

THINKING INFRASTRUCTURES

RESEARCH IN THE SOCIOLOGY OF ORGANIZATIONS

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THINKING INFRASTRUCTURES

EDITORS

MARTIN KORNBERGER

*EM Lyon Business School, France,
University of Edinburgh, UK
and WU Vienna, Austria*

GEOFFREY C. BOWKER

University of California, USA

JULIA ELYACHAR

Princeton University, USA

ANDREA MENNICKEN

London School of Economics and Political Science, UK

PETER MILLER

London School of Economics and Political Science, UK

JOANNE RANDA NUCHO

Pomona College, USA

NEIL POLLOCK

University of Edinburgh Business School, UK



United Kingdom – North America – Japan
India – Malaysia – China

Emerald Publishing Limited
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CONTENTS

<i>List of Figures and Tables</i>	<i>ix</i>
<i>About the Editors</i>	<i>xi</i>
<i>About the Contributors</i>	<i>xiii</i>

Introduction to Thinking Infrastructures

Geoffrey C. Bowker, Julia Elyachar, Martin Kornberger, Andrea Mennicken, Peter Miller, Joanne Randa Nucho and Neil Pollock

1

PART I VALUING

Chapter 1 Assembling Calculative Infrastructures

Liisa Kurunmäki, Andrea Mennicken and Peter Miller

17

Chapter 2 A Calculative Infrastructure in the Making: The Emergence of a Multi-layered Complex for Governing Healthcare

Jacob Reilley and Tobias Scheytt

43

Chapter 3 Calculative Infrastructure for Hospitals: Governing Medical Practices and Health Expenditures through a Pricing Payment System

Pierre-André Juven

69

Chapter 4 Prospective Sensemaking and Thinking Infrastructures in a Large-scale Humanitarian Crisis

Marian Konstantin Gatzweiler and Matteo Ronzani

85

PART II TRACING

Chapter 5 Infrastructures of Traceability

Michael Power

115

Chapter 6 Capitalization by Certification: Creating Information-based Assets through the Establishment of an Identification Infrastructure	
<i>Yuval Millo, Nikiforos S. Panourgias and Markos Zachariadis</i>	131

Chapter 7 Indexal Thinking – Reconfiguring Global Topologies for Market-based Intervention	
<i>Afshin Mehrpouya and Rita Samiolo</i>	145

Chapter 8 Performing Apparatus: Infrastructures of Valuation in Hospitality	
<i>Wanda J. Orlikowski and Susan V. Scott</i>	169

PART III GOVERNING MARKETS

Chapter 9 Thinking Transparency in European Securitization: Repurposing the Market’s Information Infrastructures	
<i>Antonios Kaniadakis and Amany Elbanna</i>	183

Chapter 10 Thinking Market Infrastructure: Barcode Scanning in the US Grocery Retail Sector, 1967–2010	
<i>Hans Kjellberg, Johan Hagberg and Franck Cochoy</i>	207

Chapter 11 Thinking Infrastructure and the Organization of Markets: The Creation of a Legal Market for Cannabis in Colorado	
<i>Dane Pflueger, Tommaso Palermo and Daniel Martinez</i>	233

Chapter 12 Smart Grids and Smart Markets: The Promises and Politics of Intelligent Infrastructures	
<i>Andreas Folkers</i>	255

Chapter 13 From Matchmaking to Boundary Making: Thinking Infrastructures and Decentring Digital Platforms in the Sharing Economy	
<i>Roser Pujadas and Daniel Curto-Millet</i>	273

PART IV INFRASTRUCTURING SOCIETY

Chapter 14 Social Media and the Infrastructuring of Sociality	
<i>Cristina Alaimo and Jannis Kallinikos</i>	289

Chapter 15 A Communication Perspective on the Fabric of Thinking Infrastructure: The Case of Social Media Analytics <i>François Lambotte</i>	307
Chapter 16 Infrastructuring as Bricolage: Thinking Like a Contemporary Knowledge Worker <i>Ingrid Erickson and Steven Sawyer</i>	321
Chapter 17 Designing Infrastructure for the Poor: Transactions within Unstable Ecologies <i>Céline Cholez and Pascale Trompette</i>	335
Chapter 18 Infrastructuring: On Habits, Norms and Routines as Elements of Infrastructure <i>Paul N. Edwards</i>	355
<i>Index</i>	367

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LIST OF FIGURES AND TABLES

FIGURES

Chapter 1	Fig. 1	Monitor: Compliance Consultation.	30
Chapter 6	Fig. 1	Example of an LOU Data Quality Report (Report for London Stock Exchange).	141
Chapter 7	Fig. 1	Access to Medicine Index 2018 Ranking Graph.	154
	Fig. 2	Process for Inclusion of Diseases in the Index Territory.	159
Chapter 9	Fig. 1	Information Infrastructure as Distributions along Technical/Social and Global/Local Axes.	187
	Fig. 2	Financial Crisis Lifecycle.	191
Chapter 10	Fig. 1	The Scanner (Top) and Scanner Symbol (Bottom) Developed as Part of Super Valu's "Customized Profit Improvement" Programme (1968, 12, S33–S40).	211
	Fig. 2	Computers Will Become an Integral Part of Food Store Operations in the 1970s.	212
	Fig. 3	Excerpt from a Report on One of the Early Scanner Tests (1972, 12, 36–38).	214
	Fig. 4	UPC Scanner Symbols and Evaluations in 1973.	215
	Fig. 5	Development of Scanner-compatible Auxiliary Equipment in the Mid-to-Late 1970s.	218
	Fig. 6	Thinking Infrastructure? An In-store Information System Supporting Retailer and Customer Activities Alike.	221
Chapter 11	Fig. 1	METRC.	237
	Fig. 2	RFID Plant Tags.	238
	Fig. 3	RFID Attached to Plant.	238
	Fig. 4	METRC as "Thinking Infrastructure".	247
Chapter 14	Fig. 1	The Relations between Actions and Forms of Sociality Are Mediated by Scripts, which Work as Cognitive Models or Schemata of Interaction.	293
	Fig. 2	The Relations between Actions and Forms of Sociality Online.	295

	Fig. 3	Examples of Standardized Patterns of Interaction Designed by Social Media.	297
Chapter 15	Fig. 1	SMA Tool Prototype.	312
	Fig. 2	The Translation Process under Study.	313

TABLES

Chapter 2	Table 1	Overview of a Calculative Infrastructure in the Making.	56
Chapter 4	Table 1	Distinct Modes of Evaluation within the Sphere Handbook.	96
Chapter 6	Table 1	Data Quality Criteria.	137
Chapter 17	Table 1	Village Bandolor (Senegal) Mini-grid Tariffs Table.	347

ABOUT THE EDITORS

Martin Kornberger received his PhD in Philosophy from the University of Vienna in 2002. Prior to joining EM Lyon he worked at the University of Technology Sydney as associate professor in design and management, and as research director of the Australian Creative Industry Innovation Centre; and at Copenhagen Business School as professor for strategy and organization. He is also a visiting professor at the University of Edinburgh Business School and a research fellow at the Vienna University of Economics and Business. His research focuses on collective action and strategy in non-command and control settings, with the aim to stretch the imagination of practitioners and scholars.

Geoffrey C. Bowker is the Chancellor's Distinguished Professor at the School of Information and Computer Science, University of California at Irvine, where he directs the Evoke Laboratory, which explores new forms of knowledge expression. Recent positions include the Professor of and Senior Scholar in Cyberscholarship at the University of Pittsburgh iSchool and Executive Director, Center for Science, Technology and Society, Santa Clara. Together with Leigh Star, he wrote *Sorting Things Out: Classification and its Consequences*; his most recent books are *Memory Practices in the Sciences* and (with Stefan Timmermans, Adele Clarke and Ellen Balka) the edited collection: *Boundary Objects and Beyond: Working with Leigh Star*. He is currently working on big data policy and on scientific cyberinfrastructure; as well as completing a book on social readings of data and databases. He is a Founding Member of the Council for Big Data, Ethics and Society.

Julia Elyachar is Associate Professor of Anthropology and the Princeton Institute for International and Regional Studies at Princeton University. She was previously Associate Professor of Anthropology and Economics at the University of California at Irvine, where she was also Director of the Center for Global Peace and Conflict Studies. Her Ph.D., from Harvard University, is in Anthropology and Middle Eastern Studies. Elyachar's research lies at the intersection of political economy, social theory, and anthropology; she has conducted ethnographic research in Egypt, Israel/Palestine, former Yugoslavia, and the Federal Reserve Bank of New York. Elyachar has published in top journals in anthropology, history, and social theory, and won the first book prize of the American Ethnological Society for her book *Markets of Dispossession: NGOs, Economic Development and the State in Cairo*. Her forthcoming books are *Embodied Infrastructure: Commons, Sovereignty, and the Politics of Proprioception*, and *Factories: An Anthropology of Western Economic Order from the Levant*.

Andrea Mennicken is an Associate Professor of Accounting at the London School of Economics and Political Science, and Deputy Director of the Centre for Analysis of Risk and Regulation. Her work has been published in *Accounting, Organizations and Society*, *Financial Accountability and Management*, *Foucault Studies*, *Sociologie du Travail*, among others. She co-edited *Zahlenwerk: Kalkulation, Organisation und Gesellschaft* (2007), and with Peter Miller a special issue on *Foucault and Accounting* in *Foucault Studies* (2012). Recently, she has begun work on an international research project exploring the changing relationships between quantification, administrative capacity and democracy in health-care, correctional services and higher education.

Peter Miller is a Professor of Management Accounting at the London School of Economics and Political Science, and an Associate of the Centre for Analysis of Risk and Regulation. He is an Editor of *Accounting, Organizations and Society*, and has published in a wide range of accounting, management and sociology journals. He co-edited *The Foucault Effect* (1991). More recently, he co-edited *Accounting as Social and Institutional Practice* (1994), and *Accounting, Organizations and Institutions* (2009). In 2008, he published (jointly with Nikolas Rose) *Governing the Present*.

Joanne Randa Nucho is an Assistant Professor of Anthropology at Pomona College. Her research interests include critical infrastructure studies and urban studies as well as non-fiction film and video and visual ethnography. Her book *Everyday Sectarianism in Urban Lebanon: Infrastructures, Public Services and Power* (2016), part of the Princeton University Press series on Culture and Technology, is based on 16 months of ethnographic research in a neighborhood widely known as Beirut's Armenian quarter. She is also a documentary filmmaker whose work has screened at the *London International Documentary Film Festival* and *Los Angeles Contemporary Exhibitions*.

Neil Pollock, who was originally trained in computing and Science & Technology Studies, is the Professor of Innovation and Social Informatics at the University of Edinburgh Business School. He is primarily known for his interdisciplinary research on information technologies that sits at the intersection between Information Systems, Innovation Studies and Economic Sociology. He has published in the highest rated academic journals which include *MIS Quarterly*, *Organization Studies*, *Information Systems Research*, *Accounting, Organizations & Society*, *Social Studies of Science and Science, Technology & Human Values*, and has also co-authored three books *Putting the University Online* (OU Press), *Software and Organisations* (Routledge) and *How Industry Analysts Shape the Digital Future* (Oxford). He is also a Senior Editor at the journal *Information and Organization*.

ABOUT THE CONTRIBUTORS

Cristina Alaimo is a Lecturer (Assistant Professor) in Digital Economy at Surrey Business School, University of Surrey, UK. She holds a PhD in Information Systems, from the London School of Economics and Political Science. Her research is concerned with the datification of user platform participation. She studies the mechanisms and social consequences of how platforms engineer user participation and the broader ecosystem of data exchanges in which these platforms are embedded. Her recent publication “Computing the Everyday: Social Media as Data platforms” (2017, *The Information Society*, 33/4 with Jannis Kallinikos) has been the first runner up in the category Best Published Paper Award, for the Academy of Management, OCIS, 2018.

Celine Cholez is a Lecturer in Sociology at Grenoble-Institute of Engineering and at the PACTE (Politique, Action, Territoire) Research Centre of the University of Grenoble Alpes, France. Her works aim at establishing, from an ethnographic perspective, how people achieve, through tinkering, various complex and normally disrupted activities, especially in the context of rural popular economies in Africa. Her most recent publications in English appeared in *M@nagement*, *Consumption, Markets & Culture* and *Review of Policy research*.

Franck Cochoy is a Professor of Sociology at the University of Toulouse Jean Jaurès, France, and a researcher at the Laboratoire Interdisciplinaire Solidarités, Sociétés, Territoires, at the Centre National de la Recherche Scientifique. His work concerns how technical devices such as packaging, self-service or QR codes, frame consumer behavior.

Daniel Curto-Millet is a Marie Curie Research Fellow at the Spanish National Research Council and is affiliated with the UAM-Accenture Chair at the Universidad Autónoma de Madrid (UAM). He recently completed his PhD at the London School of Economics.

Paul N. Edwards is William J. Perry Fellow in International Security and Director of the Program in Science, Technology, and Society at Stanford University, USA. He is the author of *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (MIT Press, 2010), a history of climate knowledge infrastructures.

Amany Elbanna is a Reader (Associate Professor) at the Royal Holloway University of London. Her current research revolves around information infrastructure including digital platforms and cloud computing in addition

to technology adoption and project management. Her research has been published in leading journals including *Management Information Systems Quarterly*, *European Journal of Information Systems*, *Journal of Information Technology* and *Journal of Strategic Information Systems*, among others.

Ingrid Erickson is an Assistant Professor at the School of Information Studies at Syracuse University, where she researches the influence of ubiquitous digital technologies and artificial intelligence on work, communication and new socio-technical practices

Marian Gatzweiler is a Lecturer at the University of Edinburgh Business School. His research focuses on the role of quantification and metrics as tools that actively shape organising processes and policy in response to grand social challenges. Rather than examining metrics as merely providing “evidence” for managers and policy makers, his research places numbers and visualisations in the foreground to understand how notions of knowledge, innovation and accountability are constructed and practiced in such settings.

Andreas Folkers is a Postdoc Researcher in Sociology at the Justus-Liebig University Giessen. He received his PhD in 2017 from the Goethe-University Frankfurt. He works on infrastructure, security, energy, economic sociology and social theory. Book publication: *Das Sicherheitsdispositiv der Resilienz. Katastrophische Risiken und die Biopolitik vitaler Systeme*. Frankfurt: Campus, 2018.

Johan Hagberg, PhD, is Professor of Business Administration specialising in Marketing at the School of Business, Economics and Law, University of Gothenburg, Sweden. He received his doctorate in 2008 with a thesis on retail change. His current research investigates consumer logistics and the digitalization of retailing and consumption.

Jannis Kallinikos is a Professor in the Department of Management at the London School of Economics and Political Science. His research focuses on the impact of information and communication technologies on organizations and economic institutions. He has published widely in management, information systems and sociology journals and written several monographs including: *The Consequences of Information: Institutional Implications of Technological Change*, Edward Elgar, 2007, *Governing Through Technology: Information Artefacts and Social Practice*, Palgrave, 2011. He has, together with Paul Leonardi and Bonnie Nardi, co-edited *Materiality and Organizing: Social Interaction in a Technological World*, Oxford University Press, 2012.

Antonios Kaniadakis is a Lecturer at Queen Mary University of London where he leads the IT Management Teaching Group within the School of Electronic Engineering and Computer Science. The main bulk of his research explores the social shaping of digital innovation and the implications for organizations, marketplaces and technological infrastructures.

Hans Kjellberg is a Professor of Marketing, Director of the Centre for Market Studies and Head of the Department of Marketing and Strategy, at the Stockholm School of Economics, Sweden. He is interested in economic organizing, particularly the organizing of markets. Currently, he is engaged in an interdisciplinary research programme on the digitalization of consumption and a cross-country comparison of valuation and pricing of cancer drugs.

Liisa Kurunmäki is an Associate Professor of Accounting at the London School of Economics and Political Science, and a Research Associate in the Centre for Analysis of Risk and Regulation. She has published numerous articles in accounting and related social science journals. Her current research focuses on calculative tools and calculative infrastructures in the public sector context, in particular “failure regimes” and associated metrics of quantification in health-care and related settings.

François Lambotte is a Professor of Organisational Communication at École de Communication of Université catholique de Louvain. He is the Founder of UCLouvain Social Media Lab, a laboratory questioning the use of social media in a professional context.

Daniel Martinez is an Associate Professor in the Department of Accounting and Management Control at HEC Paris. His research examines how performance measurement is implicated in the management and regulation of NGOs, pension plans and cannabis markets. He has been published in *Critical Perspectives on Accounting*, *European Accounting Review*, and *Accounting, Organizations and Society*.

Afshin Mehrpouya is an Associate Professor of Accounting and Management Control Systems at HEC Paris. He trained as a medical doctor in Iran, also holds an MBA and PhD in management. His research is broadly on the role of accounting regimes and performance measurement in transnational governance. His current research projects focus on the production and consumption of rankings and genealogical analysis of the rise of transparency in global governance. Prior to starting his academic career, he had years of experience in the design of environmental and social rankings and ratings. He has advised a range of development and sustainability related initiatives such as Access to Medicine Index, Aid Transparency Index, Medicines Transparency Alliance, Access to Nutrition Index and Responsible Mining Index.

Yuval Milo is a Professor of Accounting and the Head of the Accounting Group in Warwick Business School, University of Warwick. His research focuses on accounting for social value and sociology of valuation. He published research papers in *Contemporary Accounting Research*, *European Accounting Review* and *Journal of Management Studies*.

Wanda J. Orlikowski is the Alfred P. Sloan Professor of Information Technologies and Organization Studies at MIT's Sloan School of Management. She received

her PhD from New York University. Her research examines digital reconfigurations, with a focus on the sociomateriality of digital work practices.

Tommaso Palermo is an Assistant Professor of Accounting at the London School of Economics. His main research interests include the design and use of enterprise risk management and performance management systems, risk culture in financial sector organizations and risk regulation in new markets for contested commodities, such as recreational cannabis in Colorado.

Nikiforos S. Panourgias is an Associate Professor in Financial Market Information Systems at the School of Business of the University of Leicester. He has published in *Information System Research*, *Organization Studies*, *Technological Forecasting and Social Change* and *Information and Organization* in the areas of financial markets and technology, and digital innovation and creativity.

Dane Pflueger is an Assistant Professor in the Department of Accounting and Management Control at HEC Paris. His research, focusing on the intersection between accounting and organizations, platforms and markets, is published in leading journals such as *Accounting*, *Organizations and Society*.

Michael Power is Professor of Accounting at the London School of Economics and Political Science and a Fellow of the British Academy. Major works include *The Audit Society: Rituals of Verification* (1997), *Organized Uncertainty: Designing a World of Risk Management* (2007) and *Riskwork: Essays on the Organizational Life of Risk Management* (2016).

Roser Pujadas is a Research Fellow in Information Systems at the London School of Economics and Political Science (LSE), studying the organizational, managerial and social implications of digital interfaces, as part of the Interface Reasoning for Interacting Systems project, funded by the Engineering and Physical Sciences Research Council (EPSRC). Previously, she completed her PhD at the LSE and held an LSE Fellow position at the Department of Management.

Jacob Reilley is a Research Associate and Doctoral candidate at the Department for Management Accounting and Control at the Helmut Schmidt University in Hamburg. He holds a Master's degree in Sociology from the University of Bielefeld. His research focuses on public sector organizations, regulatory reform and social studies of accounting.

Matteo Ronzani is a Postdoctoral Research Fellow in Social Policy at the University of Edinburgh School of Social and Political Science. His research focuses on the roles of visualizations and material artifacts in processes of organizing and on how metrics and indicators are implicated in the making of transnational governance.

Rita Samiolo is a Lecturer in Accounting and Financial Management at King's Business School, King's College London. She holds a PhD in Accounting from the London School of Economics and Political Science. Her research is in the

area of social and institutional studies of accounting. She has a broad interest in the changing roles and rationales of accounting and economic calculation in different governance settings. She is particularly interested in examining economic calculation from the perspective of the history and sociology of science, unpacking the epistemic assumptions underlying costing and performance measurement approaches. She has worked on empirical topics such as the appraisal of large public sector projects and the rise of rankings in transnational governance.

Steven Sawyer is a Professor at the School of Information Studies at Syracuse University. His research builds on and advances the social informatics tradition through particular attention to the ways in which people organize to work together and use information and communication technologies.

Tobias Scheytt is a Professor and Head of the Department of Management Accounting and Control at Helmut Schmidt University, Hamburg. His research is focused on strategic control with a special emphasis on the management of quality and risk in private as well as public sector organizations.

Susan V. Scott is an Associate Professor in the Information Systems & Innovation Group, Department of Management, at the London School of Economics & Political Science. She received her PhD from the Judge Business School at the University of Cambridge. Her research focuses on digital innovation and the (re-)organization of work.

Pascale Trompette is a Sociologist, CNRS Senior Research Fellow at the PACTE Research Center at the University of Grenoble Alpes, France. Her research interest relates to market-based solutions for public and social concerns. Current projects concern the development of market-based solutions to poverty in developing countries, with a special interest on rural electrification in Africa.

Markos Zachariadis is an Associate Professor of Information Systems & Management at Warwick Business School, University of Warwick & FinTech Research Fellow at the Cambridge Digital Innovation, University of Cambridge. His research sits at the cross section of economics of digital innovation, financial technology studies and network economics.

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INTRODUCTION TO THINKING INFRASTRUCTURES

Geoffrey C. Bowker, Julia Elyachar, Martin Kornberger,
Andrea Mennicken, Peter Miller, Joanne Randa Nucho
and Neil Pollock*

WHY THINKING INFRASTRUCTURES?

If the long nineteenth century is known as a time of large-scale material infrastructure investments in roads, rails and wires stretching across Europe and its Empires as well as in the United States, the early twenty-first century is notable for investments in “thinking infrastructures.” We propose the notion of thinking infrastructures to consider a broad range of phenomena that structure attention, shape decision-making and guide cognition such as rankings, ratings and algorithms. To speak of “investments” in thinking infrastructures refers to more than direction of wealth into a particular economic activity. Rather, we think of what Thévenot (1984) termed “investments in form”: concepts, classifications, categorizations, commensurations and evaluations with reference to the notion of the market. Investments in form organize thinking and thought and direct action across multiple settings and multiple temporal scales. Platforms such as ride sharing apps are one such investment in form and organization. They render visible, knowable and thinkable complex patterns of human interaction in and out of the market, in feedback loops of learning, reformatting and redoing. As such, we emphasize, from the start, that much more than “thought” as colloquially understood, and more than fixed physical infrastructure, is at play with thinking infrastructures. Lauren [Berlant \(2016\)](#) gets to the heart of this problematic by pointing out that when a “glitch” appears, infrastructure becomes visible for what it always already was: not a reflection of structure, but rather a “convergence of force and value in patterns of movement” (p. 394). Implicit in any thinking infrastructure, we propose, is the potentiality to rethink, redo and

* The order of authors reflects the arbitrariness of the alphabet.

rework. And since thinking infrastructures are exemplars of distributed agency as well (Enfield & Kockelman, 2017), they can be upended, inverted and recaptured (Elyachar, 2014): the parasite is always part of the channel (Kockelman, 2010; Serres, 1980).

Some aspects of a world of thinking infrastructures stand out, such as machine learning (enabled by high speed, distributed information processing), algorithmic governance (Rosenblat & Stark, 2016) and other forms of automated authority (Pascale, 2011). Similarly, recommender algorithms developed and deployed by Netflix, Amazon and others make us more and more the kind of consumer who responds positively to recommendations. For a century if not centuries, of course, the analog world featured something like thinking infrastructures – from classifications in libraries, through categorizations of the yellow pages, to calculative infrastructures of accounting (see Star & Bowker, 1999; Miller, 2008; Kurunmäki & Miller, 2013). While the digital is in some ways not so different from the analog, and the divide between the digital and the “real” often fictive (Boellstorff, 2016), the sheer scale (temporal and spatial) of thinking infrastructures in the early twenty-first century is striking. This motivates the obvious question: how to approach the study of today’s thinking infrastructures?

Thinking and thought, in our approach, are not a Cartesian *cogito*; nor are they a Freudian super-ego. Rather, we join those who focus on the technologies, epistemic cultures and social practices that make thought and thinking possible in the first place. In perhaps more philosophical words (and with others thinking about infrastructure), we render visible the a-priori of (the conditions of possibility for) thinking, not in Kantian universals but in material and social infrastructures. Thinking infrastructures configure entities (through tracing, tagging); organize knowledge (through search engines); sort things out (through rankings and ratings); govern markets (through calculative practices, including algorithms) and configure preferences (through valuations such as recommender systems). In short, thinking infrastructures fold into themselves an archaeology of concepts, tasks and processes that make thought and thinking possible. In Woolgar’s (1990) classic phrase: they configure the user, cognitively.

For thinking infrastructures to emerge, social practices in and out of markets must be disclosed and enclosed, be rendered visible as potential economic value and as value-transmitting channels (Elyachar, 2010). They can be mobilized, for example, as payments platforms by firms leap-frogging absent nineteenth century wired investments or to use mobile phones as payments infrastructures (Maurer, 2012). While all of this takes place in a vast realm of social practice, repeated loops of NGOs, as well as community based and empowerment infused experimental learning (Elyachar, 2012), we argue that thinking infrastructures gives us a robust metaphor for thinking past infrastructure as public good, to a mode of distributing and distributed infrastructure in which agency, cognition and endless potential for misfire is baked into the system as pirate and parasite (Kockelman, 2010; Serres, 1980) as much as an endless loop of “learning from failure”; and in which the capture of thinking infrastructure to enact other strategic goals is multiplex and unending. In this phase of thinking infrastructures as organizational imperative for profit, peril or planning; infrastructure

bleeds out of any fixed material location in a dissolving environment, or the bounds of a “public” or “private sector” and across obsolete boundaries of the material, the human and the social. Thus, thinking infrastructures, we collectively claim in this volume, inform and shape distributed (Hutchins, 1995) and embodied cognition (Penny, 2017), including collective reasoning, structuring of attention and orchestration of decision-making. In the process, and running through multiple insights that infrastructure stretches across the domains of the once excluded material world outside the “social,” we note that the material itself is now impregnated with the capacities of a thinking infrastructure. It has even permeated the barrier of the human skin, lodging smart devices such as neural dust in our bodies.

In this short introduction, we set ourselves three tasks: first, we identify key features of thinking infrastructures. Second, we distinguish our approach from ongoing conversations about infrastructures, devices and materiality. Third, we introduce the different contributions to this edited volume, highlighting the figure in the carpet (James, 1896).

THINKING INFRASTRUCTURES AS ANALYTICAL VOCABULARY

We propose three analytic elements of thinking infrastructures: valuing, tracing and governing. While analysis of thinking infrastructures can usefully focus on any one of these elements alone, we find greatest analytic purchase in how these elements criss-cross with impunity among people, material worlds, markets and governance. We deploy this analytic vocabulary at the point of tactic, not strategy – at the local point of action where thinking infrastructures endlessly reorganize processes of thinking, sensemaking and decision-making through categorizations, classification, commensuration, calculation and other forms of sorting things out (to use Star and Bowker’s 1999 ingenious book title once again). Our analytic vocabulary is scalar. It allows us to scale up and down in the chapters that follow from micro-settings such as freelance workers plugged into the thinking infrastructure of the gig economy (Erickson & Sawyer, this volume), to wider institutional macro-contexts such as governing markets (Pflueger et al., this volume), to management of public sectors (Reilly & Scheytt, this volume) and re-ordering of global industries (Mehrpouya & Samiolo, this volume). To start, it helps to clarify what we mean by each of these three analytic elements.

Valuing

Thinking infrastructures produce value as they relate preferences, behavior and decisions in hitherto unprecedented ways (see Adkins & Lury 2012; Berthoin Antal, Hutter & Stark, 2015; Kornberger, Justesen, Madsen & Mouritsen, 2015; Kornberger, Pflueger & Mouritsen, 2017). Thinking infrastructures give form to properties and relative positions that have not hitherto been defined. They engage in qualifications (Callon, Méadel & Rabeharisoa, 2002), making

possible new modes of quantification (Mennicken & Espeland, 2019) and new distinctions: for instance, being a “5-Star” Uber driver is a hitherto unknown quality; likewise with the new Chinese citizenship scores which will soon track and control citizens in their interactions with business and government, sorting previous flotsam of experience, orienting attention and associations in new ways through infrastructural sieves. In the process, they allow for new forms and practices of adjudicating (Miller & Power, 2013), new evaluations of individual and organizational performance, and new definitions of success and failure. Thinking infrastructures constitute objects (such as success, failure, quality, etc.) – something which Kurunmäki and her colleagues (this volume) show in their analysis of accounting as the central “infrastructuring” practice. Thinking infrastructures, we propose, are always valuation regimes that constitute orders of worth (Boltanski & Thévenot, 2006; Berthoin Antal et al., 2015).

Tracing

For thinking infrastructures to emerge, they must be traced. And then, traced again. Tracing is an organizational practice that we propose gives analytic purchase on much that is essential and yet overlooked with thinking infrastructures. Thinking infrastructures trace their objects, making them visible and available as objects of and for possible interventions (see Power, this volume; Power, 2019). Tracing happens in clear fashion with clicks and traced searches, rendering ratings and rankings as platforms through which relations are remade, reworked, reestablished and, crucially, tested and objectified in an endless feedback loop (Kornberger et al., 2017). But that is not all. Thinking infrastructures build on relationality rendered visible – in which relations and nodes of connectivity among channels have been traced out via financialization or NGOification of social relations, friendship and mutual aid (Elyachar, 2010, 2014; Federici, 2014). In this sense, Uber as thinking infrastructure does more than just matching: it traces behaviors, preferences, choices, expectations and experiences (such as customers ranking drivers and drivers their customers) that provide the essential resource for its value creation process (Rosenblat, 2018). Of course, relationality has been one focus of infrastructure research since the 1990s (see Star & Ruhleder, 1996), and more recent research shows how relationality in social infrastructures is financialized, platformised and politicized (Srnicke, 2016). In this volume, we take further what was done through financialization in the realm of circulation and distribution, and move back into the realm of production itself where it began with logistics (Cowen, 2014), but now thought, acted from the bottom up, through tracing. Indeed, the business plans of the dominant corporations of our day known collectively as FANG (Facebook, Amazon, Netflix and Google) are fundamentally about tracing – and then packaging and selling the traces. In the process, that which used to be the “real deal” of economy – producing, distributing and consuming stuff – becomes the pipes and channels through which value flows and is reformatted by thinking infrastructures, with their capacities to influence thought and action.

Governing

Thinking infrastructures are also infrastructures of and for governance. Thus, in this volume, we analyse the ways in which nascent and established thinking infrastructures reciprocally enable the assembling of a wide variety of actors and entities (Miller & O’Leary, 1994). We ask: how do thinking infrastructures enable interventions into, and reorganizations of, the governing of individuals, communities, organizations and entire markets? Thinking infrastructures enable interventions through establishing a distinct conception of the objects and objectives of government – be this by the state, the private sector, NGOs or fields of power that stretch across all three (Elyachar, 2003). Here, we pay attention to how thinking infrastructures enable new modalities of distributed agency and paradoxes of power: thinking infrastructures are a form of distributed cognition and distributed agency that structure collective reasoning, attention and decision-making across multiple sites, as the set of chapters that focus on market design demonstrate (see Folkers; Pflueger et al.; Kjellberg et al., in this volume). In these settings, thinking infrastructures govern and exercise power through protocol (Galloway, 2004; Lessig, 1999) – that is they distribute control while centralizing power.

**RELATING THINKING INFRASTRUCTURES TO
ONGOING CONVERSATIONS**

We present this volume as a performance (as Callon might have it) of thinking infrastructures: revealing, reconnecting, reworking and interlinking a range of ideas about infrastructures. We aim to create an infrastructure (if a tentative one to soon be rethought, reworked and revised by the text’s readers) for thinking infrastructures. We bring into conversation thinking about infrastructure in a range of fields: anthropology, accounting, organization studies, science and technology studies, and information sciences that have focused on infrastructures with insufficient cross-cutting ties. We strive for connectivity between communities and conversations, as one small effort to take back the apparent monolithic power of “thinking infrastructures,” in the spirit of Clifford Geertz’s words about walking side-by-side rather than climbing onto the shoulders of giants, we walk side-by-side in our different fields with the thinking infrastructures we study. Walking together with an ethnographic sensibility, we can be attuned to ruptures, parasites and processes of undoing that are integral to the formatting, reformatting, stitching together, sieving and channeling of thinking infrastructures, creating more nuanced and robust analytic differentiations and distinctions in the process. In what follows, we highlight three distinct conversations that are challenged, perhaps even changed, by thinking infrastructures.

Materiality and the Performativity of Devices

A thinking infrastructure can be programmatic: it can articulate aspirations, it can envision new realities, it can make and mobilize new desires; it can also

intervene to act on the objects and objectives it makes and mobilizes. In the literature to date, consideration of such issues has been indirectly addressed by work on devices. Why is device itself important here? First, it is helpful to recall (potentially back to Heidegger or Foucault) that the very word device anticipates some kind of thinking or at least forward-looking planning through its user: a device is designed to carry out a specific task. Implicit in the device is the human, objectivized in the device, to carry out certain actions. All devices that are imbricated in society and economy – as “mediating instruments” (Miller & O’Leary 2007), “market devices” (Callon, Millo & Muniesa, 2007) or “intellectual equipment” (MacKenzie, 2009) become an important area of research. Consequently, a staggering array of artifacts have been studied as devices, including measuring tools (Preda, 2006), 2×2 matrices (Pollock & D’Adderio, 2012) and double-entry bookkeeping and other calculations (Miller, 2008). Analytically, the notion of device is useful because it captures how each device is an “artifact,” the product of a practice. The term can also be used to describe an object that offers affordances and constraints, while at the same time capturing the aspect of “clever contrivance” and “artful design.” All that allows scholars to show how devices can embody or be inscribed with certain ideas or assumptions which in turn shape specific contexts.

Introducing the term thinking infrastructures invites recalibrating the notion of device. This is a fruitful move because it remedies the somehow narrow focus of devices on singular tools, (local) framings and atomistic interactionism (Pollock & Williams, 2009). In contrast, infrastructures can be imagined as series of interconnected devices that are joined up to form a web. For instance, in their paper on evaluative infrastructures at eBay, Kornberger et al. (2017) show that eBay does not just use singular valuation devices to organize its platform: rather, a whole infrastructure made up of ratings, visualizations, feedback loops, recommender systems, categorizations and so on is mobilized to organize the encounter between producer and consumer. We propose to use “thinking infrastructures” to capture the level of analysis where local interactions with devices are part of and feed back into wider networks of knowledge and power (Williams, 1997). In other words, thinking infrastructures are apparatuses in which distributed agency and cognition are cojoined, held together, reinforced and (re)directed. Paraphrasing Star and Ruhleder (1996, p. 114), thinking infrastructures occur where tensions between local and global, technological and social, mind and matter, are (if momentarily) resolved.

Miller and O’Leary (2007, p. 707) develop this line of thought by addressing interactions between “programmes” and “technologies.” Programmes refer to “the imagining and conceptualizing of an arena and its constituents, such that it might be made amenable to knowledge and calculation” (Miller & O’Leary, 2007, p. 702). Technologies denote the “possibility of intervening through a range of devices, instruments, calculations and inscriptions” (Miller & O’Leary, 2007, p. 702). Thinking infrastructures take shape in the interaction between programme and technology. With thinking infrastructures we build on this conception while sidestepping the easy dichotomizing of programmes and technologies as if they were distinct ontological realms: thinking

infrastructures link together material artifacts, material practices and broader circuits of ideas and visions.

Distributed Cognition and Social Infrastructures

Without wandering too far into analytic philosophy or theory of mind, we cannot escape mention of what we mean – or perhaps what we do not mean – by the concept of “thinking.” As mentioned before, it is not sufficient, when thinking “thinking infrastructure,” to reduce thought to conscious cognition. Thus, like the original impetus behind the first infrastructure studies (a rejection of an overly narrow or local lens when studying complex and often distributed socio-technical phenomena; see [Hughes, 1983](#)), the notion of thinking infrastructures rejects narrow framings around cognition and decision-making. It takes a critical stance toward the idea of a “*res cogitans*” as locus of cognition. Instead we relate thinking, thought and cognition back to basic socio-material strata and build on what cognitive scientists and philosophers of mind have called distributed cognition ([Clark, 2008](#); [Hutchins, 1995](#)).

Distributed cognition cannot be separated from practice. Indeed, thinking infrastructures we analyse in this book continuously dip into, and attempt to reorganize under a different frame or organization, a whole range of social practices. Initiatives to trace, enclose, and value outcomes of such social practices as thinking infrastructures lie at the heart of our inquiry. And yet, “human infrastructures” ([Simone, 2004](#)) and “social infrastructure of communicative channels” ([Elyachar, 2010, 2014](#)) formed through social practices resist attempts to turn them into platforms for profit or other organizational aims. As outcomes of social practices, commons and the nodes of distributed cognition within them are never fully captured. There is always a potential for upending and rechanneling the political potential of the commons ([Elyachar, 2014](#); [Federici 2017](#)).

This also invites reflection on the realm of “preconceptual thought” that refuses to divide “thinking” from “feeling.” Aesthetic dimensions of infrastructures – even thinking infrastructures – are as important as functionality and in fact cannot be isolated from function ([Larkin, 2013](#)). Infrastructures work on the senses; they shape perception as well as cognition. Thinking infrastructures are neither neutral nor disembodied. Thinking infrastructures channel the flow of signals from proprioceptors to the brain, to muscle and across the bounds of a human/non-human interaction that is programmed into machine learning and robotics, and into the collective action of a populace in mass revolt ([Elyachar, 2014](#)). Here, we encounter the politics of thinking infrastructures once again: [Safiya Umoja Noble’s](#) *Algorithms of Oppression* (2018), for instance, challenges the presumed “neutrality” of algorithms which format search results in ways that reflect and reinscribe racism and bias (cf. [Sweeney, 2013](#)).

Recent ethnographies of infrastructure emphasize this point, showing how navigating mundane infrastructures ranging from bridges and roads to electricity, are part of how forms of membership and relationality are developed over time. They imply collective processes of sorting and classification that produce

forms of identification as well. For instance, Joanne Nucho (2016) demonstrates how provision of services in Lebanon for medical care, credit access and electricity moves through channels of belonging, excluding and sorting along roads and neighborhoods of urban space in a process usually glossed as “Sectarianism.” Fourcade and Healy (2013) argue that economic classifications and other evaluative infrastructures such as credit scoring technologies increasingly determine life-chances. What emerges is a kind of thinking infrastructure that produces meaningful categories in relation to changing material conditions and relationships that develop while people negotiate the dynamic processes of everyday life. These categories are sometimes official and bureaucratic “classificatory tools” (Fourcade & Healy, 2013), but they are also affective, deeply embodied forms of connection. The latter is crucial and to date little considered. Thinking infrastructures shape modes of feeling, memory and the senses. For instance, experiencing a neighbourhood after a highway overpass has been built, One feels the impact of increased sound and air pollution on the body, the feeling of being cut off from the other side of the street by the impasse of a concrete barrier, nostalgia for the time before etc.

Information, Knowledge and Thinking Infrastructures

The initial goal of infrastructural analysis, we have said, was anti-reductionist in that the unit of analysis was never a single device or actor, but rather complex interdependencies between material practice, knowledge and social organization. The early focus on technical infrastructures was quickly complemented by a focus on the less tangible notion of information and later knowledge infrastructures. Monteiro, Pollock, Hanseth and Williams (2013, p. 576), for example, define information infrastructures in terms of:

openness to number and types of users (no fixed notion of “user”), interconnections of numerous modules/systems (i.e. multiplicity of purposes, agendas, strategies), dynamically evolving portfolios of (an ecosystem of) systems and shaped by an installed base of existing systems and practices (thus restricting the scope of design, as traditionally conceived). IIs are also typically stretched across space and time: they are shaped and used across many different locales and endure over long periods (decades rather than years).

Similarly, in an earlier contribution Bowker, Baker, Miller and Ribes (2010, p. 98) defined information infrastructures as technologies (telescopes, supercomputers, big science labs ...) and organizations (research institutions, funding agencies, publishing houses, etc.) that enable knowledge work. These are strong and rich definitions which cover much of what we talk about in this volume. However, “thinking infrastructures” hint at two dimensions lacking in that prior work. In the heady early days of information infrastructures, “information” was something that could be well defined through the work (in telephony) of Claude Shannon. Much recent work has shown the impossibility of any reasonable demarcation between data, knowledge and information – data are already imbued with and in itself a form of knowledge (Gitelman, 2013); infrastructures produce knowledge as much as they channel information. Secondly, the term information infrastructure is passive. In contrast, just like road infrastructure (see Harvey & Knox, 2015), thinking infrastructures configure and transform their users and the world.