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# 1. Introduction.

# Situating Science Policy in Space

What's the *use*? Who *benefits*? Questions that many academic researchers today face, have to face, whenever they apply for funding, justify their work in institutional reviews or discuss their findings in the public realm. For some, such questions are reason for elaborate laments about the lost purity of science, while others had already embraced them within their methodology. At the same, activist groups, politicians from the entire spectrum and anti-science sceptics have been asking similar questions for decades. How we think about and act on the *usefulness* of scientific research has epistemological and political implications: what knowledge consists of, how it comes about and to what ends. The practical organisation of research ultimately corresponds to these assumptions and beliefs, and determines what kind of (relevant) research is possible. These organisational issues are often discussed in terms of *how* and *why*: how to orient researchers to societal concerns, involve diverse actors, or disseminate results to diverse publics; and why, as contribution to what public values or in response to what socio-political demand? Instead of merely analysing different meanings of the utility, relevance or value of research, I set out to expose the practical conditions for different political epistemologies of useful research. In particular, I will accentuate a spatial dimension, or the *where* question.

Because for knowledge to matter, it matters where you are. To be of use, knowledge typically has to move, from a protected environment of production into the more chaotic real world. The way in which knowledge travels depends on historically grown environments of scientific institutions, industries and education systems. The transfer of knowledge within and between environments is shaped by many spatial factors: from architectural designs, physical proximity and material infrastructures to city planning, regional development and geopolitics. And not only knowledge travels: also organisational models for research circulate. From Solomon's House to Silicon Valley, scientifically or economically less advanced continents, nations, regions and cities have copied success stories from afar. Whether, in a hundred years' time, spatial paradigms of valuable research will be located in Shenzen or Nairobi, on Antarctica or Mars, will depend on how we think about, and will determine how we organise, useful scientific research. In this dissertation, I aim to integrate concepts of utility and spatiality of organised scientific research.

Science policy is the political realm for discussion and decision-making about the organisation of scientific research with societal value. As a coherent, coordinated and politicised activity it is a phenomenon typical of the late modern Western world—the United States and Western Europe between 1950 and 2000. Where at the start of this period prominent (natural) scientists, humanities scholars and industrialists ran the show, by the turn of the 21st century, they had to share space with ministers and civil servants, policy experts, strategy consultants and well-informed activists. Science policy is typically concerned with the pay-off from public investments in scientific research at universities, polytechnics and research institutes.[1] This has also created epistemic demands: to collect facts about the amount and effectiveness of research, to study the economic impact and socio-ethical consequences of results, and to understand how this ultimately contributed to societal change and economic growth. In response, academic fields like innovation studies, technology assessment and science policy studies emerged. Specialists in these fields subsequently actively participated in the spread of concepts, models and spatial paradigms of organised, useful scientific research.

1 To be sure, when I speak of scientific research, I primarily mean academic research in a broad sense, like the Dutch '*wetenschap*' or German '*Wissenschaft*'. That is, it denotes the knowledge production that takes place within institutes of higher education and includes researchers from all disciplines. What is real 'science' and proper 'research' are themselves historically contested categories, as will become clear in both the historiographical and historical parts of this dissertation.

It is those spatial paradigms that his dissertation puts centre stage to develop an alternative approach to the intertwined histories of science policy, science studies and universities. The central question answered in this dissertation is: *in which ways do spatial models of knowledge production shape and reproduce the concepts and politics of the utility of scientific research in the late-modern Western world?* I will generate answers to this question in three historical reconstructions of Dutch developments (in an Atlantic context) between 1950 and 1990. In each case, specific places of exchange serve as focal point, respectively the Technical-Physical Service in Delft, the Netherlands Institute for Advanced Study in Wassenaar and the Bio-Science Park in Leiden. Before I turn to these concrete localities, I will ground my spatial approach to useful research in existing debates in the historiography of organised research in the US and Europe. I will highlight themes related to utility and spatiality in this body of scholarship. In the concluding chapter, the results from the historical studies will be employed to shed new light on current concepts and practices of useful research. More specifically, I reflect on the consequences of a spatial perspective for the understanding of a recent controversy in Dutch science policy over value creation from knowledge, or 'valorisation'. It will become clear that both real and imagined spatial models of research structure science policy debates (and vice versa). In conclusion, I will push this reflection beyond the empirical limitations of history to explore the potential of spatial proximity and speculations in fiction and the future.

In the remainder of this methodological introduction, I construct an epistemological perspective on the usefulness of scientific research, which will serve as a conceptual basis for the historically focussed subsequent chapters (sections 1.1, 1.2 and 1.3). To add the spatial dimension to this perspective, I also conduct a review of historical, sociological and philosophical studies of the spatial, geographical and architectural aspects of the production and circulation of scientific research (sections 1.4, 1.5 and 1.6). My contribution to these debates is the combination of the epistemological and spatial perspectives on (useful) scientific research (section 1.7). To this end, I coin the concept *utility spot,* which highlights the spatial arrangements that mediate the travel and translation of knowledge. Lastly, I introduce the science policy concept of valorisation in relation to this analytic framework, which raises several philosophical and historical questions (section 8). In later chapters I survey historical examples of utility spots, which exist in both real and virtual forms, expose political epistemologies and underpin the societal legitimation of science. This is, therefore, a historical-epistemological study of the spatial organisation of the societal value of research.

## 1.1 The Study of the Utility of Scientific Research

Utility is ambiguously ubiquitous in university research: it is everywhere, and nowhere. From the early days of modern science onwards, scientists have stressed the actual and potential usefulness of their work as part of legitimisation attempts directed to patrons and the public. Often simultaneously, we find that utility is banned from concepts, practices and places of research. In contradistinction to purely cognitive attempts at understanding the world, it is regarded as an extra-scientific phenomenon: as concern or value *excluded* from research practice, as possibility *after* an investigation or experiment is finished, as application or use *outside* the place of production. Also in philosophical, sociological and historical studies, the usefulness of scientific research is distinguished from, or opposed to, virtues such as autonomy, truth and purity.[2] Whereas an engaged scientist or science activist might argue strongly in favour of one of the extremes, most reflective studies conclude that it is more interesting (and truthful) to describe the ideology and organisation of scientific research as the result of the relations, conflicts and tensions between these different goals. Or, as Peter Dear has argued, the practice and ideology of modern science is a culturally specific and historically contingent *hybrid* of the age-old dichotomy between *theoria* and *praxis*, or 'natural philosophy' (objective understanding of an external world) and 'instrumentality' (tools to control nature for desired purposes).[3]

Whereas utility, instrumentality and power suggest that scientific practices take place within dense networks of social relations, the values of freedom, curiosity and truth have been apprehended throughout history to defend, for science, the exclusion of practical interests and isolation from societal relations.[4] This raises the epistemological question whose values, goals and interests are allowed to inform the conduct and organisation of academic research. Epistemology examines the nature of knowledge and the methods by which we can obtain true justified beliefs about the world. But the study of knowledge has, in the last half century, expanded from the philosophical examination of propositions and theories to include also the historical, sociological and anthropological analysis of the practices and consequences of knowledge production. It is with this broader field of 'science studies' that I engage in this dissertation. The difference between epistemology and science studies can be understood as a shift from a normative to a descriptive approach. Utility is rarely discussed in classical epistemology and much of analytic philosophy of science, as these fields are primarily concerned with the appropriate validation of knowledge claims. The diverse field of science studies moves beyond justification of assertions and science as a body of propositions,

2 Robert Proctor, *Value-Free Science? Purity and Power in Modern Knowledge* (Cambridge, MA: Harvard University Press, 1991); Torsten Wilholt and Hans Glimell, "Conditions of Science: The Three-Way Tension of Freedom, Accountability and Utility," in *Science in the Context of Application* (Springer, 2011), 351–370; David Kaldewey, *Wahrheit Und Nützlichkeit: Selbstbeschreibungen Der Wissenschaft Zwischen Autonomie Und Gesellschaftlicher Relevanz* (Bielefeld: transcript Verlag, 2014).

3 Peter Dear, "What Is the History of Science the History of? Early Modern Roots of the Ideology of Modern Science," *Isis* 96, no. 3 (2005): 390–406; Peter Dear, "Science Is Dead; Long Live Science," *Osiris* 27, no. 1 (2012): 37–55.

4 Wilholt and Glimell, "Conditions of Science"; Kaldewey, *Wahrheit und Nützlichkeit*; Jon Agar, "2016 Wilkins-Bernal-Medawar Lecture The Curious History of Curiosity-Driven Research," *Notes and Records: The Royal Society Journal of the History of Science* 71, no. 4 (2017): 409–29.

theories and evidence, towards an understanding of science as a social-material practice. The empirical study of knowledge production, distribution, use and destruction has epistemological implications: the economic, political, social and material conditions as well as consequences are considered an integral part of the practice of scientific research. In the following, I review economic, policy and conceptual approaches to utility in the broad field of science studies in relation to which I will develop a historically sensitive, empirically informed account of utility.

Within economics, utility prompts first of all associations with utilitarianism and utility functions. For my current purpose, however, it is not required to discuss the semantic multiplicity of utility in economic discourse.[5] Of more relevance are economic studies that seek to quantify the (macro-economic) benefits of scientific research.[6] In traditional neo-classical approaches to the economics of science the legitimisation of publicly funded research is as a remedy to market failure: scientific knowledge is non-rival and non-excludable information that industries will need in order to develop new products, but that they will not create themselves or share with competitors. The results of publicly funded scientific research, on the other hand, ideally circulate freely as 'economically useful information'.[7] In this 'informational' approach, scientific knowledge functions as a public good in support of economic growth. This abstract description might suffice for the justification of science and innovation policy, but it provides a very limited conception of useful research. In response, evolutionary approaches to the economics of science have presented a more realistic, embodied view of knowledge and its role in innovation. Michel Callon has stressed, for example, that for knowledge to be useful absorptive capacity (developed through education and training) is at least as important as the public disclosure of results.[8] Also 'tacit' knowledge, skills and networks have been identified as important factors in innovation processes. Empirical support for these two main strands in the economics of science is typically gathered through econometric studies, surveys and case studies.[9] Ultimately, they share an approach to the utility of scientific research in terms of the (possible) application of 'basic' research, 'key' industrial innovations and rates of return to relate public investments to economic growth.

The economic study of the utility of scientific research is dominated by the goal of finding proof for causal relations between monetary in- and output. Avoiding the suggestion of a linear model of the relations between science and society—where knowledge flows only from left to right—becomes almost impossible. Although a similar flaw haunts many policy studies that seek to map the usefulness of university research beyond the economic realm, most recent evaluation methods

5 D. W. Haslett, "What Is Utility?," *Economics & Philosophy* 6, no. 1 (1990): 65–94; Amartya Sen, "Utility: Ideas and Terminology," *Economics & Philosophy* 7, no. 2 (1991): 277–83.

6 Richard R. Nelson, "The Simple Economics of Basic Scientific Research," *Journal of Political Economy* 67, no. 3 (1959): 297–306; Ammon J. Salter and Ben R. Martin, "The Economic Benefits of Publicly Funded Basic Research: A Critical Review," *Research Policy* 30, no. 3 (2001): 509–32; Philip Mirowski, *Science-Mart: Privatizing American Science* (Cambridge, MA etc.: Harvard University Press, 2011), 41–83.

7 Salter and Martin, "The Economic Benefits of Publicly Funded Basic Research," 511.

8 Michel Callon, "Is Science a Public Good?," *Science, Technology, & Human Values* 19, no. 4 (1994): 395–424.

9 Salter and Martin, "The Economic Benefits of Publicly Funded Basic Research," 513.

for the societal impact of scientific research explicitly denounce linearity as property of this process.[10] Instead, they take alternative epistemological models for the study of the relations between science and society. Interaction models acknowledge that recurrent and reciprocal relations between researchers and external agents are important for the agenda-setting, production and dissemination of research.[11] Often, such methods prescribe strictly distinguished roles for different actors. Others break the wall between internal and external actors further down, by using an integration model of knowledge production which describes (and prescribes) participatory or co-production research processes.[12] Still, as most evaluation methods arise in response to a political or societal demand for more (evidence of the) usefulness or value of publicly funded scientific research, their main concern is comparability. This requires standardisation of the research process, and therefore lacks attention for contextual and historical situation of particular practices. Studies of the evaluation of the usefulness of research reflect policy developments as well as conceptual changes in the broader field of science studies, but do not themselves provide the tools to reflect critically on the concept of usefulness as such—either in theory or in history.[13]

In abstract, epistemological terms utility encompasses a multitude of concepts, practices and policies that are geared at actors and institutions other than direct academic peers: from societal relevance and knowledge transfer to societal impact and valorisation. These interactions between heterogeneous actors around the practice of research do not so much alter the precise values and facts produced in research (which a naïve relativism might hold), but do shape what research is possible and, importantly, considered valuable. This meta-scientific analytic level of utility has received some philosophical attention. Philip Kitcher and Joseph Rouse both speak of the 'significance' of science in distinction to its truth.[14] Scientists namely do not produce arbitrary truths, but rather pursue knowledge that they deem relevant, important or useful. Both Kitcher and Rouse have tried to describe how modal judgments about significance—what knowledge is considered possible and valuable—shape the practice of research.

Rouse, for example, argues that a research project at all stages (from plan and data collection to publication and dissemination) derives its significance not just from shared beliefs and values of a (research) community, but also from its place within, and transformation of, 'enacted narratives that constitute a developing field of knowledge'.[15] Scientific achievements become important as contributions to a shared enterprise which opens up options for further inquiry. The significance of research is not static, as it depends on the continuous reformulations, both contestations and reinforcements, of these narratives. In a relatively similar fashion, Kitcher designs

10 Reijo Miettinen, Juha Tuunainen, and Terhi Esko, "Epistemological, Artefactual and Interactional–Institutional Foundations of Social Impact of Academic Research," *Minerva* 53, no. 3 (2015): 257–77; Trisha Greenhalgh et al., "Research Impact: A Narrative Review," *BMC Medicine* 14, no. 1 (2016): 78; David Budtz Pedersen, Jonas Følsgaard Grønvad, and Rolf Hvidtfeldt, "Methods for Mapping the Impact of Social Sciences and Humanities—A Literature Review," *Research Evaluation* 29, no. 1 (2020): 4–21.

11 Barry Bozeman and Daniel Sarewitz, "Public Value Mapping and Science Policy Evaluation," *Minerva* 49, no. 1 (2011): 1–23; Claire Donovan and Stephen Hanney, "The 'Payback Framework 'Explained," *Research Evaluation* 20, no. 3 (2011): 181–183; Pierre-Benoît Joly et al., "ASIRPA: A Comprehensive Theory-Based Approach to Assessing the Societal Impacts of a Research Organization," *Research Evaluation* 24, no. 4 (2015): 440–53.

12 M.O. Kok and Albertine J. Schuit, "Contribution Mapping: A Method for Mapping the Contribution of Research to Enhance Its Impact," *Health Research Policy and Systems* 10, no. 1 (2012): 21; Sarah de Rijcke et al., "Evaluative Inquiry: Engaging Research Evaluation Analytically and Strategically," *Fteval Journal for Research and Technology Policy Evaluation*, no. 48 (2019): 176–182.

13 Jorrit P. Smit and Laurens K. Hessels, "The Production of Scientific and Societal Value in Research Evaluation: A Review of Societal Impact Assessment Methods," *Research Evaluation* (2021).

14 Philip Kitcher, *Science, Truth, and Democracy* (Oxford University Press, 2001), 63–82; Joseph Rouse, *Engaging Science. How to Understand Its Practices Philosophically* (Cornell University Press, 1996), 166–70. One could understand Ian Hacking's discussion of 'form' and 'content' of scientific research—which I discuss in chapter 2—in similar terms.

15 Rouse, *Engaging Science*, 168–70.

'significance graphs' to track why a particular epistemic item (be it a law, hypothesis, object etcetera) is considered possible and important at a certain point in history. With this approach he especially argues against context-independent approaches to the goals of inquiry, which appeal to either human curiosity or absolute truth. Instead, Kitcher stresses how current conceptions of significance are shaped by various values and contexts, both in the present and the past. This means that a project (and the questions, apparatus and categories it consists of) that appears 'fundamental' today, is possible only because of the more practical concerns and 'moral, social and political ideals' that motivated the research of predecessors.[16]

Implicit in Rouse's narratives and Kitcher's graphs is a limitation to scientific researchers as the main, and perhaps only, legitimate contributors to particular instantiations of the significance of research. The artificial exclusion of utility from research is one instance of the strict boundaries that have been drawn between science and society, and between content and context of research more generally. This rhetoric has typically been especially strong for scientific research carried out in a university environment: the ivory-tower metaphor endures, despite the multifarious relations with all kinds of actors and institutions.[17] Conceptual histories of research categories have, convincingly, demonstrated the contingency of rhetorical distinctions between useful and useless knowledge. Concepts like 'pure', 'fundamental', 'basic' and 'applied' do not so much describe different methodologies or epistemological categories, but rather mirror political issues with respect to the practical organisation of research and need to be embedded in larger discourses, narratives or imaginaries.[18] Ultimately, the advocates of the conceptual approach stress that language can play structuring and strategic roles in science and that science studies scholars have underappreciated this in favour of materiality and practices.[19] But turning to conceptual history seems to run into serious dangers itself: to disregard precisely the importance of practical, social and material aspects of scientific research. If those research concepts exist to *hide* complexity, as Bruno Latour argued, we should not replicate this reduction in our studies of them.[20]

In relation to the economic, policy and conceptual approaches to the utility of research, I renounce a limited view of utility of scientific research in terms of profits, products or applications. Rather, I propose to understand utility as a *meta-scientific* concept that directs the governance and politics of research. Meta-scientific concepts are *about* and *above* scientific research, not *of* a particular science; and they shape, as concept and practice, the organisation of scientific research.[21] Previous studies have demonstrated how such concepts, for example objectivity, purity or curiosity, structured both the legitimation discourse and the practical organisation of

16 Kitcher, *Science, Truth, and Democracy*, 86. This idea is very similar to the 'working worlds' concept that informs Jon Agar, *Science in the 20th Century and Beyond* (Cambridge, MA: Polity Press, 2012), 3–6.

17 Steven Shapin, "The Ivory Tower: The History of a Figure of Speech and Its Cultural Uses," *The British Journal for the History of Science* 45, no. 1 (2012): 1–27.

18 Sabine Clarke, "Pure Science with a Practical Aim: The Meanings of Fundamental Research in Britain, circa 1916 –1950," *Isis* 101, no. 2 (2010): 285–311; Robert Bud, "'Applied Science': A Phrase in Search of a Meaning," *Isis* 103, no. 3 (2012): 537–45; Graeme Gooday, "'Vague and Artificial': The Historically Elusive Distinction between Pure and Applied Science," *Isis* 103, no. 3 (2012): 546–54; David Kaldewey and Désirée Schauz, *Basic and Applied Research: the Language of Science Policy in the Twentieth Century* (New York: Berghahn Books, 2018).

19 Kaldewey and Schauz, *Basic and Applied Research*, 5–7.

20 Bruno Latour, *Science in Action: How to Follow Engineers and Scientists through Society* (Cambridge, MA: Harvard University Press, 1987).

21 Peter Galison, "Ten Problems in History and Philosophy of Science," *Isis* 99, no. 1 (2008): 111–124; Kaldewey and Schauz, *Basic and Applied Research*.

scientific research over time and between particular contexts.[22] Utility also requires to be taken seriously as historical category.[23] And as meta-scientific concept, utility is a more expansive concept of significance: it takes seriously also the interactions with 'non-scientific' actors in the historical understanding of the usefulness of a scientific field, project or expert, and the way in which this shapes what knowledge is possible. Utility ensues in the liminal space between academic and societal places and practices, and it is there that its promise and potential can guide the organisation of interactive and investigative practices; it is there that interactions between heterogeneous actors bring forth questions, issues and concerns, and enable the production, distribution and use of knowledge, or where utility shapes what research is possible. To avoid the pitfall of a too linguistic or idealistic approach, I will develop a spatial approach to take account of the practical effects of meta-scientific discourse: a study of concrete places of scientific research and societal exchange where utility concepts are turned to bricks and mortar.

Before I develop this approach, in the second half of this introduction, I will expand further on the historical, philosophical and sociological study of useful research. In section 1.2 I explore the historicity of utility as meta-scientific concept. To this end, I turn to the alleged progenitor of a 'modern' ideal of useful, publicly funded scientific research: Francis Bacon. The various historical interpretations of his philosophy of science allow me to expose how the historicity of utility also has epistemological consequences. In section 1.3 I illustrate how utility functions as organisational principle for scientific research, by comparing a diverse set of 'postmodern' concepts and models of useful research: technoscience, mode-2 knowledge production, post-normal science and responsible research and innovation (RRI). In these two steps, I draw the outlines of a historical epistemology of useful research that is required for the development of a spatio-historical approach to utility as meta-scientific concept.

## 1.2 Modern Ideals of Useful Research

'"Knowledge is power" contemplated philosopher Francis Bacon four hundred years ago. But what value does this have, if that knowledge does not reach society?'[24] In the late modern Western world it was not at all uncommon to open a science policy report, such as this Dutch government policy paper, with a reference to the seventeenth-century Lord Chancellor of England. So many twentieth-century participants in debates about knowledge utilisation have determined their stances by explicit or implicit reference to Bacon, or at least interpretations of him. Historians claimed that only with Bacon, 'utility

22 Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007); Heather Douglas, "Pure Science and the Problem of Progress," *Studies in History and Philosophy of Science Part A* 46 (2014): 55–63; Agar, "2016 Wilkins–Bernal–Medawar Lecture The Curious History of Curiosity-Driven Research."

23 This connects to Ursula Klein's study of 'useful science' in nineteenth century Prussia: Ursula Klein, *Nützliches Wissen: Die Erfindung der Technikwissenschaften* (Göttingen: Wallstein Verlag, 2016).

24 Ministerie van Onderwijs Cultuur en Wetenschappen and E. A. A. M. Broesterhuizen, *Het kennisnetwerk: de technologische kennisinfrastructuur van Nederland* (Zoetermeer: Ministerie van Onderwijs, Cultuur en Wetenschappen, 1996), 4.

became the central norm' in natural philosophy or that the Baconian programme was the 'intellectual origin for the long period of economic growth initiated by the Industrial Revolution'.[25] Opposing that line of thought, one economist baptised Bacon as the representative of a, according to him, defunct, 'linear' model of technological progress as legitimation for state funding of science—a criticism that a medical scientist recently repeated in a pamphlet on 'Science 3.0'.[26] Still, many politicians, policymakers and journalists admired Bacon, as the 'first statesman' and 'father' of modern science, to whom science owed 'the principle of its method and the (imagined) bases of its organisation'.[27] In policy advice reports, researchers use Bacon's four-hundred-year-old utopian vision of a society based on useful research, *New Atlantis,* to argue for change in current research systems.[28] To put an end to this infinite list: there is a widespread tradition of all kinds of science commentators who view Bacon as, perhaps the most, influential spokesperson for a utilitarian ideal of science *and* find in him 'over and over … expression of the ideas of the day'.[29]

This last remark explains why I turn to Bacon to argue for the historical multiplicity of concepts of utility of scientific research. The appeal of his work can be found in the zealous defence of a new method for the study of nature. Bacon presented his philosophy consciously as a break away from scholastic and alchemic traditions, for which he displaced the focus from words to works, or from contemplation and deductive logic towards experimentation and induction. This proposal for a new method came with a new concept of knowledge—discovering the unknown rather than organising eternal truths—and a new, cooperative ethos for inquiry. Bacon developed most of these ideas in the political context of his position at the Court of King James I, and his main philosophical work *Novum Organum* (1920) was published by the king's printer, just shortly before his political career ended with an impeachment.[30] But, neither the historical figure of Francis Bacon, nor the details of his philosophical works are of interest here. Therefore, I will not participate in the advanced historical, philosophical and literary debate on Bacon's epistemological contributions about the experimental method, and its relation to his cultural vision of a new ethos and organisation for science. Instead, 'Bacon' is instrumental to my interest in the historically fluid concept of utility. I will thus not study utility 'according to Francis Bacon' but the multiplicity of utility through the multiple historical interpretations of Bacon's philosophy that appear in scholarly, policy and popular literature, or *utility concepts according to Francis Bacons*.

In the centuries following Bacon's lifetime, various Bacons have been invoked to defend developments in the organisation of science.[31] Depending on the particular socio-political context, Baconian utility could be rhetorically reconstructed

25 Proctor, *Value-Free Science?*, 262–63; Joel Mokyr, "The Intellectual Origins of Modern Economic Growth," *The Journal of Economic History* 65, no. 2 (2005): 285–88.

26 Terence Kealey, *The Economic Laws of Scientific Research* (Basingstoke: Palgrave Macmillan, 1996); Frank Miedema, *Wetenschap 3.0: van academisch naar postacademisch onderzoek* (Amsterdam: Amsterdam University Press, 2010), 110–11.

27 James Gerald Crowther, *Francis Bacon: The First Statesman of Science* (London: The Cresset Press, 1960); Jean-Jacques Salomon, *Science and Politics* (Cambridge, MA: MIT Press, 1973), 7–13.

28 Stephen R. Hanney and Miguel A. González-Block, "Four Centuries on from Bacon: Progress in Building Health Research Systems to Improve Health Systems?," *Health Research Policy and Systems* 12, no. 1 (2014): 56.

29 Sergio Sismondo, *Science Without Myth on Constructions, Reality, and Social Knowledge*, 1996, 146; Donald E. Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation* (Washington: Brookings Institution Press, 1997), 32.

30 Markku Peltonen, "Introduction," in *The Cambridge Companion to Bacon*, ed. by Markku Peltonen (Cambridge University Press, 1996), 5–16.

31 Brian Vickers, "Francis Bacon and the Progress of Knowledge," *Journal of the History of Ideas*, 53.3 (1992), 495–518; Antonio Pérez-Ramos, "Bacon's Legacy," in *The Cambridge Companion to Bacon*, ed. by Markku Peltonen (Cambridge University Press, 1996), 311–334; Graham Rees, "Reflections on the Reputation of Francis Bacon's Philosophy," *Huntington Library Quarterly*, 65.3/4 (2002), 379–94.

to serve progressive or conservative interests and communist or capitalist systems. The establishment of the Royal Society, for example, was at first explicitly legitimised with a socially progressive concept of useful science, but the cultural and political meaning of his methodology was dropped quickly by British experimentalists. In the French Enlightenment Baconian inquiry was again tied to radical reform of social institutions and values.[32] Such changes did not take place only between different contexts and periods: individual scientists too could transform their concept of utility to fit new circumstances. In the nineteenth century, German agricultural chemist Justus von Liebig first employed Bacon to pit useful 'science' (*Naturwissenschaft*) vis-à-vis useless speculation (of German Idealism) to find institutional support for his new brand of chemistry, but abandoned this ideal as soon as his science professionalised and found shelter in increasingly autonomous German universities. Instead of immediate utility, he now advocated the principles of a 'pure' science for its own sake (in line with the 'advance of human freedom' of German Idealism).[33] However, many nineteenth- and twentieth-century Marxists, utilitarians and pragmatists hailed Baconian utility as the generation of profitable truths and material technologies to improve the 'comfort of life', exemplified by artefacts and tools like gunpowder and the compass. Karl Marx and later Marxists praised Bacon's useful science because it implied the same goal as their philosophy: a rational, scientific society. Ambiguously, Bacon's utility could also stand for a liberal-democratic conception of social progress on the basis of the minimisation of the political and hope for the benefits from technological development. In the Cold War context, the true instantiation of Baconian utility was declared on both sides of the geopolitical boundary.[34]

Apart from different uses of utility over time—which demonstrate that it is a historical category itself—Bacon's utility has been situated in his own time in multiple ways. There are not only multiple Baconian utilities *over time*, but also *in his time*. In an authoritative study, Antonio Pérez-Ramos situated Bacon's epistemology and ethos of an 'active science' in a tradition of artisanal making to argue for two connotations of utility: the production of effects in nature and the occasional translation of this control into useful artefacts. The first 'internal' utility is a legitimate part of science, while the second 'external' utility cannot inform an experimenter what to do and is ultimately an 'ideological excrescence' because it is relative to a system of value.[35] Several scholars, such as Edgar Zilsel, Benjamin Farrington, Paolo Rossi and Carolyn Merchant, have precisely stressed the relevance of these systems of value to the practice, ethos and utility of science, in particular the rise of capitalist societies in Europe. According to them, Baconian utility cannot be untied from the political-economic context of

32 Richard Yeo, "An Idol of the Market-Place: Baconianism in Nineteenth Century Britain," *History of Science* 23, no. 3 (1985): 251–298.

33 Otto Sonntag, "Liebig on Francis Bacon and the Utility of Science," *Annals of Science* 31, no. 5 (1974): 373–386.

34 Ladis K. D Kristof, "Francis Bacon and the Marxists: Faith in the glorious future of mankind," in *Society and History: Essays in Honor of Karl August Wittfogel* (Berlin: De Gruyter, 1978), 233–57.

35 Antonio Pérez-Ramos, *Francis Bacon's Idea of Science: And the Maker's Knowledge Tradition* (Oxford University Press, 1988), 138–48.

an imperialistic, extractive capitalism based on colonialism, the expansion of overseas trade, the increase of commercial wealth and the progress of the mining industry. Competition, for example, broke the power of the guild tradition, and stimulated the 'inventive genius' of the artisans to commercialise new inventions. This subsequently informed Bacon's attack on the fruitlessness of theoretical knowledge and his estimation of the technical knowledge and cooperative aspects of artisanal traditions.[36] But in the context of early capitalism, this seemingly progressive 'operative' science—'man can only know what he does or what he himself constructs'—also corresponded to the exploitation of the natural environment: Bacon's utility transformed nature from teacher into slave, and man accordingly from servant to exploiter.[37] In later studies, the enabling role of science in the development of extractive capitalism has been related to post-colonial criticisms of the euro-centrism, imperialism, and violence of 'modern science'.[38] Bacon then re-emerges as conservative thinker, science as conservative enterprise, and its utility restricted to the political-economic powers that be.

This critical and pessimistic perspective on the so-called usefulness of modern science, pioneered by Theodor Adorno and Max Horkheimer and advocated by feminist and post-colonial scholars, might, however, be more of a reflection of current concerns than an accurate representation of Bacon's problem situation. There, utility did not appeal only to artisans, the upcoming merchant class and patriarchal power; his practical operative science also mirrored cultural and religious structures. The organised, controlled production of new truths has to be understood in relation to hermetic and alchemist traditions and is also defended by an Aristotelian defence of the 'pure pleasure of learning'; and his concept of utility is related to Christian conceptions of charity, but also invokes sexist imagery of the then current witch trials.[39] A recent historicist account synthesised these myriad Bacons to claim that he used the language of commerce to 'sell' science, as profitable investment, object of desire and useful instrument to imperial expansion.[40] Analogous to how, today, scientists can use any Bacon they need to sell their science.

The above selection of various Francis Bacons and utility concepts participated in the internalism/externalism debate that deals with the question whether the development of science is detachable from its social, political and cultural context. Ultimately, Steven Shapin reminds us, this is 'a vitally important contest over the *value* of science and scientists in an age of unreason'.[41] And so the multiple Bacons that emerged from the studies of philosophers, historians and literary scholars were mobilised, by scientists and policymakers, as resources in post-war arguments about the appropriate political control of scientific research. The idea of planning, organising and

36 Edgar Zilsel, "The Genesis of the Concept of Scientific Progress," *Journal of the History of Ideas* 6, no. 3 (1945): 325–49.

37 Carolyn Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (San Francisco: Harper and Row, 1980).

38 Anshuman Prasad, "Provincializing Europe: Towards a Post-Colonial Reconstruction: A Critique of Baconian Science as the Last Stand of Imperialism," *Studies in Cultures, Organizations and Societies* 3, no. 1 (1997): 91–117; Dipesh Chakrabarty, "The Climate of History: Four Theses," *Critical Inquiry* 35, no. 2 (2009): 197–222.

39 Paolo Rossi, *Francis Bacon: From Magic to Science* (London: Routledge & Kegan Paul, 1968); Merchant, *The Death of Nature*, 73–91; Sarah Irving, "Rethinking Instrumentality: Natural Philosophy and Christian Charity in the Early Modern Atlantic World," *HOPOS: The Journal of the International Society for the History of Philosophy of Science* 2, no. 1 (2012): 55–76; Sorana Corneanu, "Francis Bacon on Charity and the Ends of Knowledge," in *Conflicting Values of Inquiry: Ideologies of Epistemology in Early Modern Europe: ed. Tamás Demeter* (Leiden: Brill, 2015).

40 Katherine Bootle Attie, "Selling Science: Bacon, Harvey, and the Commodification of Knowledge," *Modern Philology* 110, no. 3 (2013): 415–40.

41 Steven Shapin, "Discipline and Bounding: The History and Sociology of Science as Seen through the Externalism-Internalism Debate," *History of Science* 30, no. 4 (1992): 339–40.

controlling the pursuit of new and useful scientific knowledge can be based on 'externalist' ideas: when societal, political, cultural and economic factors have always shaped the development of science in the past, they can also do so now. From the internalist point of view, any interference that is not really 'scientific' is quickly seen as an infringement.

The modern ideology of science as a useful endeavour was thus always at stake in the post-war interpretations of Bacon's work. Utility appears as a fluid concept in two ways. First, utility is a historical category—it meant something different every time, to Bacon, his commentators, interpreters and advocates. Utility according to Bacon could mean things as diverse as individual profit-making from material technologies, the collective production of new effects, the instantiation of Christian charity or an instrument of hierarchical oppression. Second, utility can be an epistemological category, depending on the approach one takes to the study of (past) scientific thought and practice. Seemingly remote questions about whether modern science originated in 'the isolated scholar's study or the craftsman's collective workshop' ultimately have political-epistemological implications: what is considered rational conduct, and which elements are considered to be 'part of' scientific research.[42] Analogously, more recent conceptions of utility can be situated in their cultural, social and political-economic contexts.[43] Ultimately, utility appears as a historical-epistemological category, as a situated response to the question in what ways societal factors and actors do, and should, shape the dynamics of research.

## 1.3 Postmodern Concepts of Useful Research

Notwithstanding the multiplicity of utility, Bacon appears consistently as representative of modernity, a worldview in which boundaries regulate the relations between man and nature. Many philosophers and sociologists sought to overcome this dichotomy at the end of the twentieth century, moving towards post-, non- or a-modern approaches. These transcended the internalism/externalism opposition because they argued that the distinction between culture and nature was itself an anthropogenic construct. This intellectual trend coincided with a historical urgency for the epistemological question what the appropriate role for 'external' actors and interests was in (academic) knowledge production. In the post-war Western world, the social and material contexts of scientific practice changed radically. Laboratories grew in scale and number, instruments became bigger and more expensive, while the shrinking size of computers was inversely related to their growing importance. Research became teamwork, required more technical support staff, and the network of

42 Shapin, 350.

43 Aant Elzinga, "The Science-Society Contract in Historical Transformation: With Special Reference to 'Epistemic Drift,'" *Social Science Information* 36, no. 3 (1997): 435.

specialists spread over the globe, connected by the burgeoning internet.[44] The socio-political context of this 'big science' significantly shaped the types of knowledge that were produced. In the Cold War context, governments and industry needed new useful knowledge for national security and economic growth, while on the other hand societal coalitions aired concerns about the consequences and responsibility of scientific research. The 'scientification' of society and 'socialisation' of science prompted new epistemological approaches to scientific research that paid due to these changes.

Many studies that discussed the roles of 'external factors', like societal actors, public values and non-scientific interests, in the dynamics of scientific research were met with allegations of relativism. Taking external factors seriously namely conflicts strongly with a dominant discourse amongst scientists, interpreters and the public of the purity and value-free character of scientific research: a disinterested search for truth, dealing with facts and not with values.[45] Famously, Max Weber identified in 1917 the 'disenchantment'—or 'devalorization'—of the world, set in motion by the rise of experimental natural sciences, that separated issues of values strictly from matters of fact. It separated the conduct of science epistemically and practically from human affairs and action: scholarship focused on descriptions of 'the is', and abandoned any propositions of 'the ought'.[46] Not only was society banned from meddling in science; (in Weber's case, social) science could also not prescribe what to do in policy and practice. Proponents of the value-free ideal of scientific research then, embrace the thought that ideally economic, political or moral concerns play no or a very limited role in the conduct of scientific inquiry: definitely not in the methods, collection of data, and the evaluation of results and only potentially in the selection of topics and application of results. Similarly, early sociologist of science Robert K. Merton argued for an autonomous scientific community, regulated by (highly idealised) norms such as disinterestedness, universalism, and communism.[47]

However, this ideal has come under attack in a variety of ways.[48] Philosophers of science, for example, have convincingly shown that empirical data themselves do not always provide sufficient support for the confirmation or falsification of hypotheses. This problem, also known as the underdetermination of theory choice, entails that values are required to actually do research, both in theory and in practice. Although some have tried to maintain some 'purity' by limiting this to epistemic values, others have shown that social, ethical, political and aesthetic values can play a role as well.[49] Thomas Kuhn's history and philosophy of science shaped this scholarly debate to a large extent. His paradigm approach to past scientific revolutions allowed taking into account social factors in theory choice. David Bloor's 'strong programme' in the sociology of

44 Although this primarily applies to the natural, life and engineering sciences, also the social sciences and humanities experienced organisational expansion or had to relate to these general developments. In the later historical chapters, these historical themes will be discussed in more detail. See: Peter Galison and Bruce William Hevly, *Big Science: The Growth of Large-Scale Research* (Stanford University Press, 1992); Agar, *Science in the 20th Century and Beyond*.

45 Douglas, "Pure Science and the Problem of Progress"; Jorrit P. Smit, "Purity in an Impure World. Ernst Cohen's 'General Chemistry' in Early-20th-Century Netherlands" (Utrecht, Utrecht University, 2015).

46 Proctor, *Value-Free Science?*

47 Robert K. Merton, "The Normative Structure of Science," in *The Sociology of Science: Theoretical and Empirical Investigations*, ed. Robert K. Merton (Chicago: Chicago University Press, 1973).

48 Harold Kincaid, John Dupré, and Alison Wylie, *Value-Free Science: Ideals and Illusions?* (Oxford University Press, 2007).

49 Helen E. Longino, *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry* (Princeton, NJ: Princeton University Press, 1990); James W. McAllister, *Beauty and Revolution in Science* (Cornell University Press, 1996); Heather Douglas, *Science, Policy, and the Value-Free Ideal* (Pittsburgh, PA: University of Pittsburgh Press, 2009).

scientific knowledge interpreted this radically and promoted the 'symmetrical' study of scientific consensus and controversy; that is, to explain truth and falsities with the same resources, including power, social interests and rhetoric.[50] It has been intensively debated to what extent these approaches lead to (social) relativism, but main proponents like Kuhn fiercely denied it.[51] And it should be noted that in Kuhn's studies of paradigm shifts, as well as some sociological studies of controversies, the role of the social was strictly limited to an 'internal' scientific community.[52]

The value-free, pure and isolated image of science turns its practice and utility into a myth; a deus ex machina has to be invoked to explain the great impact of science on, and its orientation to, societal issues. Some of the later, 'post-Kuhnian' approaches did take external concerns and actors, as well as internal ones, into account in the study of science. Typically, they also described or proposed appropriate ways of (democratic) involvement of societal actors. But not all of them were also post-modern in a relativist sense. The finalization thesis, for example, complemented rather than fundamentally challenged the Kuhnian approach. Gernot Böhme, Wolfgang van den Daele and Wolfgang Krohn posited finalization in the 1970s to denote the 'process through which external goals for science become the guidelines of the development of the scientific theory itself'.[53] Their hypothesis was that only 'completed and differentiated', or 'post-paradigmatic' fields of science could become regulated by non-theoretical, socio-political goals. This meant that principally (and historically) theoretical, or internal, developments had priority over, and were the prerequisite for, making knowledge useful.[54] Still, this shields a certain 'basic' process of research from judgments, concerns and considerations about usefulness. And involvement of non-scientific actors in the production of knowledge took place only on the abstract level of priority-setting between fields by the state (rationality of planning) or 'afterwards', at the application stage of the discovered true knowledge (in applied and finalized science respectively).

In the 1990s a constructivist-deliberative governance approach to the political-epistemological question of utility developed, often shaped by policy debates.[55] Concepts like 'post-normal science', 'mode-2 knowledge' and the more recent 'responsible research and innovation' are analytic categories and political interventions. They share a historical observation that the socio-political context has changed to such a degree—becoming more uncertain, risky and global—that 'traditional', internally oriented, science is disappearing. One of the underlying reasons would be that it no longer leads to sufficient or the right kind of utility.[56] Again, these approaches do not throw a realist baby out with value-free bathwater. Previous relations between science

50 Sismondo, *Science Without Myth*, 36–37; Hans Radder, "Philosophy and History of Science: Beyond the Kuhnian Paradigm," *Studies in History and Philosophy of Science Part A* 28, no. 4 (1997): 633–55.

51 Thomas Kuhn, "Objectivity, Value Judgment, and Theory Choice," in *The Essential Tension: Selected Studies in Scientific Tradition and Change* (Chicago: Chicago University Press, 1977), 320–39.

52 Isabelle Stengers, *The Invention of Modern Science* (University of Minnesota Press, 2000).

53 Gernot Böhme, Wolfgang Van Den Daele, and Wolfgang Krohn, "Finalization in Science," *Social Science Information* 15, no. 2–3 (1976): 307.

54 Peter Weingart, "From 'Finalization' to 'Mode 2': Old Wine in New Bottles?," *Social Science Information* 36, no. 4 (1997): 591–613.

55 Laurens K. Hessels and Harro van Lente, "Re-Thinking New Knowledge Production: A Literature Review and a Research Agenda," *Research Policy* 37, no. 4 (2008): 740–60; Michiel van Oudheusden, "Where Are the Politics in Responsible Innovation? European Governance, Technology Assessments, and Beyond," *Journal of Responsible Innovation* 1, no. 1 (2014): 67–86.

56 Silvio O. Funtowicz and Jerome R. Ravetz, "The Emergence of Post-Normal Science," in *Science, Politics and Morality* (Springer, 1993), 85–123; Helga Nowotny, Peter Scott, and Michael Gibbons. "Introduction: Mode 2 Revisited: The New Production of Knowledge." *Minerva* 41, no. 3 (2003): 179–194.

and its surroundings ('normal' or 'mode-1' science) are not completely denounced; but the proponents also do not criticise the reversal of this relation, after which utility considerations will increasingly direct research ('post-normal' or 'mode-2' science). Helga Nowotny, Peter Scott and Michael Gibbons argue for example that policy-relevant problems, stakeholder participation, and the context of application will increasingly direct research and lead to *socially robust* knowledge—rather than to a disinterested, curiosity-driven search for *true* knowledge. In the context of European science policy, René von Schomberg has advocated a similar social constructivist call for 'responsible research'. This comprises the involvement of 'all societal actors ... to ensure that the results meet the needs of the world we live in'.[57] Instead of centralised planning and prioritisation by the state, as proposed by finalization, scholars like Nowotny and policymakers like Von Schomberg promote decentralised engagement of 'external' actors in local practices of knowledge production. This external democratisation of research can take place in different political modes. Representative inclusion of societal actors, for example, is based on the idea that powerful social groups have determined for too long the kind of knowledge to be attained, so now also underrepresented standpoints (e.g. from working class, female or non-western perspectives) should be included in the direction and execution of research.[58]

Similar to this variety of constructivist-deliberative concepts, the approach known as *technoscience* describes the inclusion of societal actors in knowledge production. But it differs fundamentally in its perspective on the history of science: not the *practice* but rather the *interpretation* of processes of knowledge production is changing. Although the concreteness of practice has always been primary, in modernity it has been possible to 'purify' it into neat categories (nature / culture, science / technology, description / intervention). However, the obstinate manifestation of research objects as hybrids of nature and technology has made it increasingly impossible to maintain these strict boundaries.[59] To describe this reality more appropriately, Gilbert Hottois coined 'technoscience', a term that became popular amongst material-discursive constructivist approaches to science, nature and technology (from Bruno Latour's actor-network theory to Donna Haraway's cyborg feminism).[60] In a-modern interpretations of scientific practices also past science can thus be understood as technoscience, where the context of knowledge is conflated with its content.[61] The modern 'purification' of different categories and processes of science and society also made possible the distinction between internal and external factors in knowledge production. Latour therefore proposed to talk no longer of a strictly separated 'science' and 'society', but of weaker and stronger associations between

57 René Von Schomberg, "A Vision of Responsible Research and Innovation," in *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*, ed. R. Owen, M. Heintz, and J. Bessant (London: John Wiley, 2013), 51–74; Oudheusden, "Where Are the Politics in Responsible Innovation?," 70.

58 Sandra Harding, *Is Science Multicultural? Postcolonialisms, Feminisms, and Epistemologies* (Bloomington & Indianapolis: Indiana University Press, 1998).

59 Gregor Schiemann, Hans Radder, and Alfred Nordmann, *Science Transformed? : Debating Claims of an Epochal Break* (Pittsburgh, PA: University of Pittsburgh Press, 2011).

60 Gilbert Hottois, "La technoscience : de l'origine du mot à ses usages actuels," *Recherche en soins infirmiers*, no. 86 (2006): 24–32; Latour, *Science in Action*; Donna Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991)..

61 John V. Pickstone, *Ways of Knowing: A New History of Science, Technology, and Medicine* (University of Chicago Press, 2001).

heterogeneous elements. The success, or usefulness, of technoscience is a result of the reciprocal shaping of the social and the natural world.[62]

This actor-network approach studies knowledge production in terms of translation networks in which scientific claims start as 'fictions' that develop the status of 'fact' only if they receive sufficient interest from others.[63] Any new scientific claim can be stabilised by gathering a wide variety of allied 'actants'—including texts, devices, skills, institutions, and humans, from researchers and technicians to industrialists, politicians and activists. Stabilising a claim, or making it reliable, thus requires extension of the network. A strict boundary between the inside ('producers') and outside ('users') of research cannot be easily drawn in this view. The diversity of actors involved in knowledge production blurs the distinction between the activities of research and its distribution 'outside the laboratory'. Contrary to the above proposals for centralised and decentralised democratic governance of scientific research, the technoscientific move is first of all at the level of research, not of policy. Current science policies aiming to improve the societal value of research typically concern themselves with the relations between scientific and societal actors, which, from the technoscientific perspective, appear integral to the network that sustains the primary research process. This implies that one cannot simply distinguish between active producers and passive recipients of knowledge, or between internal and external values, interests and factors that shape research. More strongly than for the finalization or constructivist-deliberative accounts, this view might induce the relativist reproach that this makes the credibility of knowledge dependent on the views and fads of allied actants, be it industry, politicians or society. But the issue at stake is, I believe, not an either/or choice between disinterested objectivity and relativism, or between truth and utility. The premise is instead that overlapping, if not the same, heterogeneous actor-networks (that also include non-human actors) are the condition for knowledge to appear and function as true and useful.

Although originating from diverse practical and theoretical contexts, these post-modern concepts all blurred traditional distinctions between the inside and outside of science. Instead of a simple image of an autonomous practice of research, utility is included as relevant political-epistemic factor in knowledge production. Some theories of useful research claim that this has always been the case; some argue that an epochal break has occurred in the content and practice of science. With respect to knowledge transfer, this has invariably led to the denunciation of a linear model of innovation. Instead of a one-directional flow of pure, basic or fundamental knowledge to new applications, innovations, products and ultimately economic growth, much richer models of knowledge transfer have been proposed

62 Sergio Sismondo, *An Introduction to Science and Technology Studies* (Chichester: Wiley-Blackwell, 2010), 65–66.

63 Latour, *Science in Action*; Isabelle Stengers, *Power and Invention: Situating Science* (University of Minnesota Press, 1997); Michel Callon, "Four Models for the Dynamics of Science," in *Science and the Quest for Reality* (Springer, 1995), 249–292; Smit and Hessels, "The Production of Scientific and Societal Value in Research Evaluation."

(and have arguably existed in the minds of many historical actors).[64] With the 'triple' and 'quadruple' helices of university-industry-government-society relations scholars have tried to describe a non-linear dynamics of innovation, which would have emerged as a consequence of the displacement of a Cold War (military) elite.[65] Again, this points to the networked structure between actors from universities, industry and government that both enables the alignment of research with practical interests and supports the many intermediate processes back and forth between research and use. I agree that, to understand utility, we need to be aware of the networked character of scientific research and its circulation. What is more, I argue that it points us to the spatial character of the processes that enable and sustain utility. In the next few sections, I will explore the study of this spatiality of research.

## 1.4 The Study of the Spatiality of Scientific Research

The places, sites and geographies of scientific research have received widespread attention in science studies since the 'spatial turn' in the 1990s.[66] Geographical approaches to the history of science are another way in which the 'modern' view of science has been challenged, replacing the universality and 'placelessness' of formalised knowledge with the contextuality, locality and situatedness of research practices. In this body of literature, a distinction is commonly made between *fixed sites of knowledge production* and *dynamic processes of knowledge circulation*. However, they can be perceived to be two sides of the same epistemological problem: 'How is it, if knowledge is indeed local, that certain forms of it appear global in domain of application?'[67] Or, as Thomas Gieryn reformulated it, this concerns 'the paradox of place and truth': claims originate *somewhere*, but once accepted as true they become *placeless* and apply *anywhere*.[68] Epistemological answers could be formulated in terms of the post-modern concepts of useful research described above. But in this section, I will focus on literature that approaches this question as a spatial issue.

In the following, I therefore discuss several approaches to this 'issue of travel': how can knowledge circulate (globally) if its production is fundamentally local?[69] First, I discuss approaches that stress the 'locality' of research and, second, those approaches that emphasize (global) circulation instead. Circulation is the key towards the development of a spatial understanding of the practice, policy and rhetoric of utility, and related concepts like knowledge transfer and valorisation. But, thirdly, I will argue that the exchange of knowledge, skills and values between scientific and 'non-scientific' actors

64 David Edgerton, "'The Linear Model' Did Not Exist: Reflections on the History and Historiography of Science and Research in Industry in the Twentieth Century," in *The Science-Industry Nexus: History, Policy, Implications.*, ed. Karl Grandin, Nina Wormbs, and Sven Widmalm (USA: Science History Publications, 2004), 31–57; Benoît Godin, "The Linear Model of Innovation: The Historical Construction of an Analytical Framework," *Science, Technology, & Human Values* 31, no. 6 (2006): 639–67.

65 Henry Etzkowitz and Loet Leydesdorff, "The Dynamics of Innovation: From National Systems and 'Mode 2' to a Triple Helix of University–Industry–Government Relations," *Research Policy* 29, no. 2 (2000): 109–123; Elias G. Carayannis and David F. J. Campbell, "Mode 3 Knowledge Production in Quadruple Helix Innovation Systems," in *Mode 3 Knowledge Production in Quadruple Helix Innovation Systems: 21st-Century Democracy, Innovation, and Entrepreneurship for Development*, ed. Elias G. Carayannis and David F.J. Campbell (New York, NY: Springer, 2012), 1–63.

66 Diarmid A. Finnegan, "The Spatial Turn: Geographical Approaches in the History of Science," *Journal of the History of Biology* 41, no. 2 (2008): 369–88.

67 Adi Ophir and Steven Shapin, "The Place of Knowledge: A Methodological Survey," *Science in Context* 4, no. 1 (1991): 15.

68 Thomas F. Gieryn, "Three Truth-Spots," *Journal of the History of the Behavioral Sciences* 38, no. 2 (2002): 113.

69 Steven Shapin, "Placing the View from Nowhere: Historical and Sociological Problems in the Location of Science," *Transactions of the Institute of British Geographers* 23, no. 1 (1998): 5–12.

receives less attention in this historical geographic literature. In the concluding section of this methodological introduction, I therefore elaborate the hybrid, heuristic concept of *utility spot* to highlight the local embedding of places that stimulate knowledge exchange between various contexts, communities and cultures. This adds another dimension to the problem of travel, namely, to what extent the circulation of knowledge can be considered part of its production. That, consequently, raises again the epistemological issue of the relations between the utility and truth of scientific research.

Before I begin the discussion of the historical geographical literature on science, some clarity is required about the conceptual distinction between space and place. It is quite common to perceive this as an epistemological distinction between two types of *understanding* place.[70] On the one hand, geometric representations of reality produce an abstract understanding of 'space', within which places are nodes, or mere 'locations'. On the other hand, the phenomenological approach values 'place' as concrete, meaningful milieus that mediate human activity and experience. Or, to rephrase this difference, space is merely a surface or canvas on which human life occurs, whereas place is a holistic context that makes it possible. Epistemologically, space is associated with a nomothetic approach—describing the general laws that structure spatial reality—and place with an idiographic approach—describing the particulars of lived experience and practice. This difference manifests itself in the extent to which these two approaches consider place to be incidental to, or actively shape, non-spatial processes. Although the mediating role of place in social relations and meaning has experienced a revival in geography, the passive place as location in space is still dominant in some social sciences.

However, alternative approaches have emerged that challenge the space/place dichotomy more generally.[71] Shared by these post-structuralist approaches, from neo-Marxists like Henri Lefèbvre to feminist geographers like Doreen Massey, is the emphasis on the construction of place through social practices. Place is then no more a sediment of the past and its apparent permanence is not fundamental, but an accomplishment of a temporally stable set of relations and interactions from local to global scales. Post-structuralist scholars therefore collapse the place/space dichotomy by speaking of 'relational space': physical, biological, social and cultural processes 'make' space.[72] Any place is always in the 'process of becoming', as its constituent parts are not rigid structures, but the flow of consensual and contested relations between various entities. Space becomes a 'meeting place' where relations come together and mix. This also entails that a 'power geometry' emerges: as any place is a unique intersection of social, cultural, and physical processes, some social groups

70 John Agnew, "Space and Place," in *Handbook of Geographical Knowledge*, ed. John Agnew and David N. Livingstone (London: SAGE Publications Ltd, 2011), 316–330.

71 Agnew.

72 Doreen Massey, *For Space* (London: Sage Publications Ltd, 2005); Jonathan Murdoch, *Post-Structuralist Geography : A Guide to Relational Space* (London: Sage Publications Ltd, 2006).

will be dominant or privileged, others excluded, suppressed or marginalised. The relations that constitute space can be both facilitating movement and access, as well as producing exclusion and confinement.[73]

In the historical, sociological and anthropological study of science the spatiality of scientific research has been generally studied in three ways. In some older approaches, both place and space are disregarded altogether: knowledge is universally true, it is placeless and fluently moves between locations. Second, places of knowledge production are studied in their particularity as *place*, often characterised by rigidity, permanence and partitions. Third, this localisation of research has incited the study of the global circulation of scientific results and technologies, characterised by stability-in-mobility, through *space*. These three options, which I will expand upon below, mostly fit within the space/place dichotomy. The criticisms raised of the 'circulation' concept offers the potential to study science too in relational space.

## 1.5 The Place of Scientific Research

It is much more difficult to imagine a practice of science outside space, than one outside society. Spatial, architectural and geographic factors are not external to research in the way some view societal and cultural factors to be. The latter might be contingent, historical facts of the production of knowledge, which shape (to a debatable degree, see section 1.2) the form and content of knowledge. But in theory-dominant views of science also space is incidental to intellectual work. No spatiotemporal context has epistemological privilege; any local site of investigation just functions as environment for the instantiation of universal claims.[74] Science studies in general disagree with this view because the study of research as practice has brought to light the importance of space and materiality. In this view, space is not a contingent canvas for scientific activities, but rather a condition of possibility. In an attempt to uncover the fundamental importance of space to research, historians, sociologists and anthropologists have analysed the historical variety of particular places geared at knowledge production.[75]

In science studies, and broader culture, the laboratory has functioned as an archetypical place for scientific research. Laboratories have achieved mythical status as temples of objectivity and truth. Since the 1980s, however, anthropologists have entered the lab to see for themselves what is really going on. Science studies scholars like Karin Knorr-Cetina, Sharon Traweek, Steve Woolgar and Bruno Latour have mapped the mundane activities, social interactions and material flows involved in the production of new reliable knowledge, and have

73 Murdoch, *Post-Structuralist Geography*, 22–24.

74 Joseph Rouse, *Knowledge and Power: Toward a Political Philosophy of Science* (Cornell University Press, 1987), 69–72.

75 David N. Livingstone, *Putting Science in Its Place. Geographies of Scientific Knowledge* (Chicago: Chicago University Press, 2003); Simon Naylor, "Introduction: Historical Geographies of Science–Places, Contexts, Cartographies," *The British Journal for the History of Science* 38, no. 1 (2005): 1–12; Finnegan, "The Spatial Turn"; Christopher R. Henke and Thomas F. Gieryn, "Sites of Scientific Practice: The Enduring Importance of Place," in *The Handbook of Science and Technology Studies,* ed. Edward J. Hackett, Olga Amsterdamska, Michael Lynch and Judy Wajcman (Cambridge, MA: MIT Press, 2008), 353–76.

described the variety of values and interests that shape the practice of research.[76] Ultimately, their studies have contributed significantly to the demystification of a value-free, pure image of scientific research. In these studies, space and place figured mostly abstract and schematically as part of the social-material context of knowledge production. More insight into the role of space in knowledge production can be found in microhistories of the laboratory, but also of the field, the museum or the botanical garden. Often such studies described how the (architectural) organisation of a certain space controlled *who* and *what* could be involved in research, both socially in- and excluding reliable actors, and materially in- and excluding disturbing environmental factors.

One of the most important ways to shape social interactions around science is the boundary between insiders and outsiders: between those who have access to the private backstage of knowledge production and those who are allowed to experience only the front stage of research, its results and successful public demonstration. The laboratory is situated ambiguously between the private and the public realm. The first laboratories in the seventeenth century were defined according to the presence of a furnace and mirrored the secrecy and seclusion of alchemist workplaces, often being situated in basements. The early modern experimenters that dwelled in the laboratories had to balance the privacy and exclusion of external factors required for inquiry, with the public demonstration and dissemination of their results. By physically rearranging features of gentlemen's houses, college rooms, artisan workshops and monasteries, the laboratories came to represent cultural credibility, and shaped social interaction in such a way that experimenters' claims to natural knowledge were accepted.[77] Exclusion is, both conceptually and historically, perhaps the most obvious strategy in this respect: women, for example, were excluded from official scientific spaces for a long time, and to the experimental space of the Royal Society only 'credible' witnesses of social standing were welcomed.[78]

In both cases, the exclusion or inclusion also had broader cultural significance, as the space of knowledge production became connected to powerful symbolic associations.[79] An extreme case of exclusion is represented in the image of the ivory tower, which isolates the (academic) pursuit of knowledge from all external factors.[80] This paradigm of seclusion has been reason for some philosophers to argue that societal detachment of science is a prerequisite, while many commentators have also used it as straw man to plead for a more socially engaged science. But, as Jan Golinski pointed out, even *anti*-social behaviour is not *a*-social, that is, even solitude follows social conventions and is a public pose: by seeking isolation one assumed 'the role of a dedicated searcher after truth' and was perceived to move closer to the abstract realm of truth.[81]

76 Karin Knorr-Cetina, *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science.* (Oxford New York: Pergamon Press, 1981); Steve Woolgar and Bruno Latour, *Laboratory Life: The Construction of Scientific Facts* (Princeton, NJ: Princeton University Press, 1986); Sharon Traweek, *Beamtimes and Lifetimes. The World of High-Energy Physics.* (Cambridge, MA: Harvard University Press, 1992).

77 Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (University of Chicago Press, 2005), 84–86.

78 Peter Galison, "Buildings and the Subject of Science," in The Architecture of Science, ed. Peter Galison and Emily Thompson (Cambridge, MA: MIT Press, 1999), 4.

79 The foundational study in this respect is Steven Shapin and Simon Schaffer, *Leviathan and the Air Pump. Hobbes, Boyle and the Experimental Life* (Princeton, N.J.: Princeton University Press, 1985).

80 Shapin, "The Ivory Tower."

81 Golinski, *Making Natural Knowledge*, 81–83.

Still, it is only when a claim is transferred from private to public that it can become stabilised as a reliable assertion, as 'true' knowledge.[82] Where the laboratory is an enclosed space that facilitates a transfer from private to public, fieldwork represents a very different spatial modality of knowledge production—one in which scientific work begins 'outside', where regions of space have to be translated in such a way that they can travel inside, and be manipulated to become knowledge. Fieldwork sciences do not alter space (physically and socially) by seclusion, but rather by creating networks of spatial relations, of transfer and translation, between the field and the centres of knowledge production. Knowledge production in laboratories and the field actually share the characteristic that acceptance depends on the successful extension of private claims to the world outside.[83]

Places of knowledge production also situate scientists 'in cultural space' and enable particular types of work. Laboratories, universities and museums are imbued with, and imbue their users with, cultural values and identity. The architecture and symbolical arrangements of scientific practice represent and transform scientific identity with respect to other specialities as well as society at large.[84] In addition, spatial divisions and structures stimulate particular modalities of cooperation. For example, in the twentieth century, institutions were established that facilitated research based on the interactions between theorists, experimenters and engineers, or among researchers from various disciplines. More generally, the secluded, private and highly individual ideal of a monk's cell has been replaced by the factory-like mass production of scientific knowledge in the 'big science' facilities centred on million-dollar instruments.[85]

Ultimately, space thus functions epistemologically. Not only do certain geographical locations, spatial divisions and material networks enable diverse research practices, but particular places of knowledge production also determine its perceived veracity. This aspect of spatial arrangements is what Thomas Gieryn was after when he coined *truth spots*: 'delimited geographical locations that lend credibility to claims' and consist of the 'material stuff' and the 'cultural interpretations and narrations' that give it meaning.[86] The 'geographic, architectural and rhetorical construction' of truth spots achieves 'the passage from place-saturated contingent claims to place-less transcendent truths'.[87] Highly standardised laboratories in the life sciences are primary examples of contemporary truth spots. The 'presumption of equivalence' between geographically dispersed laboratories makes the spaces *as particular places* invisible: scientists have put work in excluding all irrelevant factors from the research process, so that spatial aspects, for example, do not have to be highlighted in publications or procedures. Clearly, space has a political-epistemic function in this

82 Steven Shapin, "The House of Experiment in Seventeenth-Century England," *Isis* 79, no. 3 (1988): 373–404.

83 Golinski, *Making Natural Knowledge*, 100–102; Robert E. Kohler, *Landscapes and Labscapes: Exploring the Lab-Field Border in Biology* (Chicago: Chicago University Press, 2002).

84 Sophie Forgan, "The Architecture of Science and the Idea of a University," *Studies in History and Philosophy of Science Part A* 20, no. 4 (1989): 405–434; Galison, "Buildings and the Subject of Science," 1–3.

85 Galison, "Buildings and the Subject of Science," 15–19.

86 Thomas F. Gieryn, "City as Truth-Spot: Laboratories and Field-Sites in Urban Studies," *Social Studies of Science* 36, no. 1 (2006): 5; Thomas F. Gieryn, *Truth-Spots: How Places Make People Believe* (University of Chicago Press, 2018).

87 Gieryn, "Three Truth-Spots," 113.

approach, as it contributes to the legitimation of certain claims as reliable scientific knowledge.[88] The lack of particularity of a place makes this epistemic function possible. The assumption is that knowledge can travel when social behaviour is identical at the sending and receiving end. Although it seems that this is achieved by the standardised spatial organisation of research, which transforms unique places into generic spaces, historical and sociological studies of scientific practice demonstrate that we need to situate truth spots in specific local and cultural contexts as well as with respect to unique and reproducible social relations.

As researchers are obviously situated in concrete places to conduct their investigative work, their laboratories, libraries, observatories, archives and museums are themselves situated in geographical and societal space. They are part of universities, government departments or firms; they are located in the midst, on the fringes or outside of cities; they participate in a regional and global economy and are subject to (inter)national policies and laws; and they are involved in the construction of cultural identities of larger scientific and societal wholes, from cities to nations, from disciplines to geopolitics.[89] And, some would add, spaces for knowledge production develop in relation to environmental conditions, from the soil and climate to an area's hydrology and latitude.[90]

## 1.6 The Circulation of Scientific Research

As we zoom out, it becomes clear that scientific places of production are not distributed evenly over the globe.[91] And if we likewise zoom out culturally, it turns out that also the appreciation of the different places is uneven. Historically, various commentators have presented science as a purely Western-European creation that spread from there to the rest of the world.[92] Infamous is George Basalla's 'three stage model' for the globalisation of scientific research: first, peripheral, non-European, territories served as reservoirs of information, from which scientific knowledge was produced in the European centres; subsequently colonial science, of lower standing, was transported to and performed in these same peripheral regions; and from those practices grew independent national scientific traditions in colonised countries. However, this concept of a unidirectional diffusion of science—its results, its methods, its values—from the West to the Rest has, after waves of criticism, been rejected.[93]

This diffusion debate is one of the origins of the widespread attention for 'circulation' in postcolonial studies, anthropology and history of science. For science studies more generally, the localisation and contextualisation of what was once regarded as universal knowledge is another important origin. The travel

88 Henke and Gieryn, "Sites of Scientific Practice: The Enduring Importance of Place," 353–55.

89 Naylor, "Introduction," 7–8.

90 Harold Dorn, *The Geography of Science* (Johns Hopkins University Press, 1991).

91 Henke and Gieryn, "Sites of Scientific Practice: The Enduring Importance of Place."

92 Kapil Raj, *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, 1650–1900* (Palgrave Macmillan UK, 2007), 1–3.

93 Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850–1940* (New York: Oxford University Press, 1988); Kapil Raj, "Beyond Postcolonialism… and Postpositivism: Circulation and the Global History of Science," *Isis* 104, no. 2 (2013): 337–347.

of knowledge requires explanation if its production is unveiled to be intensely local. Studying the 'circulation' of knowledge has been proposed as a response. A necessary move because, as James Secord has argued, in science studies 'the further we move away from sites of the production of new knowledge, the vaguer our descriptive categories tend to become'.[94] Concepts like 'trading zones' and 'boundary objects' have been used to capture knowledge 'in transit'. Peter Galison introduced the trading zone concept to tackle the rather inflexible Kuhnian notion of paradigms that resulted in the problem of incommensurability. Instead he identified the possibility of communication between different disciplines or specialties, as these communities created 'inter-languages', which functioned the way pidgins and creoles do in the sphere of trade between cultures.[95] The trading zone is usually limited however to interactions between (sub-) disciplines, technicians and engineers, implicitly excluding heterogeneous societal actors. And although it can be expressed materially, the trading zone concept is primarily linguistic. The same goes for Secord's 'circulation', which is understood in terms of *communication* between individuals within *specialised* communities.

To many ears, circulation rings too smooth as metaphor for the mobility of knowledge. Its emergence in scholarship concurred with the socio-cultural phenomenon of 'globalisation'. The risk of a focus on global interconnections and the flow of ideas, people and things, would be that it erases inequality, difference and power. To use Anna Tsing's metaphor, through the lens of circulation we stare at the creek, and only notice the water running. Rather, we should also pay attention to the channel that embeds this flow. Translated to the circulation of knowledge: 'political and economic channels' as well as 'material and institutional infrastructures' enable and stimulate the flow of knowledge.[96] In addition, circulation has been criticised because it seems to endorse an implicit model of knowledge production, consisting of three subsequent stages: data collection 'outside', which is processed into knowledge in a controlled and segregated laboratory, and then finally the spread (and acceptance) of this knowledge in the larger world. The materials, ideas and skills going in and out of the lab might move through space, but as scientific knowledge they remain stable. But, according to Kapil Raj, circulation should instead bring to the fore the 'mutable nature of the materials' (including actors, their embodied knowledge and skills) and the 'transformations and reconfigurations in the course of their geographical and/or social displacement'.[97] Or, to put that differently, the study of circulation should take account also of the obstacles, hindrances, detours and alterations of knowledge in transit.[98]

The mutability and infrastructural embedding of knowledge flows relate to 'immutable mobiles'. In *Science in Action*, Bruno Latour introduced this concept to explain the travel of scientific

94 James A. Secord, "Knowledge in Transit," *Isis* 95, no. 4 (2004): 662.

95 Peter Galison, "Trading with the Enemy," in *Trading Zones and Interactional Expertise. Creating New Kinds of Collaboration*, ed. Michael Gorman (Cambridge, MA: MIT Press, 2010), 25–52.

96 Anna Tsing, "The Global Situation," *Cultural Anthropology* 15, no. 3 (2000): 336–38.

97 Raj, *Relocating Modern Science*, 20–21.

98 Wiebke Keim, "Conceptualizing Circulation of Knowledge in the Social Sciences," in *Global Knowledge Production in the Social Sciences*, ed. Wiebke Keim, Ercüment Çelik, and Veronika Wöhrer (London: Routledge, 2014), 107–134.

knowledge: first, raw data travel as immutable mobiles to 'centres of calculation', where they are combined with others to produce scientific facts, which subsequently can travel as new immutable mobile from these local situations of production to laboratories elsewhere.[99] Or, in Simon Schaffer's words: 'We should then distinguish between the process of 'localisation', through which local techniques get to work at sites like labs via the concentration of widely distributed resources, and 'spatialisation', through which techniques which are efficacious within the lab, manage to travel beyond it.'[100] Characteristic of scientific knowledge, then, is that it can move in geographic space, while retaining its meaning, characteristics and effects by institutionalisation and standardisation. Preventing 'slippage within the network' is precisely the point of scientific practices but seems at odds with the origins of the circulation metaphor. In economic models of wealth creation through trade the circulation of money and commodities requires that 'not everywhere [is] the same as everywhere else', the opposite is required for the 'circulation' of scientific knowledge.[101]

Although Raj retains the circulation metaphor, he launches a fundamental criticism of the immutability of scientific knowledge. Instead, he proposes to consider the material of science as 'mutable mobiles', as they also change shape in the process of circulation. John Law and Annemarie Mol explicated these concepts by distinguishing between the different kinds of 'space' in which change takes place. Both Raj and Latour agree that technological and scientific things displace geographically, i.e. they are mobile in the geometric sense of space. But where Latour claims that the mobiles maintain stability in the 'network space', Raj argues that also this space mutates: that is, their position in the network—the relations to a whole configuration (or: channel) of other things, people and ideas (or: actants)—that defines their functioning and meaning *also* changes as they change places.

Law and Mol rather understand both mutable and immutable mobiles to be modalities of the circulation and spatiality of knowledge. What they dub 'fluid' spatiality allows the geographical *and* gradual network displacement of a thing, similar to Raj's concerns.[102] In their interpretation, we can distinguish this as one of four 'topological systems': with 'regions' they capture the attention for the 'local' sites of knowledge production (the 'somewhere' of research, as an immutable immobile); with 'network' the possibility of stability during travel (immutable mobile); with 'fluid', as mentioned, the possibility of configurational variance during geographical displacement (mutable mobile); and lastly, they add a 'fire' topology to exhaust the possibilities of Latour's original concept, namely to represent a 'mutable immobile'. The fire spatiality returns to the local, but now finds the global as always already a part of it. Things that remain in place, but in flickering patterns show the

99 Latour, *Science in Action*.

100 S. Schaffer, "The Eighteenth Brumaire of Bruno Latour," *Studies in History and Philosophy of Science* 22, no. 1 (1991): 190; Richard C. Powell, "Geographies of Science: Histories, Localities, Practices, Futures," *Progress in Human Geography* 31, no. 3 (2007): 313.

101 Dear, "Science Is Dead; Long Live Science," 49.

102 John Law and Annemarie Mol, "Situating Technoscience: An Inquiry into Spatialities," *Environment and Planning D: Society and Space* 19, no. 5 (2001): 609–21.

presence and absence of distant but conjoined alterities.[103] In a similar fashion, Tsing stresses that the local is *not* a stopping point for global circulations; rather, flow does not transcend or obliterate place, but is continuously 'making terrain' and 'making place'.[104] Also Raj's proposal to study circulation as 'site of knowledge production' takes the enduring significance of localities into account, while simultaneously calling out the historicity of the 'nature and geography of the spaces of circulation'.[105] As such, the historical and anthropological exploration of modalities of circulation concurs with the post-structuralist relational space, as it integrates 'space' and 'place', dynamism and stasis, the past, present and future.

Still, much literature in history and philosophy of science is focused on the transfer of knowledge between spatially dispersed specialised communities, (sub)disciplines and heterogeneous actors within a disciplinary practice. Although this literature often takes social, cultural and political factors into account, the focus is on movement of knowledge within 'scientific' boundaries. By delimiting the study of circulation, epistemic transfer, or 'flow of cognitive goods' to intra-scientific displacements between different disciplines (e.g. at the intersection of history and physics), these approaches participate in, or reproduce, boundary work; that is, it is implicated that knowledge exchange with society is not of similar epistemic interest.[106] However, constructivist studies of knowledge production support the idea that these different processes of knowledge exchange are epistemologically on a par (see section 1.3 above).[107] What is required therefore is the productive synthesis of two bodies of literature: one focusing on the political epistemology of *useful* research and one taking the *circulation* of scientific research as its site of analysis. Crosbie Smith and Jon Agar have pointed in this direction, when they ended their introduction to *Making Space for Science* with a section 'Of Knowledge Transfer'.[108] But an overarching analytical perspective on the circulation of useful knowledge is still lacking. In the following section of this introduction I therefore propose the heuristic concept *utility spot* to highlight, study and interpret the intersection of spatiality and usefulness in (the history of) scientific practice. This is the basis for a historical-geographic approach to the epistemology of useful research.

## 1.7 A Spatial Approach to the Utility of Scientific Research

The argument of this dissertation is that a spatio-historical approach is a fruitful way to study epistemological questions about science policy concepts. This concerns questions about the relation between knowledge production and value creation, and whether interactions with non-academic actors are

103 Law and Mol, 610–16.

104 Tsing, "The Global Situation," 338.

105 Raj, *Relocating Modern Science*, 234; Keim, "Conceptualizing Circulation of Knowledge in the Social Sciences."

106 Rens Bod et al., "The Flow of Cognitive Goods: A Historiographical Framework for the Study of Epistemic Transfer," *Isis* 110, no. 3 (2019): 483–496; Catherine Herfeld and Chiara Lisciandra, "Knowledge Transfer and Its Contexts," *Studies in History and Philosophy of Science Part A* 77 (2019): 1–10.

107 Smit and Hessels, "The Production of Scientific and Societal Value in Research Evaluation."

108 Crosbie W. Smith and Jon Agar, "Introduction: Making Space for Science," in *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, ed. Crosbie W. Smith and Jon Agar, Science Technology and Medicine in Modern History (Basingstoke: Macmillan Press, 1998), 21–23.

conceptually, practically, temporally and spatially part of the research process. The concrete geographic, architectural and spatial arrangements for useful scientific research on which these concepts build, or that have been built because of these concepts, expose answers and entail political epistemologies. In this dissertation I will therefore study the *places* that stimulate and shape the interactions between 'scientific' and 'societal' actors, to be able to map useful knowledge production in circulation. Or what I call *utility spots*. As a heuristic concept, 'utility spot' is proposed as conjectural hypothesis that will inform, and be informed by, empirical studies. Its plausibility, in conclusion, will depend on its usefulness for the organisation and interpretation of historical reconstructions of scientific practice.[109] In this section, I combine the epistemology of useful research and the spatiality of scientific research into a historical-geographical approach to the meta-scientific concept of utility and its concrete instantiations in science policy concepts such as knowledge transfer, societal relevance and valorisation.

As might be obvious from the above, my methodological focus is informed by the broad field of science studies, especially historical and anthropological approaches to the geography, architecture and spatiality of research. There exists, however, also an extensive body of research on the economic geography of innovation. Much of this literature focuses more on firms and industries than on university knowledge production.[110] One important strand of research that is concerned with university-industry knowledge exchange focuses on the relation between (tacit) knowledge spill-overs and geographical location. Similar to the economic studies of utility, these studies are mainly interested in relating inputs (like the number of prominent researchers or publications) to outputs (like the number of new biotech firms or citations in patents).[111] In this particular case, their local and regional focus adds a spatial dimension to the understanding of the relations between science and society. However, these economic approaches tend to overemphasize the concrete (quantifiable) products of research in terms of new firms, patents, and profits, whereby they also adopt a limited (ahistorical and apolitical) understanding of usefulness and knowledge exchange.

The utility spot concept, and my historical geographical approach more in general, is instead informed by concepts that have been used to understand (post-) colonial knowledge circulation as well as knowledge exchange between science and society. This is not just a coincidental combination; Latour, for example, uses imperialistic discourse to discuss the circulation of knowledge through society because it have been 'patterns of military domination, colonialism and worldwide trade' that created the channels for the spread of knowledge.[112] And post-colonial critiques challenge linear models of knowledge transfer from centre to periphery (or North to South),

109 Compare the 'conjectural hypothesis' of instrumentality in: Dear, "Science Is Dead; Long Live Science." (pp.40, 55)

110 Augusto Cusinato and Andreas Philippopoulos-Mihalopoulos, *Knowledge-Creating Milieus in Europe* (Springer, 2016).

111 Ajay K. Agrawal, "University-to-Industry Knowledge Transfer: Literature Review and Unanswered Questions," *International Journal of Management Reviews* 3, no. 4 (2001): 294–96; Jeremy R. L. Howells, "Tacit Knowledge, Innovation and Economic Geography," *Urban Studies* 39, no. 5–6 (2002): 871–84.

112 Shapin, "Placing the View from Nowhere."

while science studies attack linear models of knowledge transfer from science to society. In the former, the emphasis is on the geographical displacement of knowledge within specialised communities. In the latter, the emphasis is instead on the movement of knowledge from a specialised community to a practical realm, and this is assumed to take place within a relatively homogeneous geographical space (like a nation). In both cases, 'linearity' of these relationships is the straw man to criticise. Instead, these scholars stress interaction, transformation and negotiation patterns between actors spread in either social or geographical space. When we consider both processes as interactions between different cultures or communities (without reifying them into homogeneous units) they are both processes of knowledge-production-in-circulation. These processes are themselves sites of knowledge production, and are not ephemeral but can be, and often are, situated in specific locales. The concept of utility spot is a lens to identify, magnify and examine such places.

Conceptually, I define utility spot dialectically with respect to three concepts from science studies and postcolonial studies that pay due to the locality of circulation. First, utility spot is an epistemological mirror-image of *truth spot*. I endorse Thomas Gieryn's attention for the geographic, architectural and rhetoric arrangements as well as cultural meanings that embed the practice of scientific research.[113] But where his concern ultimately is for *credibility* of knowledge, for example in relation to an international specialised scientific community, mine is for the *utility* of knowledge, precisely realised outside this 'internal' community. Second, I therefore adopt aspects of *spaces of circulation*, which direct our attention to the requirements for the exchange of knowledge to society. The movement of immutable mobiles, or the process of spatialisation, requires nodes in the network that function as landing strips, where practices also work outside their original site of production. Interpreting Pasteur's vaccination work, for example, Latour argues that knowledge was able to move—as an immutable mobile—from his laboratory into society by creating new local spaces where they could land, on which the required network space was transposed.[114] Building on the work of Latour, and Schaffer's interpretation of it, I aim to further concretise the spatialisation process in specific spots.

Utility spots thus are not only extensions of sites of knowledge production, but also testing grounds for societal use. This is, thirdly, stressed also by *contact zones*: the configuration for circulation of knowledge is determined by all involved actors. Mary Louis Pratt describes these zones, especially with respect to colonial situations and their aftermath, as 'social spaces where cultures meet, clash and grapple with each other, often in contexts of highly asymmetrical relations of power'.[115]

113 Gieryn, *Truth-Spots*.

114 Bruno Latour, "Give Me a Laboratory and I Will Raise the World," in *Science Observed. Perspectives on The Social Study of Science.*, ed. Karin Knorr-Cetina and Michael Mulkay (London: SAGE Publications Ltd, 1983), 141–70; Schaffer, "The Eighteenth Brumaire of Bruno Latour."

115 Mary Louise Pratt, "Arts of the Contact Zone," *Profession*, 1991, 34; Mary Louise Pratt, *Imperial Eyes: Travel Writing and Transculturation* (London and New York: Routledge, 1992).

‘Transculturation’ takes place: through strategies of critique, collaboration, translation, mediation, parody and denunciation also marginal groups selectively appropriate parts of the dominant actor into their traditions. Kapil Raj generalises the contact zone as a space for mutable mobiles, with a focus on ‘encounters … between different types of human activity—trade, statecraft, and knowledge-making—in the same or different geographical settings’. As different practices, knowledges and people come together in these contact zones, attempting to create a common world, the role of mediators emerges as crucial.[116]

Contact zones, spaces of circulation and truth spots respond to the question of travelling knowledge, without completely obliterating the importance of place. To understand places of knowledge transfer to society, *utility spot* combines the attention for the meeting place of heterogeneous cultures and its politics of the contact zone, with the emphasis on networks of spaces of circulation and the contextual meanings of a particular place of truth spots. I propose the following initial working definition:

> Utility spots consist of the spatial arrangements that facilitate and stimulate the political-epistemic interactions between heterogeneous actors, which actively shape the significance of research, with the public aim of creating and circulating useful scientific knowledge.

In this way, I view scientific sites of knowledge production and exchange not only as contexts of veracity, reliability and control, but especially as contexts of utility, extra-academic interactivity and power struggles. Analytically, I approach these spatial arrangements as modal conditions: they structure what useful research is considered possible. In the following chapters, I will use this framework to be able to identify such places in post-war Western societies. Reciprocally, the historical study of concrete meeting places will inform further refinements of the conceptual approach. The analysis of these places is informed by the concept of relational space, so that I will take seriously physical structures of various utility spots in relation to the social, cultural and power relations that form their fabric. Without reducing the spatial to the social, or vice versa, the utility spot concept serves as a lens that brings out the historically changing networks of useful research. Ultimately, my aim is to make past and current science policy (concepts) tangible by situating its problems, instruments and effects in concrete places and geographical dynamics. In the following section, I elaborate on recent Dutch valorisation policy to explicate what kind of epistemological questions will be investigated through the utility spot concept.

116 Raj, *Relocating Modern Science*, 225–33.

## 1.8 The Valorisation of Scientific Research

'I like to see science [*wetenschap*] as a city. A beautiful, strong fortified city [*vestingstad*],' spoke the Dutch secretary of state for science at the beginning of 2017, when he sent the 'valorisation letter' to parliament. Instead of an ivory tower, he continued, science as city sustained 'interactions with the world around it, [which] have, fortunately, increased in the last few years'.[117] Valorisation—'value creation from knowledge'—seemed to become the central concept of Dutch science policy after a decade of debate. In 2004, the Dutch minister responsible for science introduced valorisation in a strictly economic sense but it was hastily 'broadened' to include 'societal value' as well.[118] It had to encompass and stimulate a variety of activities, such as dissemination, application and co-production of scientific research. Notwithstanding plenty of opposition from the Dutch academic community, it materialised into specific 'valorisation paragraphs' in grant proposal assessments at funding organisations, valorisation support centres at universities, as well as rankings and indicators to evaluate 'valorisability' of research, researchers and universities. But the resistance persisted; the Royal Dutch Academy of Sciences (KNAW), representing the academic elite in the Netherlands, for example rejected valorisation because it still carried 'for many an economic connotation'.[119] A criticism that the new minister of Education, Culture and Science seemed to comply with when she restricted herself to the term 'societal impact' in a recent policy letter.[120]

Historically, the concept of valorisation first rings economically. Taking a conceptual historical approach, one could trace it to the English translation of Karl Marx's *Capital*. There, valorisation (*Verwertung*) denotes the creation of surplus value by labour power 'in the secret laboratory of production'. It is the process by which capitalist production escapes the paradigm of exchange. In French, valorisation is also used in a more abstract sense as an act that 'assigns greater value to something'. Philosopher of science Gaston Bachelard for example, in *L'air et les songes* (1943), described life as a poetic process of valorisation.[121] Etymologically, valorisation derives from the Latin *valor*, or value. The valorisation of scientific research thus has to do with the value of knowledge. More precisely, with a process of *valuing* knowledge. As valuation practice, we have to distinguish valorisation from evaluation.[122] In evaluating something—scientific research—we are merely estimating its value; when we valorise it, its value is actually modified. Where evaluation does not create value, but unveils a value already present in the good, valorisation adds value to the good. This distinction between evaluation and valorisation seems to parallel the difference between Bachelard's and Marx's use of the term.

117 All translations from Dutch are my own, including those used in quotations. 'Van publicatiedrift naar wetenschap met impact', *ScienceGuide*, 19 January 2017; State secretary of Education, Culture and Science, 'Wetenschap met impact', Parliamentary Papers 2016–2017, 31 288 (574), 19 January 2017.

118 Stefan P. L. de Jong, Jorrit Smit, and Leonie van Drooge, "Scientists' Response to Societal Impact Policies: A Policy Paradox," *Science & Public Policy (SPP)* 43, no. 1 (2016): 102–14.

119 KNAW, *Maatschappelijke impact in kaart* (Amsterdam: KNAW, 2018), 30.

120 Ministerie van Onderwijs, Cultuur en Wetenschap, *Nieuwsgierig en betrokken – de waarde van wetenschap.* (Den Haag: Ministerie van Onderwijs, Cultuur en Wetenschap (OCW), 2019).

121 Karl Marx, *Capital Volume 1*, trans. Ben Fowkes (London: Penguin Books, 1976), 293–306; Gaston Bachelard, *L'air et les songes* (Paris: José Corti, 1943).

122 François Vatin, "Valuation as Evaluating and Valorizing," *Valuation Studies* 1, no. 1 (2013): 31–50.

Even when we broaden our view from concepts to practices, valorisation still encompasses activities in the economic sphere of value increase and (re)creation: as a process to increase a product's exchange value on the market or as a process to create surplus value from products. For commodities like herring, dairy, coal, cacao, and coffee the issue of valorisation was raised whenever more monetary value had to be generated from existing production processes. Brazilian coffee producers and American cotton planters for example dominated the world market by conducting 'valorisation projects': they collected their coffee or cotton in a central depot, which required capital investments by the state, and then set prices by controlling distribution to the world market.[123] At other times, valorisation denoted specifically the exploration of new production processes to create more use value. Fisheries, for example, discussed in valorisation committees the conversion of pollack into animal flour.[124] In this sense, it connected to the use of the term in the context of valorising 'waste streams': the creation of 'useful applications' from residual goods through, for instance, chemical research.[125] Historically, then, valorisation refers both to practices that *increase* and practices that *create* value. The difference lies in the relation of valorisation to its object: value increase merely updates the value of the good through extrinsic measures (like control of distribution, cf. evaluation); value creation modifies the good itself, through new or improved production processes. It is the latter that takes place in the 'secret laboratory of production'.

Nowadays, one can speak not only of the valorisation of cotton and coffee, but also of the valorisation of scientific research. What does valorisation then entail epistemologically? In Dutch policy circles, including the ministry for Education and Science and intermediary bodies like the national research council and the association of universities, some consensus developed between 2005 and 2015 about the definition of valorisation. Namely, that it is a process that appears in diverse modalities and that leads not only to economic but also to societal use.[126] The Rathenau Institute, a publicly funded Dutch think tank for science policy and technology assessment, in 2011 articulated the definition that is currently in use at universities and the ministry:

> Valorisation is the process of creating value from knowledge by making it suitable and/or available for economic and/or societal use and translating it into [competitive] products, services, processes and entrepreneurial activity.[127]

This definition prompts epistemological questions such as: how do knowledge production and value creation exactly relate to each other? Are the same actors involved in both? Is valorisation part of the research process, or are they

123 Mercator, "Handelskroniek," *De Economist* 56, no. 1 (1907): 254–259; Th Luytelaer and J. Tinbergen, "De Koffievalorisaties: Geschiedenis en Resultaten," *De Economist* 81, no. 1 (1932): 517–538.

124 Nationaal Archief Den Haag (NA), Stichting Nederlandse Visserij, 2.19.031.02 inv.nr. 100, 'Valorisatie-cie, 1969–1970'.

125 NA, Ministerie van Landbouw; Directie Landbouwkundig Onderzoek, 2.11.73 inv.nr. 1148, 'Valorisatie van afvalstoffen 1986–1988.'.

126 de Jong, Smit, and van Drooge, "Scientists' Response to Societal Impact Policies," 108.

127 Leonie van Drooge et al., *Waardevol – Indicatoren voor Valorisatie* (Den Haag: Rathenau Instituut, 2011).

conceptually, practically, temporally and spatially distinct? Or, more generally put, is the utility of knowledge intrinsic or extrinsic to scientific research? Notwithstanding its apparently broad concept of value, an obdurate aura of commercial exploitation has persisted in policy contexts. The conceptual histories of valorisation can only partly explain this. The main thrust of this dissertation is instead that utility spots structure the epistemological questions and policy debates about the relation between research and value creation, and vice versa. In the conclusion of this dissertation, I will situate valorisation therefore with respect to real and imaginative spatial arrangements, *the science park* in particular. The historical part of this dissertation can thus also be viewed as an analysis of the emergence and circulation of this type of utility spot—and its impact on policy.

## 1.9 Overview

In the remainder of this dissertation, I develop the *utility spot* concept to test its fruitfulness as historical-geographical approach to the epistemology of useful research. My method will be historical in nature, with a main focus on the post-war period, 1950–1990, and on the United States, Western Europe and the Netherlands. A special interest lies with the transformation of universities and academic space more generally; this follows from the fact that a large share of publicly funded research takes place at universities and that science policy concepts like valorisation apply to this realm specifically. First, I will survey literature on utility spots in the US to refine the concept. Secondly, I will employ the spatial lens to revise history of science policy and universities in three chapters on utility spots in the Netherlands and Europe. These reconstructions will make manifest the spatiality and geopolitics of science policy, as well as the particularities of the circulation of utility spot models. I will cover this historical ground to develop further the methodological approach that I have introduced conceptually above. In the conclusion, I reflect in more abstract terms on the relations between the various excursions and what they have afforded us conceptually. As a consequence, I propose a fully developed definition of the utility spot concept that can incite further research.

Chapter 2, 'Utility Spots in the United States: Architecture, Location and Circulation', surveys the historiography of the organisation of scientific research in the US in the twentieth century through a spatial lens. This survey touches upon epistemological issues of knowledge production and transfer: the impact of external funders on the form and content of research as well as the debated existence of a linear model of innovation. But these themes will consistently be interpreted spatially by describing the scholarship on specific places of knowledge production that have functioned as paradigms of useful research, from Bell laboratories to RadLabs and Silicon Valley. Special attention goes to the origins of this last place, and the Stanford science park model more specifically, and its relation to larger political-economic shifts in the 1980s. From this I draw architectural, location and circulation aspects of the utility spot concept.

The employment of the spatio-historical approach in chapters 3 and 4 leads to a revision in the Dutch history of science (policy): concrete spatial tensions in, and virtual spatial solutions for, the organisation of useful research preceded (more abstract) science policy discussions in the 1960s. Chapter 3, 'The Spatiality of Science Policy. Para-University Institutes for Sponsored Research, 1954–1963', looks at a bottom-up, interuniversity debate about the appropriate place for independent and contract research in technical and general universities in the Netherlands. Policymakers, university governors, professors and industrialists discussed, in spatial terms, the organisation of useful research on campus. The ideal distance between academic and extra-academic actors turned out to be a delicate issue. Chapter 4, 'The Geopolitics of European Universities and Advanced Institutes for Humanities, 1955–1975', discusses that same issue on a larger scale, namely in terms of an international academic institution that would contribute to European cultural, scientific and/or economic integration. These virtual utility spots—plans for places of useful knowledge production—shaped political debates about the organisation of research also within the Netherlands. In particular, I will make a connection to an advanced institute for the social sciences and humanities, to show how internationally circulating spatial models are implemented locally.

Chapter 5, 'The Spatial Politics of Knowledge Transfer. From Science Shop to Science Park, 1970–1985', ties together the preceding historical chapters. It acts at the intersection of the circulation of North American models of useful research, for which the political-economic origins of the research park are relevant, and the local European histories of organising research for societal purposes. I describe the shift from the democratisation to the commercialisation of academic research in terms of various utility spots that were imagined and built in the late twentieth century: science shops, transfer points, technological business centres and science parks. Besides explicating the political and epistemic origins of these places, I relate them to changes in science policy: they both reflected new concepts, such as innovation, and informed new legislations, in this case an article on knowledge transfer in the Scientific Education Act. The science park, still today a shining example of the promise of progress through scientific research, will emerge as both a continuation, displacement and spatial transformation of the political-epistemic coalitions surrounding university research.

Each chapter on concrete utility spots in Dutch university history (chapters 3, 4 and 5) commences with a public university event where the utility of research was explicitly or implicitly at stake. These chapter openings serve two functions in the historical narrative of this dissertation. First of all, the successive discussion of events in 1954, 1963, 1975 and 1985 allows me to describe changes in the ideology and identity of academic actors and institutions. Here I follow an anthropologically informed approach that views public events like rituals, as instances of 'the enactment of new institutional narratives' and 'the symbolical articulation of the shifting political relations within the universities as well as between the universities and external actors within the society at large'.[128] At typical academic rituals like a university's dies natalis or lustrum I probe changing dynamics within and around academic knowledge production. This connects to the second, historiographical function of these festive events: just as the historical actors used these events to pause for reflection, I will employ them to review historiographical claims about change and continuity in the organisation of (useful) research in the respective periods. By situating such temporal concerns at the start, I can concentrate on the spatiality of useful research in the main body of the chapters.

In the concluding chapter, I summarise the findings from the historical experiments with the conjectural utility spot concept and distinguish three relevant analytic dimensions: the *politics of proximity*, the *spatiality of science policy* and the *spatial imagination of useful research*. In terms of the *politics of proximity* I will draw epistemological consequences of the spatial organisation and circulation of useful research. The embedding of this conceptual aspect of utility spots in social studies of innovation and socio-technical transitions will prompt a call for further fine-grained studies of utility spots both in the past and the present. In terms of the *spatiality of science policy*, I claim that abstract concepts, strategies and regulations often originate in concrete spatial issues and typically have geographic effects. I will illustrate this briefly by applying the spatio-historical approach to the current valorisation concept. Viewed through the utility spot lens, the science park emerges as spatial model for valorisation which enables an alternative explanation of the controversy surrounding the concept. Lastly, I will explore potential futures for a societally relevant science by taking seriously the role of the *spatial imagination of useful research*. This methodological introduction started with Bacon as the father of a modern ideal of useful knowledge production; in the last chapter I also visit his science policy utopia: *New Atlantis*. Spatial imaginaries have (had) the potential to direct our

128 Wil G. Pansters and Henk J. van Rinsum, "Enacting Identity and Transition: Public Events and Rituals in the University (Mexico and South Africa)," *Minerva* 54 (2016): 22.

thinking about, and acting upon, the organisation of scientific research—and the tensions between the different goals and conditions for science, from autonomy to societal relevance. This dissertation therefore ends with a speculative outlook on the potential value of scientific research, in spatial terms.