Reengineering the Sharing Economy

Design, Policy, and Regulation

Edited by Babak Heydari,
Ozlem Ergun, Rashmi Dyal-Chand
and Yakov Bart

REENGINEERING THE SHARING ECONOMY

The current sharing economy suffers from system-wide deficiencies even as it produces distinctive benefits and advantages for some participants. The first generation of sharing markets has left us to question: Will there be any workers in the sharing economy? Can we know enough about these technologies to regulate them? Is there any way to avoid the monopolization of assets, information, and wealth? Using convergent, transdisciplinary perspectives, this volume examines the challenge of reengineering a sharing economy that is more equitable, democratic, sustainable, and just. The volume enhances the reader's capacity for integrating applicable findings and theories in business, law and social science into ethical engineering design and practice. At the same time, the book helps explain how technological innovations in the sharing economy create value for different stakeholders and how they impact society at large. Reengineering the Sharing Economy is also available as Open Access on Cambridge Core.

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1

Introduction

Babak Heydari, Ozlem Ergun, Rashmi Dyal-Chand, and Yakov Bart

A lawyer, an engineer, a sociologist, and an economist are sitting in a bar. The lawyer says, "The sharing economy is a tough regulatory nut to crack. Platform-based systems clearly have the potential to benefit many participants in markets for rides, rooms, tasks, and so much else. But there is already exploitation and manipulation in these markets, and technology keeps outpacing our ability to regulate them." The sociologist adds, "Indeed, the social phenomenon of the sharing economy is so rapidly changing and developing that it is hard even to know what to call it – platform economy, gig economy, collaborative economy … And I would anticipate that the stakes will be even higher as the sharing economy spreads to markets for such things as energy and health care." The economist interjects, "No matter what you call it or what the context is, the key to a successful platform-based system is to understand how technologies, extrinsic incentives, and intrinsic motivations impact behaviors of all relevant stakeholders." The engineer comments, "If technology is the confounder here, could it also be part of the solution? Could we talk about designing platforms that address some of the social and regulatory problems we are seeing? And could such platforms succeed in the competitive market environment?"

While this conversation may start out sounding like a bad lawyer joke, the purpose of this book is to demonstrate that conversations like this are essential to understanding, designing, regulating – and participating in – the sharing economy of the future. This book is a product of just such a conversation (though it took place in a classroom, not a bar) among an interdisciplinary group of industrial, civil, and environmental engineers, computer scientists, sociologists, economists, business experts, and lawyers. Our purpose in coming together was to understand and address the challenges of the sharing economy. In our conversation, we noted the deep commonalities in our articulation of these challenges, even

The development of the book was partially supported by NSF Grant 1840493. The editor names appear in reverse alphabetical order. The editors are grateful to Soumyakant Padhee, a PhD student at Northeastern University, for his assistance with unifying the format and reference management of the different chapters.

as we used the varied vocabularies of our own disciplines. We also have come to recognize that addressing these challenges requires us to achieve convergence in our thinking.

The core argument of this book is that our predominant understandings of the sharing economy have led to a range of system-wide deficiencies even as the sharing economy has produced distinctive benefits and advantages for some (and at times many) of its participants. As the sharing economy continues to develop, it will be necessary to shape its development in order to correct those deficiencies. In particular, it is incumbent upon all of us to reengineer a sharing economy that is more equitable, democratic, sustainable, and just. But doing so will require us to reach new understandings of how to engineer, participate in, regulate, and govern future generations of the sharing economy. Our goal is to optimize not just toward efficiency in sharing markets and platforms, but also toward these other features. To achieve this goal, we must translate concepts of sharing into technological designs and applications. We must also examine closely the particular contexts in which such sharing has already occurred and in which it will likely occur as platforms continue to develop.

We intend for this book to serve as a template for convergent thinking – and convergent design – of sharing technologies, markets, and systems. Much of the literature on the sharing economy has noted its disruptive impact on markets and communities. The resulting fragmentation has produced marked inequalities in access, participation, and benefits. The first generation of sharing markets has led some commentators to ask shockingly basic, yet apt, questions: Will there be any workers in the sharing economy? Can we possibly know enough about these technologies to be able to regulate them? Is there any way to avoid the monopolization of assets, information, and wealth? By addressing these questions from a range of disciplinary perspectives, we provide a framework for finding meaningful answers to the core challenges created by this new and disruptive market force.

As this book describes, we all need the sharing economy more than we ever thought we would. However, to make the fairest and best use of the sharing economy, we also need interdisciplinary and systemic dialogue and research that can help us to understand its complexities. What is needed today is a convergent, transdisciplinary dialogue to understand, predict, design, optimize, manage, regulate, and govern the distributional impacts of the sharing economy. We envision that such dialogue will result in an enhanced capacity to integrate applicable findings and theories in business, law, and social science into ethical engineering design and practice. At the same time, such a dialogue will contribute to an understanding of how technological innovations create value for different stakeholders and how they impact society at large.

The purpose of this brief introductory chapter is to lay a foundation for the interdisciplinary conversation that follows in this volume. The contributors to this conversation present a range of perspectives and approaches to reengineering a more just sharing economy. Our effort here is to provide the context and vocabulary that will make their contributions both more accessible and more impactful.

