepts

[118] This switch in emphasis may reflect the coming to the recognition that the interrelations seen as pertaining to nature are a result of human interpretation of nature and of his interaction with nature.

[119] This corresponds to Cartwright's claim that "causal capacities and their strengths go hand-in-hand" (Cartwright 1989: 77).

[120] Although it is *setting upon* nature, upon the real, that *effects* or *occasions* her coming forth in a way not her own, if this setting upon may also be interpreted as disturbing the natural way of social being-together – to which natural order was normative in China. It may also be questionable, whether the order that the Chinese assigned to nature was that of causality in the sense given in paragraph 1.3.2 – it may be that this or similar kind of causality or occasioning was indeed associated only with human actions (upon nature).

[121] The principles of retribution or reciprocity were: a deed is to be reciprocated only once and equally to it, from which the principle of equality of cause and effect stems (also the conservation laws in physics); retribution or reward always follows the reciprocated deed, from which the order in time and clear distinction of cause and effect stems (Kelsen 1939/1940: 106–108). Kelsen criticises the thus generated notion of causality for its inappropriate request for clarity and discrimination in matters nature on the illegitimate example of matters society (see also footnote 51). So both Heidegger and Kelsen relate the origin of 'causality' to legal concepts, but they emphasise different points of inadequacy in its evolvement (illegitimate analogy between natural and social spheres vs illegitimate objectification of the natural sphere).

are quantifiable attributes, mutually mathematically definable and thus determining each other, and as described by Paul Davies, express this understanding of physical mathematical theory as a web. Davies (1995: 264) characterises physics theory thus: physical notions are code-words which denote complex properties in mathematical models that sciences use to link facts of observable reality to each other; those notions become so customary that one comes to assign them equivalents in external reality, but in contemporary physics reality is relations between observations, not the external world, as due to indiscernibility of the subject and the object, one also cannot discern 'the external'. This can be interpreted variously in Heidegger's light. This 'external' fades, on the one hand, because reality is set and processed in an experiment, where each setting and processing is in its part determined by enframing, by some physical theory – the "reality" is worked out to respond to the enframing. On the other hand, reality fades in pure theory where, as Heidegger expresses it, the subject and the object are absorbed as reserve parts. In such a form, the enframing reaches its utmost durability, as pure (mathematical) theory does not let itself be disturbed by the differences of concrete material circumstances. Thus in a laboratory experiment, *Gewirk* is enacted: a network of properties is created and it is believed that those properties in this shape act or work. That is, not material things themselves but their properties act. Cartwright (1989: 141) says something similar: properties [not things?] have capacities; and causes have capacities (ibid: 121). For example, the property of being aspirin is a certain kind of *Gewirk*: as it is a material thing that is assigned this property, it is multifarious, it has various properties and relations with what it comes in touch with, including various properties that are called chemical. Some of them are considered as defining aspirin (or defining the property of being aspirin). On this basis Cartwright says that something has the property of being aspirin – it possesses said bunch of chemical properties which is regarded as defining aspirin.[122] If we simplifyingly regard salicylic acid as the defining "property" of aspirin, we are lead to an even starker contrast between the (material) thing and reductive *Gewirk*: the willow with all her being is first reduced to her bark as the useful part of it against head-aches, and this, on its part, is reduced by science to a chemical composite, acquiring its name after its descent from *salix*, that effects this alleviating of head-aches. So the one who was an integral node in the fabric and pattern of nature and man in their indissoluble being-together, has become an idealised and abstracted concept in the laws of chemical and biological theories.

Why is it necessary to call 'being something' 'the property of being something'? So that it would be possible to formulate "laws" 'ravenness implies

[122] Cartwright could also be interpreted as saying: a *thing* has the property to be aspirin and due to this it has the capacity to alleviate headache. On this reading, do capacities refer to the thing as a gathering site, something in and of itself, of its inherent being? However, the inherent being of a thing cannot be reduced to a bunch of properties of disciplinary bearing. Now arises the difficult question, what is this inherent being of a thing that makes it up as a gathering site? This will be to some extent touched upon in the next paragraph.

blackness', 'aspirinness implies headache-alleviatingness' etc. – that is, to formulate Universes of Properties? For it being possible to express "pure object" without properties, that *x* that properties can be assigned to? But what is that *x* without properties? Can things/entities exist without determinate properties? Lowe (1989, 2009) argues on the basis of the structure of some languages (Russian) that the 'being somehow' (having certain properties) is inherent to things (as in Russian, attribution sentence requires no 'is'). In Aristotle's conception of the four debts (to be focussed on in the next paragraph) the debts inherent in a thing or making up its nature are claimed to be "brute" matter (protomatter) and form (the '*x*'?), whereas quality (powers), quantity (mass-energy) and relation (the '*F*' and '*G*'?) are said to be external debts (accidents) (Wallace 1997: 64–66).[123] Rouse, inspired by Heidegger, argues for the same on the grounds that what is, is only through our practical interaction (that is, relation) with it, where entities acquire their meanings, that is, determination of their properties; however, Heidegger distinguishes existence from essence, and believes in being of things independent of human cognition (see Kochan 2011: 91 ff.), that I also believe in. Does this belief imply the belief that an '*x*' can exist without properties? No, it rather implies an epistemic humility similar to the Chinese attitude described above. An account of properties as attributable refers firstly to the transcendent view of laws, or accordingly of properties (and it may be said, at least in some contexts: "epistemic access of properties consist in the laws"[124]), which may be considered dangerous as implying passivity, lifelessness and disorderliness of nature as if awaiting human ordering of it (Mumford 2004: 202–204) – thus possibly leading to mis-ordering or blocking the world; and secondly it refers to the *Gestell*-attitude: Man creates shelves (clearly delimited categories) on which he sets well defined, sorted and arranged properties that can be combined in creating or describing objects; and objects, on their part, are perceived as combinations or webs of well defined properties – as Universes of Cases and nothing more.[125] Objectness becomes the durability of the stand determined by the enframing: "The relation of subject and object realises only in their pure character of "relation" or enframing, where both subject and object are absorbed as reserve parts/supplies (Heidegger 1959b: 61)." Account of properties as

[123] That the mere form (like a silhouette) of a thing makes up its nature can accord with the above presented ancient Greek view of being as being seen. I am sceptical about such a discrimination and the specific favour of the form as the nature of thing, as mere form without regard to matter and how the thing relates to other things cannot exhaust its being to my mind, and the "accidents" I see as inherently dependent on the matter and form of the thing.

[124] Michael Esfeld in his paper "Structures, Dispositions, and Causation in Fundamental Physics", on the seminar "Causation and Structuralism", 8.2.2013, Cologne, Universität zu Köln

[125] This seeing the reality as entirely apprehensible in compositions of well defined properties, or models, is evinced also in Alchourrón's and Bulygin's account of logic of law: they say that although no model can capture all aspects of reality at once, there is no aspect of reality that could not be captured by any model (Alchourrón and Bulygin 1971: 9).

being there solely through human practical interactions with the world refers to the epistemic arrogance that one can know everything, as if the world were merely human handiwork, whereas in the realist understanding of nature, these are merely the properties that manifest themselves and deserve attention in human practices, but they do not exhaust nature (or thing). A theory of reality in this form diverges from the cognizable reality to the extent that the actuality represented by it is impossible to perceive in nature (good examples of this are Higgs bosons – massive scalar particles, or in a simplified expression, "embodied mass"(!), and strings: the former were long tried to be found in experiments without great success and the recent results are unsure, the latter has not yet even lent itself be translated from theoretical language into experimental language).[126] Therefore the sentence in the previous but one section "actuality becomes pursuable (*verfolgen*) and looked over (*übersehen*)" could rather be read "actuality becomes traceable and overlooked."

On the basis of practice-based philosophy of science adopted here (paragraphs 1.3.2 and 2.3 – account of phi-science), scientific theory and cognition cannot be quite arbitrary, as it has and is formed in interaction of man and the world. Although talk of (measurement) errors and uncertainties due to material idiosyncrasies is guided by a theoretical enframing (see Appendix 4 about this; also Hon 2003: 190), there is irreducible materiality in concrete handling and application of laboratory equipment. Proper application requires material experience that evolves only in practical handling of the apparatus, in manual activity, through which man develops a bodily cognition of the apparatus as a material thing (Baird's (2003) notion of 'thing knowledge'). On this concrete material individual level modern technology seems to resemble earlier technology that can also be understood as non-phi-scientific: wandering a path, whether that of thinking or that of perception, is like historical development of cognition, but at the same time historical development of technology; the views opened to the thinker – a smith, an engineer or a technician (*causa efficiens*) – are gathered into new knowledge. In Heidegger's account, this would not do (Glazebrook 2000: 95): unlike Aristotle, Heidegger does not deem oneness with the thing to equal knowing the essence of the thing; hence Baird's thing knowledge as material knowledge does not bring knowledge of the essence of the thing as Heidegger thinks of it (essence as not material). What then is essence? Suppose the essence of a tree is treeness and materiality belongs to treeness, then materiality, or matter, is (contra Heidegger) at least partly the essence of a tree. Analogously materiality or matter is a part of the essence of (laboratory) equipment. As *techne* is not equipment but knowledge or skill, then with contemporary laboratory equipment, it is bringing the world into this

[126] Agassi (1956 Part II: 405) claims ad-hocness of the fluid theory to be "rooted in the fact that it is a method of speaking of a property as if it were a subject" – which seems to hold similarly in case of Higgs boson. However, Stepin (1999b) considers this as a constituent feature of the theoretical knowledge that properties come to be treated as objects. Hence not only objects come to be taken account of in terms of properties, but also the other way around – the distinction between those categories evades, as Heidegger claims.

mathematical *Gewirk* and into still-stand, that also means making the world and nature technical in both the anthropological as well as instrumental senses.

Not only *Gewirk*, but also *Gestell* is a historical conception, if understood either as the essence of *techne* in the first place – appropriating natural things for technical ends according to preconceived projects (Glazebrook 2000), or as the analytic standing – dissecting the world into elementary indivisible parts, making up a system that possibly can combine or be combined to make up everything else. Instances of manifestations of such dissecting are the various systems of elements that all the matter is supposedly made of[127]: {{earth, air, water, fire}, {love, hate}}, {water}, {air}, {*homoiomerion*}, [Pythagorean] {numbers}, (De Crescenzo 2007: Part 1; Collingwood 1965: Part I), the atomic theories of matter (van Melsen 1957), but also the idea of the four debts or "causes" (*aitia*), yin and yang and the five elements earth, wood, metal, fire and water in the Chinese view of nature (Needham 1951b, Bodde 1957, 1963, 1979), and many others. So already in Antiquity, although there was no shaping of matter on the basis of those theories, the world was mentally dissected into exclusive compound particles, that could either be material (matter, substance) or immaterial (like the Pythagorean numbers or laws of nature[128]) and which guarantee a kind of security by being unchangeable (Collingwood 1965: 11). I think that enframing should also be regarded more broadly than Heidegger does: it is both a scientific theory, but also a broader view of the world (as described in Vihalemm 1979: 40, 183–184), that has been formed in an interaction of nature and society and that also disposes one to act on them in one way or another, that is, it determines *causa finalis*. Man cognises the world through an enframing, some worldview, and reduces it to some composition, be the reserve parts atoms, forces or measurable properties. Silversmith reduces silver to a material, *causa materialis*; a village commune reduces forest to building material (which is not any longer there when the forest is cut down for smelting metals); town inhabitants reduce river to a source of fish necessary for making delicious dishes (which it is no more when mines pollute the river water). In this respect, also Merchant is mistaken when she generalises and says that the earlier worldview was ecological – for an ecological worldview to emerge, also nature must claim man in a more manifold, complex mode, namely so that the complicatedness and non-fitness into an enframing of her "compositions", "standing-reserves", comes forth more sharply, and perhaps more painfully, already irretrievably.

John Finnis' (1980) discrimination of the world into four kinds of order (or four kinds of Universes of Discourse), and correspondingly human endeavours

[127] Curly brackets {…} stand for sets, that is, for systems of basic elements theorised to make up the world; elements of the systems in the brackets are separated with commas.

[128] However, as De Crescenzo (2007 Part 1: Ch. 8) states, Pre-Socratic Greek thinkers hardly imagined anything immaterial or ideal, and even the Pythagorean numbers as basic, elementary building blocks of the world were imagined with a certain thickness. Whether laws of nature in the Antique comprehension were essentially material or immaterial is also not unquestionable; more about this in the next paragraph.

that are related to those orders, is an evidence of the *Gestell*-shaped thinking and of dissolution of the entanglement of natural and human spheres, and thereby I regard it as an illustration of the contemporary *Gestell*-shaped (world-) cognition, or the violent setting of the world, reduction of being, into objects of different (scientific) disciplines: I. order humanly understandable but not creatable, studied by natural sciences; II. order brought into human understanding (fields of discourse), studied by logic, epistemology, etc.; III. order humanly imposed upon matter, studied by arts, technology, linguistics; IV. order in actions and dispositions, studied by psychology, political and legal science, etc.. Such discrimination also supposedly underlies differences in the laws that are formulated in different (scientific) disciplines. Finnis' approach manifests the drive towards order, ordering the world in perception and in action, and in this way rendering it easily administrable and controllable for man with disciplinarily specialised theories, means and methods piece by piece, without regard to the complicating wholeness and interrelatedness. Just a few hints suffice: how and what can be thought and told about nature (II order), and how it is shaped (III and IV order), influence how nature can be perceived, what cognition can be built up of her – or what is unconcealed of her (I order).

Oliver Wendell Holmes' view of how legal theory, or legal treatment of the world evolves, exemplifies the abstractifying action of scientific *Gewirk* and fits with the above given comparison of law and science by Dretske (paragraph 1.2), both of the theories being abstracting and idealising. According to Holmes (1897, 1899), law develops towards idealisation case by case: by treating a concrete case (an element of a Universe of Discourse), a lawyer has at first a description of a situation from parties and witnesses; from this description he has to eliminate all details that do not pertain to the legal character of the situation, and retain only the abstracted description containing purely legal terms (elements of a Universe of Properties). Holmes shows on the basis of examples of particular areas of law how different cases came to be treated as subspecies of one and the same kind of interaction (an element of a Universe of Cases), thus economising legal language and legal code through abstraction of inessential details and idealisation of essential features. This generalising tendency can be seen as analogous to various examples of generalisation of different phenomena under one heading, like the examples of medicine and mathematics in Babylonia, Egypt and Greece mentioned in paragraph 1.1, or generalising various material situations into one concept and phenomenon of electricity[129] (Agassi 1956 Part II: 400–404, Hand 2004: 236–238, about units of electricity). In a sense, the de-subjectivation that Holmes describes (i.e. eliminating subjective elements from the descriptions of judicial cases) contributes to the de-objectivation in Heidegger's sense (that the world loses its objectness, its concrete material ob-jectivity (*Gegenständigkeit*). That is,

[129] Stepin (1999a: 85, 93, 163) uses this instance of unifying electrical phenomena as an example of his partial and fundamental theoretical schemes; the model of power lines enabled to connect the different kinds of electricity.

subjectively sensuously given things or objects of the material world are rendered more “theoretical”, or “ideal”, by tearing off their sensuously identifying idiosyncratic properties and treating them as having only the attributes allowed by, or essential in, the theory. As the theory is thought to be non-subjective in the sense as holding for the objective world independently of any individuals, the treatment of things is in this sense de-subjectivated. Thus things transform from concrete objects to embodiments or representatives of theoretical entities, that is, they become de-objectivated.[130] Through such abstracting process, law is to achieve compactness that enables jurists to logically draw concrete applications from a small set of legal codes. This resembles claims to the fundamental compactness and unity of scientific theories in the sense of the theoretical possibility to derive all particular laws from a small set of general laws (e.g. Feynman 1965: 49–50). Langdell has in mind a similar process of making law compact, but through classification and arrangement of legal doctrines (Haack 2007), which resembles natural scientific approach to theorising as classifying-descriptive-historical (in Vihalemm’s understanding).[131]

One could see here a way how the development of science, particularly the idealisation and abstraction, and methodological unification through mathematisation, has affected understanding of the world and of science as purportedly the true description of it, and hence the criteria for a discipline to count as scientific.[132] However, the examples that Holmes gives about the development of legal concepts towards unification and generalisation reach back to the eras when contemporary science was not yet born and could not therefore have set any norms of knowledge and rationality. Rather, I surmise that the generalisation process is more general in (Western) cognition and world picture, and theories in sciences and law are just manifestations of it, as are laws that are formulated, to be applied to organise the world or believed to describe it. It is a way of simplifying comprehension and manipulation of the world. The tremendous success of exact sciences in their cognitive activities and applications has created an image of them as having a privileged epistemic access to the world. The requirement that laws of physics, as they are mathematically formulated, must apply independently of concrete place and time and of other circumstances that are deemed irrelevant to the phenomenon of interest to the physical science (Descartes, referred to by Dorato 2005: 23), has guided the cognition and

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130 This corresponds to the above expounded Heideggerian understanding of contemporary science: both things as well as human beings, then objects and subjects, are abstracted away, the subject-object relationship evades, and a pure abstract theory remains as the “true description of the world” (Heidegger 1959b).

131 See Pantin 1968 for an exposition of natural scientific methodology.

132 Agassi (1956 Part II: 371; underlining in original): “The methodological point is this: the more general a theory is, the more scientific it is. When ’under the condition A’ is prefixed to a theory, its scientific character deteriorates; it becomes more ad-hoc, it becomes, if you will, less an explanatory theory and more and more an economical description of its past confirmations.“

theoretical and practical treatment of the world under the honorary title of science. The mathematical language is seen as a universal language independent of any natural language. In this respect, law resembles science, as Lunstroth (2009) points out, referring to the colonial practices of law: they both claim to be universal and universally applicable – as I see it, the claim for universality rests on their generalising and idealising nature, as contingent circumstances and peculiarities of concrete situations are regarded as noise and hence as irrelevant to the phenomenon, and their abstract categories are taken to be universal by interpreting the real world situations in their terms and designing the world accordingly (for science the designing practices, besides experiment, have been colonial practices like for law; see Anghie 1999 and Harding 2003 for this). The regular abstract "world" of ideal well-defined categories and relations established by theories is claimed to be onticly primary with respect to the irregular and "imperfect" local material worlds (e.g. Woodward 1989, Dorato 2005: 24, about Galilei and Descartes, Stepin 1999a: 74, contrasting an idealised mathematical law as "reliable, true knowledge" to empirical generalisations).[133] However, there are approaches that urge the other direction – accounting for the complexity and multifariousness of nature and occurrences that escape theoretical treatments, scientific or legal: the phenomenological and hermeneutic approach in judicial handlings (Hermann 1982) urging the decisive import of individual, idiosyncratic aspects of concrete situations in which human beings find themselves; Nancy Cartwright's urge on the fuzziness and ambiguity of the material world deviating from the elegant mathematical descriptions imposed on it by sciences (Cartwright 1983, 1989, 1999); the "reenchantment of the world" as a reaction to the pretensions to "disenchantment of the world" by science and the ecologically disastrous results of this claim, and the parallel deep-ecology movement (Naess 2003, Devall 2003).

2.3.2. Roots of normativity of (mathematical) laws of nature

There are various theses about the (historical) origins or grounds of the notion of laws of nature or some essential features of them: political or sociological[134], theological[135], juridical[136] (nearly equal with the theological), etymological[137],

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[133] In Appendix 4 I argue on the basis of measurement errors and uncertainties for the ontic primacy of (material) irregularities and the need for a more pragmatic (vs representational and even substantial) understanding of measurement and of fundamental physical theories.

[134] Zilsel 1942a, 1945, Keller 1950, Molland 1978, Lunstroth 2009, Harding 2003, Merchant 2003, Henry 2008, Lemons et al 1997, Tinker et al 1982, Dorato 2005, Gorelik 2012a,b,c; about the Chinese laws of nature or science Needham 1951a,b, Sivin 1985, Bodde 1957, 1963, 1979, Lin 1995

[135] Oakley 1961, 2005, Dorato 2005, Henry 2001, 2004, 2008, Jalobeanu 2001, Beebee 2000, Gorelik 2012a,b,c, Miller 2003

[136] Oakley 1961, 2005, Stratan 2008, Gorelik 2012a,b,c, Bodde 1957, 1963, 1979

[137] Ruby 1986; about the Chinese laws of nature Bodde 1957, 1963, 1979, Needham 1951b

technological-mathematical(-economic)[138], metaphysical[139]; the categorisation being necessarily conditional and imputed, as based on how lines are drawn between those spheres nowadays, thus overlapping in several cases (e.g. theological-juridical, juridical-political, sociological-metaphysical, technological/technical-metaphysical etc., metaphysics accompanies each argument and line of development and etymology probably has no own being independent of other lines of evolution), or hybrid or combined hypothesis[140]. Most of these possible origins have normativity explicitly in them (juridical, theological), or at least some element or flavour of it in one or another sense. I will briefly present some of these theses with an emphasis on the kind of normativity in them and their relevance to my argument about their normativity or prescriptiveness, and particularly normativity of mathematicalness.

Technology as something directly involving human activity (particularly technology as an instrument) correlates with one of the defining elements of normative systems – Universes of Actions. As Trish Glazebrook (2000) argues, contemporary science erases the distinction between *physis* and *techne*, or natural things and artefacts, so development of technological thinking will inform about the essence of science and of its normativity. For analysing the various aspects of origins of normativity in science, two distinctions will be informative, overlapping in some cases and pointing towards the variability of views on the nature of nature, hence on the meaning of laws of nature (and also of laws of society), that was touched upon in the previous paragraph. Firstly, the division of comprehensions of laws (of nature) as either immanent/inherent or transcendent/imposed (Oakley 1961, 2005, Jalobeanu 2001, Henry 2004, Glazebrook 2000): laws as immanent mean that essences or properties of things correlate with relations between them, that they are mutually dependent; transcendent (or established, superimposed) laws mean that things and their essences are independent of, and do not affect, each other, relations between them are established from without and cannot be known merely knowing properties of things (Oakley 1961: 435, referring to Whitehead 1937). Secondly, the enframing of four debts or faults or "causes" of things (*causa materialis* or matter (ύλη), *causa formalis* or form (μορφή or εἴδος), *causa efficiens* or ground (αρχή, that brings forth a thing or a change), and *causa finalis* or end (τέλος, why something is brought forth)) that I see closely related to the split between immanence and transcendence of laws of nature.[141]

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138 Zilsel 1942b, 1945, Rothbart 2007, Stratan 2008, Henry 2001, 2008, Hanzel 2008, Hand 2003, Authier 1997, Serres 1997, Benoit 1997b, Ruby 1986, Lin 1995, Ritter 1997a,b, Tinker et al 1982, Gorelik 2012a,b,c

139 Thorndike 1955, Henry 2004, 2008, Hine 1995, Benoit 1957a, Collingwood 1965, Dorato 2005, Heidegger 1959a, 1977a,c, Glazebrook 1998, 2000, Merchant 2003, Miller 2003, Molland 1978, Needham 1951a,b, Remus 1984, Jalobeanu 2001

140 Stratan 2008, Henry 2004, Gorelik 2012a,b,c, Stepin 1999a,b, 2005, Dorato 2005

141 Heidegger's (1959a) example is of a silver chalice: its matter is silver, form chalice, ground the silversmith, and end is sacrificial rite. This is the debts for an artefact; an example of a natural thing might be: a tree has wood as matter, treeness as form, itself as

The etymological, juridical(-political) and theological theses about the origin of 'laws of nature' lie very near to one another. In the etymological thesis, emphasis is on order and regularity brought or denoted by laws. The meaning of the word 'law' in itself implies normativity – a statement of a prescriptive nature, a prescription (from someone) to be followed (by someone): *lex* was understood both as jurisdiction, and as "principles laid down by authorities or developed by custom for the practice of various disciplines" (Ruby 1986: 347). *Regula*, that Ruby sees to be related with the evolution of the notion of law of nature, referred both to straightedge or ruler and to a guideline or standard. *Nomos*, the Greek equivalent of *lex*, meant rules for studying and interpreting some particular subject, some particular Universe of Discourse (like in *oikonomia* or *astronomia*) (ibid); *nomos* stems from administration: administrative units for land and analogously for the sky, relating to moral and social order or the order of observing the sky (Pelseneer 1949: 61). Bodde (1957, 1963, 1979) handles in principle the same issue in the Chinese understanding of laws, where terms of legal or moral laws (*tu*, *tse*) were applied to denote natural regularities. However, the '*fa* of nature' which denotes the mathematical laws of nature in contemporary sense, is a contradictory expression: *fa* stands for prescribed, that is written, law, but in the Chinese understanding of nature, nature is spontaneous and cannot obey any prescriptions (Needham 1951b: 228). As Ruby suggests, laws and rules, including *nomoi*, as what at first were meant as regularity prescribed for conscious human behaviour and operation, later came to be seen as regularity in things, or nature, themselves, starting with the most general logical principles, other mathematised regularities following – as mathematics is apodictic, so mathematically describable natural regularities must be necessary. I see this process to be related to the technical-mathematical thesis: when (in the mechanistic world view) the world is seen as a machine whose separable parts perform certain functions, the laws pertaining to this machine can only be descriptive because a machine can have "neither plans nor conscious motives" (the emphasis on descriptiveness in contrast to God as legislator, prescriber of laws to nature) (Dorato 2005: 3). I will come to the mechanistic thesis later. Another line of development, relevant to '*lex*' and the Chinese notions for law, is provided by the theological-juridical thesis (which also discharges into the technological thesis with the emergence of mechanistic world view; Dorato 2005: 2–6).

In juridical and theological theses, it is not only the order and regularity in focus, but its origin or the "lawgiver".[142] 'Laws of nature' is often seen as a relic of the conception of divine legislation – laws prescribed by God to be followed

ground and again itself as its end – treeness (perhaps including blossoming and bearing fruit and offering shelter to lichens and moss, birds and animals).

[142] I call 'juridical' those theses which explicitly state the common origin of laws of nature and natural (moral or juridical) laws, like Oakley does, and Bodde for the corresponding Chinese conceptions. The thesis that links the emergence of written laws of nature with written or codified law (Needham 1951a,b), I categorise under the political-sociological thesis.

by nature, or in the animistic world-view as wilful regulating of the world by spirits (Dorato 2005: 1–2; Collingwood (1937–1938) regards also the notion of causality as now attributed to laws of nature metaphorical as if stemming from an animistic world view). Here the difference between laws as immanent or as transcendent to nature is essential: the prescriptions by a God are transcendent to nature as being superimposed by someone from outside her, spiritual regulating is (presumably) immanent, as spirits are seen as inherent in nature. I take both these as belonging to the theological thesis and consider them more closely in the following, as the difference is essentially important to my consideration of normativity of science.

In the Chinese understanding of nature, laws are immanent to the nature being there materially – the pattern of nature is not woven by anyone but is there as the natural order, in the very material being of the world. "[E]very event and thing has each *its own* rule of existence (Needham 1951b: 216: quoting Chu Hsi, emphasis in original)", no general, universal laws are assumed. The ground is nature herself, but also man, as human doings could occasion nature to behave differently from her own ways. This sounds like mixing of nature and technology analogously to contemporary climate and environmental engineering, only that in the Chinese understanding the ways of nature cannot be planned and calculated, hence a fundamental assumption of technology is missing.[143,144] Similar assimilation of natural and human grounds were (and still are) characteristic to folk beliefs, of which numerous are described by Pelseneer (1949). Hence both the Chinese as well as other peoples had prescriptions as to how to behave in certain natural conditions, for example in certain times of year.[145] Also in Stoics' understanding of nature, social laws (moral and legal norms) were to accord with laws of nature, whereas laws of nature were regarded immanent in nature (Oakley 1961, 2005, Henry 2004, Bodde 1979, Dorato 2005: 6–9), whereby Hellenic view of Cosmos as rational reflects what was considered rational, normal or natural in the society; this rationality was extended, projected onto nature (Dorato, ibid). However, Stoics can be debated about whether laws of nature are immanent in their view or transcendent: Needham (1951b: 222) sees a difference in that in Stoicism,

[143] But also when trying to engineer climate and environment, this assumption is hardly ever satisfied.

[144] Another analogy with technology in the Chinese understanding of nature is likening the main natural rhythms – the four seasons and Earth and Sky – with tools that "represent" the essence and working of those rhythms, which "govern" nature and society like those tools, with similar principles (Bodde 1957). This, however, need not counter the Chinese view of nature, as technology or invention in China was spontaneous, based on experience, not purposeful (aim-oriented), planned experimentation (Lin 1995: 276), and thus answered the social-natural life-world.

[145] Examples from Estonian folklore: staying awake during the Yule night to help the Sun start the new circle of year, or keeping silence during the souls' time in Fall, for the souls of the ancestors are said to wander around, which can be related to the general condition of nature at that time – everything is dying, slowly falling asleep in anticipation of winter, greyness prevails over colours, darkness prevails over light.

things were taken as "citizens" subordinated to universal laws, whereas in Taoism things *make up* the pattern that is the laws of nature (also Dorato 2005: 9). De Crescenzo (2007 Part 2: Ch. 9) titles Stoics the first real pantheists. The difference between the Chinese and animistic views and Stoicism may be traceable to the Greek enframing of debts, where these four aspects of things are discerned, which may have not been so in the other earlier societies, thus it could not have set the mind to partition things in the world into such elements (matter, form, ground, end). In Spinoza's (and Leibniz's) conception of laws of nature, again materiality is essential: he favoured laws inherent in concrete material individual beings as the true laws of nature, pertaining immediately to substance, in contrast to the more abstract intra- and inter-species laws (Miller 2003), and similarly to the Chinese and Stoic views, he considered laws of nature as the guide to be followed by human and social laws (ibid: 267–268). However, he regarded laws as an independent entity and independent causal actor (which may have been influenced by Descartes) (ibid: 265–266), even though immanent in matter and stemming from the thing's essence. In all these accounts, nature is taken to have her own being or essence, her own ground and end. This kind of comprehension is exemplified and illustrated by the above mentioned Celtic understanding of the sanctity of Earth.[146] The Renaissance understanding of nature was most honouring: she was regarded as comprising both her own ground as well as end in her; her every detail was taken as worthy of attention and respect (Collingwood 1965: 93–94). Scientists like Kepler or Gilbert reflected upon the planet having a soul: planet knowing the geometric laws according to which it moves (Zilsel 1942b: 267), Earth moving herself with the help of her magnetic kernel (Henry 2001: 117). This is often called the organismic view of nature (or Earth), already exemplified with Merchant's disquisition above (paragraphs 2.1 and 2.2), that Needham also takes the Chinese view to be (by comparing essential features of the Chinese understanding of laws of nature; according to Bodde (1979: 154–155), the notion of laws of nature in China was mainly developed by animists, that comes close to the organismic view.)

In the Old Testament, "law" (or the word translated thus) means both 'limit' or 'border' as also 'inscription' (the Ten Commandments), thus alluding to the limits that human beings and nature are not to overstep (Dorato 2005: 6). Also the concept of retribution or punishment was present in ancient thought of laws of nature or natural laws: that which gives the laws that beings in the world must obey, is also responsible for the results of injustice: "the fault (cause) is

[146] Many examples could be brought of native peoples who venerate and sanctify nature (Earth, trees, formations of landscape etc.) as having her own essence and ends and as being indissolubly imbued in the being of that people, this sanctification guiding the people's conduct towards nature. A rather broadly extended taboo was carving, that is injuring the Earth, her surface: it is prohibited in sacred groves (e.g. in Estonia); some American indigenous peoples avoid cultivating land with such techniques that carve the ground (Merchant 1983: 106); Mongolians restrain from wearing shoes with profiled soles to avoid damaging the Earth's surface (Mets 2012).

inevitably followed by the punishment (effect)", exemplifying the indistinctness of description and prescription that Dorato ascribes to the pre-Modern eras (ibid: 6–7).[147] In both Hellenic as well as Semitic understanding of natural order, things are thus foreseen their limits or borders that they are not to transgress, and if they do, they must pay penalty for this (Dorato 2005: 6–7, Heidegger 1977b), thereby there is no difference made between natural and social affairs: being is taken as a whole in its diversity (Heidegger 1977b: 331), everything is subsumed to "laws" or to its proper limits and punishments for injustice with respect to those limits. Such a concurrence of what now are discerned as fault, pertaining to morality, and cause, pertaining to nature, is highlighted by Heidegger (1959a) in his contemplation about (mis)understanding of the four debts. There are, however, significant differences between Hellenic and Semitic understanding of laws as proper limits of things or beings: in Semitic understanding, the limits are superimposed by a higher kind of being (God) from outside nature, in Hellenic view, the limits are inherent in things (Jalobeanu 2001, Oakley 1961, 2005, Henry 2004); and the Semitic laws are given by God in a "written" form, or carved into stone, hence stable and settled once and for all – the world, its order, is brought to still-stand and revealed (I will come back to this aspect particularly with the technology thesis).

However, immanence of order in nature is not so straightforward in Hellenic view. One clue to this is given by Pelseneer's (1949: 32) contention that polytheism was a partial objectification of the world [cognition]: instead of acting immediately on nature as did the most primitive peoples, one acts on gods and spirits. I understand this as a step towards "abstracting form, end and ground from matter": the various gods stand for, or are responsible for different parts or aspects of the world (and wilderness?). Hence the principle of the order of a thing is not anymore in the thing itself, but in something outside the thing. Another clue is given by Glazebrook (2000) in her discussion of Aristotle's view of the four debts: nature, Aristotle says, never reaches her (ideal) form and is thus always in becoming with the aim to reach it. Hence the form that a natural thing, a small tree for example, at any moment has, that is inherent to that natural thing at that moment, Aristotle regards as imperfect; and as the tree never reaches its perfect form, this form, the ideal order of this natural thing, remains transcendent to it (Wallace's (1997) explication of Aristotle's four debts and essence and accidence (in paragraph 2.3.1) confirms this conclusion). These moments may constitute yardsticks to the alienation of nature of her own essence and end, underlying contemporary technology. It seems like in the Chinese understanding order really is immanent in the material nature, but even there we find abstractions in the form of the five elements, yin and yang and reduction to few outstanding features. As referred to in footnote 144, natural phenomena were ascribed concrete functions, derived from human practice, from working with tools. The complex and multiply related natural rhythms and

[147] See also Kelsen 1939/1940 about this and footnote 121 here.

things are reduced to a few simplified abstracted functions of aim-oriented tools. This may be primarily a pragmatic approach to render the complex orders of nature understandable to the extent that human (moral, legal) norms could lean on them; and if it is so, it may in this aspect resemble contemporary science that also tries to render nature understandable for man to follow her laws (as Francis Bacon urges, Merchant 2003); however, the attitude in and aim of following the laws of nature remain different (Stepin 1999a,b, 2005).

Glazebrook (2000: 98–108) brings forth essential differences that were made between natural and artificial things by Aristotle (whom Heidegger sees as the cusp of pre-Socratic thinking; ibid: 99), and which are essential for my account of normativity of science: nature has her ground and her end (e.g. treeness) in herself, inherently to nature, whereas artefact has its ground and end outside of it, transcendentally to the artefact; for nature, her end is her form which she never achieves perfectly, and this end, or "moving" or becoming towards this end, is the ground of (change in) nature; in contrast, an artefact reaches its form and will be completed. An essential feature of technology – preconceived project (*Entwurf*), and namely preconceived by the bringer-forth of an artefact, who is its ground (*causa efficiens*) (Heidegger 1977a, Glazebrook 1998, 2000) – is yielded by the two said differences of *techne* from nature: the ground of an artefact drafts the form of the artefact and imposes this form upon matter, bringing the artefact into completion. The erasing of distinction between *fysis* and *techne* in contemporary science means for Heidegger that science deprives nature of her own end, so that technology can superimpose its end on nature (Glazebrook 2000: 107; Collingwood (1965: 93–94) says the same, the Renaissance having been the turning point). I think this means at once that contemporary science and technology want to bring *fysis* to still-stand[148] that offers security. Law as transcendent would associate in Heidegger's account with *techne*, as the end and form are superimposed upon the subject of the law from outside. I think that the Greek notion of four distinct debts enabled and perhaps co-occasioned this abstracting from material circumstances in the first place, as matter was in this enframing already at least mentally separable from the other aspects of a thing. This may have happened on the example of technology, where, in contrast to nature, matter and form do not belong together necessarily but according to the craftsman's choice (Glazebrook 2000: 105–106). Such conscious choice, however, can only be made if there really are known different kinds of materials which can function in the same way and hence be chosen from among for a certain kind of artefact, or being imposed the same form. Hence matter and form might have been seen as more necessarily bound to each other in artefacts in the dawn of tools and of artefacts at all, that is, when natural objects came to be applied as tools for functionalities that were

[148] Ernst Mach: fact is a phenomenon fixed in measurement and experiment (Stepin 1999a: 283); Ilya Prigogine: Measurement is the irreversible process of birth of stability in dynamical chaos (ibid: 204); I think measurement brings in some sense stability or fixity in any process and state of affairs – if not epistemic (or is epistemic stability illusory), then at least psychological.

found in them (e.g. that a certain stone can have hard sharp edges that can be used for cutting). Heidegger's understanding of *techne* as essentially immaterial, and in general his understanding of essence also abstracts from *causa materialis*.

The legislator, that is – imposer of form upon matter, that modern laws of nature are mostly associated with, is the Christian God whose forerunner and *Leitbild* is the Semitic God, transcendent to the world and legislating it from outside. The great pathfinders of modern science like Newton, the Bacons, Descartes, Galilei, took laws of nature as laws prescribed by that God that nature is to follow (Zilsel 1942b, Jalobeanu 2001, Oakley 1961[149], 2005, Stratan 2008).[150] With the voluntarist theology and nominalist metaphysics endorsed by the church, one can associate various tendencies. On the one hand, as science has been something dealing with certainty, something that can be known, that is stable and reliable, as the (material) world was claimed to be entirely under the discretion of a transcendent God, this occasioned theology to be the epitome of science for some time, as dealing with that very ground of (the only) possible certainty (Benoit 1997). On the other hand, to bring some feeling of certitude and repose to human mind, this very God was assigned stability, he was claimed

[149] Oakley (1961: 440) points to nominalist philosophy in the Middle Ages and Renaissance which implies imposed or transcendent laws.

[150] This coming to domination of the view of laws of nature (and in parallel with this, of natural (moral) law) has strong political grounds, namely the church effectuated the abolishment of the immanent (realistic) view of laws of nature, replacing it with voluntarist theology that was to save the almightiness and unlimited will of God (Henry 2004: 88–89; Oakley 1961: 438). I call this thesis political for I surmise that the background of the church's decision is the will to retain power: voluntarist theology presumes that God has unlimited power to choose how to steer the world and he can also change the laws with which he governs the world at his discretion; church as the enlightened, the privileged to know God's truth, has access to God's decisions, but not the laymen. This attitude that laws of nature, or truth, is only accessible to few (Henry 2004: 79) has many parallels: in China it was surmised that *li*, the unchanging law of nature and basis of morals, was known to noble people but not the low ones who needed to be governed with written law *fa* or subsumed under the government of the nobles (Peerenboom 1990); the high esteem and authority of wises among governors in Babylonia (Ritter 1997a) and of scientists and technocrats today is the same.

The sociological thesis of Zilsel (1942a) and Needham (1951a,b) about the genesis of contemporary science exemplifies anthropomorphism: it is hypothesised there that the notion of laws of nature is grounded by the social order or polity – namely kingship as the source of laws and of social order suggested the world view that order comes from a sovereign in the form of laws superimposed upon inferiors, and so also order in nature may come from a sovereign – God – and is imposed upon things and being in the material world in the form of natural laws. This view of the origin of laws of nature has been criticised (Oakley 1965, 2005, Henry 2004); however, it may represent (a part of) some underlying, non-conscious and non-explicit condition (e.g. as the basic deeper level of culture in Schein's (2010) analysis of culture; see footnote 74) for the conception of administration or ruling by one higher power that all else must obey as being subordinated to it. Thereby the theological thesis is a more conscious layer on the same level as science itself (Schein's middle level of culture), and the sociological conditions are underlying them as well.

to stay by the laws he has established and imposed on the world and not change them, so that the laws can become known to man by empirical inspection, as Ockham, Suarez, and others surmised (Oakley 1961: 441–443). So also for Descartes, laws of nature, which he considered to be mathematical in form, are a manifestation of God's immutability: laws are immutable and universal in the sense that they are valid in all places and in all times, and their constancy is a reflection of the constancy of the divine creator of the natural world (Dorato 2005: 23).

Both in China and in Ancient Greece, order and laws of nature were thought to be fixed and unchanging. But this nature for the Greeks was not the sensuously perceivable material world, but the essence of things (Collingwood 1965: 11, 44–45), theories or speculations of the "fundamental" or "basic" constitution of matter (see the listed "basic elements" in the previous paragraph). In China, there was no theorising about nature and her laws due to her complicatedness, no mathematizing, (hence) no speculation[151,152]; theoretical thinking was restricted to practical spheres, to solving concrete practical problems (Sivin 1985: 46). Stepin (1999a,b, 2005) takes this theorising attitude since Antiquity as one of the foundations of contemporary science (as does Needham 1951a,b). For Descartes, laws of nature were not about the actual world, but about conservation of movement that was consciously considered by him as non-actual, purely ideal circular and straight motion – although he claims there be no other kinds of motion than circular (Jalobeanu 2001: 11–13), which is a brave speculation. It seems like there had been an evolution towards epistemic unity in the sense that the things to be accounted with for knowing one's way around has been decreasing, and at the same time towards epistemic abstractness, or rather ontological ideality, as 'nature' denotes ever less perceivable and ever more idealised things (see also Pelseneer 1949 and Collingwood 1965): Whereas in ancient world cognition, nature and world as material situations were individual and to be approached individually to provide cognition; in polytheism, as a step away from particularity, there are several "abstract" or occult principles or characters to be taken into account; then monotheism is to guarantee unity and rationality of nature – there is just one God, thereby an unreachable one, whose plans with the world must be revealed (Stratan 2008: 2). And in the mechanist world view where nature is seen as having no own end nor even ground, God is also to guarantee causality (Henry 2004: 99).

This brings us to the technical-mathematical thesis about the origin of laws of nature, which, I think, has two lines of ideas coming together into the contemporary mathematical laws of nature: one is mathematical-theoretical(-metaphysical), and the other is technical-practical(-economic) (however, they

[151] 'No-speculation' attitude is manifested also by the tendency to turn supernatural beings of their myths like gods into sage-kings and heroes (Bodde 1963: 380).

[152] One can, of course, argue that linking human and natural spheres indissolubly like the Chinese did is a speculation about causal relations in the world; but this can also be a kind of "precautionary principle".

are not clearly separable from each other, as mathematics belonged to magical practices (Henry 2008: 20) that has both lines of ideas in it). The second guarantees the applicability of mathematics to concrete material situations that all who have to do with technical problems (craftsmen, sailors, surveyors, merchants, etc.) find themselves in. Mathematics itself stems from such practical activities and its form is dependent on concrete practices of the society where it springs from (Ritter 1997b). Mathematics and its elements and operations were abstracted from tools, like the ruler and circle (Goldstein 1997: 205) or the sun-dial (Serres 1997); from techniques of counting and calculation (like multiplication with number the same number abstracted; Ritter 1997b: 82). Abstracting geometry as pure mathematics from mechanics as instrumental and sensuous with Archimedes and Plutarch, as merely an application of the first (Authier 1997), parallels the distinction of the four debts and abstracting them from each other, particularly separating form from matter. As mathematicians used experimental methods, they were exemplary for craftsmen and other scientists – including the certitude of mathematics – who introduced mathematical methods and instruments into crafts (Henry 2004: 82–83, Rothbart 2007). Craftsmen's instructions in the form of tables inspired early scientists about expressing nature's order as mathematical proportions or laws (Zilsel 1942a,b, Henry 2001). Galilei himself as a craftsman hoped to demonstrate everything geometrically, saw nature as written in geometrical language (Stratan 2008: 17–20). The theoretical-mathematical line of ideas may stem from Pythagoras' idea of numbers as the basic elements of matter, which was carried on by Plato and Aristotle, whereby form was abstracted from matter and number became an ideal form (Collingwood 1965: 77–93). Kepler's view that mathematics gives divine archetypes belongs to this line of idea (Henry 2004: 98–99), but Kepler, at the same time, dealt with "occult" arts and held "occult" theories, as did Newton, Boyle and the Bacons (Stratan 2008, Henry 2004, 2008).[153] Crafts and occult arts both aim at bringing forth material effects, or enacting causal chains to bring forth the desired result, and the pressure by church forced the latter to reveal causality as natural (in contrast to demonic). As man learned to bring forth various effects through creative mechanisms, experimental practice effectuated secularisation of the 'laws of nature' (Dorato 2005: 2 and Ch. 1), the ground of change is man and not God anymore – which accords with the manipulational understanding of causality.

Francis Bacon believed that his proposed scientific method, which might be called experimental-descriptive (but not mathematical), would discover the true secrets of nature, her true essence, or forms or laws (Bacon equated essence and laws of nature), and her ways (Agassi 1956, Merchant 2003, Dorato 2005). Thus Bacon appealed to unprejudicedness and truth-revealing capacity of

[153] Also to the Chinese view on natural order numericalness is not totally alien: the concept of law *tu*, which applies both to human (social) and to natural things, associates with numerical regularity, as law of any kind was seen to be something with measure (Needham 1951b: 204–205).

natural science. His authority served to disrepute "feigning hypothesis" (Agassi 1956 Part I: 274) and making errors in science (ibid: 239). So when for example Newton claimed not to have invented the mathematical formulae of his laws of motion, as if nature herself "spoke in the language of mathematics" – similarly to Kepler's understanding of laws as the divine mathematical order, and to Galilei's (and Roger Bacon's) contention that the universe is written in mathematical or geometrical language (Dorato 2005: 19 and 21) – he created the illusion that the mathematical science of physics indeed discovered how the world really is in itself. The normative nature of natural and physical sciences and of mathematicalness – particularly of laboratory practices – seems to be already historically hidden behind the requirement for 'truth' of scientific theories. But if the technicality of contemporary science is taken seriously, then the original meanings of *nomoi*, *lex* and *regula*, along with Heidegger's understanding on truth – *aletheia* or unconcealment – and technology, propose a different effect to scientific truth: it is not the relation between theory and the world (*episteme*), but rather how the world or nature comes to the fore, or is seen as showing herself, through scientific-technical activity, in the constructions which order nature in one way or another.

The conception of four debts clarifies the broader practical normativity (3b) by making explicit the Universe of Actions in play. In Heidegger's example of silver chalice, the Universe of Actions is nested in the sacrificing rite, namely as material-practical configurations of the rite. Such a rite includes a silver chalice as an indispensable part, so the rite is the *telos* of manufacturing the chalice. The role of the chalice in the material-practical configuration of sacrificing rite is an element of Universe of Actions for the art of silver smithing, determining an end state of smithing. Similarly for legal norms and judicial practices, policy making and engineering practices, their end is reaching a particular wished social, technical, or social-technical(-natural or -quasi-natural) state of affairs; examples might be: the owner of an illegally appropriated thing retrieves his possession; the global average temperature rise does not exceed 2 degrees within *n* years; extracting hard accessible natural resources. As the given examples as pertaining to society and technology, and the notion of Universe of Actions suggest, the end as an element of the latter is something determined by man imposed upon the subjects of those ends ("elements" of a Universe of Discourse).[154] Is the analogy legitimate, particularly – can parallels be drawn between the other three debts and engineering and legal practices? Universe of Discourse as the target (or subject in legal discourse) of laws, the particular beings and happenings in concrete times and places, should be viewed as the matter for those laws and policies, the laws and policies are or prescribe the (ideal) form for this matter (and thereby perhaps erase the own form of that

[154] Slade (1997) argues for discerning ends and purposes: purposes are set by individual human beings intentionally, ends are independent of individual will; this accords with Heidegger's understanding (also concerning *Gestell*) and is also partly meant here – I do not want to exclude the influence of certain individuals and their idiosyncratic purposes altogether.

matter – as these beings do not come as formless mass of matter). Ground, or perhaps more appropriately *causa efficiens*, would be all those who participate in the accomplishment of a law or policy.

How does the fourfold debt clarify, or first of all – unconceal, the Universe of Actions or the end pertaining to laws of nature? It depends on the notions of nature and of laws of nature that we look at and how the *aitia* are connected to this notion. In the example of tree, corresponding to the Aristotelian notion of *aitia*, that which makes up something that might be called 'laws of nature' seems to be the form, where form is primary to matter, but matter is as indispensable as form. An example that has an analogy in contemporary understanding of laws of nature would be that of falling bodies: a stone falls downwards or towards the centre of the Universe because its end lies in being situated there, and this end is the ground of its falling. Nowadays end is not granted to nature anymore and just the ground is kept as (efficient) cause (Glazebrook 2000: 112) which in this case is the action of the gravitational force and expressed in the formula $F=GMm/r^2$. But if there is no end or final cause in this law, is there then no promised Universe of Actions? Some straightforwardly normative accounts of mathematical laws of nature suggest otherwise: like that of Lowe's described above, and that of Hage and Verheij (1999: 1051) according to which, in this case (their example is Newton's law of gravitation) it is a rule that binds the state of affairs that the stone has a mass m_1 and is at distance r_1 from the Earth with the state of affairs that the gravitational force between the stone and Earth is F_1. If both these accounts can be interpreted as I interpreted Lowe's account as prescriptions to the subjects of cognition (scientists, for example), then Ronald Giere's (2010) agent-based account of modelling pointedly brings forth the end-orientation of this law: a scientific model is composed with a certain aim which is determined by the modelling agents (scientists), the aim determining which features of the world and how are to be represented in the model; so a science as a set of models in his account, hence a set of aim-oriented representations to which also the law of free fall belongs, has certain aims and ends, or Universes of Actions.[155] But the scientists in their research are a part of the social-technical situation which determines the possible ends of the research and hence of the models created for representing the real world phenomena. So when modelling falling of a body as subsumed under such a set of factors in such connection to each other, the end may be making nature "understandable"[156], predictable and calculable, bringing nature into picture, reaching epistemic certainty and controllability; the mathematical law of gravitational force is a law for man to project nature, or for nature projected in this way. What about matter and form? I think matter, that was indispensable in Aristotelian account of nature, has been exempted from

[155] Although Hage and Verheij seem not to mean their account of the law of gravitation (and, consequently, of scientific laws in general) as prescriptions for scientists as I interpret Lowe, I think that in light of Giere's account it can be reinterpreted this way.

[156] Galilei: only mathematics gives explanation on nature (Stengers 1997: 349).

contemporary "laws of nature" and what is left is form (F-ness→G-ness) or, considerably simplifying, ('the property of having mass m_1 and being at distance r_1 from the Earth' yields 'the property of having gravitational force F_1 with respect to the Earth').[157]

The often assumed imperativeness of the cognition of the world and of nature determined by contemporary science is again manifested by Needham (1951b: 226) who contends that the Chinese *failed* to develop a science analogous to that in Europe because they did not build a coherent theory nor applied mathematics in technology (this is just partly true, as mentioned above referring to Sivin 1985). This view presupposes the striving towards this "advanced", "progressive" way of life as is peculiar to the contemporary (Western) technical and technologised life-world as Heidegger describes it, to the technogenic society (Stepin 1999a, 2005) (Sivin (1985: 44) makes a similar point of criticism). The aims to strive towards are objectivity of knowledge, control and dominion over nature – particularly over the material wilderness, to minimize uncertainties and hazards and to make nature into natural resources for man. The objectivity of knowledge is to avoid the morally pregnant subjectivity, or anthropomorphised view of the world and of nature. Such a view is said to have held by "primitive" peoples (Stepin 1999a: 361; 1999b, Pelseneer 1949: Chapter I). Organismic views of the world are expressly anthropomorphic. Science is said to have liberated humankind from such illusions by providing objective knowledge. But – is it at all possible to have a non-anthropomorphic understanding of the world? For one thing, the world as explicated above – as times and spaces filled with humans, as something through and for humans, cannot be but determined by human, his mutual quarrel with wilderness; so the world as the result of taming the wilderness by man and for man inescapably has a human face. For another thing, when reflecting on Heidegger's words "man comes to see himself as standing-reserve", just like he sees the world and nature as a standing-reserve, one might be occasioned to look deeper and further. When man does not discern himself from nature, he sees all in one as a whole, with no distinctions, and thus as much anthropomorphic as nature-morphic; both are spirited and have their own being.[158] When man objectifies nature, he sets himself counter to her, so they are like adversaries to each other; he sees himself as much limited from nature as nature from him; Heidegger specially accentuates objectifying: the more objective the object becomes, the more protrusive is the subject (that is man), this means that observing world turns ever more into a doctrine about man (Heidegger 1977a: 93). When man deprives nature of her own being, of her end, he bestows on her his own end and thus shapes nature according to his will and

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[157] Also Serres (1997: 121) says that in contemporary science there is only form and number but no matter.

[158] Heidegger (1977b) denies the anthropomorphism of this ancient cognition on the basis of Anaximander's indiscriminate application of juridical and moral notions on nature, hence without acknowledging limits between natural and human-social spheres – and hence without transgressing any limits with his phrasings.

aims and his picture of the world; hence nature comes to have a human-defined shape. When he reduces nature into a series of joined causes, he does this in his laboratory where causation will be understood manipulatively – if man can manipulate the forces enacted on test site, he can state causal relations; so causation as "inherent in nature" is human-defined. When he reduces nature to bunches of clear-cut measurable properties and their functions that can be controlled by him and that are exploitable for practical aims, that is the *Gestell*-shaped world cognition that makes a standing-reserve out of nature, he himself is one of the reserves, reduced to practically functional measurable properties.

(Re)Drawing a line between man and nature parallels (re)drawing line between the world and wilderness, that brings me to again question the sphere that Finnis assigns to natural science as its subject. On the one hand, natural science tames "nature" by fixing her in (mathematical) "laws of nature". Thus man makes nature known and controllable to him, brings her into his world. This he does actively by rebuilding nature: sciences create their success (Cartwright 2008: 6, reference to Mitchell); that is, with the help of experimental and observation techniques, engineering and technology, politics and policies, science makes its laws hold; depending on the science, its engineering branch is more or less successful.[159] When there is no fixed ideal, law, theory, to normalise cognition and action, to guide separating "erroneous" from "normal", then nature is as she is, she makes no errors. Agassi (1956 Part II: 95) concedes analogously: A fact seems 'magical' or miraculous only in the light of a theory; and Giora Hon (2003: 190): Error is an epistemic phenomenon that is relative to a chosen standard. Similarly magic and religious belief, the concept of 'magical world view by the prehistoric peoples' is normative and not at all restricted to the "prehistoric" people: the limit was drawn only later and largely due to the political pretentions of the church that induced probing of nature and, as a by-product, strengthening of natural science (Henry 2001, 2004). The entities of physics were often not less occult or unobservable than spirits, gods or God: forces and action at distance (Newton), perfectly circular motion (Descartes), mathematics as the cause of motion (Copernicus).[160] By ascribing to nature various "hidden features and orderliness", man opines to render her knowable, less magical and wild, and to know his way around. Were it possible otherwise? If we allow nature to remain wild – would 'law of wilderness' be a contradictory expression like 'spontaneous *fa*' is for the Chinese? If law is an epistemic phenomenon like error, then wilderness, by definition, remains unknowable. Even its limits may remain unknowable, when man rebuilds nature

[159] Giere's (2008: 126) admission (on Cartwright's account of models) that at least in some cases "we construct the devices to fit our models as much as we construct models to fit the devices" means the same.

[160] About the import of various "occult" theories and arts in the history of science: Thorndike 1955 about astrology; Stratan (2008: 10–16) about Kepler's analogies of Solar system to music, polyhedrons etc.; Henry 2001 (there 106–107, about Copernicus); Henry 2008 about practices of magic and their relation to contemporary science; Jalobeanu 2001; Pelseneer 1949: 136.

and the world according to his theories and may thus blind himself as to the limits of the theories: what comes forth is not merely a human power nor handiwork (Heidegger 1959a: 26; 2003: 257); or as Oliver Wendell Holmes (1915: 43–44) says:

> [T]he part can not swallow the whole – […] our categories are not, or may not be, adequate to formulate what we cannot know. If we believe that we come out of the universe, not it out of us, we must admit that we do not know what we are talking about when we speak of brute matter.
>
> If we think of our existence not as that of a little god outside, but as that of a ganglion within, we have the infinite behind us. It gives us our only but our adequate significance. A grain of sand has the same, but what competent person supposes that he understands a grain of sand? That is as much beyond our grasp as man.[161]

2.4. Examples

Let us consider said aspects of normativity on the ecology-related example of science-based policy making introduced above, namely the complex model of Yucca mountain as a planned heavy nuclear waste repository (Lemons et al 1997). The broader conceptual normativity (1a) consists in the demand to handle the natural thing – a mountain – as, or reducing it to, a limited bunch of well defined, clear-cut measurable properties which can be combined into a calculable mathematical model when represented by variables and parameters. The narrow conceptual normativity (1b) consists in the prescription of the concrete attributes considered in the model, and their (in this case flagrantly inadequately) restricted range of values, coming from the disciplines of geology, nuclear physics and climatology, which are all "hard" sciences, mathematised and to a considerable extent based on experimental knowledge. Due to the narrow focus on possible geological processes, no concepts from biological or cultural-religious concerns were taken into account. The mathematical and practical epistemic normativites (2a,b) are manifested by the lastly mentioned facts that said "hard" sciences apply mathematised models and if not all, then at least a considerable portion of their mathematical laws (sub-models) are tested in laboratory experiments for their fit with aimed material situations. In addition, the 95 percent rule applied in this case as the basis for deciding on the reliability of the mathematical models and simulations, of the conjectured (causal) links, is applied for avoiding "false positives" – a norm from science, even though inadequate in this highly complex and risky plan. The narrower practical normativity (3a) lies in designing and building the repository with the

[161] Let us notice how Holmes' expressions imply the organismic view of the world or nature (or Universe): if we are ganglions, then the whole of which we are parts is a minded or at least sensuous organism (with a nervous system).

help of corresponding theoretical and engineering sciences; and the broader practical normativity is manifested in the changing of the mountain from a natural-cultural thing – something living and spirited to be taken joy of – into a useful material resource – one of hiding waste, the unwanted and in this case dangerous exploited matter, hence into something to be itself exploited, thereby in a way blocking the previous view on it.

Science ignores the individuality of things and places. E.g. if a place is subject to (industrial or other) plans, like in the case of Yucca mountain, it is ignored that the place is home to someone, possibly including humans (or belonging to their life-world), and that it has or may have a meaning for the humans who have the place as their home (by 'home' I mean also spiritual situatedness). How does this relate to the place's own being and essence and end? The meaning it has for the people – is it the end superimposed by those people? Yes. But often those people take this place to have its own being and essence. Or is it the gods and spirits that bestow a meaning on the place? This is again something abstracted of the place itself. Even if the place is valued for its ecological richness, then it is not the place itself but the species and their numerical (statistical) features at that place, that is, clearly discernible properties (species) and their measure (multitude of species and representativeness at that place or how many individuals of this species per unit area). If a place is home to someone, then the "ecological richness" or "geological richness" or "aesthetic value" as comparable and/or scalable properties need not have that much importance.

An example that unifies both Dretske's and Oppenheim's observed kinds of law, that is, law *designing* the (natural and/or social) world and law *applying to* human beings acting in this designed world: traffic. In the course of his social existence man has created routes – parts of the land on which he lives that connect him with other people in other places (sometimes with parts of nature, for example in quarries and mines). The routes can be mathematically represented, like on more or less precise geographical maps or graphically (topologically) like the schemes of public transport (metro, train, etc.) where nodes denote stations and edges denote connections between stations. In addition man has created various ways and methods to move ahead on the routes, and correspondingly rules that must be kept in order to safely use the routes and connect between places. From the point of view of the law or set of rules of traffic, people on the road are just subject to that law, namely they are so as long as they are located on the roads and hence can impact others who are then also subjects of that law. For the participants of the traffic, they just embody the attributes, defined in the law, that exactly determine their role, rights and duties when participating in the traffic, and other subjects are those with respect to whom they have those duties and rights, and who make up, for them, hindrances on the way connecting between places. However, as a traveller on the road, a human being has innumerable other properties or being that is not captured in his being a carrier of traffic. He is in a state of mind that is influenced by his recent and earlier past, his bodily peculiarities, the end of his journey, the perceptions he receives during the journey, his acquaintance with the road and with situations of being on the road and participating in the traffic, etc. Thus taking the human being just as a participant in the traffic and hence as a subject of the law of traffic is setting him into an impoverishing enframing and in a sense blocking his own being. But not only the human being, but also the road taken as merely a space regulated by certain laws (and thereby determining humans to be subject to certain laws) or as mere connection between two points (a cognition empowered by fast transport techniques and highways) is not just a route but a place on the Earth, a place with its history that may have been home for plants and animals, later lending itself to humans for communicating, helping bring them from one place to another and bringing people together. But also – and ever more so – not only connecting but separating beings from each other by cutting their earlier connections and being insurmountable hindrances (e.g. for animals and their populations, but also for people). Roads also determine human dispositions by predetermining (and thus prescribing) possible directions and ways of moving around. They are for and through man – a part of the world, a tamed portion of the Earth, bringing him safely to the other side of wilderness. A road may suggest alienation from nature and the fastest possible leaving her, like a highway which at the same time is an alienation of the Earth from its own being; or it may be a home for wanderers and gather in itself not just the mortals but also the divine, like pilgrimage ways and hiking trails[162].

[162] "Wandern ist Einklang von Natur und Seele" („Wandering is unison of nature and soul", a quotation from a hiking path near Kall, Germany)

3. CONCLUSIONS

The arguments set forth in the Introduction were defended or refuted as follows:

1. "Scientific laws, or laws of nature as often called, are normative in a similar sense as legal laws are normative: they prescribe ways of acting and sanctions in case of non-conformity": It has been found that scientific laws are implicitly normative in various senses as enumerated and expounded in paragraph 1.3.2, Chapter 2 and Appendix 3. Thereby their normativity is logically similar to that of legal laws: they prescribe ways of acting, but they do not do it directly and explicitly – not to concrete persons or in a logically prescriptive form, and not through sanctions in case of non-conformity, but rather indirectly. The indirect or implicit ways of prescription are through world view (or cognition) making up the basic perception of the (Western) life world that is taught in science classes, followed in production and policy making etc.; in scientific practice, for example in laboratory, it is on the basis of (experimentally) established relations between mathematical formulations and the controllable laboratory environment that theory implies prescription for setting matter to conform it. The guideline for action is both the concrete (mathematical) laws of nature (the formulations that have already reached this status) that are to hold on the material world, as well as the mind-set incited by them and their guided ordering activity; that is: both 'how' and 'that' the world is ordered. Laws of nature, in their various historical and possible meanings, are normative in even more senses than the contemporary conception of them as scientific laws. Often their prescriptiveness includes sanctions in case of non-conformity (for example, the theological concept of laws of nature). Even if the laws and sanctions are not given in a written or codified form, they are perceived or thought of as something imperative to human behaviour, hence in this sense explicitly normative.
2. "The aim of laws (scientific and legal) is achieving epistemic and practical certainty – simplicity and foreseeability (predictability) in actions upon the world": Laws bring certainty: whether they are understood as something in nature herself – then it is the perceived regularities of nature that enable man at least to some extent foresee future situations and adjust his undertakings accordingly; or they are prescribed to the world – then the world is designed into accordance with the laws that are already known. This designing can be either of social realm, where the subjects of the laws consciously follow them (Appendices 2 and 3, paragraphs 1.1 and 1.3) or it may be natural realm that is formed into settings whose ways of acting the laws predict (Appendices 2 and 4, Chapters 1 and 2).
3. "Mathematicalness and mathematical laws are pragmatic in the sense that they provide the repose of mind due to (illusory) simplicity in the complex, often irregular world": This is yielded by Appendices 4, 2 and 3, and paragraphs 2.3 and 2.4. Mathematicalness, although abstracted from material world, material settings, is remote to materiality precisely because

it is abstract. Hence mathematical laws, as is well known, do not describe material reality, but rather models of reality. However, manipulating with mathematical entities in a sense seems to be so innocent and uncomplicated: they are immaterial, thus cannot do any harm, and undisturbed by material idiosyncrasies, hence reliable. Their ideality has been seen as divine, and as such steering the world. So man can achieve knowledge of this steering when the supposed underlying mathematical relations of material entities are discovered. Even when divinity is abolished, mathematics remains as the point of support and certainty: if the chaotic material world can be made as similar to mathematical system of relations as possible, then the calculations are expected to say something essential about their acting. This is believed to spare the effort of thinking, but also the trouble of attentiveness to the surroundings.

4. "Mathematical laws of nature gain validity through active human agency in restructuring the world according to those laws, or forcing the world to display regularities expressed with the laws. The aim of doing so is as said with argument 2. This is how scientific laws are normative as said with argument 1": This has been discussed in Appendices 4 and 2, paragraph 1.3.2 and Chapter 2. Firstly, in laboratory matter is designed keeping in mind its correlations with mathematical formulations of its properties. The situations found in nature hardly ever display clear numerical or mathematical properties and relations. It is through human designing activity, including designing objects that are taken as references in measurement (etalons), that matter is rendered into numerical form that can count as a domain for mathematical treatment. Further, the world outside laboratory is constantly changed, rebuilt, complemented and impoverished by human activity through various technologies that become ever more mathematical or scientific – not only technical devices and apparatus, but also social technologies. By forming the world according to those mathematical laws holding for those technologies, they are made to hold on the world.
5. "The concept of nature depends on the concept of laws of nature; hence the more technical or abstract the concept of laws of nature, the more technical or abstract the concept of nature": Chapter 2 attempts to show some correlations between the notions of lawfulness or regularity and that of nature. However, which is dependent on the other is rather ambiguous and the conditioning is probably mutual, and there are difficulties tracing this particularly for the lack of knowledge about possible earlier perceptions of the world, of man and nature. When the dependence of man on nature is perceived more immediately, man must also respect nature's own being and her often irregular ways, adapt himself to be able to manage his life. Taking ever more control over nature necessarily goes some way of technology or *techne*, thus being is brought into some work, for example a device or a law that displays regularity, works regularly. Appendix 4 presents some aspects of how measurement acts to this effect, thus measurement is a *techne* – bringing being into work. Appendices 1 and 2 illustrate the way how the

abstract mathematical notion of law of nature occasions seeing being itself as regular and assuming its subsumability to mathematical laws.

6. "World view is dependent on the concepts of nature and of laws of nature, and it is normative to human agency": Nature belongs to the world and what is regarded as natural is normative to thinking and action. This depends on the relation of wilderness and regularity in the concept of nature (Chapter 2). The less nature is allowed to be wild and the more it is seen as regular, displaying (cognoscible) laws and regularities, the more natural or normal it is considered for man to order the world accordingly.

Several problems remained or arose in course of the discussions that could not be addressed to a satisfactory extent, including: What is cognition? How is self-cognition related with world-cognition? What is world? What is wilderness? Can there be world or laws without violence toward wilderness, toward nature, toward Earth? That is, without reorganising nature according to human needs (for repose of mind) and thus neglecting its (natural?) wilderness? Do some notions of laws of nature refer closer to nature herself, or are they all human imputations or reductions of nature? Can man get a closer cognition of nature without an enframing of some conception of laws of nature? What is greater violence – assuming nature merely as material, or assuming a soul in addition to matter thus potentially taking matter as "dead"? If the distinction between descriptive and normative vanishes, is there anything at all that is merely descriptive and not normative at all? Is any description – whatever it is a description of (e.g. of some imagined world like fiction or of "the world as it [allegedly] is" supposing a God's-eye-point-of-view or of the world as experienced relatively to a subject or to a practice, the relativity kept in mind) – in some way and to some extent normative (at least conceptually normative)? (Is normativity perhaps a more-or-less feature? Or is the here supposed normativity of scientific laws not merely normativity but (also) a forecast?) Even if it is possible to escape the epistemic normativities, is it possible to escape conceptual and practical normativities? etc., etc.. I must leave them for further inquiries.

REFERENCES

Agassi, Joseph (1956). *The Function of Interpretations in Physics* (Thesis). University of London

Agassi, Joseph (1966). Sensationalism. *Mind* 75, 1–24

Agassi, Joseph (1973). Testing as a Bootstrap Operation in Physics. *Zeitschrift für allgemeine Wissenschaftstheorie* IV/1, 1–24

Agassi, Joseph (1982). The Detective Novel and Scientific Method. *Poetics Today* 3:1, 99–108

Agassi, Joseph (1995/96). Blame not the Laws of Nature. *Foundations of Science* 1, 131–154

D'Agostini, Giulio (1999). *Bayesian reasoning in high-energy physics: Principles and applications*. CERN – Cervice d'information scientifique, Geneva. Retrieved on 5.4.2010 from: http://cdsweb.cern.ch/record/395902?ln=en

Alchourrón, Carlos Eduardo and Eugenio Bulygin (1971). *Normative Systems*. Vienna: Springer

Anghie, Anthony (1999). Finding the Peripheries: Sovereignty and Colonialism in Nineteenth-Century International Law. *Harvard International Law Journal* 40:1, 1–71

van Asselt, Harro, Francesco Sindico and Michael A. Mehling (2008). Global Climate Change and the Fragmentation of International Law. *Law & Policy* 30:4, 424–449

Auberle, Anette (2001). *Herkunftswörterbuch*. Mannheim: Dudenverlag

Austin, John (2001). *The Province of Jurisprudence Determined*. Cambridge University Press

Authier, Michel (1997). "Quatrième bifurcation : Science pure, science appliquée, science militaire ? Archimède : le canon du savant (Fourth bifurcation: Pure science, applied science, military science? Archimedes: the canon of the sage)". In Serres, M. (ed.) 1997, 155–197 (in French)

Ayer, Alfred Jules (1998). "What is a Law of Nature?". In *Philosophy of Science. The Central Issues* (edited by Martin Curd and J.A. Cover), New York, London: Norton, 808–825

Baird, David Carr (1964). *Experimentation: An Introduction to Measurement Theory and Experiment Design*. Englewood Cliffs: NJ Prentice-Hall

Baird, Davis (2003). "Thing Knowledge. Outline of a Materialist Theory of Knowledge". In *The Philosophy of Scientific Experimentation* (edited by Hans Radder), Pittsburgh: University of Pittsburgh Press, 39–67

Beebee, Helen (2000). The Non-Governing Conception of Laws of Nature. *Philosophy and Phenomenological Research* LXI:3, 571–594

Benoit, Paul (1997a). "Septième bifurcation : Un ou plusieurs concepts de la science? La théologie au XIIIe siècle : une science pas comme les autres (Seventh bifurcation: One or many concepts of science? Theology in the XIII century: science like no other)" In Serres, M. (ed.) 1997, 269–296 (in French)

Benoit, Paul (1997b). "Huitième bifurcation : Une ou deux arithmétiques? Calcul, algèbre et marchandise (Eighth bifurcation: one or two arithmetics? Calculus, algebra and merchandise)" In Serres, M. (ed.) 1997, 297–336 (in French)

Bodde, Derk (1957). Evidence for "Laws of Nature" in Chinese Thought. *Harvard Journal of Asiatic Studies* 20:3/4, 709–727

Bodde, Derk (1963). Basic Concepts of Chinese Law: The Genesis and Evolution of Legal Thought in Traditional China. *Proceedings of the American Philosophical Society* 107:5, 375–398

Bodde, Derk (1979). Chinese "Laws of Nature": A Reconsideration. *Harvard Journal of Asiatic Studies* 39:1, 139–155

Cartwright, Nancy Delaney (1983). *How The Laws of Physics Lie*. Oxford: Oxford University Press

Cartwright, Nancy Delaney (1989). *Nature's Capacities and Their Measurement*. Oxford University Press

Cartwright, Nancy Delaney (1999). *The Dappled World: A Study of the Boundaries of Science*. Cambridge: Cambridge University Press

Cartwright, Nancy (2008). God's Order, Man's Order, and the Order of Nature. Retrieved on 18.2.2013 from http://personal.lse.ac.uk/cartwrig/PapersGeneral/Gods%20Order%2010%20July%202008.pdf

Dalla Chiara, Maria Luisa and Roberto Giuntini (2002). "On the Notion of "Law"". In *History of Philosophy of Science. New Trends and Perspectives* (edited by Michael Heidelberger and Friedrich Stadler), Kluwer Academic Publishers, 1–11

Collingwood, Robin George (1937–1938). On the So-Called Idea of Causation. *Proceedings of the Aristotelian Society* 38, 85–112

Collingwood, Robin George (1965). *The Idea of Nature*. Oxford: Oxford University Press

De Crescenzo, Luciano (2007). *Geschichte der griechischen Philosophie* (Hörbuch). Zürich: Diogenes

Davies, Paul Charles (1995). "Algorithmic Compressibility, Fundamental and Phenomenological Laws". In *Laws of Nature: Essays on the Philosophical, Scientific and Historical Dimensions* (edited by Friedel Weinert), Berlin, New York: Walter de Gruyter, 248–267

Devall, Bill (2003). "The Deep Ecology Movement" (1980) (abridged). In Scharff, R.C. and Dusek, V. (eds.) 2003, 471–479

Diehl, Paul F., Charlotte Ku and Daniel Zamora (2003). The Dynamics of International Law: The Interaction of Normative and Operating Systems. *International Organization* 57, 43–75

Dorato, Mauro (2005). *The Software of the Universe. An Introduction to the History and Philosophy of Laws of Nature*. Aldershot, Burlington: Ashgate Publishing

Dretske, Fred Irwin (1977). Laws of Nature. *Philosophy of Science* 44:2, 248–268

Feynman, Richard Phillips (1965). *The Character of Physical Law*. London: British Broadcasting Corporation

Finnis, John (1980). *Natural Law and Natural Rights*. Oxford: Clarendon Press

Fowler, Catherine S., Maribeth Hamby, Elmer Rusco and Mary Rusco (1991). *Native Americans and Yucca Mountain*. A revised and updated summary report on research undertaken between 1987 and 1991. Volume I. Reno, Nevada: Cultural Resource Consultants, Ltd. Retrieved on 6.6.2011 from http://www.state.nv.us/nucwaste/library/se-039-91v1.pdf

van Fraassen, Bastian C. (1989). *Laws and Symmetry*. Oxford: Oxford University Press

Fritsche, Johannes (1999). *Historical Destiny and National Socialism in Heidegger's* Being and Time. University of California Press. Available in: http://publishing.cdlib.org/ucpressebooks/view?docId=ft5k4006n2;brand=eschol

Gasking, Douglas (1955). Causation and Recipes. *Mind* 64:256, 479–487

Giere, Ronald N. (1988). *Explaining Science: A Cognitive Approach*. Chicago and London: The University of Chicago Press

Giere, Ronald N. (2006). “Perspectival Pluralism”. In *Scientific Pluralism. Minnesota Studies in the Philosophy of Science, Vol. XIX* (edited by Stephen H. Kellert, Helen C. Longino and C. Kenneth Waters), Minneapolis: University of Minnesota Press, 26–41

Giere, Ronald N. (2008). “Models, Metaphysics, and Methodology”. In *Nancy Cartwright’s Philosophy of Science* (edited by Stephan Hartmann, Carl Hoefer and Luc Bovens), New York and London: Routledge, 123–133

Giere, Ronald N. (2010). An agent-based conception of models and scientific representation. *Synthese* 172, 269–281

Glazebrook, Trish (1998). Heidegger on the Experiment. *Philosophy Today: A Quarterly Survey of Trends and Research in Philosophy Directed to the Interests of Scholars and Teachers within the Christian Tradition* 42:3, 250–261

Glazebrook, Trish (2000). From φύσις to Nature, τέχνη to Technology: Heidegger on Aristotle, Galileo, and Newton. *The Southern Journal of Philosophy* 38:1, 95–118

Goldstein, Catherine (1997). “Cinquième bifurcation : Une ou plusieurs idées pour un seul concept mathématique? L’un est l’autre : pour une histoire du cercle (Fifth bifurcation: One or many ideas for one and the same mathematical concept? The one is the other: for a history of the circle)”. In Serres, M. (ed.) 1997, 199–233 (in French)

Gorelik, Gennady (2012a). How the Modern Physics Was Invented in the 17th Century, Part I: The Needham Question. *Scientific American* 2012/04/06; retrieved on 16.11.2012 from: http://blogs.scientificamerican.com/guest-blog/2012/04/06/how-the-modern-physics-was-invented-in-the-17th-century-part-1-the-needham-question/

Gorelik, Gennady (2012b). How the Modern Physics Was Invented in the 17th Century, Part II: Source of Fundamental Laws. *Scientific American* 2012/04/07; retrieved on 16.11.2012 from: http://blogs.scientificamerican.com/guest-blog/2012/04/06/how-the-modern-physics-was-invented-in-the-17th-century-part-2-source-of-fundamental-laws/

Gorelik, Gennady (2012c). How the Modern Physics Was Invented in the 17th Century, Part III: Why Galileo Didn’t Discover Universal Gravitation. *Scientific American* 2012/04/08; retrieved on 16.11.2012 from: http://blogs.scientificamerican.com/guest-blog/2012/04/06/how-the-modern-physics-was-invented-in-the-17th-century-part-3-why-galileo-didnt-discover-universal-gravitation/

Gotthelf, Allan (1997). “Understanding Aristotle’s Teleology”. In Hassing, R.F. (ed.) 1997, 71–82

Grimm, Jacob and Wilhelm Grimm (1966). *Deutsches Wörterbuch*. (various issuers, lastly Leipzig)

Haack, Susan (1999). An Epistemologist in the Bramble-Bush: At the Supreme Court with Mr. Joiner. *Journal of Health Politics, Policy and Law* 26:2, 217–248

Haack, Susan (2004). Truth and Justice, Inquiry and Advocacy, Science and Law. *Ratio Juris* 17:1, 15–26

Haack, Susan (2005). Trial and Error: The Supreme Court’s Philosophy of Science. *American Journal of Public Health* 95:S1, 66–73

Haack, Susan (2007). On Logic in the Law: “Something, but not All”. *Ratio Juris* 20:1, 1–31

Haack, Susan (2008). The Pluralistic Universe of Law. *Ratio Juris* 21:4, 453–480

Haack, Susan (2009). The Growth of Meaning and the Limits of Formalism: In Science, in Law. *Teorema/Analisis Filosofico* XXIX (1), 5–29

Hage, Jaap and Bart Verheij (1999). The law as a dynamic interconnected system of states of affairs: a legal top ontology. *International Journal of Human-Computer Studies* 51:6, 1043–1077

Hägerström, Axel (1953). *Inquiries into the Nature of Law and Morals*. (edited by Karl Olivekrona, translated by C.D. Broad). Stockholm, Uppsala: Almqvist & Wiksells

Hand, David J. (2004). *Measurement Theory and Practice. The World Through Quantification*. Oxford University Press

Hanzel, Igor (2008). Idealizations and Concretizations in Laws and Explanations in Physics. *Journal for General Philosophy of Science/Zeitschrift für allgemeine Wissenschaftstheorie* 39:2, 273–301

Harding, Sandra (2003). "Dysfunctional Universality Claims? Scientific, Epistemological, and Political Issues". In Scharff, R.C. and Dusek, V. (eds.) 2003 154–169

Hart, Herbert Lionel Adolphus and Tony Honoré (1973). *Causation in the Law*. Oxford University Press

Hassing, Richard F. (editor) (1997). *Final Causality in Nature and Human Affairs. Studies in Philosophy and the History of Philosophy, Vol. 30*. Washington, D.C.: The Catholic University of America Press

Hassing, Richard F. (1997). "Modern Natural Science and the Intelligibility of Human Experience". In Hassing, R.F. (ed.) 1997, 211–256

Heidegger, Martin (1959a). "Die Frage nach der Technik". In *Vortäge und Aufsätze*. Verlag Günther Neske Pfullingen, 13–44

Heidegger, Martin (1959b). "Wissenschaft und Besinnung". In *Vortäge und Aufsätze*. Verlag Günther Neske Pfullingen, 45–70

Heidegger, Martin (1959c). "Das Ding". In *Vortäge und Aufsätze*. Verlag Günther Neske Pfullingen, 163–185

Heidegger, Martin (1966). *Einführung in die Metaphysik*. Max Niemeyer Verlag Tübingen

Heidegger, Martin (1977a). "Die Zeit des Weltbildes" (1938). In *Gesamtausgabe, I. Abteilung: veröffentlichte Schriften 1914–1970, Band 5 Holzwege*. Frankfurt am Main: Vittorio Klostermann, 75–96

Heidegger, Martin (1977b). "Der Spruch des Anaximander" (1946). In *Gesamtausgabe, I. Abteilung: veröffentlichte Schriften 1914–1970, Band 5 Holzwege*. Frankfurt am Main: Vittorio Klostermann, 321–373

Heidegger, Martin (1977c). *The Question Concerning Technology and Other Essays* (Translated and with an Introduction by William Lovitt). New York and London: Harper & Row

Heidegger, Martin (1989). Küsimus tehnika järele (The Question Concerning Technology). *Akadeemia* 6 (1989), 1195–1222 (in Estonian, translated by Ülo Matjus).

Heidegger, Martin (1999). *Sissejuhatus metafüüsikasse* (*Introduction into Metaphysics*). Translated by Ü. Matjus. Tartu: Ilmamaa (in Estonian)

Heidegger, Martin (2003). "The Question Concerning Technology" (Translated by William Lovitt, translation slightly edited). In Scharff, R.C. and Dusek, V. (eds.) 2003, 252–264

Heisenberg, Werner (1955). *Das Naturbild der heutigen Physik*. Hamburg: Rowohlts deutsche Enzyklopädie

Heisenberg, Werner (2010). *Der Teil und das Ganze: Gespräche im Umkreis der Atomphysik*. München und Zürich: Piper

Henry, John (2001). Animism and Empiricism: Copernican Physics and the Origins of William Gilbert's Experimental Method. *Journal of the History of Ideas* 62:1, 99–119

Henry, John (2004). Metaphysics and the Origins of Modern Science: Descartes and the Importance of Laws of Nature. *Early Science and Medicine* 9:2, 73–114

Henry, John (2008). The Fragmentation of Renaissance Occultism and the Decline of Magic. *History of Science* xlvi, 1–48; retrieved on 8.1.2013 from
http://philoscience.unibe.ch/documents/MaterialHS11/PSWissRev/Henry2008.pdf

Hermann, Donald H.J. (1982). Phenomenology, Structuralism, Hermeneutics, and Legal Study: Applications of Contemporary Continental Thought to Legal Phenomena. *University of Miami Law Review* 36:3, 379–410

Hine, William L. (1995). Inertia and Scientific Law in Sixteenth-Century Commentaries on Lucretius. *Renaissance Quarterly* 48:4, 728–741

Holmes, Oliver Wendell (1897). The Path of the Law. *Harvard Law Review*, 991–1009

Holmes, Oliver Wendell (1899). Law in Science and Science in Law. *Harvard Law Review* XII (7), 444–463

Holmes, Oliver Wendell (1915). Natural Law. *Harvard Law Review*, 40–44

Hon, Giora (2003). "The Idols of Experiment: Transcending the "Etc. List"". In *The Philosophy of Scientific Experimentation* (edited by Hans Radder), Pittsburgh: University of Pittsburgh Press, 174–197

Jalobeanu, Dana (2001). Forms, Laws, and Active Principles: What Happened with the Laws of Nature in the Scientific Revolution? *Analele Universităţii de Vest din Timişoara Seria Philosophie / Annales Universitatis Occidentalis Timisiensis Series Philosophia* XIII, 5–34

Keller, Alex C. (1950). Zilsel, the Artisans, and the Idea of Progress in the Renaissance. *Journal of the History of Ideas* 11:2, 235–240

Kelsen, Hans (1939/1940). Die Entstehung des Kausalgesetzes aus dem Vergeltungsprinzip. *Journal of Unified Science* (*Erkenntnis*) 8, 69–130

Kelsen, Hans (1976/1960 [1932]). *Reine Rechtslehre*. Wien: Verlag Franz Deuticke

Kluge, Friedrich/Seebold, Elmar (1989). *Etymologisches Wörterbuch der deutschen Sprache*. Berlin, New York: Walter de Gruyter

Kochan, Jeff (2011). Getting Real with Rouse and Heidegger. *Perspectives on Science* 19:1, 81–115

Ladyman, James and Don Ross (2007). *Every Thing Must Go. Metaphysics Naturalised*. Oxford: Oxford University Press

Landers, Scott (1990). Wittgenstein, Realism, and CLS: Undermining Rule Scepticism. *Law and Philosophy* 9, 177–203

Lange, Marc (1993). Natural Laws and the Problem of Provisos. *Erkenntnis* 38:2, 233–248

Laudan, Larry (1984). *Science and Values: The Aims of Science and their Role in Scientific Debate*. Berkeley and Los Angeles: University of California Press

Laudan, Larry (2006). *Truth, Error and Criminal Law: An Essay in Legal Epistemology*. Cambridge University Press

Lemons, John, Kristin Shrader-Frechette and Carl Cranor (1997). The Precautionary Principle: Scientific Uncertainty and Type I and Type II Errors. *Foundations of Science* 2:2, 207–236

Lin, Justin Yifu (1995). The Needham Puzzle: Why the Industrial Revolution did not Originate in China. *Economic Development and Cultural Change* 43:2, 269–292

Lowe, Ernest Jonathan (1980). Sortal Terms and Natural Laws. *American Philosophical Quarterly* 17:3, 253–260

Lowe, Ernest Jonathan (1982). Laws, Dispositions and Sortal Logic. *American Philosophical Quarterly* 19:1, 41–50

Lowe, Ernest Jonathan (1987a). Miracles and Laws of Nature. *Religious Studies* 23, 263–278

Lowe, Ernest Jonathan (1987b). What Is the 'Problem of Induction'? *Philosophy* 62:241, 325–340

Lowe, Ernest Jonathan (1989). *Kinds of Being. A Study of Individuation, Identity and the Logic of Sortal Terms*. London, New York: Basil Blackwell

Lowe, Ernest Jonathan (2009). *More Kinds of Being. A Further Study of Individuation, Identity and the Logic of Sortal Terms*. London, New York: Basil Blackwell

Lunstroth, John (2009). Aping Political Science. *The American Journal of Bioethics* 9:5, 15–17

Mackie, John Leslie (1980). *The Cement of the Universe. A Study of Causation*. Oxford: Clarendon Press

MacCormick, Neil (2007). On "Public Law and the Law of Nature and Nations": A Tercentenary Lecture in the University of Edinburgh. Available at: http://www.law.ed.ac.uk/blogsandpodcasts/podcasts.aspx

Matjus, Ülo (1989). Tehnika järele küsimise järel: Martin Heideggeri tõlkimisest. *Akadeemia* 6 (1989), 1222–1227 (in Estonian)

van Melsen, Andreas Gerardus Maria (1957). *Atom gestern und heute. Die Geschichte des Atombegriffs von der Antike bis zur Gegenwart*. Freiburg/München: Karl Alber

Merchant, Carolyn (2003). "Mining the Earth's Womb". In Scharff, R.C. and Dusek, V. (eds.) 2003, 417–429 (originally published in *Machina Ex Dea: Feminist Perspectives on Technology*, ed. Joan Rothschild, Oxford: Pergamon Press, 1983, 99–117)

Mets, Ave and Piret Kuusk (2009). The Constructive Realist Account of Science and its Application to Ilya Prigogine's Conception of Laws of Nature. *Foundations of Science* 14:3, 239–248

Mets, Ave (2009). On Scientificalness of Social Sciences. Rein Taagepera *Making Social Sciences More Scientific*. *Studia Philosophica Estonica* 2:1, 112–134 (in Estonian)

Mets, Ave (2012a). Some Limitations of Universal International Law from a Philosophical Point of View. *Law, Innovation and Technology* 4:1, 85–106

Mets, Ave (2012b). Measurement Theory, Nomological Machine and Measurement Uncertainties (in Classical Physics). *Studia Philosophica Estonica* 5:2,

Mets, Ena (2012). Elu Mongoolia päri- ja pahupoolusel (Life on the bright side and on the dark side of Mongolia). *Tartu Ekspress* 8.9.2011 (in Estonian). Available at: http://www.tartuekspress.eu/index.php?page=1&id=625

Metsmägi, Iris, Meeli Sedrik and Sven-Erik Soosaar (2012). Eesti Etümoloogiasõnaraamat (Estonian Etymological Dictionary). Tallinn: Eesti Keele Sihtasutus (in Estonian)

Miller, Jon (2003). Spinoza and the Concept of a Law of Nature. *History of Philosophy Quarterly* 20:3, 257–276

Molland, A. George (1978). Medieval Ideas of Scientific Progress. *Journal of the History of Ideas* 39:4 561–577

Morgenthau, Hans Joachim (1940). Positivism, Functionalism, and International Law. *The American Journal of International Law* 34:2, 260–284

Mumford, Stephen (2000). Normative and Natural Laws. *Philosophy* 75:292, 265–282

Mumford, Stephen (2004). *Laws in Nature*. London; New York : Routledge

Müürsepp, Peeter (2012). The Changing Role of Scientific Experiment. *Studia Philosophica Estonica* 5.2, 152–166

Naess, Arne (2003). “The Shallow and the Deep, Long-Range Ecology Movement”. In Scharff, R.C. and Dusek, V. (eds.) 2003, 467–470
Needham, Joseph (1951a). Human Laws and Laws of Nature in China and the West (I). *Journal of the History of Ideas* 12:1, 3–30
Needham, Joseph (1951b). Human Laws and Laws of Nature in China and the West (II): Chinese Civilization and the Laws of Nature. *Journal of the History of Ideas* 12:2, 194–230
Newell, Peter (2003). Globalization and the Governance of Biotechnology. *Global Environmental Politics* 3.2, 56–71
Oakley, Francis (1961). Christian Theology and the Newtonian Science: The Rise of the Concept of the Laws of Nature. *Church History* 30:4,433–457
Oakley, Francis (2005). *Natural Law, Laws of Nature, Natural Rights: Continuity and Discontinuity in the History of Ideas*. New York, London: Continuum
Oppenheim, Felix E. (1944). Logical Analysis of Law. *Philosophy of Science* 11:3, 142–160
Pantin, Carl Frederick Abel (1968). *Relations between the Sciences* (edited and introduction written by A.M. Pantin and W.H. Thorpe). Cambridge University Press
Paul, Hermann (1992). *Deutsches Wörterbuch*. Tübingen: Max Niemeyer Verlag
Peerenboom, Randall P. (1990). Natural Law in the “Huang-Lao Boshu”. *Philosophy East and West* 40:3, 309–329
Pelseneer, Jean (1949). *L’évolution de la notion de phénomène physique des Primitifs à Bohr et Louis de Broglie; Leçons sur l’histoire de la pensée scientifique, professées à l’Université libre de Bruxelles* (*The evolution of the concept of physical phenomenon from the primitives to Bohr and Louis de Broglie; Lectures on the history of scientific thought held at the Université libre de Bruxelles*). Bruxelle, Liège: Desoer (in French)
Ratcliffe, Matthew (2004). Review. Joseph Rouse *How Scientific Practices Matter: Reclaiming Philosophical Naturalism*. *British Journal for the Philosophy of Science* 55, 179–184
Remus, Harold E. (1984). Authority, consent, law: Nomos, physis, and the striving for a ‘given’. *Studies in Religion / Sciences Religieuses* 13:5, 5–18
Rip, Arie (2009). Technology as prospective ontology. *Synthese* 168, 405–422
Ritter, James (1997a). “Première bifurcation : Une ou plusieurs origines? Babylone - 1800 (First bifurcation: One or many origins? Babylonia -1800)”. In Serres, M. (ed.) 1997, 33–61 (in French)
Ritter, James (1997b). “Deuxième bifurcation : Une ou plusieurs mathématiques? Chacun sa vérité : les mathématiques en Égypte et en Mésopotamie (Second bifurcation: One or many mathematics? For everyone his truth: Mathematics in Egypt and in Mesopotamia)”. In Serres, M. (ed.) 1997, 63–94 (in French)
Ross, Alf (1998). Tû-Tû. *Enquètes* 7, 263–279 (in French)
Rothbart, Daniel (2007). *Philosophical Instruments: Minds and Tools at Work*. Urbana and Chicago: University of Illinois Press
Rouse, Joseph (1987). *Knowledge and Power. Toward a Political Philosophy of Science*. Ithaca and London: Cornell University Press
Rouse, Joseph (1996). *Engaging Science. How to Understand Its Practices Philosophically*. Ithaca and London: Cornell University Press
Rouse, Joseph (2002). *How Scientific Practices Matter. Reclaiming Philosophical Naturalism*. Chicago: University of Chicago Press
Ruby, Jane (1986). The Origins of Scientific “Law”. *Journal of the History of Ideas* 47, 341–359

Rundle, Bede (2004). *Why there is Something rather than Nothing*. Oxford: Oxford University Press

Scharff, Robert C., Val Dusek (editors) (2003). *Philosophy of Technology: The Technological Condition: An Anthology*. Oxford: Blackwell Publishing

Schein, Edgar Henry (2010). *Organizational Culture and Leadership*. San Francisco: Jossey-Bass

Scoones, Ian (2002). *Science, Policy and Regulation: Challenges for Agricultural Biotechnology in Developing Countries*. IDS Working Paper 147

Serres, Michel (1997). "Troisième bifurcation : Une ou deux mathématiques grecques? Gnomon : les débuts de la géométrie en Grèce (Third bifurcation: One or two Greek mathematics? Gnomon: The beginnings of geometry in Greece)". In Serres, M. (ed.) 1997, 95–153 (in French)

Serres, Michel (editor) (1997). *Éléments d'histoire des sciences*. Paris: Larousse-Bordas

Seubold, Günter (1986). *Heideggers Analyse der neuzeitlichen Technik* (*Heidegger's analysis of contemporary technology*). Freiburg/München: Verlag Karl Alber (in German)

Sivin, Nathan (1985). Max Weber, Joseph Needham, Benjamin Nelson: The Question of Chinese Science. *Comparative Civilizations Review 10–11 Civilizations East and West: A Memorial Volume for Benjamin Nelson*, 37–49

Slade, Francis (1997). "Ends and Purposes". In Hassing, R.F. (ed.) 1997, 83–85

Soble, Alan Gerald (2003). "In Defence of Bacon". In Scharff, R.C. and Dusek, V. (eds.) 2003, 451–466 (originally published in: *A House Built on Sand: Exposing Postmodern Myths about Science*, ed. Noretta Koretge, Oxford: Oxford University Press, 1998, 195–215)

Spenser, Edmund (1758). *The Faerie Queene, Vol. 1* (edited by John Upton). London, 1590–1595

Stengers, Isabelle (1997). "Neuvième bifurcation : Un ou plusieurs procès Galilée ? Les affaires Galilée (Ninth bifurcation: One or many Galilean procedures? The Galilean affairs)" In Serres, M. (ed.) 1997, 337–375 (in French)

Stepin, Vyacheslav (1999a). *Теоретическое знание* (*Theoretical knowledge*). Moskva (in Russian). Retrieved on 8.07.2010 from
my.sibsutis.ru/company/personal/user/8199/files/element/historyget/679934/Стёпин.%20Теоретическое%20занание.pdf

Stepin, Vyacheslav (1999b). *Теоретическое знание* (*Theoretical knowledge*). Chapter III "Foundations of Science". Moskva (in Russian). Retrieved on 22.06.2012 from http://philosophy.ru/library/stepin/03.html

Stepin, Vyacheslav (2005). *Theoretical Knowledge*. Dordrecht: Springer

Stratan, Gheorghe (2008). "The Notion of Physical Law of Nature: Aspects of its Genesis and Evolution in the Galilean Perspective". Paper presented at the LNF Seminar, Instituto Nazionale di Fisica Nucleare, 15.10.2008. Retrieved on 16.11.2012 from http://www.lnf.infn.it/sis/seminars/talks/stratan_15_10_08.pdf

Taagepera, Rein (2008). *Making Social Sciences More Scientific. The Need for Predictive Models*. Oxford: Oxford University Press

Thorndike, Lynn (1955). The True Place of Astrology in the History of Science. *Isis* 46:3, 273–278

Tinker, Anthony M., Barbara D. Merino and Merilyn Dale Neimark (1982). The Normative Origins of Positive Theories: Ideology and Accounting Thought. *Accounting, Organizations and Society* 7.2, 167–200

Vihalemm, Rein (editor) (1979). *Teaduse metodoloogia* (*Methodology of science*). Tallinn: Eesti Raamat (in Estonian)

Vihalemm, Rein (1989). Keemia metodoloogilisest samastamisest füüsikaga (On the problem of methodological identification of chemistry with physics). *Teaduslugu ja nüüdisaeg IV*, 30–40 (in Estonian)

Vihalemm, Rein (1995). Kas teaduse piirid või tegelik algus? Ilya Prigogine'i teadusekäsitusest (The limits of science or its actual beginning?: On Ilya Prigogine's treatment of science). *Akadeemia* 7:12, 2527–2540 (in Estonian)

Vihalemm, Rein (2001). "Chemistry as an Interesting Subject for the Philosophy of Science". In *Estonian Studies in the History and Philosophy of Science* (edited by Rein Vihalemm). Kluwer Academic Publishers, 185–200

Vihalemm, Rein (2011). "A Monistic or a Pluralistic View of Science: Why Bother?". In *An der Grenzen der Wissenschaft. Die "Annalen der Naturphilosophie" und das natur- und kulturphilosophische Programm ihrer Herausgeber Wilhelm Ostwald und Rudolph Goldscheid* (edited by P. Stekeler-Weithofer, H. Kaden and N. Psarros). Sächsische Akademie der Wissenschaften zu Leipzig, 79–93

Wallace, William A. (1997). "Is Finality Included in Aristotle's Definition of Nature?". In Hassing, R.F. (ed.) 1997, 52–70

Whitehead, Alfred North (1937). *Adventures of Ideas*. New York

Woodward, James (1989). Data and Phenomena. *Synthese* 79:393–472

von Wright, Georg Henrik (1951). Deontic Logic. *Mind* 60:237, 1–15

von Wright, Georg Henrik (1963). Practical Inference. *The Philosophical Review* 72:2, 159–179

von Wright, Georg Henrik (1972). On So-Called Practical Inference. *Acta Sociologica* 15:1, 39–53

Zilsel, Edgar (1942a). The Sociological Roots of Science. *American Journal of Sociology* 47:4, 544–562

Zilsel, Edgar (1942b). The Genesis of the Concept of Physical Law. *The Philosophical Review* 51:3, 245–279

Zilsel, Edgar (1945). The Genesis of the Concept of Scientific Progress. *Journal of the History of Ideas* 6:3, 325–349

SUMMARY IN ESTONIAN

Teadusseaduste normatiivsusest

Väitekiri tegeleb maailma korrastamise, maailmas korra leidmise implitsiitse ja eksplitsiitse normatiivsusega. Kord, seaduspära ja regulaarsus seostuvad episteemilise (tõsi)kindlusega ehk võimalusega ette näha ja planeerida. Seega on see töö kindla teadmise normatiivsusest ehk vajadusest kindlustunde järele ning sellest ajendatud reguleerimisest ja korrastamisest (ehk kindlustunde saavutamise normatiivsusest). 'Loodusseaduste' all kitsas tähenduses pean ennekõike silmas kaasaegsetes empiirilistes täppisteadustes matemaatiliselt väljendatud seadusi. Ometigi on see vaid tipp sellest, mida võib vaadelda ja on vaadeldud korda ja regulaarsust väljendavana meid ümbritsevas maailmas või looduses. Nende kitsas mõttes loodusseaduste matemaatiline kuju põhineb vastavate nähtuste või entiteetide omadustel, mis on kvantifitseeritud, viidud arvulisele kujule ehk muudetud mõõdetavaks. Kuid täpne, range ja arvuline võrreldavus – mõõdetavus – ei ole omaduste välistav, vaid pigem astmeline iseloomustus. Matemaatiliste loodusseaduste normatiivsuse ehk ettekirjutuslikkuse üle mõtisklemise puhul on asjakohane loodusseaduste sisuline mõistmine ja selle mõistmise areng, seega ka nende seaduste niisugused tähendused, mida ei väljendata matemaatiliselt. Asi pole pelgalt selles, kas "loodus" on armutult sundiv või mitte või kas inimene vajab episteemilist tõsikindlust või mitte; asi on pigem selles, mida mõistetakse loodusena ja kust seda tõsikindlust otsitakse. Minu hoiak teaduse ning tema teooriate ja seadusi sätestavate praktikate kui normatiivsete suhtes võlgneb paljugi Joseph Rouse'i (2002) arusaamale teadusest kui mitmes mõttes normatiivsest ning praktikate esiletõstmisest vastukaaluks keelele, mida ta peab praktika alamstruktuuriks. Ma näen tema käsitust Edgar Scheini kolmekihilise kultuuri mõiste (nähtavad tehisesemed, teadlikud omandatud uskumused ja väärtused, teadvustamata põhjapanevad eeldused) alumise kihina. Selle kihi teadvustamatus ilmneb asjaolust, et vastavate põhjapanevate eelduste normatiivsust tavaliselt ei märgata, see on praktikates implitsiitne. Seejuures praktikaid endid ja teaduskeelt ei tajuta tavaliselt ettekirjutuslikena (teadust ja tehnikat peetakse tavaliselt mittenormatiivseks). See alumine põhjapanev kultuuri- ja maailmataju kiht on minu nägemuse kohaselt tugevasti kujundatud sellisel viisil nagu Martin Heidegger kirjeldab kaasaegse teaduse ja tehnika olemust ning minu põhiline eesmärk on selle taju üksikasjalikum väljatoomine. Mu ülejäänud peamised inspiratsiooniallikad – eriti mis puudutab seda, mida teadus täpsemalt ette kirjutab, kuidas ta kujundab inimese ja maailma koosolu – on Heideggeri tehnikafilosoofias ja Carolyn Merchanti ökofilosoofias. Lisaks olen veel saanud ideid autoreilt (nii teadlastelt kui teadusfilosoofidelt), kes rohkem või vähem eksplitsiitselt järgivad teaduse norme, nt. püüdes neid rakendada väljaspool vastava eriala rakendusi, või kirjutavad tema normatiivsusest.

Väitekiri koosneb sissejuhatavast osast, mis ise koosneb kahest peatükist ja rakendustest, ning neljast lisast, mis illustreerivad ja toovad välja mõningad üksikasjad sel teemal. 1. peatükis “Mida nimetatakse ‘seadusteks’? Seaduste keel ja loogika” võtan vaatluse alla seaduste keelelise ja loogilise vormi. § 1.1 “Normatiivsete süsteemide loogilised elemendid ja omadused” esitab Alchourróni ja Bulygini eksplitsiitselt normatiivsete süsteemide loogilise rekonstruktsiooni. See koosneb järgmistest elementidest: diskursuse universum, omaduste universum, juhtumite universum, tegevuste universum ja lahendite universum (mis omistab tegevuste universumi elementidele deontilised operaatorid), kus viimased kaks on normatiivsete süsteemide eristavad elemendid. Seda loogilist süsteemi rakendan katseliselt teadusteooriale, kusjuures tegevuste universumit võrdlen vanaaegsete praktikatega, kus tegevusi kirjutati eksplitsiitselt ette, saavutamaks teatud tulemust ehk eesmärki, näiteks konkreetsete ülesannete lahendamisel (mis on analoogne kaasaegses õppetöös). § 1.2 “Arutluse tasandid – loogiliste elementide viited” on seaduste empiirilisusest või ideaalsusest teaduses ja õiguses ehk diskursuse universumi rollist ja olemusest. Nii teaduses kui õiguses on normiks, et mõisted tuleb hästi defineerida. Ometigi kui materiaalset reaalsust tõsiselt võetakse, siis peab tal olema mõju teoreetilistele definitsioonidele ning seega muutustega tegelikkuses ja tajus muutuvad ja hägustuvad ka mõistete tähendused.

§-is 1.3 “Seaduste modaalsus” on keskpunktis suhe ‘→’ vormelites $(x)(Fx \rightarrow Gx)$ või (F-sus→G-sus). Õigusnormide puhul öeldakse, et ‘→’ tähistab kohustust, loodusseaduste puhul – paratamatust või põhjuslikkust. Seepärast on §-s1.3.1 “Põhjuslikkus” käsitletud põhjuslikkuse mõistet ja selle rolli õiguses ja teaduses. Leitakse, et kui põhjuslikkust mõistetakse Hume’i poolt antud tähenduses üksteisele diakrooniliselt järgnevate sündmustena või ajendamiste/tekitamistena, siis arutluse konkreetsel materiaalsel tasandil on põhjuslikkus sama nii õiguses kui teaduses, kuid tal on erinevad rollid tulenevalt nende praktikate eesmärkidest: õiguses (aga ka strateegiate loomisel) mingi juhtumi kohta tõe leidmine, selleni viinud (viiva) põhjusliku jada leidmine; teaduses kindlate (nt. eksperimentaalsete) tingimuste loomine. Teaduspõhisel strateegiate loomisel on need kaks eesmärki olulised. §-is 1.3.2 “Implitsiitne normatiivsus” esitan mitmete autorite käsitusi normatiivsusest teaduses ning pakun välja (mittevälistava ja mitte-kõikehõlmava) normatiivsuse liikide klassifikatsiooni: (1) Kontseptuaalne normatiivsus: 1a) laiem kontseptuaalne normatiivsus ehk analüütiline maailmavaade, 1b) kitsam kontseptuaalne normatiivsus ehk terminoloogia, mis pärineb erinevatest teaduslikest distsipliinidest ning mida propageeritakse teadusliku maailmapildi raames; (2) episteemiline normatiivsus: 2a) matemaatilis-teoreetiline arvestatavus ehk püüdlemine maailma matemaatilise arusaamise poole, 2b) praktilised laboritegevused selle eesmärgiga; (3) praktiline normatiivsus: 3a) kitsam praktiline normatiivsus, eriti tehnikas rakendatud teadus ehk tehniliste lahenduste ettekirjutamine, 3b) laiem praktiline normatiivsus – kuidas kujundatakse ümbritsevat temast teadusliku (kontseptuaalse) arusaamise põhjal, nt. poliitikas, strateegiate loomine.

2. peatükk “Korrastatud maailm ja normatiivsuse allikad” uurib loodusseaduste ja mingil määral õigusnormide küsimusi, mis on seotud maailmakäsitusega. §-id 2.1 “Tehnilise käsituse suhe mäendusega: ökofilosoofiline

analüüs" ja 2.2 "Kaasaegne teadus ja tehnika kui viisid looduse uurimiseks: ökofeministlik lähenemine" tõlgendavad Martin Heideggeri kaasaegse teaduse ja tehnika alusmõisteid ökoloogiast ajendatud tunnetusest lähtuvalt, nagu see oli veel levinud renessansiajal, kus Maad ja loodust nähakse elava, hingestatud tervikutena analoogselt inimese (eriti naise) organismile, keda inimene üritab allutada oma vaimsele ja tehnilisele võimule. § 2.3 "Heideggeri mõiste 'seadestu' tõlgendus kaasaegse teaduse ja tehnika olemusena" tõlgendab Heideggeri mõistet *Gestell*, mida ta käsitab kaasaegse teaduse ja tehnika ning neil põhineva maailmatunnetuse olemusena, (Rein Vihalemma) praktika-põhise teadusemõistmise raames. *Gestell* on tunnetuse struktuur, mille kaudu maailm ilmneb koosseisuna, millele ma omistan kolm olulist omadust: püsivus, mõõdetavus ja kättesaadavus/käsutatavus. Need tugevdavad ja tingivad üksteist ning tagavad selle, et maailma matemaatiline kohtlemine teoorias ja praktikas õnnestub. § 2.3.1 "*Gewirk* ja *Gestell*, abstraktsioon ja mateeria" otsib tähendusi, millistes maailma on tunnetatud koe ehk võrguna (*Gewirk* – Heideggeri tegelikkusemõiste nähtuna läbi teadusliku teooria): seda võib näha tegelike, materiaalsete asjade ja nende suhete, kaasa arvatud inimolendite võrguna; või kui põhjuslike toimimiste jada, mida inimene suudab esile kutsuda näiteks uurimislaboris; või kui abstraktsete, idealiseeritud muutujate võrgustikku, mida eeldatakse esindavat tegelikke suurusi (tegelikkuse mõõdetavaid omadusi). § 2.3.2 "(Matemaatiliste) loodusseaduste normatiivsuse juured" jälgib mõiste 'loodusseadused' ajalugu, tuues esile selle arengu aspektid, mis panustavad nende seaduste normatiivsusse ning nende kaasaegsesse mõistmisse matemaatilistena: 'seadus' kui iseenesest kellegi poolt seatud mingit laadi norm, mida tuleb järgida; loodusseadused kui materiaalse loodusliku maailma enda regulaarsused, mida inimene peab oma käitumises silmas pidama; loodusseadused kui jumala ettekirjutused, mida loodus (ka inimene) peab järgima, ning matemaatika kui nende jumalike seaduste keel; kutsealased reeglid (sageli matemaatilised) kohtlemaks vastavaid osi maailmast vastavates distsipliinides ja praktikates, nt. käsitööd ja kaubandus (seega vastavad tegevuste universumile kui loogiliselt ehk eksplitsiitselt normatiivsete süsteemide defineerivale osale).

Lisa 1, "Teaduse konstruktiiv-realistlik käsitlus ning selle rakendus Ilya Prigogine'i loodusseaduste mõistele" (Mets, Kuusk 2009) illustreerib arusaama, et matemaatika on see tõene keel, milles maailma kirjeldada ja temast aru saada. Kritiseerime Prigogine'i katset laiendada oma matemaatilist lähenemist sellele, mida ta nimetab 'tegelikkuse fundamentaalseks tasandiks' ning 'inimtunnetuse fundamentaalsele tasandile' (eriti ajale). Meie kriitika tugineb peamiselt täppisteaduste teooriate olemusele: nad on konkreetsete eesmärkidega idealiseeritud, abstraktsed teooriad, kus nimetatud eesmärgid määravad nõutava või lubatud abstraheerituse tasandi ja läheduse empiiriale.

Lisa 2 "Sotsiaalteaduste teaduslikkusest. Rein Taagepera *Making Social Sciences More Scientific. The Need For Predictive Models*" (Mets 2009) seostub teadusliku, matemaatilise lähenemise normatiivsusega ühiskonna nähtuste valdkonnas. Taagepera vaidlustab matemaatika, või pigem statistika, numbriliste meetodite väärkasutust ühiskonnateadustes ning põhjendab täppisteaduslike, kvantifitseerivate, eesmärgile suunatud meetodite rakendamist, mida ta peab teeks mõistmiseni (mis on tema jaoks teaduse eesmärk). Normatiivsus tema hoiakus teooriast ja matemaatikast juhitud uurimise esmatähtsuse suhtes avaldub selgelt tema selgituses teaduse alustest, nimelt teises neist kahest uurimist innustavast küsimusest: “Mis *on*?” ja “Kuidas *peaks* olema loogilistel alustel?” (Taagepera 2008, 5). Implitsiitselt ilmutab Taagepera lähenemine täppisteadusliku ratsionaalsuse normatiivsust – et täppiskvantifitseerimine annab mõistmise ning seda tuleb püüelda, kui inimlikud pürgimused tahavad kasulikud olla. Minu analüüs asetab Taagepera lähenemise praktika-põhise teadusfilosoofia raamesse ning toob esile mõned ühiskonnanähtuste eripärad, mis peaksid matemaatilise lähenemise korral ettevaatlikkusele kutsuma.

Lisa 3 “Rahvusvahelise õiguse mõned piirangud filosoofilisest lähtepunktist” (Mets 2012a) tõmbab paralleele teaduslike ja õiguslike režiimide vahele teoreetilisel ja praktilisel tasandil. Ta rõhutab praktika, materiaalse tegelikkuse esmatähtsust võrreldes teooria ehk kontseptuaalse mõistmisega. Viimast peetakse aga sageli selgeks ja hästi defineerituks ja sellisena tõest mõistmist tegelikkusest pakkuvaks ning eeldatavalt rakenduvaks ülemaailmselt sõltumata “kohalikest materiaalsetest idiosünkraasiatest”, mida peetakse kõrvalekaldeks korrektsusest ja seetõttu korrigeerimist vajavaks. Ma vaidlen nii teaduslike kui õiguslike seaduste ja vastavalt korra (korrapärasuste) universaalsuse vastu ning maailma kohalikult mugandatud teoreetilise ja praktilise kohtlemise poolt. Ühtlasi sean kahtluse alla regulaarsuse mõiste, mis tundub mõnel autoril (nt. Tunkin) olevat fundamentaalne juriidiliste seaduste praktikale viitava käsituse jaoks, nimelt kui toimingute või tegevuste regulaarsuse.

Lisa 4 “Mõõtmisteooria, nomoloogiline masin ja mõõtemääramatused (klassikalises füüsikas)” (Mets 2012b) puudutab suhteid füüsika matemaatiliste seaduste ja “mürarikka” materiaalse laboritegelikkuse vahel, millele nad peaksid rakenduma. Mu eesmärgiks on näidata, et ei fundamentaalsed ega fenomenoloogilised (arvulised) seadused ei kirjelda materiaalset tegelikkust, kuna nii lihtne matemaatika kui arvude omistamine on liiga idealiseeritud materiaalse maailma ähmasuse ja keerukuse suhtes. Ma väidan, et matemaatika kasutamine mateeria käsitlemiseks on pragmaatiline ehk juhitud eesmärkidest ja tegevustest, ning et seda on ka müra ja (mõõtmis)vigade mõisted, nende modelleerimine ja matematiseerimine, olles maailmaga lihtsa arvutatava kontseptuaalse ja praktilise ümberkäimise teenistuses.

Lisad 1, 2 ja 4 illustreerivad peamiselt teaduse teadmisteoreetilisi normatiivsusi, lisa 3 laiemat praktilist normatiivsust, ning kõik neli lisa illustreerivad rohkem või vähem teaduse kontseptuaalseid normatiivsusi.

APPENDICES

II

On scientificity of social sciences[1]

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1. Introduction

Physics has for a long time been regarded as the most mature of all sciences due to strict mathematically formulated laws of physics and success of theories in applications, for which it has been taken as the example of scientificity which other sciences should strive towards. Just what aspect of physics it is that is regarded as the cause of its success and hence the yardstick of scientificity – this question has given rise to differing opinions. In his book *Making Social Sciences More Scientific. The Need For Predictive Models* Rein Taagepera criticises the opinion that physics is a rigorous science 'merely' due to the use of mathematical operations and numerical accuracy of results. He shows that the strictness of physics consists instead in its method that allows to set numbers and mathematical formalism into correspondence with real phenomena in a way that enables application (first of all prediction), and to unite physical theories into uniform, integral systems. At the same time he teaches how it would be possible to reach the same in social sciences.

In the first part of my review I will give an overview of the book's chapters, describing in more detail Taagepera's general understanding of science and scientific method. In the second part of the review I analyse the positions presented in the book from the point of view of philosophy of science (particularly that of constructive realism), providing examples from social sciences. With my critique I show that the society cannot be handled with strict theories similar to those of physics, and that in order to raise the applicational strength of social sciences, other means often suit better than rendering them similar to physics by developing mathematical formalism.

[1] This is a translation from the Estonian original:
Mets, A. (2009). Sotsiaalteaduste teaduslikkusest. Rein Taagepera, Making Social Sciences More Scientific. The Need for Predictive Models. Oxford: Oxford University Press 2008, 254 pp., ISBN 978-0-19-953466-1. – *Studia Philosophica Estonica* **2.1**, 112–134 (On-line version ISSN: 1736-5899; available on-line: http://www.spe.ut.ee/ojs-2.2.2/index.php/spe/article/view/79/43)

2. Overview of the book

In the book *Making Social Sciences More Scientific. The Need for Predictive Models*, Rein Taagepera, professor emeritus of the University of Tartu, takes a critical look at the method of contemporary social sciences from a physicist's point of view, and hints to ways of improving it. The method that is in the focus of Taagepera's criticism is misuse of statistics, that is using statistics in all possible instances – even if it adds nothing essential to the content of the scientific work and may in some cases even hinder substantial research. The solution that Taagepera offers to improve the situation is to adopt mathematical models analogous to those of exact sciences, that would be constructed on the basis of the logic of the phenomenon under study and would enable prediction.

Foreword is an excerpt of the article "Duncan Luce" by Duncan Luce, originally from the collection *Psychology in Autobiography* (1989), where Luce criticises psychology as one of the fields that most employs statistics, at that for very modest results that often provide no understanding of the phenomenon itself. In the preface Taagepera describes the collision of two approaches: his approach, originating from exact sciences, and that of social scientists having social scientific background: different are both methodologies (explanation and prediction *versus* description) and what is regarded as a result (logical quantitative models *versus* statistical "models" that can be abundant and different for the same set of empirical data). Taagepera considers mainly political science, but he emphasizes that the same holds for all social sciences. He regards computers to be one of the means for misusing statistics – ready-made statistics programs the use of which only requires pushing the right button, but not logical thinking. With this book the author tries to open the eyes of the reader about how limited statistical methods are, while showing the way to constructing logical models; at the same time, the book can be used as a textbook in high schools.

The book is divided into three major parts: (1) "The limitations of descriptive methodology", (2) "Quantitatively predictive logical models" and (3) "Synthesis of predictive and descriptive approaches". I will give an overview of each of them separately, thereafter add my comments.

In the first chapter of the first part "Why social sciences are not scientific enough" the author describes the relation between social sciences and mathematics and highlights the deficiencies of that relationship. In social sciences, mainly statistical analysis is employed, most of all general and linear regression, to test hypothesis about impacts of some variables on other variables, and this is used when tackling any problem regardless of the essence of the problem at hand. Explanatory approaches are not regarded. Many statistical indicators are presented, that is just a bunch of numbers that do not contribute to the understanding of the problem.

Taagepera presents his understanding of science (Taagepera 2008, 5):

> Science stands on two legs. One leg consists of systematic inquiry of "What *is*?" This question is answered by data collection and statistical analysis that leads to

> empirical data fits that could be called descriptive models. The second leg consists of an equally systematic inquiry of "How *should* it be on logical grounds?" This question requires building *logically consistent and quantitatively specific models* that reflect the subject matter. These are explanatory models.

The 'should' here is logical, not moral, and it can be corroborated and disproved. The legs also have to be joined somehow, that requires systematic qualitative thinking. Taagepera contends that contemporary social science has disregarded the other leg – thinking on logical grounds. Quantitativeness in models does not only mean direction, as it tends to be in social sciences, but exact numerical relation that can be corroborated through testing. But the results of social sciences consist of a bunch of regression coefficients that explain nothing and cannot be used in practice in any way whatsoever.

Taagepera contrasts descriptive and predictive methods: in case of prediction we have an explanation in the form "This *should* be so, *because*, logically….", whereas in description "This *is* so, and that's it" there is no explanation. The latter only says how things are interrelated, and it says this postdictively – only in the best cases can such a description be applied to new similar cases, and they offer no new ideas nor raise questions. The basis of explanatory models is inquiry for causes – why do things affect each other exactly as they do. If the model turns out to be successful in testing, then it holds for the particular phenomenon more broadly. This is how it goes in physics and should also go in social sciences, according to Taagepera. But standard statistical programs make it possible for social scientists to create bunches of numbers that are never used after having been published.

In chapters 2, 3 and 4 Taagepera exemplifies the limits of the descriptive method and offers a cursory insight into predictive modelling. In chapter 2 "Can social science approaches find the law of gravitation?" it is described how, by applying linear regression, without using any other mathematical methods or other methods of analysis, the regularities underlying data remain undiscovered. This happens even in cases where the coefficients received through statistical analysis are very good, for example, correlation is high. James McGregor has carried through linear regression for three laws of nature (Galileo's law of falling objects, Boyle's ideal gas law, Newton's law of gravitation). Results were very good, but nothing in them hinted to the underlying laws of nature. Taagepera himself carried through an experiment on social scientists, in which he asked them to analyse data that nearly perfectly matched the universal law of gravitation. No one of the respondents discovered the underlying law. This is a warning example that shows that even if there is a regularity in data, social scientists probably do not find it, particularly if the statistical analysis gives good results – then social scientists do not even consider using other methods.

In the 3rd chapter "How to construct predictive models: simplicity and non-absurdity" Taagepera looks more closely at creating predictive models. Social scientists' understanding of exactness is generally limited to finding statistical coefficients with as many decimals as possible for every variable. These are, though, only for linear relations, also if data are clearly related non-linearly. Linear approximation can indicate the direction (if one variable increases, the other increases/decreases), but not the quantitative relation between the variables. For this, Taagepera suggests to begin with setting the relation logically: one has to exclude logically impossible cases (taking into account the real properties of the quantities, for example if they cannot be negative), and the model should be as simple as possible, containing only those variables and coefficients that are essential in the problem at hand (these are namely those which in statistical models are exaggerated with). Interdependence of variables should also be considered, not only dependence of one variable on other, independent variables.

The 4th chapter "Example of model building: electoral volatility" demonstrates the more concrete steps in the process of building a model. The most important recommendations before looking at empirical data are: dare to simplify – one has to retain as few variables as possible; delimit the conceptually possible domain of variance; determine the behaviour of variables in extreme cases, or anchor points (which may even not appear in reality, but are important for understanding the phenomenon as a whole); find means that give an idea of the possible form of the model (equation) that is probably non-linear (because linear equations usually violate some boundary conditions), presupposing the model to be a continuous curve between two anchor points. Then the preliminary model can be tested on empirical data and amended if necessary. As an example, electoral volatility in successive suffrages dependent on the number of political parties is given. The regression coefficient R^2, so much loved by social scientists, may say nothing about fitness of the model, as it depends also on consistent set of data.

In chapters 5, 6 and 7 Taagepera criticises more thoroughly the disproportionate dependence on descriptive methods. The 5th chapter "Physicists multiply, social scientists add – even when it does not add up" compares general features of the equations of physics and those of social sciences. The most essential differences between them are as follows:

- in physics' equations there are few variables, as problems are divided into smaller parts that are solved separately, and common operations are multiplication and division; in social sciences there are many variables – all impacts are being tried to insert into one equation – and usually they are added and subtracted, multiplication is sometimes used, but division is always replaced with subtraction;
- physics' equations contain up to one freely adjustable constant and that has substantive meaning (there may be more constants in applied physics); in regression equations such constants are more numerous than variables and they have no substantive interpretation, they can have whatever value;
- physics usually has one equation per phenomenon – if there is none, it is achieved; regression equations are several alternative and advantages of one over the others are as often as not practically substantiated;

- in physics, inconsistencies are avoided even in extreme cases: when an outcome appears absurd, the equation is modified; in social sciences inconsistencies are tolerated, they do not force to modify the regression equation;
- the aim of physics' equations is to predict both in the narrower sense (inside one equation) and broader sense (as to the mutual dependence of variables, on different levels of the phenomenon), and the failure of prediction requires explanation; the aim of social sciences' equations is at best postdiction, usually they do not present causal relations, being too freely modifiable;
- physicists indicate the possible error ranges of measurements and give only meaningful decimals; social scientists present correlation coefficients even if equation itself is not given completely, and often excessively many decimals;
- physics' equations are reversible and transitive that enables them to form networks interrelating variables; standard regression equations are unidirectional and non-transitive, variables are not interrelated.

The 6th chapter "All hypothesis are not created equal" takes a closer look at the hypothesis raised in social sciences. Research procedure much used in social sciences is as follows: a hypothesis is formulated, data are gathered, the hypothesis is tested and then either accepted or rejected. Taagepera criticises that such method is too robust, not allowing modifications of hypothesis, hence important details can remain unnoticed. Also the character of the hypothesis of social sciences is weak: the compulsory null hypothesis ($\mathrm{d}y/\mathrm{d}x \neq 0$) says nothing about possible or expected results, and also the merely directional hypothesis ($\mathrm{d}y/\mathrm{d}x > 0$ or $\mathrm{d}y/\mathrm{d}x < 0$) can easily be fulfilled due to accidental coincidence, but they are equally useless for prediction. For prediction and drawing practical instructions one needs quantitative hypothesis, that is, a model in a functional form ($y=f(x)$) that can easily be falsified, but in case of confirmation it is equally more useful, as it informs about exactly in which proportion and why quantities co-vary. Large set of positive cases is often regarded as confirming weak hypothesis, but this can be deceptive. According to Taagepera, building a model should follow a cyclic path in which hypothesis and empirical data cooperate.

The 7th chapter "Why most numbers published in social sciences are dead on arrival" presents details of methods for solving problems. Whereas in physics (and also in common sense) solving a problem starts with figuring out a causal model (that is, one contemplates, how things might be connected), in social sciences data are collected without prior expectation about them. Then some data analysis method is applied, but there are different methods and they provide different results, that is, they give different accounts of the reality. In physics few numerical results are published and these are meant for employing in further inquiry. In social sciences plenty of numerical results are published and usually none of them is employed by other scientists. Their aim is to mimic quantitative science.

In the second part of the book "Quantitatively predictive logical models" we find chapters 8–13 that present model building in more detail. The 8th chapter

"Forbidden areas and anchor points" gives general instructions for building certain types of models. First of all one has to determine the conceptually possible values of variables (domains of variance) and the values of output variables corresponding to extreme values of input variables (anchor points). According to this the appropriate scale for presenting graph is to be chosen, that is, the possible form of the function (usually nonlinear). Parameters are determined empirically. If there are several input variables, the operation between them (multiplication, division, …) has to be decided according to the way they logically relate to each other (whether they annihilate or enhance one another).

Why may we employ simple functions in social sciences as we do in physics? Taagepera proposes that their suitability is to be tested at the least, as in physics they are suitable. The models received are deterministic in respect to average results, but probabilistic in respect to particular cases – analogously to computing the location in quantum mechanics.

The 9th chapter "Geometric means and lognormal distributions" explicates the advances of geometric mean in relation to arithmetic mean with the help of examples: geometric mean reflects real tendencies better. In certain cases it is also not possible to use arithmetic mean, and in some cases lognormal distribution has to be used instead of normal distribution (if the values of the variable cannot be negative).

In the 10th chapter "Example of interlocking models: party sizes and cabinet duration" an example from social sciences is presented about how it is possible to create logical quantitative models analogously to physics. Variables are the size of cabinet, the effective number of parties (Taagepera's own created notion), the duration of cabinet, the number of parties that have won seats in the cabinet, the proportion of votes for the winning party – that are interrelated – and there is one empirically determined constant. Through logical argumentation a quantitative multiplicative model is achieved (the inverse square law of cabinet duration) that approximates well many real cases. The difference of the argumentation from physics is that variables are derived from each other in line, not as a network, where each relation would bring with it an additional factor. Taagepera says that one reason for this is the absence of physical dimensions.

Taagepera does not regard it important to call his models "substantive" as some other authors have, as generally he does not need to take into account factors specific to social sciences when creating these models, although in some cases such factors may pose conceptual constraints. Nevertheless, these models are theoretical. He takes the requirement for narrowly social substantive explication to be sterile when anchor points are all that is needed for constructing a model.

The 11th chapter "Beyond constraint-based models: communication channels and growth rates" presents new techniques of building models with examples. One of the most important variables in political science and in social sciences in general is taken to be communication channels, that is also the number of possible conflicts and is related to cabinet duration as well as to the representative assembly size. Taagepera names some other elements that can be taken over from physical sciences: minimization and maximization, differential equations, notions of entropy and information adapted as appropriate, conserved quantities. As an example of minimization, Taagepera gives the changing of the representative assembly size that often follows the tendency towards the cube root law of assembly sizes without this law being consciously taken as template. According to this law the work load of one representative is minimized – analogously to the light that minimizes efforts, "choosing" shorter path when travelling through a denser medium.

In the 12th chapter "Why we should switch to symmetric regression" the author explicates the advances of symmetric regression in relation to ordinary least square regression. The main shortcomings of the latter are that equations are non-unitary, irreversible and non-transitive. Regression curves *y* against *x* and *x* against *y* are different and are not deducible from each other, hence they do not show the real trend. This jeopardises scientific results as when comparing logical model and real data incidental scattering can considerably distort their conformity when using standard ordinary least square method only in one direction. Such equations cannot make up interlocking systems. In contrast, symmetric regression gives only one regression line that is both reversible and transitive, making it possible to create interlocking systems of variables. However, it does not replace conceptual modelling, being descriptive and still apt to mislead. Physics equations form interlocking systems, and due to mutual dependence of variables it is possible to reverse equations, even if in reality the phenomenon is causally directed (an example is given of law of gravitation, force being dependent on masses and their distance).

The short 13th chapter "All indices are not created equal" explicates testing a model with data. Taagepera warns that empirical data should not be taken as the ultimate truth, because measurements are usually imperfect: there are different measuring methods, measurement errors etc. If for the same index describing a phenomenon different values are received, one should prefer the one which better coincides with the logically expected relation, because it encompasses causal link, it enables generalisation and is more useful for prediction – the likelihood that the coincidence is random is very low.

The third part of the book "Synthesis of predictive and descriptive approaches" contains chapters 14–18. In the 14th chapter "From descriptive to predictive approaches" Taagepera gives the most detailed explication about his understanding of scientific theory. Statistical methods employed in social sciences cannot lead to laws: they do not distinguish causes, causal chains, being too coarse and enabling only to describe, but not to analyse phenomena. In physics, theory is a conceptually grounded and empirically tested interlocking set of models. But social sciences presently resemble rather the pre-Newtonian physics or alchemy where one "philosophers' stone" was to do everything: theories of everything, according to Taagepera, appear namely during the dawn or noon of theories, at forenoon scientists are too busy researching *something*. In social sciences different things are called theory: one merely directional model can be a theory, but theory can also be "weaker than "hypothesis": "A theory is a set of interconnected assumptions…. From the theory, we derive one or more hypothesis"" (quoting Souva 2007). In Taagepera's opinion an important feature of theories is cumulativeness: successive paradigms do not replace each other, they build on each other (as on those that are presumed). In social sciences cumulativeness means heaping up empirical data, accounts of them diverge and paradigms shift often.

Also the ways how sciences use statistics differ. In physics, linear regression lines are mainly used in applications for approximating complex nonlinear laws, adapting underlying laws to particular conditions. But those fundamental laws themselves cannot be discovered with the help of only statistical methods. One starts with qualitative observation, on the basis of which the important measurable quantities present in the phenomenon are conjectured. Those are tested on a small preliminary set of raw data, using linear regression *inter alia* to hypothetically filter out most important factors (but it is not trusted without reserve, however). Further, the nature of the phenomenon is conjectured and more data collected. In this way, applying logical discourse and empirical testing in conjunction, a quantitative predictive model is finally created. For testing this, statistical methods are again employed (preferring symmetric regression), but now not anymore on raw data, but on data transformed according to the model – that is, it is the model that is tested now, not the hypothesis like in social sciences. If the test does not confirm the model, then not only the model but also test data are revised. The result of such a cyclic model building can be a scientific law.

In the 15th chapter "Recommendations for better regression" advice is given on how to get the best out of concrete empirical data when creating a model. The most important is to draw a graph of the data – this enables to visually assess whether linear regression makes sense at all and which function would best approximate the data. The graph should present the whole domain of the function and means to get a more complete view of the phenomenon and arrangement of existing data on it.

In the 16th chapter "Converting from descriptive analysis to predictive models" Taagepera gives to the descriptive statistics some hope to be useful: in some cases and conditions (if the quantity has a natural scale and zero-point, and the logical model contains all variables simultaneously), it is possible, with the help of somewhat more complex mathematics, to use its numerical results to evaluate the parameter of predictive models.

In the 17th chapter "Are electoral studies a Rosetta stone for parts of social sciences?"[2] Taagepera explicates his understanding of the relation between mathematics and particular fields of science. In a sense, sciences constitute a hierarchy: more mature sciences are mathematically more formalised, and are

2 Rosetta stone was a historical multilingual document that aided to decipher Egyptian hieroglyphs.

partly a basis for other sciences, helping them in explaining phenomena, and in this sense they can be taken as fundamental. Natural sciences (physics, chemistry, biology) are mature, formalised, cognitive and social sciences that follow them in the hierarchy are not yet mature. Mathematics influences sciences and sciences influence each other as to the use of mathematics for modelling fundamental phenomena, but they also influence mathematics as to developing formalisms. Taagepera presents historical data about the relative importance of the elements of quantitative formalisms (data tables, formulas, graphs) in publications of different fields as one of the possible indicators of the maturity of sciences.

Comparing natural sciences with social sciences from the aspect of laws, it turns out that the boundary between them is fuzzy. Although laws of nature (laws of physics) are regarded as eternally true and those of social sciences as dependent on contingent context, however, laws of physics should be regarded as predicting certain results in certain conditions (Colomer 2007), and in this sense social laws can also be regarded similarly. Simply the more generally holding laws of physics are formalised using less factors – one has to recognize what is essential in the phenomenon, what is additional in certain conditions. Observer's influence on what is observed is taken to be stronger in social sciences, weaker in natural sciences. At the same time, it appears to be strongest in quantum mechanics. Is it comparable to social sciences? In both nature and society one encounters subject's resistance to influences (for example microorganism's reaction to antibiotics, society's reaction to acknowledged regularity). Taagepera proposes that social sciences should not pretend to be(come) totally similar to natural sciences, rather, it should be found out if some parts of them can be made more exact than they presently are. That is what he is trying to do with the help of electoral studies.

The most important point about electoral studies is that many of their quantities have natural unit and also natural zero-point. The former is missing in case of many quantities in physics, the latter in case of many quantities in social sciences (for example in opinion measurements). At the same time they have the shortcoming that units are not divisible, that is, differently from physics they have no natural interval (in other words, they are discrete, whereas quantities of physics are continuous). Hence in political science it is possible to apply a more stringent scale than in other social sciences. Nevertheless, also in other social sciences there exist quantities the soft scale of which can be turned into a firmer one, analogously to temperature, that is one example in natural sciences where determining the scale has not been unique. That electoral studies can be the Rosetta stone for some parts of social sciences, is demonstrated by the fact that creating quantitative models based on soft scales has succeeded in some cases (De Sio 2006a,b, 2008), but caution is still required, because handling those scales in this way is not without problems.

Therefore, political science can partly be taken as similar to natural sciences due to scales of quantities, but as a social science it remains a non-laboratory science the subject of which is in constant changing.

The 18th chapter "Beyond regression: the need for predictive models" briefly rehearses statements formulated in several places in the previous text: social sciences might be more quantitative and more successful in prediction than they are. They do not correspond to society's needs, providing merely postdictive descriptions that have no practical use. With the help of techniques given in the book it is possible to render them more scientific and hence raise their usefulness, enhancing the possibilities to use them in social engineering. Following the current stream, social sciences end up in a dead end that resembles the Ptolemaic system in physics.

3. Analysis

In the following I give my comments on Taagepera's account.

The reproach that social scientists are too fond of statistics seems to be justified – others, too, have complained about this. For example a PhD student whose topic is essentially qualitative is reproached for the lack of statistical data and analysis in the research work, regardless of the fact that statistics would have no essential role in the particular work. Likewise justified is the critique that the role of statistics in social sciences is often mainly ritual, aiming at giving a scientific impression. But when a work already contains the numbers and looks scientific enough, one needs no other mathematics and the research is finished. Prediction – that is supposed to be the main aim of science – is not reached. I regard both aspects separately. But firstly I present some philosophical conceptions of science and situate the social science criticised by Taagepera into this context.

Rein Vihalemm (1989, 1995) discerns between exact sciences, or physics-like sciences (phi-sciences) and non-exact sciences. The former are constructive-hypothetico-deductive by their method: they construct their research area mathematically, on the basis of these mathematical constructions hypotheses are formulated, those are tested experimentally, whereas any experiment must be reproducible. If an experiment is not possible, like in celestial mechanics, hypotheses are tested by observation (quasi-experiment), which also must be reproducible. Mathematico-experimentally abstracted idealised laws are mathematically deducible from each other. Those sciences so-to-say adapt the world to their cognition – the mathematical conceptualisation (mathematical in the general sense) – and the aim of the laws formulated in these sciences is to say what is possible and what can be done, and not to describe what the world in itself is like, as is the popular understanding; that is, the exact scientific laws say which experiment enables producing a particular phenomenon, which observation should be conducted for detecting a certain phenomenon or event. Non-exact sciences (more precisely – non-phi-sciences) are by their method classifying-descriptive-historical: they divide the world to be examined into classes according to its detailed description, where also its historical development (forming) has to be taken into account. These sciences adapt their cognition to the world – they must notice all details and the phenomenon as a whole for adequately describing it. Non-exact-scientific method stems from natural history, from which Vihalemm yet discerns social and humanitarian studies (Vihalemm 2008, 418), that he regards rather as philosophies that stem (or should stem) from rational-critical approach, from a method that receives feedback regarding values and goals, and that enables corrections. But they are not inferior because of this, only their goals and possible methods of action are different than those of phi- and non-phi-sciences.

Let us notice how Vihalemm's understanding of the character of physical laws differs from that of Taagepera. Whereas Taagepera regards the two fundamental questions of science to be "What *is*?" and "How *should* it be on logical grounds?", then Vihalemm rejects the first question requiring descriptive answer: "The aim of science is not drawing a true image of some phenomenon, some sphere in all its diversity, but discovering laws, finding out what, how and to what extent obeys laws, what is possible and what is impossible according to the laws" (Vihalemm 2008, 414). To its stead Vihalemm takes the question "What can be *done*?" This is inseparable from the experimental character of the laws of physics – experiment shows what can be done, and if our logical presumptions hold – if it is possible to operate with the world according to such a logic, that is, if a phenomenon with such a logic can be selected from the world. This kind of selectivity enters Taagepera's account only in the stage of testing when the test data are processed according to the logical model. Of course, he does not miss the concrete aspect of doing something with the world either, but this appears explicitly only in engineering. This can be an important aspect because developing exact scientific laws in some field should presuppose the possibility of conducting (in principle) reproducible experiments in that field, but in social fields this is highly questionable, if not absolutely impossible.

According to Ronald Giere's (1988, 2009) account any scientific theory (of both exact and non-exact sciences) consists of sets of models. He regards a model to be a non-linguistic entity that is defined by some language (for example, in exacts sciences mathematically) and that has a similarity in some aspect and to some degree with the world, that is, with the part of the world modelled. Whether the similarity of a particular model with what is modelled is good enough (with respect to the goal and context of the model) is decided by the community of scientists. There are models of different levels and they are hierarchical: the most abstract are general principles (principled models) that correspond to fundamental theories, from which those representational models are derivable when concrete conditions are added. From the other side, the least abstracted are empirical data, gathered with the help of experimental and mathematical means, from those models of data and models of experiment are derived. From representational models and models of experiment scientific hypothesis are derived that are tested on models of data. For some parts of the world, however, principled models may be lacking in principle, in which case representational models are constructed based on models of data with the help of additional empirical and mathematical considerations.

According to Vihalemm's account social sciences are non-exact sciences and they must differ from physics: the statistics employed in social sciences is just a particular kind of description – a numerical description. Also collecting and using empirical data without the prejudice that some data might be superfluous or do not fit into the account should go well according to this account – as all details of a phenomenon must be noticed. But if we think about the criticism by Taagepera, the question arises: what is the aim of such a description? What is the aim of social sciences in general? Taagepera himself seems to endorse the point of view (that he explicates to some extent) that the aims of sciences consist in their application: the aim of physics, at least for the general public and practitioners, is technical engineering, or applying physics to design the external physical world; the same holds for natural sciences more generally; likewise the aim of social sciences should be social engineering, designing the society. Offering knowledge for deriving practical instructions of action, it would be useful for the society. Can a social science, descriptive in the way presented, enable to design the society? If statistics is a goal in itself for social scientists as a research result and there are no more general conclusions about the processes in society accompanying it, then probably it happens as Taagepera says – its results are dead on arrival. In physical engineering numerical models can be used for creating devices because one can select materials with (nearly) identical physical properties, process them into (nearly) identical elements, taking into account the allowed tolerance, to assemble them in the same way – then such model describes every such artefact. However, the existence of theoretical understanding of the underlying phenomenon is presupposed. But in social sphere one cannot find two identical "materials", each object of study must be approached individually, and if statistics is done on raw data without prior understanding of the phenomenon (as is often done for example in econometrics, and probably in many other fields), then indeed this statistics cannot say anything more general, if anything at all.

What kind of models, according to Giere's classification, could be the so-called statistical models created in social sciences? And are their hypotheses the same in this classification as those that Giere calls hypotheses? Giere says that for testing hypotheses, models of data are used, not directly data, and let us notice that in Taagepera's account data come into play in both creating and testing a model, and he discerns the data used in social sciences from those used in natural sciences, as the former piles up data without principled selection both for creating and testing a model, the latter stems from a preliminary understanding of the phenomenon when collecting data for creating a model, and from the created model itself when testing it, on the basis of which is created what Giere calls model of data. What is lacking in social sciences? Obviously they feature no generally accepted principled models, then, according to Giere, representational models should be constructed on the basis of models of data and additional empirical and mathematical considerations. According to

Taagepera, in social sciences usually no such kinds of models are constructed that Giere would call representational models, although there exist data and also something like mathematical considerations – statistical methods. But if those methods are applied without contemplating their meaning (that is what Taagepera reproaches social sciences for), can they be called considerations? Also empirical considerations seem often to be lacking – those would be these numerous advices that Taagepera gives (taking into account the conceptual character of variables, the meaning of anchor points etc.). Is the way data are used in social sciences really such that also according to Giere there is no selection criterion? Probably there is some, but much more weakly defined than in natural sciences. Perhaps the statistical descriptions (or "models") received can be taken for models of data – also the possibility, proposed by Taagepera, to employ them in creating a conceptual (or representational) model seems to hint at this. As according to Giere's schema hypotheses are derived from representational models, this yields that those called "hypotheses" in social sciences, at least the null- and directional hypotheses criticised by Taagepera are not hypotheses in Giere's sense. Perhaps it is those that can be taken for the (implicit) criteria for creating models of data? If so, then it seems that in case of social sciences we are not dealing with sciences.

Nevertheless, one could not say, as Taagepera claims, that social sciences approach data or observation from an absolutely theory-free position. Theory-ladenness is a matter of fact emphasized by philosophers of science already long ago, that among other arguments helps to refute naïve forms of inductivism and falsificationism (the first of which could be regarded close to the methodology of social sciences on the basis of Taagepera's presentation) and that has been shown as empirical fact by several studies in cognitive sciences. Also social scientists have some understanding of the area they study, of which phenomena appear and interact there, what their essential features the correlation of which is to be looked for are. At the same time, striving to defy one's prejudices is sometimes necessary, especially when studying a society the cultural and historical background of which differs significantly from that of the researcher, because radically different factors may appear to be essential there.

Would it be possible to render social sciences similar to physical sciences as Taagepera wishes – at least to some extent? To some extent he has already done this of course, as he exemplifies in his book, particularly with political science: he has constructed idealised mathematical laws that approximate real systems and processes, that is, which have good enough similarity with real systems (verified through observation) for being used in prediction. Predictability stems from there being identified fundamental phenomena and causal relations in the modelled systems, for example communication channels in the case of the chamber of representatives and others. Often those phenomena are such quantities that can be uniquely measured – that makes it possible to formalise their relations mathematically. Nevertheless one must notice that mathematical formalism, or rather its interpretation for a real case, is significantly softer than in natural sciences: there is always the possibility of big digression that depends on particular society in which those systems are regarded. This means, on the one hand, that there are a lot of *ceteris paribus* conditions that complement the formulation of a law and that diminish their generality; on the other hand, it may be that the subject of social sciences is not deterministically predictable enough like those of natural sciences. They have a great and very essential difference: the subject of social sciences has consciousness that the subjects of natural sciences, especially those of physics, presumably do not have.

We presume that the light does not choose how it behaves out of its own free will, when passes from a sparser medium into a denser one: we presume that it necessarily changes direction and that it has no other choice but to shorten its way through the denser substance. But we cannot presume that people always know or want to behave in the way that is easier for them or that they have the possibility. Human consciousness and free will, even understanding of free will, depend heavily on the culture where the human being has formed as an individual, and probably on many other factors. Laws and political rules are conscious artefacts of human beings that possibly can be mathematically described (and many of them have been), but at the same time they can be consciously changed, and broken either consciously or unconsciously. Taagepera himself gives an example of how one society digressed from the cube root law of assembly size. If we have a predictive model for describing some (political, institutional) phenomenon of the society, can we predict when it will not hold? If even such an essentially formalised field can digress from prediction, then we can expect even more in fields of social sciences that have less of softer rules.

Taagepera writes that when creating his models, there was no need to take into account any specifically social scientific matters, although these may in some cases pose limitations. For the regulated phenomena that he regards one can indeed rely, for example, on the law of large numbers or principles of mass behaviour that make it possible to average over peculiarities of individuals and therefore to abstract from several factors appearing in society. But there are factors in society for which such an averaging is not possible: those are dealt with in such disciplines as psychology, pedagogy, management theory and others. Here such phenomena become fundamental for which mathematical formalism analogous to political science may not be realisable, hence it would not be possible to construct quantitative models, either. Taagepera does briefly mention standardising quantities with a softer scale, but here one must take into account factors specific to the society. Many conceptions may have such dimensions that render their formalising futile. For example comparing different societies as to how they conceive some qualitative conceptions (e.g. democracy, capitalism etc.) may be impossible, because different societies perceive these things differently due to their different historical relation to them, to language (conceptual networks), general mindset dominating in the society and other factors that all influence one another and change constantly.

But also in the cases observed and formalised by Taagepera a particular society seems to be a prerequisite: the Western democratic society. For example, one of his presuppositions is that there is communication between members of representative assembly and the voters – that not necessarily functions in every society. Social institutions that are regulated with some law or the will of sovereign are arbitrary in the sense that they can also be changed in the same way. They are not necessary. Likewise there are cases in politics where the reality departs significantly from the public propaganda, where according to the law one state of things is the case (e.g. democratic polity), but in reality things function differently (e.g. authoritatively). Thus it is justified to doubt if models based on phenomena and tendencies that seem necessary (like minimising and maximising) would indeed hold in all possible states and polities, including, for example, the Soviet Union, North Korea and others. In different states, polities, societies, radically different factors may emerge as decisive. For example, the role of religion in society may be inconsiderable or fundamental (e.g. Estonia vs India), that on its part is not necessarily reflected in politics or economics (compare the low religiosity of Estonian population in Christian confessions vs the shares of state budget allotted to the Church, particularly in contrast to other religions, including native religion).

I would give an example from organisation theory as presented by Mary Jo Hatch. She considers the following core concepts (we could perhaps also say "dimensions"), that are relied upon when constructing organisation theories: the environment of organisation, strategy and goals, technology, organisational social structure, organisational culture, and physical structure of organisation. For each of these aspects, there are several theories stemming from different fundamental assumptions (generally divided into modern, symbolic-interpretive, and postmodern views by Hatch) and emphasising different aspects in organisations. As it turns out, no theory is futile, but has its own span of applicability – as there are organisations of differing sizes, core activities and goals, cultural backgrounds etc, and different theories are useful for different aims, for example the modernist view is often helpful for managers in concrete decision-making process, the symbolic-interpretive view is useful for a more coherent understanding of organisations as a social phenomenon. So is each of these dimensions on its part divided into sets of core concepts, or dimensions, that can take different values that usually are non-exact, non-numerical (or for which numerical formalism might not make much sense), but that nonetheless can be used to define categories for classifying organizations. These concepts are, of course, interdependent, influence each other, and even include each other as elements: for example, organisational environment can be divided into basic concepts as cultural, political, social, technological, economical, physical and legal environment (that, on their part, are not independent of each other, and, depending on the context, cannot always be regarded as separate aspects, but some of them should often be regarded as one, e.g. cultural and social, or economic and political).

Besides the multiplicity of factors as presented, Hatch points out some more features of the subject that I take to be essential from the point of view of exact sciences. One of those, strategic management – "an important link between the organization and its environment through which information and influence pass" – was regarded as one-directional by modernists, environment influencing the organisation; but the link also includes the other direction: "just as strategy emerges from organizational processes, so the environment emerges from the actions and interactions of organizations." This means that, unlike exact scientific objects that can be (nearly) isolated from the surrounding environment, its possible intermittent influences, and be studied as an abstracted, simple phenomenon (mathematically speaking: boundary effects are reduced to minimum), the objects of social sciences usually cannot be isolated from their environment – environment with all its aspects constitutes an integral part of the object, the boundary between the object and its environment cannot be drawn uniquely and unambiguously, which also Hatch explicitly states.

The other important aspect, which pertains to most social sciences, is their fundamental "quantities" (I put the word into quotation marks, because of the analogy to the relevant notion in physical sciences, but in the case at hand, as we will see, they may not be taken as quantities, that is, as having numerical values, at all). In physical sciences, the fundamental quantities like length, mass, time and others can be either directly measured, or a unique and unambiguous relation between the phenomenon (e.g. temperature or pressure) and a measurable quantity can be established (usually experimentally) so that it is possible to formulate strict mathematical laws having those quantities as components. In social phenomena those underlying, most fundamental "variables" are different. Hatch presents the theory of organisational culture by Edgar Schein, according to which culture exists of three levels: the deepest, most fundamental level is basic beliefs and assumptions, on which values and behavioural norms lie, and on the surface lie artefacts. Schein takes the interrelated core assumptions and beliefs about the reality to be the most fundamental level of explanation in social affairs. They are invisible, often inaccessible to consciousness and taken for granted. Values are social principles and standards held within a culture and norms are unwritten rules, usually pertaining to values, both being supported by underlying assumptions. Usually they are become aware of when they are challenged in a fundamental way. Artefacts are the most observable and accessible manifestation of culture, or "remains of behaviour", but, as Hatch writes that "artifacts lie furthest from the cultural core. Their remoteness from the core indicates that they are easily misinterpreted by those who are culturally naïve, including cultural researchers when they begin a new study." These levels may not be consistent and relations between them are not straightforward and unique, hence quantifying the fundamental level with the help of the more accessible levels may be problematic and doubtful. Even their conceptualisation is problematic: approaching from the researcher's conceptual framework (modernist approach), the studied culture's constituent concepts may be distorted and the result may not adequately reflect it, even though be better understandable to the researcher.

If the fundamental factors of some fields of social sciences cannot be mathematically formalised, or to be more exact – to set into a numerical scale (for example they are not measurable straightforwardly but only through a complex of other factors), this does not yet imply that they cannot be used for creating models. This has been done, but the models are not quantitative but qualitative. Those exist, for example, in entrepreneurship studies, in management science, but also elsewhere. As these models are often in the form of a graph or matrix (e.g. in a lot of cases presented by Hatch, where two dimensions of organisation are regarded together, each having grossly two values, making up four categories) they might be regarded as mathematical in the general sense (whether they also classify as exact in the sense specified by Vihalemm requires perhaps special study). Although these models are qualitative, they are nevertheless strict and theoretical: they are idealised from empirical observation, taking into account specificities of concrete sphere, and they present causal and functional relations between elements of phenomena and conditions in which the relations hold. They can also have a form of equation, that is, to resemble a law of physics, if they contain measurable quantities (for example the effect of multiplication in entrepreneurial cluster of which there exists a theoretical logical model corresponding to Taagepera's criteria and an equation for idealised case (the author is Tõnis Mets)), but this is not always necessarily so. However, this does hint to one more context, besides that proposed by Taagepera, where the statistical "models" of social sciences, or statistical research, are useful: namely testing the hypothesis about the modelled phenomenon. But this presupposes that the phenomenon itself is very clearly described, its essential elements explicated, and there is a theoretical schema about their interaction: that is, there exists a representational model in Giere's meaning. Such a method is applied for example in studies about organisational culture, where also questionnaires and factors derived from their responses (models of data) are used for testing models and measuring concrete quantities of organisations (for example to what extent the organisation is a learning organisation[3]). Often phenomena on this level are so complex that creating an algebraic model for them would be too complicated, and that is why the least square method is chosen that provides a regression equation to be applied to other cases.

Hatch also provides examples from which we see that the method of social sciences starting from zero-hypothesis is not totally useless. Joan Woodward studied the performance of organisation in relation to the dimensions of structure proposed as underlying by different management theorists: span of control, number of management levels, degree of centralization in decision-making practices, management style. Her hypothesis was that one of the established views is more effective than the others (essentially a zero-hypothesis), and her method was statistical (data analysis based on empirical research). Having found no such relations, she continued her research and finally came up with technology as another important dimension of organisation. Besides, her study served as a starting point for other following studies

[3] I'm thankful to Prof. Tõnis Mets for the explications and examples from the field of management science.

that resulted in more thorough understanding and detailed models of the particular subject matter. This is a good example of how the criticised social sciences' methods, if applied with consideration, can lead to meaningful results.

Keeping in mind the assumed goal of social sciences – designing society (or social engineering) – such qualitative models and accounts are no less useful than strictly quantitative. But they have to be taken with as much precaution: we are dealing with a sphere of the world that subsumes to prediction significantly less than those of physical and natural engineering. Whereas in the latter it is possible to experimentally determine the limits and conditions of validity of laws, reproducing experiments in different settings if needed to get all conditions under control (if some conditions remain uncontrollable and the law candidate unpredictable due to this, then it is abandoned), then in society one cannot conduct the same test several times: it is not possible to create exactly the same experimental conditions, to use exactly the same test sample, because all samples are different (at that, probably not all their differences are describable qualitatively, more the less quantitatively), they change in the course of experiment, and the experimental conditions change both because of, and without the help of, experiment. If in the shaping of society some models about it are applied, then the one shaped is always different and reacts to shaping differently. Also in natural scientific design there exist such complicated, complex systems, for example, organisms and ecosystems that contain a multitude of factors that influence one another and constantly change in time. Taagepera himself provides one such comparison as to the reaction of the subject to designing, but he regards natural sciences to be similar – physics and biology are both mature natural sciences in his account of science, although the latter is mathematically less formalised, hence to some extent less mature. Nevertheless, one should discern from the point of view of the studied subject what and why can be moulded in a strict quantitative shape and to what extent also be designed according to those shapes. Vihalemm even thinks that there are no laws on the basis of which it would be possible to forecast and control evolution, either biological or cultural, social – this process is constant adapting to contingent accidental occurrences the results of which cannot be foreseen. Forecasting and control can be employed in technique and physics that can be accounted for from the point of view of constructive rationalism (Vihalemm refers to August von Hayek), but not in conceptions of society.

To conclude, I firstly must emphasize that the problems regarded in the book by Taagepera are real problems that needed to be highlighted and brought to attention, and Taagepera's advice for overcoming them are well to the point and hopefully will receive the attention they deserve by social scientists, and will be taken into account, and that henceforth the parts of social sciences that are in the focus of this critique indeed will be amended and become more scientific. Nevertheless one has to be attentive, to follow the advice that Taagepera also gives: each problem must be approached individually. But even more: each particular case must be approached individually. Not everything is mouldable into a quantitative functional form, and if this does succeed to some extent, then due to the subject of social sciences we are dealing with a very uncertain prediction, for due to variability of context it is not possible to check the same statement repeatedly. In this sense social sciences cannot be exact sciences: their subject is too self-determined and autonomous and not subjected to infallible rules, to necessary laws. Contrary to the subject of physics that of social sciences is a conscious being with free will, who can willingly or unwillingly ignore the rules and laws created by, or formed among, alike beings. In this sense here also the meaning of laws of nature or laws of science becomes fuzzy: even if a logical model about a phenomenon is found, be it quantitative or qualitative, it is not certain that it applies to a particular case.

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References:

Colomer, Josep M. (2007). What Other Sciences Look Like. *European Political Science*, 6, 134–142

De Sio, Lorenzo (2006a). *Political Involvement and Electoral Competition*. Center for the Study of Democracy, University of California, Irvine. Research Monograph CSD 06–02, www.democ.uci.edu

De Sio, Lorenzo (2006b, April). A Matter of Attraction: Voting Behaviour of Heterogenious Voters. (Presentation ECPR Annual Joint Workshops, Nicosia)

De Sio, Lorenzo (2008). Are Less Involved Voters the Key to Win Elections?. *Comparative Political Studies*, 41, 217–241

Giere, Ronald (1988). *Explaining Science. A Cognitive Approach*. (Chicago and London: The University of Chicago Press)

Giere, Ronald (2009). An Agent-Based Conception of Models and Scientific Representation. *Synthese*. DOI: 10.1007/s11229-009-9506-z

Hatch, Mary Jo (1997). *Organization Theory. Modern, Symbolic, and Postmodern Perspectives*. Oxford: Oxford University Press

von Hayek, Friedrich August (1997). *Hukutav upsakus*. Tallinn: Olion

Luce, R. Duncan (1989). R. Duncan Luce. In G. Lindzey (editor), *Psychology in Autobiography*, vol VII (247–289). Palo Alto, CA: Stanford University Press

McGregor, James P. (1993). Procrustus and the Regression Model: On the Misuse of the Regression Model. *PS: Political Science & Politics* 26, 801–804

Souva, Mark (2007). Fostering Theoretical Thinking in Undergraduate Classes. *PS: Political Science & Politics* 40, 557–561

Taagepera, Rein (2008). *Making Social Sciences More Scientific. The Need for Predictive Models*. Oxford: Oxford University Press

Vihalemm, Rein (1989). On Keemia metodoloogilisest samastamisest füüsikaga. *Teaduslugu ja nüüdisaeg* IV, 30–40 (in Estonian)
Vihalemm, Rein (1995). Kas teaduse piirid või tegelik algus? Ilya Prigogine'i teaduse-käsitusest. *Akadeemia* 7:12, 2527–2540
Vihalemm, Rein (2008). Philosophical-theoretical complements to the forum on values (2005). In R. Vihalemm, *From the Philosophy of Science Point of View* (composed by Ülo Kaevats) (390–419). Eesti Keele Sihtasutus (in Estonian)

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Mets, Ave (2009). Reflection on differences in sciences and engineering. Konverents "Philosophy for Science in Use", Linköping 28.9.–2.10.2009

Mets, Ave (2010). Towards a practice-based and Heideggerian account of international climate law. Meistriklass "The Challenge of Regulatory Cosmopolitanism", Amsterdam 8.12.2010

Mets, Ave (2011). Measurement theory, nomological machine and measurement uncertainties (in classical physics). Õpituba "Practical Realism – Towards a Realistic Account of Science", Tartu 15.–17.6.2011

Mets, Ave (2011). Measurement theory, nomological machine and measurement uncertainties (in classical physics). Konverents EPSA11, Ateena 5.–8.10. 2011

Mets, Ave, Rafaela Hillerbrand (2011) Messtheorie und Messunsicherheiten (poster). Konverents "Exploring Uncertainty", Aachen 9.–11.10.2011

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