TILBURG UNIVERSITY LEGAL STUDIES
WORKING PAPER SERIES

Ten Dimensions of Technology Regulation - Finding Your Bearings in the Research Space of an Emerging Discipline

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Tilburg University Legal Studies Working Paper Series
No. 015/2010
July 4, 2010

Chapter 15. Ten dimensions of technology regulation. Finding your bearings in the research space of an emerging discipline

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Abstract
We are at the start of what may be emerging as a new discipline of academic study: technology regulation, the study of how technologies are or should be regulated. With a broad definition of technology – the wide range of tools and crafts that people use to change or adapt to their environment – and of regulation – the intentional influencing of someone's or something's behaviour – this is a wide-ranging and complex field indeed. To get a grip on this emerging field, we need theoretical grounding. So far, few attempts have been made to map the space in which regulators and researchers who deal with technology regulation move. This chapter provides a first, essayistic attempt at comprehensively mapping the space of the emerging field of technology regulation by distinguishing and describing the ten dimensions that together span up this space. Starting with technology-related dimensions (type of technology, degree of innovation, place, and time), it moves on via regulation-related dimensions (type of regulation, normative outlook, and knowledge) to research-related dimensions (discipline, problem definition, and frame). The articulation of technology regulation as a ten-dimensional space is an analytic tool that may help us to understand what this emerging discipline is about, how it approaches its research, which known unknowns need to be researched, and to get an intuition of the unknown unknowns that await us out there when we further travel in technology regulation research space.

15.1. Introduction

When I studied mathematics, I was always fascinated by multi-dimensional spaces. For a mathematical problem, it doesn't fundamentally matter whether you're dealing with two, four, or sixty-three dimensions (granted, calculating problems in 63-dimensional space is perhaps somewhat more complex than solving a two-dimensional equation). Unlike some mathematicians and all computers, most people – myself included – have difficulty in visualising and dealing with a problem in a space with more than three or four dimensions.

The difficulty of handling more than three or four dimensions stems of course from the fact that our universe is spanned up by three spatial dimensions and one temporal dimension. Or rather, we humans perceive the universe as being spanned up by these four dimensions. If we are to believe fundamental scientists in quest of the Theory of Everything, timespace is actually spanned up by ten or eleven dimensions. We only perceive four of them – the others are compacted away beyond human perception (unless your brain happens to have the perceptive and imaginative qualities of the likes of Albert Einstein or Stephen Hawking).

Perhaps a similar mechanism occurs in technology regulation. When we define, attack, and solve problems in technology regulation, we have difficulty in dealing with more than three or four dimensions. The problem as we perceive it may well be addressed in this manner – we are only human, after all – but the underlying mechanisms are often infinitely more complex and multi-faceted, leading to a limited understanding of the real problem (whatever that may be) or of the full thrust of a solution we come up with.

Technology regulation certainly is a multi-dimensional space. Academics and regulators have realised this for many years, and the papers in this volume again show ample evidence of the complexities of technology regulation. But do we actually understand *how* complex it is, and how many different perspectives are involved? To do so, we should at least bring together insights from various legal fields, legal theory, governance studies, ethics, policy studies, public administration, political science, media and communications theory, science & technology studies, and philosophy of technology, to name the most obviously relevant fields, along with different fields of science and technology itself. One of the aims of the conference that lay at the basis of this volume was to bring together scholars from these different disciplines, to discuss together topical problems in the field of technology regulation. As the contributions to this volume demonstrate, the topics and issues we are dealing with bear some close resemblances and interrelations, but they are also quite varying and divergent, as they move along different lines of research. Nevertheless, they are all moving around in the same space – the space of technology regulation research.

As I perceive it, we are at the start of what may be emerging as a new discipline of academic study: technology regulation. 'Technology regulation' here indicates the study of how technologies are or should be regulated, technologies being the broad range of tools and crafts that people use to change or adapt to their environment, and regulation being the intentional influencing of someone's or something's behaviour.

It is actually too early to speak of an emerging discipline yet, but the contours are certainly appearing on the map: all around the world, conferences, journals, and research centres are emerging devoted to technology regulation. Not all of these cover the full range of issues that fall within the broad scope of my working definition of technology regulation, which ranges from bio-ethics to innovation theory and from intellectual property to cybercrime, but increasing ties between the diverse researchers and research centres facilitate an exchange of ideas and insights across the board.

Let us assume that at some point, technology regulation will indeed emerge as a new discipline, or at the very least as a broadly studied field of trans-disciplinary research. To get a grip on this multi-dimensional field of technology regulation, we need theoretical grounding. Unsurprisingly for an emerging field, technology regulation is rather under-theorised so far, and few attempts having been made to map the space. To be sure, attempts at theorising have been made that, even if they do no fulfil the promise of their comprehensive titles, provide relevant insights into technology regulation (Cockfield and Pridmore, 2007; Mandel, 2007), but these do not aim to comprehensively describe all relevant factors that are at issue in technology regulation. For space mapping, perhaps Roger Brownsword (2008) comes closest in the introductory chapter to his *Rights, Regulation, and the Technological Revolution*, in which he succinctly lists key regulatory aspects for the technologies of the 21st century, including regulatory styles, modes, pitch, phasing, and range. Roger Brownsword and Han Somsen (2009) have also sketched major contours of technology regulation in their introductory article to the new journal *Law, Innovation and Technology*.

Perhaps technology regulation need not go as far as developing a superstring theory or M-theory of fundamental physics, let alone a Theory of Everything, at this stage of its development. But it certainly is useful to attempt to further map the space in which the researchers of technology regulation travel, for two reasons. Firstly, determining the axes of the multi-dimensional space that constitutes technology regulation research will help us to get a grip on where we are, to find our bearings by seeing the co-ordinates of our point in space, and to become more aware of those other dimensions that influence our state of being beyond the three or four visible ones. Secondly, once we see more clearly where we are and what space surrounds us, we can look ahead to those areas of the universe that are as yet unexplored. Knowing the dimensions of technology regulation research can help us to define future research agendas and to set our course accordingly, taking on board new disciplines and insights along the way as we come to understand better what we need for solving the known and unknown problems that await us 'out there'.

In this chapter, I provide an attempt at comprehensively mapping the dimensions of the emerging field of technology regulation research.

Within the limitations of this book, this can only be done in a sketchy and provisional way, and this chapter should be read as an essay proposing one way in which the universe of technology regulation can be perceived. If this essayistic map helps researchers or regulators to some extent to find their bearings or to see interesting paths for future research, my aim will be more than fulfilled.

15.2. Ten Dimensions

To see where you are, or where you want to go, in technology regulation (TR) research space, all you have to do is determine the coordinates along ten different dimensions. Starting with technology-related dimensions, we move on via regulation-related dimensions to research-related dimensions. Just step on board and travel along.

15.2.1. Technology Type

The first and most obvious dimension to begin with is the type of technology at issue. Since 'technology' refers to the broad range of tools and crafts that people use to change or adapt to their environment, many different types of technologies can be the focus of research, and obviously, the questions raised by a certain development in technology depend very much on the character and level of abstraction of the technology at issue.

In terms of character of technology, we can look at seemingly simple material applications, for example bicycles, bakelite, and (light) bulbs, in the attractively alliterative analysis of Wiebe Bijker (1995), or at modern-day innovations in materials such as nano-products (Schellekens*; Gammel et al.*) and chemical substances (Versluis et al.*). Information and communication technologies (ICT) have different characteristics from material technologies, in that the concerns raised by ICT often reside not only in their physical aspect – hardware, electrons, quantum bits – but also, and often more pertinently, in their immaterial, virtual aspect – cyberspace (wherever that space may be), information, and knowledge (Hildebrandt*; Hendry and Goodall*). And while these technologies can be characterised as 'thing-related' technologies, yet other issues are raised by 'life-related' technologies, meaning technologies that impact or use organic or living bodies, such as plants through GMOs (Van Asselt et al.*) or humans through embryo-affecting technologies (Gavaghan*; Zeegers*), or other applications of human biotechnology, genetics, or neuro-technologies. And as we travel along the axis of technology, we

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* An asterisk denotes that the paper referred to is included in this volume. It is therefore not listed separately in the References section.

will observe that, increasingly, these different types of technologies are being combined in what is usually termed 'converging technologies' or NBIC (nano-bio-info-cogno technologies), for example in nano-medicine (Dorbeck-Jung*), bio-computing, or synthetic biology. This alone is a sufficient reason to bring together scholars from different fields to jointly study technology regulation, since insights from different technology fields must be combined as technologies converge.

The level of abstraction is also a feature of the technology dimension. We can look at very concrete applications of a certain technology, such as Facebook (Hendry and Goodall*) or the creation of hybrid human-animal embryos (Zeegers*). At the other end of the spectrum, 'technology' can be studied as a phenomenon in itself, for example how people interrelate with pervasive 'technoscience' today and tomorrow (Zwart*). Most research is situated somewhere in between the very concrete application and the very concept of technology; this ranges from the somewhat concrete – web 2.0, nano-medicine, or psycho-pharmaceuticals – to a more abstract category like ICT or neuro-technologies.

15.2.2. Innovation

Some technologies seem plain and well-known; we are so used to them in everyday life that our brain hiccups for a fraction of a second when you refer to a ballpoint, a brick, or a pair of glasses as 'a technology'. At one point in time, however, these were radical innovations. Other technologies seem completely new today; brain-controlled bionic limbs or colour-changing nano-coatings sound like science fiction rather than *Science* facts to most people, even though they have featured on the research agenda for several years, and at some point in time they may become as plain as a plane. The degree of innovation clearly is a relevant dimension in technology regulation research. Well-known, 'more-of-the-same' technology applications will usually fall within the scope of existing legislation or other regulatory instruments, in contrast to radically new technologies.

This is a different dimension from the first, since the type of technology is, in principle, independent from how innovative it is. Although we talk easily of 'new technologies' or 'emerging technologies', often with the implicit or explicit understanding that we refer to nano-technologies, neuro-technologies or converging technologies, the applications in these fields need not always be 'new' or 'emerging', but may simply be an improved version of existing tools. And conversely, 'old technologies' can also deliver innovative applications; some of the most exciting developments today take place in, for example, synthetic materials, robotics, and cars. Admittedly, most of these developments involve some form of ICT or biotechnology, underlining the increasing interwovenness of the branches of science and technology. But in principle, any type of technology can yield both more-of-the-same and very innovative tools and crafts.

The degree of innovation is relevant for regulatory research, not because innovative technologies raise more questions than non-innovative ones, but because the type of questions at issue differ. With 'large' innovations, research will tend to be exploratory in nature and focus on the core effects of the innovation at issue. 'Small' innovations can lead to more analytic questions of compliance or the exact formulation of rules, and often, regulatory implications of unforeseen side-effects will be the object of scrutiny – sometimes, a small step for a technology (such as embedding a text message option in mobile phones) turns out to constitute a giant leap for society (changing patterns of language and communication). It is also important to realise that the degree of innovation need not always lie in the quality of a technology, but that quantity is equally important. It is far from rare that a change in the scale of a technology gives rise to significant regulatory questions, for example with cryptography (becoming almost impossible to crack when based on mathematical algorithms instead of traditional ciphers) or with biobanks for medical research (yielding new types of information when interconnected on a massive scale). Here, innovation arising from quantitative steps can have truly qualitative implications.

15.2.3. Place

An obvious dimension, if only because it is the one most associated with our understanding of space, is place. Where a technology is developed or used, in which environment, in what kind of organisation – these are all relevant factors for appreciating the implications of a given technology. Even though globalisation and the increasingly international organisation of science and technology imply that technological innovations travel far and fast nowadays, this by no means implies that technologies evolve in a global 'technospace' without local, national, or regional geographical components. This applies *a fortiori* to regulation, which retains a strong geographical component however much international law, global governance, and international standardisation have gained ground over the past decades. Questions of technology regulation always have to take into account the location of both the technology and regulatory attempts, so that relevant socio-cultural, legal, economic, and institutional factors associated with that place can be factored in.

This applies as much to physical space as to virtual space, if we understand cyberspace or a virtual world to be a 'place' that exists in another realm than the computers, software, cables, and wireless waves that make this virtual space come into being. Virtual worlds also have socio-cultural, regulatory, economic, and institutional elements associated with their geography, which, depending on the perspective from which they are considered, will to a greater or lesser extent be connected with those of the physical locations where virtual space and real space intersect and interact.

15.2.4. Time

As it is the fourth dimension in timespace, so is time the fourth dimension in TR research space. Time is essential for technology and for regulation. This dimension to a large extent corresponds with the temporal development cycle of technology: from fundamental science to applied science, and from research & development via product development to product marketing and product use. The various stages of technology development involve different regulatory issues, although some elements – such as distribution of responsibility and the social shaping of technology – feature in each stage. Regulatory issues in the earliest stages of fundamental research may focus on long-term, large-impact effects and scenario forecasting of a technology *in abstracto*, while the latter stages of technology marketing and use can focus on short-term effects of concrete applications. But of course the reverse is also possible: one can ask concrete questions about health and safety regulations for fundamental research of nanotubes, and study the long-term effects on identity of social-network sites.

Many issues along the time dimension relate to the question of when regulators can or should intervene if they want or ought to regulate. Collingridge's dilemma is perhaps the most pertinent formulation of the challenges of time: controlling a technology is difficult in its early stages because not enough is known of its possible or probable effects, and it is also difficult once the technology is well-developed because by then intervention is expensive and drastic (see Van Asselt et al.*). A major challenge for research is therefore to find ways to regulate in early stages when it is still possible – albeit in the dark – to regulate, which calls for innovative approaches (Rip*; Mandel, 2009).

Challenging as the dilemma was in 1980 when Collingridge formulated it, it has become only more acute in light of 'technological turbulence', with short innovation cycles in, for example, the ICT sector. The Internet is a good example of another time-related phenomenon: namely, Gartner's hype cycle, which observes how technologies start with a trigger, rise to the peak of inflated expectations, only to plummet in the trough of disillusionment, from which it can slowly climb the slope of enlightenment to finally reach the plateau of productivity (Fenn, 1995). Researchers of technology regulation may observe that regulation frequently follows a similar hype cycle in itself. Although the regulatory cycle can follow the technology cycle with a time lag, at other times it intervenes in the technology cycle by inflating expectations (regulating electronic signatures in the mid-1990s), pushing the technology into the abyss of disgrace (prohibiting embryonic stem-cell research in the US), or giving the technology a leg-up in its ascent of the slope of enlightenment (liberally handing out patents in biotechnology) (cf. Van den Daele*).

15.2.5. Regulation Type

With place and time, we have already come close to the more regulation-related dimensions of TR research space, where we have now arrived. The primary dimension in this region is the type of regulation at issue. As I use a broad notion of regulation – the intentional influencing of someone's or something's behaviour – this is a very rich dimension indeed. It comprises, for example, the regulatory 'toolbox', in which we find – depending on who crafted the toolbox – Lessig's (1999) four modalities of regulation (law, social norms, market, and architecture) or Hood's tools of government (nodality, authority, treasure, and organisation) (see the reappraisal of Hood by Raab and De Hert, 2008). Equally important are the actors wielding these instruments, the regulators (governments at different levels; NGOs; standardisation bodies; public-private partnerships, etc.), and the actors targeted by them, the regulatees, not to mention popular hybrids of these in the form of self-regulation and participatory governance. Moreover, these actors act within regulatory institutions, such as the EU regulatory framework, UN bureaucracy, or cybercultural Internet governance networks, which shapes the tools and actors as much as it is shaped by them. There is thus a significant interdependence between tools, actors, and institutions, which is why I have stretched them together along one axis of regulation type.

Further refinements can be made of different aspects of regulation type. Brownsword (2008: 16) has introduced regulatory 'pitch' as a relevant factor, i.e., in what tone of voice regulators speak to regulatees. They can use for example a paternalistic, command-and-control voice ('thou shalt not copy') or a soft-sisterly, caring voice ('do protect your e-banking password'), but also a practical voice ('introductory offer: biometric passports now with 20% discount!'). He also mentions regulatory range (Brownsword, 2008: 19-21): behaviour can be influenced by negative (stick) or positive (carrot) or neutral means. And these can again be implemented in different ways, for example a stick to discourage undesirable behaviour can take the form of criminal, administrative, or civil sanctions. Many other aspects can be distinguished of regulation types that can help us to better understand this dimension. It is therefore highly relevant for technology regulation research to engage with scholars from legal theory, political science, policy studies, law & economics, and business administration.

15.2.6. Normative Outlook

Technology regulation does not take place in a neutral vacuum. On the contrary, since it focuses on influencing behaviour, normative elements enter the picture as a matter of course. The substantive goal of the regulation – which will of course always be normative in nature to a greater or lesser extent – is included in the previous dimension, since that is part and parcel of the regulation type. There is more to norms than the goal of regulation, however, and that is the normative outlook that underlies or implicitly feeds technology regulation. This can be a certain ethical paradigm, such as utilitarianism or communitarianism, a religious belief, or widely-shared values that are almost taken for granted in a certain community, such as individual autonomy in Western liberal democracies, kinship bonds in the South Pacific, or originality in the global academic research community.

Normative outlooks do not necessarily involve the most obvious normative paradigms such as ethics or religion. There are also more subtly normative assumptions that underlie regulatory decisions. For example, one's risk attitude or tolerance of risk is a hugely important factor in risk governance processes; risk-averse regulators will reach for precaution where risk-tolerant regulators may sooner adopt a wait-and-see or early-warning approach. This can be seen as an instance of what Brownsword (2008: 21) has termed 'regulatory tilt', i.e., the default position set by regulators, which can lean towards the permissive or the prohibitory side, and which is influenced by all kinds of underlying assumptions or attitudes. Uncertainty attitude could also be included here, which refers to the level of uncertainty that regulators can or want to cope with (Van Asselt et al.*).

Such normative outlooks are the substrata on which technology regulation is cultivated, and therefore significantly affect how concrete cases of technology regulation grow and flourish (or not). They are, however, rarely made explicit, and it is a primary task for TR research to expose how the implicit normative outlooks influence the process and outcome of technology regulation. For this reason, the normative outlook is an important dimension in its own right.

15.2.7. Knowledge

Uncertainty attitudes, and the associated 'uncertainty paradox' (Van Asselt et al.*), have much to do with the level of knowledge that is available. Here we encounter the dimension of knowledge, which should be seen as a separate dimension from normative outlooks; the latter focuses on knowledge on a meta-level (how we deal with knowledge), whereas the dimension of knowledge itself deals with its substance. It comprises what we know and how much (or how little) about a technology and its effects, about certain regulatory aspects, or about some instance of technology regulation. The major factors here are, in the well-known distinction from risk regulation, knowns and unknowns, with the useful distinction that there are known unknowns (we don't know how psycho-pharmaceuticals affect the brain in the long term) as well as unknown unknowns (we are not yet able to imagine all possible effects that nanomaterials may have on life, the universe, and everything). Particularly the unknown unknowns make technology regulation tricky, because we do not know exactly what types of ignorance or uncertainty we should focus our efforts on. Fortunately, unknown knowns may come to the rescue, i.e., things that we know but are unaware of as being relevant to the case at hand, for example, because they are common knowledge in a different field but unknown in the primary discipline from which a problem is approached. Unknown knowns are a category that is somewhat underappreciated in technology regulation. Bringing together different disciplines, which is one of the key aspects of TR research, may well bring to light unexpected insights that help to identify the relevant knowns and unknowns or to turn an unknown into a known. Technology regulatory challenges that we suspect of involving significant unknown unknowns can clearly benefit from structural transdisciplinary research or, as we may wish to call it, organised serendipity.

15.2.8. Discipline

Knowledge has brought us closer towards the end of our journey through TR research space, as we enter the region of research-related dimensions. The discipline or field of research itself is the primary dimension here. Along this axis the disciplines of academic research are spread out. Technology regulation can be researched from all kinds of disciplinary perspectives, including law and its subdisciplines, governance studies, ethics, policy studies, public administration, political science, economics, media studies, communications theory, psychology, sociology of technology, philosophy of technology, cybernetics, information theory, systems theory, robotics, genetics, neuroscience, and so on and so forth. Some of these fields are age-old;

others are very young, emerging on the map after years of multidisciplinary and interdisciplinary research to become a discipline in their own right. We need not go into the semantics of multi-, inter-, cross-, trans-, neo-, or post-disciplines here; for the purposes of this chapter, it suffices to note that the dimension of discipline is rich, diverse, and dynamic. What you research, and how you research it, is to a large extent defined by the research discipline you use. But it also works the other way around, since research disciplines evolve and are transformed by the gradual change in the research problems they deal with.

15.2.9. Problem

Technology regulation research is not random, but aims at addressing a certain issue, usually a problem in theory or practice. A crucial dimension of TR research space is therefore the problem definition. Is it the aim to understand how a certain mechanism works, in technology, in regulation, or in technology regulation? Is it to elucidate an emerging phenomenon, such as *de facto* regulation in early-stage nanotechnology development (Rip*)? Does the research focus on solving a problem in theory, such as how to overcome Parfit's dilemma (Gavaghan*) or how to reinvent the legal system after the advent of Ambient Intelligence (Hildebrandt*)? Or does it aim to solve a problem in regulation practice, for example, to consider what are the most satisfactory current regulatory regimes for regulating nanotechnologies (Bowman et al.*); or whether patent law is being applied adequately to stimulate innovation (Schellekens*)?

Problem definitions thus range from understanding something to solving something, and the consequent research involves approaches ranging from the purely descriptive through the analytical to the normative. Often, the type of problem and the type of approach go hand in hand, a descriptive approach usually being applied for enhancing understanding, a normative approach being applied for solving an actual problem. This is not necessarily the case, however: part of a solution to a regulatory problem may be to describe the known or possible consequences of various solutions, without taking a stance on which solution 'best' solves the problem; and a problem definition aimed at better understanding a certain mechanism, such as how regulatory interventions affect fundamental rights, can well be normative in character. This shows that researchers face a range of choices in the problem definition of what they want to address: what problem exactly do they target, what kind of problem is this, what is a suitable approach to addressing this problem, and what methods can or should be used for that?

Note that this dimension does not exclusively apply to researchers. Regulators also have to think about how they define the problem when they regulate. To address a regulatory problem, the same questions of problem definition and approach apply. Some such questions fall within the dimension of regulation type, but several questions are more preliminary than that, as regulators have to define the problem before they can go on to choosing regulatory instruments, involve actors, etc.

15.2.10. Frame

Whereas the 'problem' dimension deals with framing research questions, many other factors are also involved in 'framing' technology regulation research, in the sense of constraints that define the 'window' through which you view the world. It is useful to distinguish between these two kinds of framing: a) actively framing the problem in a certain way for research purposes and setting the parameters that you can play with (such as the type or scope of the problem), which is dimension no. 9, and b) finding oneself in a frame of reference that constrains the room for action. This constitutes a separate dimension, because many factors function as relevant research constraints. For example, the system bias of the organisation of research (which influences whether research is conducted in private or public institutions or public-private partnerships, in commercial or not-for-profit settings, with certain levels or types of researchers) affects the types of research that can be or are being done. Obviously, the available amount of money – and the ways in which it can be spent – also influences the research. Moreover, social norms (what is 'accepted' or 'acceptable' research) and ethical or legal research guidelines constrain the scope for research, for example to what extent experiments can be done with animals or humans. And all kinds of other biases – such as gender, cultural, or beliefs bias, for example when the world is perceived from the perspective of a WASP – affect the research. In short, similar to the way in which normative outlooks constrain the regulation region of TR space, the frame constrains the research region of TR space, often 'under the skin' and beyond the awareness of researchers or regulators. It is important to become aware of these constraints if the results of research are to be appreciated on their merit and limitations.

15.3. Finding Your Bearings in Research Space

So, what have we gained by having travelled through this ten-dimensional space? Hopefully, journeying, albeit briefly, along each consecutive dimension has elucidated the multi-faceted nature of technology regulation and has shown how complex it is to research technology regulation. Most dimensions will have been very obvious but others were possibly less so. Becoming aware of all ten dimensions can help researchers as well as regulators to find their bearings in TR research space. To find out where we stand (or float, if we do not have ground to stand on), all we have to do is determine the ten co-ordinates in space of our current position. Although it remains impossible to graphically represent ten dimensions on two-dimensional paper, the following graph may help to represent the ten dimensions, grouped together by the three constitutive elements of technology regulation research.

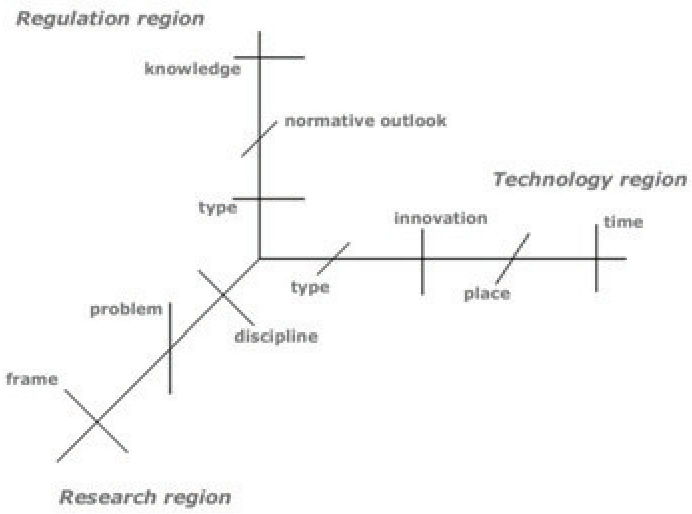

Figure 15.1. The ten dimensions of technology regulation research space

An assumption underlying this map of TR research space is that the dimensions are orthogonal, i.e., that they are independent from each other. This is a serious simplification, since in real life, no neat distinctions apply, and most things are related in some way or another. Certain dimensions are no doubt interrelated to some degree, such as the normative outlook that feeds regulation and the framing constraints of an associated research problem, or the type of technology and the discipline that studies its regulation. I am sure, too, that my own frame of reference has affected my drawing the map in this way, being influenced, for example, by a Western liberal-democratic background, working in a law faculty, and a mathematician's predilection for dimensions. Other researchers may distinguish certain other dimensions, or in fact group all the aspects of TR research in a somewhat different way based on other metaphors than multi-dimensional space. The map drawn here does not pretend to be, literally, a map of 'real' space. It is a map that may help travellers in technology regulation research to determine their coordinates by providing a checklist to look around and take into account all possibly relevant aspects.

To illustrate how the map could be used, take a look at, for example, the chapter in this volume by Bärbel Dorbeck-Jung*. We can situate her contribution in the upper regions of the map: the dimensions most visible in her analysis are regulation type, knowledge, and innovation. The paper is a quest for prudent *types of regulation* for a technology – nanomedicine – that raises problems because its *innovativeness* (nano-structures calling into question the distinction between medicinal products, medical devices, and biologic products) causes gaps in *knowledge*, not only in terms of uncertain risks associated with nanomedicine but also in terms of the applicability of existing regulatory regimes. Interestingly, the dimensions of innovation and knowledge are not only active in the problem definition, but also in the search for solutions: knowledge gained in the regulation of adjacent technologies (medical products, in particular advanced therapy medicinal products) may show good practices that can help to regulate nanomedicine, applying an innovative approach to regulation of 'prudent regulatory hybridisation'.

Albeit less visible in the main argument of Dorbeck-Jung's chapter, other dimensions nevertheless also play a role. The problem at hand is triggered partly by nanomedicine being a hybrid *type of technology* – nanotechnology applied in the life sciences – in a *temporal* state of rapid development that calls for continual vigilance throughout the entire regulatory product cycle. The *place* of action is Europe, which brings along a *normative outlook* of democratic values of, *inter alia*, openness and participation that influence the direction of regulatory solutions. It would be interesting to conduct a comparable analysis for other places, such as South-East Asia or the United States, and see whether their regulatory traditions and attitudes to risk and uncertainty lead to similar preferences for hybrid forms of soft-law and hard-law regulation, and whether in their regulatory contexts, nanomedicine is also seen as problematic for the way in which it blurs the distinction between medicine, device, and biologic product that underlies health regulation. Moreover, the analysis is grounded in the *discipline* of governance studies, but also draws upon valuable insights from legal theory and Science & Technology Studies. It might be further enriched by scholars who could incorporate insights from other fields, such as systems theory, with knowledge of how hybridisation processes of different systems work. Finally, it could also be an interesting exercise to analyse how the problem definition – "what lessons can the regulation of nanomedical products learn from the European Union's medical product regulation?" – is *framed* by the presentation of the latter as an example of 'prudent' regulation, with the epithet subtly leading the reader to have an uncritically favourable attitude to hybridisation of regulation: surely, no-one would advocate 'imprudent' regulation that sticks to monolithic forms of regulation? The underlying assumption is that hybridisation of regulation – merging soft-law and hard-law elements – will combine the best of both worlds rather than lead to a lose-lose situation; this may not be an unwise assumption, but it could do no harm to test it explicitly, perhaps in ex-ante evaluation of proposed regulatory solutions, or in continual vigilance of the regulatory cycle of emerging nanomedicine regulation.

The map of dimensions of technology regulation space can be used in this way as a heuristic tool to position research – *ex post*, as I have done here, but also *ex ante* by researchers embarking on writing a paper – and therewith show the major directions in its argument. Perhaps more importantly, it also elucidates its less-developed elements, which can point the way to relevant questions for further research. It would be a great exercise to do a similar mapping of the other chapters in this volume, in order to come up with a comprehensive agenda for future research, but I am running out of space here and will leave this exercise to the imagination of the reader in her role of armchair traveller.

15.4. To Boldly Go

As I indicated in the introduction, I have presented here an essayistic attempt to comprehensively map the dimensions of the technology regulation research. I am open to other maps, as well as to other metaphorical representations of the field we operate in. What is important, I think, is to support the emerging discipline to gain some foothold in terms of analytic tools that help us understand what this discipline is about, how it approaches its research, what it can contribute to the body of knowledge, which known unknowns need to be researched, and, most excitingly, to get an intuition of the unknown unknowns that await us out there when we travel further in TR research space.

As the contributions to this volume attest, technology regulation can be fruitfully studied from many different perspectives and disciplines. But ultimately, it is the combination and integration of the many perspectives and research backgrounds that moves the field forward onto another level of understanding of how technology interacts with society, how regulation responds to and intervenes in

this interaction, and how regulation at the same time is shaped by the interaction of technological and social developments.
Bringing together various researchers and their insights into a single volume is more than an act of book-binding – it is an act of research-binding and discipline-building as well. Technology regulation makes up a most complex multi-dimensional space, but with joined forces, we are well equipped to embark on the journey to explore unknown parts of the universe. To ask questions that no-one has asked before. To boldly go, where no researcher has gone before.

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