1.1 A BRIEF REVIEW OF THE SHARING ECONOMY'S ENABLERS

As a beginning point, it may be useful to examine the major enablers of the sharing economy at different development stages and across varied contexts. Except in certain communities where sharing predominates over private ownership (such as in Amish and some Native American communities in the United States and Kibbutzim in Israel), much of the world today operates with economic systems in which the concept of private ownership seems foundational. Thus, it is commonly perceived that the only way to consume any good is either to own it directly (typically after purchasing it at a market price) or to rent access to the good from somebody who owns it. However, ownership is inherently an inefficient arrangement for many assets and goods that are of low "granularity," defined by Yochai Benkler (2004) as the extent to which an asset is utilized relative to its total capacity. Examples of goods with a relatively low granularity are cars and trucks (unless they are driven constantly), second homes, private airplanes, and large equipment (such as lawn mowers or power drills). Some intangible assets (such as the ability and license to drive) may also fall into this category. Another inefficiency may stem from the high degree of "lumpiness" of many assets, defined as the impossibility of purchasing some rather than all asset features, such as the power of a computer's central processing unit (Benkler 2004). Owners may well prefer to reduce this inefficiency by unbundling and allowing temporary access to their assets and goods by consumers who would prefer to pay only for what is used and when it is used.

While theoretically such matching could be done by allowing market-based exchanges to allocate access to goods and expertise in such a way as to fully utilize available capacities, high transaction costs historically prevented exchanges that would otherwise benefit all parties involved. For example, imagine you own an apartment that you only visit infrequently. In order to be paid for use of its unutilized capacity when you are not there, you would need to first find somebody interested in a short-term rental of the type of apartment you own and in the given location; then figure out the contractual arrangements for receiving payment, organizing temporary access to your apartment, and guarantying that the apartment will not be damaged; and finally, be able to trust your counterparty to fulfill their part of the contract. Munger (2018) refers to these three components of transaction costs as *triangulation* (information about identity and location, and agreement on terms, including price), *transfer* (a way of transferring payment and goods that is immediate and as invisible as possible), and *trust* (a way of outsourcing assurance of honesty and performance of the terms of the contract).

While access-driven economic activity is not new, such as the apartment rental described, substantial decreases in these transaction costs enabled by rapid advances in information and communication technologies have spurred the development of the modern sharing economy. Founded in 1995, eBay pioneered a peer-to-peer retail marketplace model. Though it is often described as just a distant cousin of today's sharing economy (Sundararajan 2016), the reputation and feedback systems the company created for building the trust needed for online markets to work have substantially impacted the ways that sharing economy platforms digitize trust today. Triangulation and transfer costs for sharing economy participants also declined as smartphones, geolocation services, online social networks, and digital payments became ubiquitous in the latter half of the 2000s.

Once consumerization of digital technologies lowered transaction costs, another major driver of the sharing economy's growth occurred in the form of socioeconomic changes following the Great Recession. Many owners of assets and skills saw the new opportunities enabled by sharing economy platforms as a means of replacing lost earnings resulting from unemployment during that period. At the same time, consumers were looking to save by shifting from purchasing and maintaining goods to paying for access only. Beyond purely economic reasons, two other consumer trends sped up sharing economy growth over the past decade and a half. First, it was generally assumed that many younger consumers no longer considered car or home ownership as an important status symbol, with one survey finding that 43 percent of American consumers viewed such ownership as mainly a hassle associated with acquiring, maintaining, storing, and securing assets (PWC 2015). However, as the final chapter of this book discusses, this assumption must be reevaluated based on the structural changes in people's consumption patterns since the early 2020s. Second, the same survey found that environmentally friendly and sustainable consumption has been growing in importance, especially for younger consumers, and that 76 percent of American adults who are familiar with the sharing economy believe that sharing-based business models are more environmentally friendly (PWC 2015). (Eckelman and Kalmykova discuss the extent to which this belief is matched by reality in Chapter 2 on the sharing economy and environmental sustainability.)

1.2 THE SHARING ECONOMY TODAY

Today, the increasing digitization of the economy and resulting growth of digital platforms have dramatically altered how individuals, organizations, and governments exchange and allocate resources. Experts believe that by 2025, over $60 trillion (approximately 30 percent of forecasted total world revenue) will be mediated by digital sharing economy platforms (Atluri et al. 2017). Such platforms have already disrupted multiple industries, upended labor economics and practices, and fundamentally transformed resource management, asset allocation, and market design. These heterogeneous impacts have produced a range of conundrums.

As an economic matter, even though sharing economy platforms were quick to capture large market shares and change the way society acquired services, to date many of these platforms are still not profitable. Their costs of operations are higher than the revenue they generate. For example, Uber had operating losses exceeding $8.5 billion in 2019 (Statista 2021). Many experts believe that some of the largest sharing economy platforms are not optimally designed because they are too complex and offer too much flexibility. As an economic proposition, this drives up operating costs (Lee and Nahmias 1993). These design features, combined with artificially low prices that are intended to capture larger shares of the market as fast as possible, have resulted in some business failures and many examples of businesses operating without profits for extended periods – despite their development and dissemination of new technologies.

From sociological and regulatory perspectives, platforms have democratized the provision of and access to services and products with low entry and transaction costs. Yet their broader impact on society remains unknown. For example, during the COVID-19 emergency, knowledge of the design and operation of digital platforms enabled the quick development of platforms that took in demand and supply information and guided the matching of severely limited resources to urgent need. The repeated success of such platforms operating in core sectors, for example in matching medical personnel to nursing homes (Zarei et al. 2021; Zarei et al. 2023), saved lives and built societal resilience. However, the pervasive adaptation of digital platforms to different uses has outpaced knowledge about and regulation of the societal impacts on the workforce, public services, the environment, information privacy, and equity. One need look no further than examples such as the impact of Airbnb on housing affordability (Barron et al. 2018), concerns related to user data sharing across different digital platforms (Chakravorti 2020), or Amazon's direct competition with its own suppliers (Zhu and Liu 2018) to understand why the developers of new sharing economy technologies, namely engineers and computer scientists, must consider the social effects of these new technologies. These same phenomena demand the attention of policy makers and regulators, for whom it is now imperative to understand digital platform technologies that enable sharing economy ecosystems.

The economic, sociological, and regulatory challenges posed by the sharing economy are exacerbated by the enormous complexity of sharing economy systems (see Chapter 2), which produce many potentially unexpected consequences. As our contributors discuss, one should not evaluate the environmental impact of bike-sharing systems without considering the emissions from vans used to reposition bikes throughout the cities (Chapter 3). Similarly, the congestion and emissions impacts of delivery lockers could depend on many factors including population density, customer preferences, and other mobility patterns, as well as how customers and lockers are distributed over the area of concern (Chapters 3 and 12). Hence in many cases the answer to the question of total societal impact of a sharing economy system, or the appropriate regulations, is "it depends." Any truly meaningful version of this answer calls for holistic and systemwide analysis, evaluation, and redesign of sharing economy ecosystems with a multidisciplinary perspective that considers the impact on all stakeholders.

1.3 THE SHARING ECONOMY OF TOMORROW? THE CHALLENGE OF REENGINEERING A COMPLEX SYSTEM

From an engineering perspective, the multiple conundrums posed by the sharing economy raise the following urgent question: Can we envision future sharing economy systems that have sustainable business models and contribute to the public good while producing minimal negative externalities? The very question smacks of an engineering perspective – a sweet spot between those who love and those who hate the sharing economy. This perspective includes a problem-solving approach and involves understanding, recognizing, and modeling various trade-offs. It requires the use of broad design methodologies not just to balance the underlying trade-offs between business efficiency and societal benefits, but to push their frontiers to enable system-level improvements for the benefit of all relevant stakeholders. Finally, it posits that sharing conducted over technology-enabled platforms covers a wide spectrum of needs, behaviors, resources, applications, and goals. Thinking about the entire spectrum of sharing economy markets and behaviors as a system can be a powerful mechanism that enables the design of sharing technologies toward certain goals, a process that engineers describe as optimization.

The engineering system perspective also can help broaden the notion of the engineering design process. This can be achieved by pushing the boundaries of *engineering* beyond just the task of satisfying the technical requirements of sharing platforms. It requires the adoption of a sociotechnical approach to design decisions, related to platform algorithm and architecture, within an ecosystem that includes various stakeholders' perspectives, market mechanisms, and regulation and governance considerations. As several chapters in this book show, this sociotechnical perspective is essential for asking the right questions and identifying key trade-offs.

Crucially, optimizing in the direction of a more equitable, fair, and just sharing economy is a fundamentally interdisciplinary pursuit. Indeed, the push to generalize the engineering approach in the direction of sociotechnical systems is not just coming from the engineering community. Social scientists, especially economists, have increasingly been moving beyond simply examining existing markets into designing and engineering new ones (Roth 2002).

Moreover, this new and audacious optimization challenge will require convergent thinking and solutions. Presently, enormous gaps exist among different disciplines, and between different sectors of the sharing economy, on questions as fundamental as the *normative value* of sharing. What does collaboration mean? What goals underlie the impulse to share and how do those goals translate into technology design? Who are the appropriate beneficiaries of the sharing economy?

Such basic questions currently generate widely divergent answers depending on who is asked. While existing scholarship about the sharing economy examines critical issues and concerns, much of this scholarship is limited just to one disciplinary focus and often just to one or a few sectors of the sharing economy. However, to address a core problem such as inequitable access, the sociologists and lawyers among us must articulate the behaviors that lead to such inequities, the economists and psychologists must disentangle how external market forces and internal human motivations lead to such behaviors, and the engineers and computer scientists must design technological responses to such behaviors. Convergent thinking is an essential feature in addressing this core challenge.

Consider the possibilities enabled by combining the systemic perspective and engineering approach. One area of significant research progress could involve the development of more informed approaches to platform governance. Platform governance is a set of guiding principles that determine who makes what decisions about the platform (Gorwa 2019). Such decisions address the rules and modes of interaction among different sides of the platform. They also structure the interaction of key constituents in the platform ecosystem, such as users, workers, platform owners, local and national governments, complementary businesses, and regulatory authorities. One goal of reengineering sharing should be to create and evaluate a set of metrics relevant to platform governance. By means of cross-sectional analysis, comparison of different sharing markets using both qualitative and quantitative methodologies, historical analyses of the first generation of sharing technologies, and controlled experiments, it should be feasible to promote and nurture certain features of sharing markets and also to inhibit and limit other features. Another goal should be to identify decisions – by the platform owners or regulators – that could act as leverage points to implement the desired outcomes. This book applies systemic approaches such as this in a range of sharing economy contexts and to address a variety of contemporary conundrums in the sharing economy.

1.4 THE APPROACH OF THIS BOOK: A BRIEF OVERVIEW

In meaningful respects, the contributions to this volume are intended to demonstrate the core principle of this book, namely that reengineering the sharing economy to optimize for goals such as sustainability, fairness, and equity will require interdisciplinarity and convergent thinking. We intend for the interdisciplinary approaches that are described in this volume to help platform owners with a range of decisions to increase their value and make their business models more sustainable. Such decisions at times concern familiar technologies that can be redesigned to produce better matching between different sides of the platform or better resource-management solutions (for example, more efficient routing algorithms). They also include design decisions geared to more complex sociotechnical constructs such as trust towards the platform or the optimal level of control over platform-enabled transactions.

We also intend that the full range of our contributions will be relevant to policymakers and researchers interested in developing new principles for regulating and governing the sharing economy. The theoretical foundations and methodologies discussed in this volume are intended to provide interdisciplinary guidance to those seeking to create better outcomes for a broader collection of stakeholders.

Finally, and as importantly, we intend for this volume to be a source of information for consumers and workers involved in the sharing economy. Still today, much of the most informative work on the design, operation, and regulation of the sharing economy is written for sharing platform proprietors – and not for users. This volume is intended to correct that informational imbalance by providing straightforward, often critical, perspectives on a range of sharing economy platforms.

Part I provides a cross-disciplinary theoretical foundation for engineering a more just sharing economy. The Part includes six chapters, each of which provides a discrete disciplinary perspective on the sharing economy while also connecting that perspective both to the development trajectory of the sharing economy and to other disciplinary approaches required to reengineer – and redirect the development of – the sharing economy. Chapter 2 explicates the sociotechnical ecosystem perspective on the sharing economy that serves as the foundation for much of the convergent thinking undertaken by the interdisciplinary group that has contributed to this volume. This perspective takes a multi-stakeholder approach that includes platform owners, policymakers, and users, and that incorporates contextual and stakeholder forces that drive the formation and evolution of sharing economy systems.

Chapter 3 uses an environmental engineering and design perspective to evaluate the extent to which the key rhetorical norm of sustainability in the sharing economy has in fact been made a reality. The chapter documents the unintended consequences that have been observed for different sharing platforms, including for mobility, housing, and secondhand goods, many of which are mediated by the economic rebound effect, concluding that the real story of sustainability in the sharing economy is quite complex.

Chapters 4 and 5 provide perspectives from economics and market analysis by focusing on core issues that connect consumers with proprietors in sharing economy markets. Chapter 4 examines the exchange of information among various stakeholders in sharing economy systems and provides a comprehensive framework for examining the privacy issues that recurrently arise in this context. Chapter 5 addresses the development of feedback and reputation systems that are critical for fostering trust and are central to the operations of every sharing economy platform.

Chapters 6 and 7 add the perspectives of additional stakeholders in the sharing economy. Written by two sociologists, Chapter 6 provides essential information about the rights, needs, and treatment of workers across a range of sharing economy platforms. The chapter provides multifaceted perspectives on labor in the sharing economy. As with many of the contributions to this volume, the chapter concludes by raising a number of important questions that must be answered in the journey toward a more just sharing economy. Chapter 7 contributes a legal perspective on the sharing economy. After surveying the regulatory approaches to the first generation of sharing platforms, this chapter proposes new regulatory principles for governing future sharing economy systems.

Part II of the book offers a range of disciplinary perspectives on both highly popular sharing economy contexts and markets, and on some that are new and emerging. Part II-A covers the popular contexts of mobility and lodging. Although these contexts have been the subject of significant study, the contributions in this section add important new perspectives, often as a result of new methodologies and original research.

Chapters 8 and 9, both written by engineers, cover ride sharing and mobility platforms. Chapter 8 focuses largely on the significant externality of traffic congestion. The chapter analyzes the current debate on the impact of ride-sharing services on urban traffic congestion and proposes future research opportunities that could help settle this debate. Chapter 9 takes a broader perspective on mobility platforms by examining the tension between on-demand mobility and shareability. Relying on original empirical research using a large dataset, the chapter proposes alternative business models to improve shareability.

Chapter 10, which reflects collaboration between engineering and public policy experts, also features original empirical research, in this case focusing on the multiple effects of Airbnb at the neighborhood level. According to this chapter, as sharing economy platforms have provided new mechanisms for transactions and commerce, they have shifted *where* such transactions are most likely to occur. Understanding the externalities produced as a result of this geographical shift is crucial for advancing the design state of platforms, and for supporting policy makers in crafting effective regulations.

Part II-B of the book focuses on freshly emerging sharing contexts, specifically the domains of energy systems and last mile delivery. Chapter 11, which also features a collaboration among public policy and engineering scholars, explores the integrated potential of technological and social innovations enabling sharing in future energy systems. As this chapter discusses, sharing in future energy systems has the potential to radically disrupt relationships governing utilities, energy consumers, and distributed electricity generation at the individual and household levels, at the community and organizational levels, and at the regional, state, national and even international levels. The chapter also explores the potential for such sharing to contribute to the concept of "energy democracy." Chapter 12 examines the potential for sharing platforms to improve options for last mile delivery while also optimizing for positive societal impacts. As this chapter discusses, sharing economy platforms may provide a promising solution for reducing both delivery costs and emissions in last mile delivery. The chapter identifies the gaps and opportunities for improved economic, social, and environmental outcomes in last mile delivery systems.

This volume concludes with a chapter drawing substantive lessons that provide a framework for engineering a just sharing economy. We consider some of the core principles and features that should be relevant to those engaged in convergent thinking about future sharing economy systems. We also highlight key questions for future research and exploration. As we discuss, while there are still many unknowns, there is also great potential for future sharing platforms to optimize for a range of socially beneficial outcomes.

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PART I

Cross-Cutting Foundations and Norms for the Sharing Economy of Tomorrow

2

A Sociotechnical Ecosystem Perspective of Sharing Economy Platforms

Babak Heydari

2.1 INTRODUCTION

In barely more than a decade, sharing economy platforms transitioned from venues for true sharing of underused assets by people with social and environmental motivations, to a number of for-profit – although not always profit making – corporations worth tens of billions of dollars each, to a pillar for coping with the COVID-19 pandemic that enabled easier access to essential resources. The short, yet intense, history of the sharing economy is filled with overoptimism about its business potential and social consequences. This history reveals sharp contrasts between the high valuation of sharing companies and concerns about their potential for sustainable profit-making. It also features public debates regarding the consequences of sharing economy business models for the participating labor forces, reports of discrimination and user abuse, and concerns regarding the broader negative social and economic externalities of these platforms.

The debates over the costs and benefits of sharing economy platforms have been vast and have engaged a multitude of disciplines such as business and management science, economics, computer science, and different engineering disciplines, sociology, law, and public policy. Each of these disciplines has naturally focused on a limited set of problems and tried to understand these platforms through levels of abstractions established in those disciplines. For example, for economists, the multisided market has been the dominant level of abstraction by which many platforms' strategic decisions and market dynamics have been studied, whereas the notion of matching, and efficiency, and equity of various matching algorithms has been the center of attention for operations researchers and management scientists. Much of the social science literature on the subject has focused on the macroeconomic context, the evolution of capitalism, and the potential of sharing platforms to abuse their workers. And the list of disciplines/concerns/levels of abstraction goes on.

These disciplinary approaches are crucial because they not only are rigorous and subject to peers' scrutiny, but they also provide valuable methodologies to be used in interdisciplinary and system-level studies. However, many important questions that must be addressed in order to understand the underlying trade-offs of sharing economy platforms, and in order to provide useful insights to some of the debates mentioned earlier, fall at the *boundaries and intersections of different levels of abstraction* and require a system-level approach. Key questions arise at the boundary between multisided markets and the employee/contractor debate, at the intersection of economic externalities and the evolution of social norms, and at the intersection of matching algorithms and regulatory design. A systemic perspective on sharing platforms adds other benefits as well. Such benefits follow from two premises: First, that a holistic approach, which focuses on the relationship between different parts of the system, will provide additional useful insights; and second, that using a systemic perspective enables us to transfer findings, experiences, and insights between contexts that seem different in detail, but have enough system-level commonalities to justify such transfers.

My overarching thesis in this chapter is that many of the fundamental challenges of sharing economy platforms can best be understood and dealt with by considering these platforms embedded in a *sociotechnical ecosystem*. This perspective, which is the first contribution of this chapter, builds upon the diverse literature on business and industry ecosystems, but it is a departure from a narrow view of ecosystems that is focused mostly on business decisions from the perspective of the platform owner. In justifying this new perspective, I will first make a case for a sociotechnical approach to sharing economy platforms and will describe different lenses that constitute this approach. Then I will argue that many crucial questions about the design, governance, and regulation of sharing economy platforms are best formulated by embedding the platform in a sociotechnical ecosystem, which is a departure from the more common notion of business and industry ecosystems. To further justify this transition, I will provide a few examples of such ecosystem-motivated issues and questions that include a broader consideration of socioeconomic externalities, decisions about modes of platform governance and the relative weight of internal versus external regulations, and public–private partnerships.

My second contribution in this chapter is to provide a set of differentiating dimensions that can help with classifying various sharing economy platforms, guide decisions regarding ecosystem boundaries, and shape more relevant sociotechnical questions and hypotheses for a given sharing economy. These differentiating dimensions intend to serve a middle ground for two schools of thought, one that stipulates that each sharing platform needs to be treated as a separate case and there is little insight that can be transferred from one platform type to another, and the other that seeks to create levels of abstractions for studying the sharing economy platforms that are applicable to all such platforms. Establishing such differentiating dimensions, instead, acknowledges that the answer to many fundamental design, governance, and regulation questions can vary from one platform to another; however, it strives to further pin down those dependencies by identifying various classes of sharing platforms to enable more reliable transfer of insight from one case to another and determine when such transfers make sense. In so doing, it helps to create models and methods that can work for all members of each class.

2.2 THE SOCIOTECHNICAL APPROACH: WHY AND WHAT?

Sociotechnical systems and the sociotechnical perspective have been used in different contexts and different applications in the past few decades. The notion is based on the pioneering works by Eric Trist in the 1950s and 1960s at the Tavistock Institute for Social Research in London (Trist 1981), and later found its way to other fields and applications such as sustainability (Geels 2019), innovation management (Geels 2005), energy systems (Li, Trutnevyte, and Strachan 2015), and digital ecosystems (Morgan-Thomas, Dessart, and Veloutsou 2020). Such applications often involve important changes in the definition, scope, and goals of the approach, which makes it hard, and largely unhelpful, to provide a unifying definition that includes all uses of the term in the academic literature. Suffices to say that while the focus of the first generation of studies using a sociotechnical approach was primarily on guiding the innovation and change process in an industry ecosystem, the notion of sociotechnical has resurfaced in recent years to make a case for an integrated approach towards design, governance, and regulation of modern engineered systems. This recent attention is motivated by recognizing that such systems are increasingly connected, with complex interactions among social and technical aspects, both during the design process and after introduction in the market. Moreover, the technical side of these systems coevolves with the social and institutional sides (Heydari and Pennock 2018), a feature with broad implications for design, governance, and regulation.

With this contemporary perspective of sociotechnical systems, I argue that sharing platforms are paradigmatic examples of complex sociotechnical systems (Heydari and Herder 2021). They involve multiple classes of social agents (mostly individual humans, but also groups and organizations in some cases) with heterogeneous types on different sides of the platform, whose relationships are dynamically regulated by the structure and behavior of the platform. In a way, sharing platforms also make a great case study for the so-called *technological systems approach* (Carlsson and Stankiewicz 1991) that looks at "networks of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse, and utilize technology." The interaction between the social and technical sides, however, goes beyond the usual dynamics seen in most engineering systems where the dynamics are often unidirectional and include adaptation of the social layer to changes in the technical layer (e.g., changes in human travel patterns following the prevalence of commercial airplanes). Instead, in many sharing economy platforms, the social and technical sides often *coevolve*, where new local or population-level norms are formed on the social side, as a function of the structure of the platform (e.g., basic modules of transactions or spatiotemporal constraints) and the function of platform algorithms (matching criteria, level of transparency, review aggregation

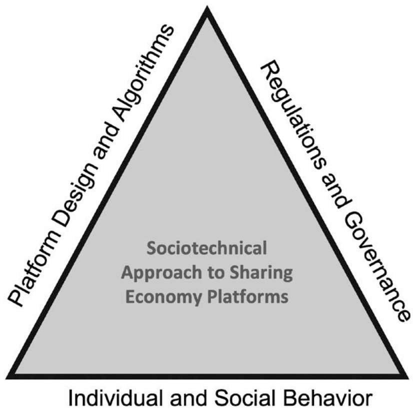

FIGURE 2.1 Three components of a sociotechnical approach to sharing economy platforms.

methods, and pricing strategies). This combination of platform structure and function can give rise to new social norms or steer the existing ones. Examples of such norms include trust, cooperation, equity and fairness, communication norms among different sides of the market, and how platform users balance some trade-offs such as those between data privacy and match efficiency. These evolutions in norms and collective behavior then result in evolutionary changes in the platforms, either through shifts in the way people prioritize different considerations to balance various trade-offs, or, increasingly, as a result of artificial intelligence algorithms that learn to adjust platform behavior in response to such changes.

This sociotechnical perspective, which is based on recognizing a coevolutionary dynamic between the social and technical side, can be captured by the sociotechnical triangle (Figure 2.1). These three lenses are crucial in many aspects of the sharing economy, informing core questions such as the following: How can we design modular architecture and algorithmic incentives to promote trust between different sides of transactions? How can we balance external regulation and self-regulation, based on platform internal governance mechanisms? How can we think about and measure neighborhood externalities of platforms such as Airbnb in the short term and long term?

2.3 THE ECOSYSTEM PERSPECTIVE: MOVING FROM BUSINESS TO SOCIOTECHNICAL ECOSYSTEMS

The mutual dynamic perspective described earlier goes beyond the interaction of platform design and participants' behavior and often extends to other areas such as technology and regulation. This extended perspective would then require us to think of sharing economy platforms in a broader ecosystem, the second lens of a systemic perspective. In this section, I will argue that we need to make a transition from the more common notion of business and industrial ecosystems to the more contemporary and expansive notion of sociotechnical ecosystems. The need for such a transition is not restricted to sharing economy platforms, but as I will argue in more detail, it is more crucial for these types of systems due to some of their characteristics that are either unique or are bolder compared to other products' or services' ecosystems.

The notion of business ecosystems entered the management-science and product-design literature as an alternative to the more linear supply-chain framework, largely through the influential writings of James F. Moore during the 1990s. The framework was inspired by the notion of biological ecosystems, which capture complexity-related concepts such as self-organization, coevolution, emergence of new forms and behaviors, and complex dynamics of simultaneous competition and cooperation. In one of his first publications to introduce the concept, Moore suggests that, "a company be viewed not as a member of a single industry but as part of a business ecosystem that crosses a variety of industries. In a business ecosystem, companies coevolve capabilities around a new innovation: They work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations" (Moore, 1993, p. 76). The concept was then further developed by a number of other scholars in the past two decades and applied to a wide range of cases in different industries (Adner and Kapoor 2010; Autio and Thomas 2014; Iansiti and Levien 2004; Pierce 2009). Given the metaphoric nature of the concept, however, not all the studies that use the notion of ecosystem as a framework agree on a common definition (see Tsujimoto et al. [2018] for a review of the literature).

The ecosystem perspective of industry platforms has also been introduced in the past, often in a narrower sense, which includes the combination of a multisided platform, a set of related firms that develop their complementary products and services, and in some cases, the end users (Cusumano, Gawer, and Yoffie 2019). This perspective of platform ecosystems has been used primarily to model and provide recommendations for two different faces of innovation that occur *within* and *outside* the platform-owning firm (Gawer and Cusumano 2014), or to inform organization designers to opt for a more suitable organization structure, level of openness, and degrees of product and organizational modularity (Baldwin 2012, Heydari, Mosleh, and Dalili. 2016). Although various definitions for platform ecosystems are offered in the literature, the majority of these definitions are focused either on the technology or on the markets. In the former, platform ecosystems are considered, as "a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components" (Baldwin and Woodard 2009), while in the latter, they focus on issues such as network externalities across different platform sides, market competition among different platforms, and the complementary roles of firms whose products are designed based on one or more platforms (e.g., smartphone platforms or cloud computing platforms). Although different in their components, both these approaches have focused on the perspectives of platform owners (Schreieck, Wiesche, and Krcmar 2016) to inform their business decisions.

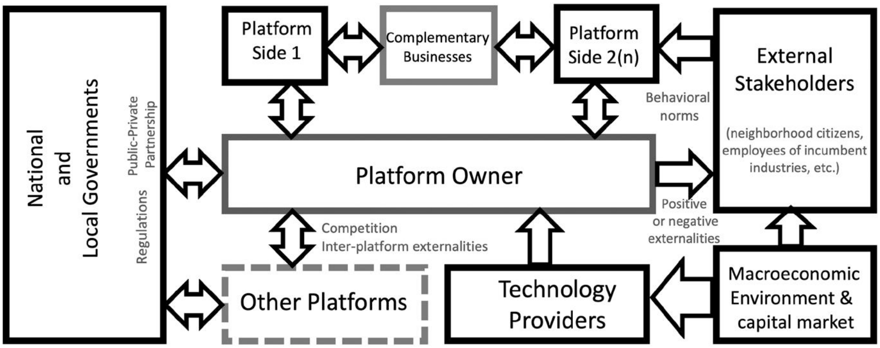

FIGURE 2.2 Sharing economy platforms ecosystem components

Here, I argue that we need a broader sense of ecosystems for sharing economy platforms that goes beyond innovation modeling and business complementors and extends the ecosystem boundary to include a broader range of stakeholders. This extended notion of platform ecosystem helps with formulating more relevant questions regarding analysis, design, governance, and regulation of sharing economy platforms. It also helps in creating shared value between the platform owner and the societal stakeholders (Porter and Kramer 2011, Rong et al. 2021), which then can be addressed using the sociotechnical perspective mentioned earlier.

The need for a more expansive view of ecosystems isn't limited to sharing economy platforms. In fact, it can be applied to a wide range of products and services. Having said that, this need is particularly bold for certain platform-based companies and sharing economy platforms in particular for a at least three interrelated reasons. For one thing, many of these platforms are taking up parts of the roles of public infrastructures, making them essential for the socioeconomic wellbeing of many regions. Moreover, there are many potential negative and positive externalities that touch various corners of the social fabric, especially in urban environments, because these platforms change the meaning of ownership and blur the line between what is business and what is personal use. Finally, these platforms are one of the key contributors to a rapidly evolving notion of work, both for those who directly use these platforms and those whose previous forms of work are being disrupted by sharing platforms. In what follows, I will elaborate more on the components (Figure 2.2) and benefits of this expansive view of the sharing-platforms ecosystem.

A. A Broader Perspective of Externalities: The literature on platform systems has always been cognizant of externalities, with most of the attention being focused on network externalities, also known as network effect. The discussion thus has focused on how additional agents who use the platform affect the utility of other agents who are on the platform. In addition to this – often positive – externality, critiques of sharing economy platforms sometimes point to potential negative externalities of such platforms based on their negative impact on others who do not use the platform. One example of such indirectly affected people are neighborhood residents who might be negatively affected by Airbnb (Gurran and Phibbs 2017), or who might be affected by increased congestion caused by ride sharing (Schaller 2021). Other examples are workers and owners of incumbent industries, such as hotels owners and employees who might be affected by Airbnb (Roma, Panniello, and Lo Nigro 2019; Zervas, Proserpio, and Byers 2017), or Medallion owners and cab drivers who might be affected by Uber (Angrist, Caldwell, and Hall 2017; Rogers 2015). The ecosystem view of sharing platforms leads us to think more broadly about externalities, especially when it comes to their regulation and the evaluation of their overall effect on social welfare.

First, the scope of platform externalities should be expanded in the range of stakeholders who are affected. Importantly, the scope should also include efforts to understand the mechanisms by which externalities affect certain stakeholders. For example, on the supplier side, in addition to the dyad of platform and incumbent workers, sharing platforms could trigger creation of a number of complementary businesses whose owners and employees are not technically platform users, but they provide facilitating services to platform users. Airbnb, for example, resulted in the emergence of a series of start-up companies and local businesses that help the hosts by providing them with cleaning services (Flycleaners), management (Beyond stay, Keycafe), guest communications (Guesty), marketing (Renting your place), and pricing analytics (Pricelabs, Beyond Pricing). Airbnb also helped stimulate local businesses such as professional photographers and property managers. Moreover, the penetration of sharing economy platforms into urban neighborhoods can stimulate local businesses by bringing visitors to otherwise residential neighborhoods, which in turn can result in potential positive externalities for neighborhood residents because of improvements in service quality, or negative externalities due to potential increase in prices. Measuring the relative magnitude of these two factors requires comprehensive empirical studies, something that the research community of sharing platforms could consider in the future.

We also need to consider the interplatform interactions as a particular instance of broadening the scope of externalities. Such interplatform interactions could happen across different platforms that provide similar services whose interactions go beyond the widely studied competition (Armstrong 2006; Rochet and Tirole 2003) and in some cases can involve cross-platform positive network effects that can become more complex than the usual single-platform network effect often discussed in the literature. For example, growing an initial group of drivers is often easier for a new ride-hailing company that enters a city with an existing base of drivers who work with a competing company. It might also be easier to attract the first group of customers who already have gone through the learning curve of a similar concept with a competing platform. More important, however, is the interaction of complementary platforms, as happens for example in the case of ride-sharing and short-term rental platforms (Zhang et al. 2020), where easier and more affordable access to transportation into residential neighborhoods enabled by ride-sharing platforms makes short-term rentals more attractive for prospective visitors, which in turn results in more use of ride-sharing services, once those visitors decide to stay in the residential neighborhoods. Other examples include interaction of short-term rental companies with travel and hospitality platforms such as TripAdvisor, Yelp, and Urbanspoon. Although much of the discussions in these areas are anecdotal, we can expect that in the coming years, new network externality models with the goal of formulating and quantifying a more general notion of network effect will emerge in the academic literature of sharing economy platforms.

Beside the expansion in scope, one needs to differentiate between the *short- versus longer-term externalities*, with special attention to the latter, which are often more difficult to identify and measure. The longer-term view is crucial, primarily for two reasons. First, the prevalence of sharing platforms can change the structure of social interactions and impact local norms, sense of belonging, and social capital, a rather slow process in nature. Such changes, in turn, can result in changes in collective behavior, with possible negative consequences for local residents. For example, a recent study by (Ke, O'Brien, and Heydari 2021) demonstrates that spatial penetration of Airbnb (as opposed to merely the number of Airbnb visitors) in a neighborhood can result in an increase in criminal activities in subsequent years, presumably due to its negative effect on the overall sense of belonging by removing a set of long-term resident nodes from the neighborhood social interaction network.

B. Regulation and Governance in Platform Ecosystems: Regulating sharing economy platforms has been a controversial issue (See the Chapter 7 in this volume), with some scholars going so far as to conclude that successful regulatory avoidance is one of the main driving forces behind the rapid growth of sharing platforms (Stemler 2017). Various categories of regulations include platform-user protections, competition and antitrust concerns, taxes, privacy concerns, discrimination, and other forms of market failures. Here, I briefly emphasize two points, related to the ecosystem perspective.

B. 1. Public–Private Partnership: First, the relationship between governments and platform owners needs to include *public–private partnerships*. Public–private collaborations have largely been discussed in the context of urban mobility as a way to make urban transportation more accessible, affordable, and efficient. They can be implemented at various levels, such as dynamic trip-planning, on-demand minibuses, and first- and last-mile ride sharing (Bouton, Canales, and Trimble, n.d.); Also see (Chapters 8 and 9 in this volume.). More recently and with the goal of establishing trust between the platform and local governments, Airbnb has introduced City Portal in fifteen pilot cities in North America, which claims to streamline information about various travel-related trends to provide cities with more information about their Airbnb businesses, share with them detailed data that they can use for their urban resource-management activities, and provide easy-to-use tools for city officials to design and implement short-term rental policies (Airbnb n.d.). Although it is likely that sharing economy companies enter such partnerships as a public-relations activity to avoid strict regulations down the road, successful public–private partnership can have a wide range of public benefits by increasing access to financial resources for public infrastructures, contributing to efficient dynamic resource allocation using analytics collected by sharing platforms, and offering efficient solutions for the last-mile problem in many transportation and logistics services. However, not all public–private partnerships based on sharing economy platforms are successful, and it remains a crucial area of research to identify determinants of success and failure based on the differentiating characteristics of sharing economy platforms (see Part IV).

B.2. Public Mediated Governance: Even when we restrict our attention to the regulatory role of governments, we need to think beyond restrictions that are implemented to limit negative externalities and avoid different forms of market failures. Although such regulations are needed in some cases, they often tend to be static, responding to yesterday's problems. The interaction of such static, reactive rules with dynamic, adaptive algorithms used by platforms and some of their users could result in undesirable (game-theoretic) equilibria. Meanwhile, platform owners often argue that regulatory frameworks that were designed for incumbent industries (e.g., hotels or taxi cabs) do not apply to them, in part because they can self-regulate by leveraging a wide range of algorithmic platform governance mechanisms that are available to them. In a way, this argument tries to extrapolate from the success of marketplace platforms in efficient dynamic matching of market sides (thereby shaping supply and demand via dynamic pricing) to make a case for the efficacy of self-regulation. This claim holds that those adaptable, dynamic algorithms can be extended to other areas where the sociotechnical behaviors in the ecosystem need to be steered, based on the objectives that the regulator has in mind. Such a solution could draw elements from both the market and regulatory perspectives. Much of the concerns of regulators can still be addressed using internal algorithmic governance that can be embedded into the design of the platform; however, the design specifications, objectives, prioritization of conflicting goals, and the verification processes cannot be left solely in the hands of the platform owners and must be determined by what I refer to as *public-mediated platform governance*. Given the complexity of platform regulation and the increasing prevalence of platforms, I expect that questions on the relative role of external regulation versus public-mediated governance, the implementation mechanisms for the latter, and the role of citizens in providing inputs to some of the key decisions of platform governance will be key areas of research and public discussion in the coming decade.

2.4 BUILDING A TAXONOMY FOR SHARING ECONOMY ECOSYSTEMS

The ecosystem perspective of sharing economy platforms is useful in formulating a number of important questions, some of them related to the discussions offered in this section. For example, how many of the goals of the regulator can be achieved using external regulation as opposed to platform-mediated governance? How widely should regulators look in capturing the effects of positive and negative externalities in order to make regulatory decisions? Or when it comes to internal platform design and governance: How much control does the platform owner need to exert on transaction details, pricing, and active matching of different sides of the market? How much transparency, modularity, and openness are optimal for platforms in order to balance the trade-off between competition and growing their ecosystem? How actively does the platform owner need to intervene to establish trust between different sides of platform transactions and how can the platform owner balance this need with the privacy concerns of users? How much should platform owners and public agencies pursue public–private partnerships?

The short answer to all these questions is that *it depends*, and the answer varies for different types of platforms and different characteristics of the ecosystem in which they are embedded. But can we go further than this short answer? How can we know, more specifically, what drives the answer to these questions? In this section, I take the first steps in digging beyond that short answer by providing a number of key dimensions that amount to a taxonomy of sharing economy systems that can help us answer different ecosystem-related questions. In addition to setting forth some important differentiating dimensions, I explain why those dimensions are important and provide a few examples of how those dimensions affect some of the key questions related to platform control or governance. I intend in this section to use broad brush strokes in describing the driving forces active in each dimension. A comprehensive description for any given platform will require a more thorough mapping of the ecosystem, more precise formulation of the questions using the sociotechnical approach, and further modeling and empirical work.

The taxonomy I provide here differs from other taxonomies of sharing economy platforms. Although some comprehensive classification studies have been conducted in recent years (Acquier, Daudigeos, and Pinkse 2017; Benoit et al. 2017), the majority of these classification efforts have focused on making sense of the variety of business models used by sharing platforms, either as a whole (Muñoz and Cohen 2017; Sanasi et al. 2020), or in a particular sector or essential component such as mobility (Cohen and Kietzmann 2014), hospitality (Kuhzady et al. 2021), and logistics (Carbone, Rouquet, and Roussat 2018). However, my goal is to introduce a number of dimensions that could be used to better approach the ecosystem-driven questions, some of which I presented in the previous section. Furthermore, these dimensions can be used in conjunction with the sociotechnical approach that brings together the engineering design, business models, and regulatory and governance aspects of sharing economy platforms.

2.4.1 *Key Differentiating Dimensions of Sharing Economy Platforms*

A. What is shared: Sharing economy platforms are used to share resources among different platform participants; yet it is not often immediately obvious what is shared on these platforms. