

1 Science, Culture, and Modern State Formation

Theory and Analysis

A newly invigorated synthesis is under way in science and technology studies (STS), one that gives as much attention to broad sociological questions concerning organizational, institutional, and state forms of power as it does to more micro-issues raised by the focus on epistemological questions. The effort has been evident for some time in the work of a wide range of STS scholars, such as Bruno Latour, John Law, Steven Shapin, Karen Knorr-Cetina, and Donald McKenzie. It is currently reflected in organizational studies (for instance, the work of Diane Vaughan),¹ in the sociology of science (for instance, the work of Thomas Gieryn),² and in analyses of socio-technical networks.³ More recently, Sheila Jasanoff and others have laid out an expansive research agenda around the theme of the “co-production of science and social order.” Such work is not only forging productive dialogue between STS and broader sociological traditions but also opening up opportunities to reconnect with earlier research that has much to offer contemporary social scientists.

As well as Merton’s early work on the institutionalization of a new technology-centered science in seventeenth-century England, and Boris Hessen’s work on the relationship between Newtonian mechanics and industrial capitalism, Edgar Zilsel’s “The Sociological Roots of Science” has generated a great deal of renewed interest.⁴ Originally published in 1942, Zilsel’s article was reprinted in 2000, with commentary, in *Social Studies of Science*. Zilsel linked the development of capitalism directly to the birth of the new experimental science in the sixteenth and seventeenth centuries, suggesting that the rise of craft knowledge with respect to literary knowledge created a new synthesis of theory and practice. Zilsel’s analysis centrally informs my elaboration of the concept of engine science, since it shows the importance of the *integration* of practical mathematics (mechanics), engineering, and theory

in the development of a specifically modern and crucially Baconian science. The idiom *engine science* foregrounds ingenuity and design, material technologies of inquiry, and power and control as key to the success of the new science. However, while Zilsel suggested that the new synthesis resulted from a “breakdown of social barriers.”⁵ An aristocracy of the intellect eventually subordinated engineering to theory, viewing the latter as the wellspring of scientific knowledge and the former as its “mere application.” But STS has shown that abstract theory and practical engineering stand in a dynamic and dialectical relationship in modern scientific practice, that the power and success of modern science lies in this relationship, and that it is a relationship crucially mediated by the language of mathematics. Science is no longer conceived in terms of purity (the idea of “pure science”) and is not reducible to any one of these three key elements, each of which at any moment in history is a specific and semiautonomous cultural formation. The conceptualization of science as “impure” opens up new ways of thinking about the question of the relationship between science and the state.⁶ The purpose of this chapter is to introduce my conceptualization of that relationship, explain how a cultural analysis of science reveals the unique character of *modern* states, and discuss the implications for how we think about the state.

Charles Tilly has developed one of the most influential general theories of state formation.⁷ For Tilly, the crucial activity of states is coercion, but they must make concessions to groups in order to raise the capital required for both building their coercive structures and waging their coercive campaigns.⁸ The theoretical beauty of Tilly’s model lies in its empirical reach. It is practically universal in scope, covering some ten thousand years of state history across all regions of Europe (perhaps even the world). At the same time it orders all the diversity of state forms (which Tilly readily acknowledges and documents copiously) into three basic types: coercion-intensive, capital-intensive, and capitalized-coercion.⁹ Tilly’s model readily explains key aspects of state formation in Ireland. War making and resource mobilization were without question the basic grounds for what John Walton calls “conquest and incorporation.”¹⁰ My own analysis is consistent with this general model but aims at a more particularized explanation of the specificity, and indeed uniqueness, of the modern Western state. Just as Walton turns to culture and ideology as a way of providing a more historically grounded explanation of local collective action and its relationship to broad societal forces and change, so I argue that by conceptualizing science in cultural terms we can fully appreciate its significance for the formation of the modern state. While reference to science is not required for the kind of general theory that Tilly has developed, it is crucial with respect to the particularity of

the modern Western state. The rise of modern science, at the center of which is a special form of experimental and engineering practice, becomes institutionalized only within a limited area of Europe between the seventeenth and nineteenth centuries. This new science, I suggest, transformed the activities of governing, the processes of capital accumulation, and the relationship between the two. Government and capital accumulation, in turn, shaped the development of science in a process of coproduction.¹¹

SCIENCE, CULTURE, AND CAUSALITY

Science is a transformative collective activity rooted in local communities of meaning and extended over time through various strategies and technologies to the level of a social movement and social institution. Collective action in the domain of science confronts the same difficulties identified by Walton with respect to more explicitly political organizations, unfolding within a moral economy that constantly reconstructs its past in the face of immediate obstacles. In this process science constructs an ideology of legend, remembering its past in terms of heroic and stoic individuals struggling against irrationality, ignorance, and obfuscation. Local articulations of what science is and what it offers emerge in relation to wider social conditions, not least of which are the demands and expectations of statecraft and the need for any particular vision of science to secure the blessing of government (no matter how begrudgingly). As political power was centralized in the early modern state, scientific practitioners were confronted by new limitations and opportunities. Experimentalists were forced to defend their natural philosophy against philosophical, political, and religious enemies, but they did not do so simply in the negative sense of resistance. The early experimental philosophers actively pursued new opportunities to align their designs with religious precepts and political realities. They spoke of mathematics as the language of God, and of God himself as a designing engineer. They offered up scheme after scheme for the “Empire of Man over Nature,” and more specifically for the aggrandizement of the state and the invigoration of economic development. Their capacity to deliver on these claims in the short term is not the issue here: the point, rather, is to explain how the culture of the new science moved from a local form of collective action to an institutionalized culture that caused the emergence of a state form that was without precedent in world history.

The key theoretical issue is how to conceive of culture,¹² and a useful way of introducing my approach is by comparing how Walton and Tilly

theorize the concept. Both conceive of culture in broadly cognitive terms, but their emphases are sufficiently different that they lead to a divergent argument concerning culture's efficacy as an *explanatory* category with respect to social (or collective) action. Drawing upon Clifford Geertz, Walton defines culture as "the meanings that people construct for their lives and their environment."¹³ Tilly defines it in a similarly cognitive fashion, as "shared understandings and their representations."¹⁴ The emphasis for Walton, however, is on the *active construction* of meaning rather than simply the fact that such meanings are shared. Walton seeks to establish culture as an explanatory category with respect to "collective action," whereas Tilly argues that we should start with "social interaction" and from that point of departure explain culture.¹⁵

Like Walton, I seek to advance a conceptualization of culture as a causal explanatory category, one that can explain historical change. However, I wish to advance a concept of culture that goes beyond the realm of symbolic meaning. With Stuart Hall and Chandra Mukerji, I suggest that we should also view culture as belonging to the realms of practice and materiality. Hall, for instance, argues that culture encompasses "both the meanings and values which arise amongst distinctive social groups and classes . . . [and] the lived traditions and practices through which those 'understandings' are expressed and in which they are embodied."¹⁶ Mukerji shows how culture becomes embodied in the material world, acting back on cognitive meanings and organizational practices in uniquely powerful ways.¹⁷ As George Steinmetz points out, this broader concept of culture is distinctively "socioanthropological," and its elements can be traced back, if somewhat vaguely, to the late eighteenth century.¹⁸ John Hall, Mary Jo Neitz, and Marshall Battani have recently affirmed that all three elements should be included in the concept of culture, placing particular emphasis on the need to theorize the material dimension.¹⁹ What I wish to do is articulate these three elements in a more explicit and theoretically symmetrical way and elaborate on each as a crucially structural pillar in the "architecture of culture."²⁰

TRIANGULATING CULTURE: DISCOURSE, PRACTICE, AND MATERIALITY

All three dimensions of cultural formation—discourse, practice, materiality—can be granted their peculiar agential power, though in a manner, and this is a crucial point, that does not theoretically subordinate one dimension to

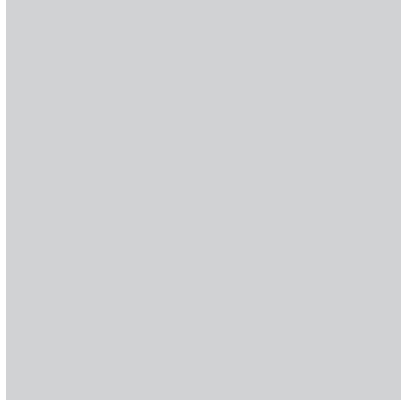


FIGURE 2. Triangulating culture.

the other. The relative agency of discourse (symbolic meaning, representation, and cognitive structure), practice (social activity variously organized), and materiality (constructed environments, spaces, and technologies) in processes of cultural formation can be treated as an empirical issue to be settled in each case by research. The Royal Society of London (1660), for instance, is an organizational form of collective action that mobilizes resources and becomes a powerful catalyst of new webs of discursive meaning. But in the approach I am proposing, culture does not thereby become secondary to organized action and resource mobilization. Rather, organizational culture becomes the primary agent with respect to the growth and institutionalization of meaning in a particular context and at a particular moment in history, for example, as it did in England in the 1660s. The collective action that led to the organization of the Dublin Society (1683), on the other hand, can be better understood as an organizational instantiation born of meanings that were already becoming institutionalized. In the English case, the organization was the forcing house of meaning; in the Irish case, the organization was established more through what DiMaggio and Powell call “mimetic processes.”²¹ As I hope will become clear, these distinctions are particularly important if one wishes to understand the material dimensions of science and the state. Figure 2 seeks to illustrate the distinctions in terms of *centers of gravity*, an analytic concept that maintains reference to embeddedness and internal relatedness.

I should perhaps anticipate a likely criticism: that by expanding the concept of culture beyond the bounds of the cognitive or discursive in order to include practice and materiality, I have drained it of any specific

theoretical efficacy. Or to put it another way, making culture embrace everything ensures that it can explain nothing. The solution cannot avoid either ontological or epistemological issues. Ontologically, it seems impossible to conceive of practices (variously organized) as anything but cultural. Skill, and the tacit knowledge that goes along with it, is a revealing example. Developing an observation made by both Michael Polanyi and Thomas Kuhn, Harry Collins has demonstrated that not only is tacit knowledge distinct from abstract knowledge in that it is acquired in practice rather than through formal communication, but also in many cases it is in principle impossible to communicate other than through practice.²² One cannot learn, for instance, to be a carpenter or surgeon from a book. Knowing how much pressure to put on a knife in order to cut through the skin of a body without cutting too deep and causing damage to organs is a knowledge that can be gained only by practicing with actual materials. Thus, practice must have its own cultural agency; it must be a form of communication that is embodied and tactile, experiential in the most material sense of the term.

With respect to the material world a similar argument can be made. The material world created and transformed by cultural discourses and practices (institutionalized and organized)—whether tools, instruments, engines, buildings, landscapes, and so on—is indisputably cultural, not simply in the meanings such a world has for social actors, but also because humanly transformed materiality embodies cultural designs, aspirations, and objectives, materializing and structuring discourses and practices. Lyn Lofland, for instance, illustrates how the materiality of an urbanscape exerts power over social interaction, structuring action in ways that could not be achieved by purely symbolic means.²³ Similarly, Chandra Mukerji has demonstrated the importance of the material culture of Versailles in the construction of Louis XIV as the Sun King and indeed of France as a new Rome.²⁴ It was not simply that the gardens functioned as a symbol but also that they served as forces that structured interaction in a manner that served symbolic articulation. And Susan Davis has shown how the great thoroughfares of modern cities provided the material conditions of possibility for the development of disciplined “parades” and “demonstrations” as new forms of political action.²⁵

The point I wish to make here, however, is that I do not advocate a conceptualization of culture that uniformly and homogeneously applies to “everything.” While from an ontological perspective it is impossible to deny the internality of culture with respect to practice and humanly transformed materiality, analytically useful distinctions can still be maintained. Applied to the state, the triangulation method results in distinctions/connections



FIGURE 3. Triangulating the state.

among the state-idea, the state-system, and the state-country. Figure 3 does not attempt to capture all aspects of the state. Its purpose, rather, is to illustrate how some of the aspects of the state with which this study is concerned map onto the analysis of culture outlined above.

STATE-IDEA, STATE-SYSTEM, AND STATE-COUNTRY

The idea of the modern state is variously institutionalized, ideological, philosophical, and scientific. In the context of these wider discourses, the modern state-idea is articulated with respect to at least six key centers of gravity: discourses of legitimacy (e.g., Hume's concept of "natural liberty"); discourses of political representation (who should be represented and by what mechanism); discourses of nation (the "nation-state" idea); discourses regarding the proper scope of government authority (e.g., with respect to the economy, political liberties, etc.); discourses of security (including generalized health and safety); and discourses of design (schemes for governing land, the built environment, and the population). The focus of this study is on discourses of design, for it is there that ideas in science and government most clearly intersect. But it should be noted that a focus on design necessarily provides a route to discussions of the other five centers of gravity, for

most matters concerning the modern state-idea ultimately become matters of design and craft, social and political engineering, and security. In terms of practice and materiality, my focus is on scientific and governing activities that targeted land, people, and the built environment. The aim is to explain how these materialities were transformed into techno-territoriality, bio-population, and infrastructural jurisdiction.

DESIGNING STATES

The French revolutionaries of the late eighteenth century were among the first to suppose that one could wipe the political slate clean and engineer a state from the bottom up on the basis of an entirely new and abstract design. Their attempt, like that of the Bolsheviks in the early twentieth century, stumbled and failed, partly because the inertia of the existing conditions called forth the application of brute force, a strategy that from the outset betrayed and corrupted the very values the revolutionaries claimed their designs sought to realize. The English took a somewhat different approach, in which a strong tradition of localism, an ideology of self-government, a peculiarly modern worship of indigenous antiquities, and a more empirically oriented idea of science than one finds in Cartesian France shaped an engineering culture that sought to build into what already existed rather than erase older forms in the name of an overly abstract rational plan.

When Ireland was completely mapped in the second quarter of the nineteenth century, enormous effort was made to research the oldest and most "authentic" civic boundaries and place-names, and their inscription on the new map affirmed continuity with antiquity. The English and French cases demonstrate how the business of engineering the modern state in different contexts drew upon divergent designing ideas, sometimes highly abstract and "rational," other times resembling those of the *bricoleur*. These ideas about the state were, one might say, "internal" to its construction. There were others who sought to understand the state from the "outside," from the perspective, in particular, of the social, political, and economic sciences. The distinction, once again, involves a center of gravity rather than an absolute or categorical separation, but the point of the distinction is to make possible a reflexive stance, one that places social-scientific conceptualizations of the state on the same level as those articulated by the state engineers. The interests of social scientists are generally quite different from those of state engineers, but that is not sufficient reason to treat the two

asymmetrically. Indeed, as discursive formations, academic constructions of meaning oftentimes exhibit an easily identifiable traffic with the ideas of state engineers. In this context an important effect of a critical reflexive stance is to question the idea of the state as an *actor*, an idea first fully elaborated by Hobbes and still central to discourses of state that emerge from both within and without the offices and chambers of government.

THE LIMITS OF THE ACTOR-STATE IDEA

While it makes sense to speak of the state as an actor in some contexts, the idiom has its limitations, because, as I hope to show, states are complex and historically changing configurations of meanings and institutions, agencies, technologies and practices, and land, built environment, and people. While sovereign governments act in the name of states, they are not coterminous with states. Indeed, to conflate “the state” with the “government” or its bureaucratic agencies is in effect to rob a people of a body politic that is importantly constituted through that people’s very corporeal being, bestowing on a particular government or regime, at a particular moment in time, the image of the universally representative state-as-actor, philosophically conceived by Hobbes as the sovereign. When social scientists uncritically adopt the idiom *the actor-state*, they do not so much describe a political reality as become agents in the construction and institutionalization of the Hobbesian state-idea, the idea that when the head of state acts, the state itself acts. John Meyer has noted the problem, acknowledging that states “are by no means really actors,”²⁶ despite the deeply institutionalized idea that they are.

Questioning the idea of the actor-state is not an idle academic exercise. Philip Abrams, one of the founders of historical sociology in Britain, has suggested that one of the crucial ways through which organized political subjection is effected in modern societies is by a particular and interested government presenting itself as the universal and disinterested organization of the society as a whole.²⁷ A particular political organization thus presents itself as a unitary entity, speaking and acting in a unitary manner and in a highly personified form. Abrams alerted sociologists to this state-supporting discursive strategy in order to warn about the ease with which social-scientific discourses might unwittingly serve it. Yet his remedy, that sociologists reject the notion of the state as a “real” object and instead focus on the ways the state-idea is constructed and legitimized, directs analysis toward ideology rather than material forms. Problematizing the personified

actor state-idea need not, however, lead analysis in this idealist direction. While accepting that such a state-idea is central to the ideological project of legitimizing organized political subjection, one need not be diverted from the ways the material environment is itself constituted as a force of moral and political governance. Like Abrams's analysis, Meyer's analysis of the state does not get us there, because he reduces the state to its "tendentious" culture, suggesting that its real foundation is a series of discursive "myths."²⁸

If treating the state-idea as *the* center of gravity of *the state* leads us into idealism, an exclusive focus on the state-system is also problematic. Treating the state-system as though it is coextensive with the state as a whole²⁹ circumvents analysis of the material forms of state power that do not reside in the apparatus of governing bureaucratic agencies. Foucault rejected such an analysis precisely because it implied the existence of another domain, that of civil society, which was set in opposition to the state, and this is one of the reasons he was "led to raise the question of power by grasping it where it is exercised and manifested, . . . without considering, for example, the presence of a state which would exercise its sovereignty upon a civil society which itself would not be the depository of analogous processes of power."³⁰ Foucault suggested that we should cut off the king's head in political theory, and work inspired by Foucault has seriously questioned the value of talking about the state as an actor.³¹ Such work has not generally done so, however, on the basis of an analysis of ideology. Rejecting the idea that power and ideology stop at the water's edge of knowledge, the work focuses on discourses of knowledge-power and the discursive rationalities of governance. Though centrally concerned with issues of science and power, "governmentality studies" largely remain at the level of discursive "mentalities." This is true even though governmentality studies emphasize the importance of science and technology in politics. As Mitchell Dean acknowledges, "thought" rather than practice is the center of gravity of governmentality studies.³²

DISCOURSE, PRACTICE, AND IDEOLOGY

Without an analysis of the ideological aspects of discourse, maintaining an efficacious analytic distinction between discourse and practice is difficult. For instance, by presenting "medical police" as an essentially German or Continental phenomenon inherently at odds with English political discourse, Thomas Osborne dispatches it as irrelevant to English history. "Britain," he

declares, “was a country without a tradition of police.”³³ Osborne arrives at this conclusion because his theoretical orientation takes discursive formations at face value. Accepting the central premise of English liberal discourse, that is, the idea of self-government, as a sufficient measure of social reality, he precludes empirical analysis of the role of government through police in eighteenth-century England. Yet as Karl Polanyi has demonstrated, the discourse of classical liberalism was crucially ideological, because there was “nothing natural about laissez faire.”³⁴ On the contrary, the “road to the free market was opened and kept open by an enormous increase in continuous, centrally organized and controlled interventionism.”³⁵

This mismatch between discourse and practice is difficult to grasp without acknowledging the ideological aspects of discourse. Polanyi’s insight is readily applicable to the history of the relationship between police and public health in England. Though the liberal discourse of nonintervention and self-regulation with respect to markets was extended into the domain of public health, that domain was, in fact, secured (to the extent that it was) by the expansion of the police power of government.³⁶ This is an important point, because it counters the claim that medical police was a feature of English colonial government but not of English domestic government. Such arguments tend to downplay the role of police in modern liberal state formation. Thus, while governmentality studies provide a rich resource for understanding the development of liberal rationalities of government, much greater attention needs to be paid to actual practices of government. This is beginning to happen. Patrick Joyce, in his remarkable book *The Rule of Freedom*, navigates the dis/continuities across discourses and practices with respect to liberalism and the modern English city, noting that liberal ideas of self-government have never fully displaced practices of police government.³⁷

Others inspired by Foucault, most notably Timothy Mitchell, have confronted the ideological problem head on, approaching the state as an “object of analysis that appears to exist simultaneously as material force and as ideological construct.”³⁸ Mitchell interrogates this and a range of other contradictions, such as that between the coherence of the analytical/popular state-idea and the incoherence of state practices, and the distinction between the state and the economy/society. He provides a much needed problematization of the basic concepts through which the state is understood, but I suggest that we need to move beyond the deconstruction of dualisms and begin instead with a single triangulated distinction among state discourses, state practices, and state materialities. The actor state-idea, because it is centered in discourse, reaches well beyond the state-system in precisely the way Foucault suggests, and by virtue of being believed it

structures a whole range of apparently nonstate practices and oppositional politics. The state-system, however, can be viewed as well bounded once it is analytically distinguished from the state-idea. The state-system is the organizational apparatus of governing organizations, from courts, legislatures, and executives to government departments, police organizations, postal systems, census offices, and so on. It is through the state-system that governing *practices materially incorporate* land, bodies, and built environment into the state-country.

STS AND HISTORICAL SOCIOLOGY

Trying to speak to many disciplines, and especially across STS and historical sociology of state formation, I sometimes make observations that are news to one paradigm but not in the least to the other. The effort to integrate the theoretical and methodological strategies of historical sociology with those of STS has, however, great potential for advancing explanation in both areas. The scientific, engineering, and technological culture that facilitated the Western takeover of the world is now being recognized for the power that it has been. Jack Goldstone, for instance, explains why the technological “effervescence” of modern Europe did not give way, as in other regions and at other historical moments, to a period of technological stagnation.³⁹ Goldstone’s emphasis on the significance of the steam engine, and the science and engineering culture that fostered its invention and development, provides a more specific explanation of the rise of the West than more general theories of rationalization, bureaucratization, institutionalization, capitalization, or modernization. Indeed, Goldstone demonstrates that much of what is cited as unique to the West can be found in many regions of the world at different points in history. The steam engine, however, was the first really powerful technology in that it transduced fire into mechanical motion, a dream pursued by a number of engine scientists in the seventeenth century, including William Petty. Though the steam engine represented a departure from previous technologies, its invention is not surprising when viewed in the context of over a century of experimental engine science, the engineering culture it fostered, and the material technologies it spawned.

One of the aims of this book is to further advance the emerging dialogue between STS and historical sociology by revealing the intimate relationship between science and statecraft. This relationship is evident when viewed in the context of the rise of modern engineering culture, the coproduction of

this culture in both scientific and governing practices, and the proliferation of institutional, organizational, and material relations between science and government. Modern statecraft is science-based as well as coercion-based. Developments in scientific statecraft are, of course, importantly related to the rise of modern political economy (in its various forms) and the social sciences generally. Equally important, however, is the reconceptualization of political objects in terms of the natural ontology attributed to them by the new experimental science in the seventeenth century. This reconceptualization resulted in land, built environment, and people becoming “boundary objects”⁴⁰ that linked science and governance together. On the basis of the concepts of “engine science” and “engineering cultures,” I seek to show that the relationship between science and state formation is profound and that a modern state is, by definition, an “engineering state.”

TRIANGULATING SCIENCE AS CULTURE

The post-foundationalist question of how to distinguish science from other domains of culture is a critical problem in current science studies.⁴¹ Once again I triangulate the question, distinguishing among the idea of science, the practices of science, and the material culture of science. (See figure 4.) Three crucial dimensions of the modern science idea can be distinguished: mechanical philosophy (the grand unifying concept), ingenuity (a cognitive culture of intellectual and technological inventiveness), and experimentalism (the concept of how to practice natural philosophy). I suggest that experimentalism implies an overarching engine science that places material technologies at the heart of natural scientific inquiry. Engine science requires the integration of natural philosophy, engineering, and mathematics *in practice*. The result is a culture of inquiry⁴² in which the conceptualizations of theory are tied to the manipulations of engineering and the operations of mathematics.

This new culture of inquiry is importantly defined by the role of material engines in the key epistemic practices of measuring, scoping, graphing, and manipulating. The four forms of material engine that correlate with these practices are meters (barometer, hydrometer, etc.), scopes (telescopes, stethoscopes, etc.), graphing technologies (cartographic instruments), and chambers (e.g., hydraulic and pneumatic technologies). I conceive of these as *epistemic engines*, because they generate objects of inquiry, institutionalize and structure practices of inquiry, and drive the research agenda.

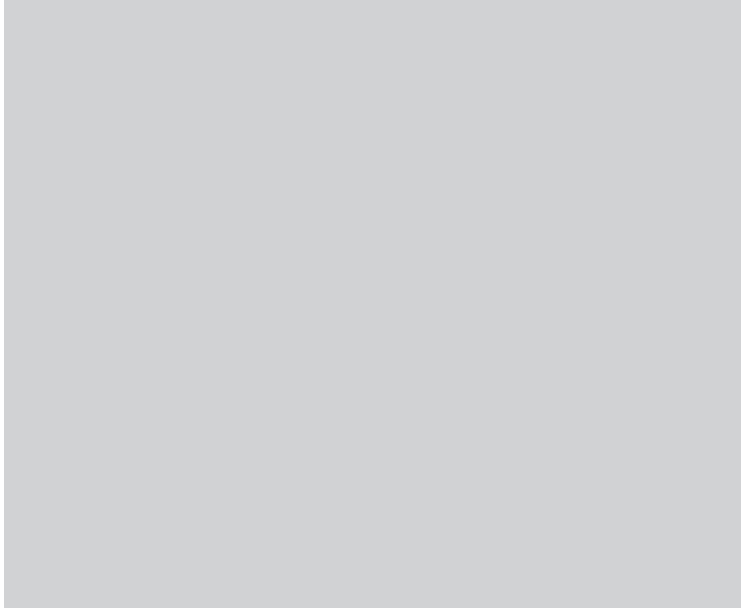


FIGURE 4. Triangulating science.

In doing so, they become what Latour calls “obligatory passage points” in scientific inquiry.⁴³ Attention to these technologies facilitates a comprehensive and naturalistic understanding of science as a very specific cultural complex of discourses, practices, and material culture. And though the specific technologies employed in statecraft may differ from those in natural inquiry, analogous practices of scoping, metering, graphing, and manipulating can be identified. Geological surveys and censuses, for instance, can be understood as terrascopes and sociometers. The point is to view the specific technologies in terms of the wider practices of engineering culture that straddle science and government in the modern period. Practices are the lynchpin between discourses and materiality, because they participate in both.

TRIANGULATING THE SCIENCE-STATE RELATIONSHIP

My conceptualization of the relationship between state and science follows the same analytic strategy. The relationship is conceived from the three angles of discourse, practice, and material culture. (See figure 5.) In this context I investigate discourses that sought to orient government practice toward experimental intervention. I connect the theological “argument



FIGURE 5. Triangulating the science-state plexus.

from design”—the conceptualization of God as the “Contriver and Maker of the Whole World”—to the emergence of engine science. I draw connections between engine science and ideas about the virtue of labor, the idea that civility and grace were signified by a cultivated nature, and show how the supposed absence of culture among “barbarous nations” legitimated colonization as a civilizing mission. The ideology of “improvement,” at the heart of the civilizing mission, served the construction of colonies as spaces of experimental statecraft and social engineering.

Viewed from the angle of practice, the period of modern state formation (1650–1900) is one of continual proliferation of the relations between government and science that results in what I call the science-state plexus: a dense web of heterogeneous connections among scientific and governing practices. From public health and geology to cartography and censuses, the land, built environment, and people were targeted as natural and artificial objects whose cultural, political, and economic capital could be augmented. Land, people, and the built environment, as I hope to show in the following pages, were materially incorporated into forms of governing through the practices and knowledge of science and were transformed into a socio-technical network of techno-territory, bio-population, and infrastructural jurisdiction.

THE CASE

The case of Ireland might strike some readers as an unlikely one to illustrate the rise of the engineering state, since that country is so often associated with the worst poverty in all of Europe. There is, however, no reason to believe that the rise of the engineering state implies a prosperous and just social system. Beyond this, Ireland is not simply one case among others. A crucial site for experimental statecraft, constructed as such on behalf of one of the greatest modern engineering cultures, Ireland is as revealing to historians and social scientists now as it was to those who treated it as an experimental field between 1650 and 1900. Ireland was the first and greatest “living laboratory” of English science and government and as such reveals the emergence of modern state forms at the very point of their experimental development. As William Nassau Sr. put it in conversation with Alexis de Tocqueville, “Experiments are made in that country, and pushed to their extreme consequences . . . [such] that they give us results as precious as those of Majendie.”⁴⁴ I argue that Ireland provides an especially revealing case of the way modern institutions of science and government were forged through the experimental designs and practices of an engineering culture.

As well as analyzing the ideas that informed the science-state relationship, I investigate how science and government networked in cultural practices that constituted new objects of inquiry and intervention, particularly those where Ireland led the research frontier, such as in cartography, public health, medical institutions, censuses, and police. The Irish case demonstrates that while it makes sense in one context to speak about a relationship between science and the state, in another it is more appropriate to speak of a complicated entanglement of things material and immaterial, human and nonhuman, in an elaborate socio-technical network.⁴⁵ The generalizability of the Irish case will depend on research into other modern cases, particularly Western cases. Yet the modern Irish state was so successfully engineered in the English and European image that it provides a revealing window on both European state formation and European colonialism.⁴⁶

While the triangulation of culture in terms of discourse, practice, and materiality allows me to capture and hold together a diverse set of objects, my presentation of the empirical material follows a narrative approach. In chapter 2, I develop the concept of engine science through a narrative that traces the *discursive* meaning of mechanics, mechanical philosophy, engines, and experimentalism in the writings of some seventeenth-century English

philosophers, particularly Robert Boyle. I develop an understanding of engine science that draws together the discourses of ingenuity, the practices of experimentation, and the *material culture of inquiry*. By focusing on the material culture of inquiry, the scopes, meters, graphs, and chambers, I place emphasis on the *practices* of sensing, measuring, writing, and manipulating, practices at the heart of engineering culture—a specifically *modern* engineering culture that was immanent in the activity of both modern statecraft and experimental scientific inquiry.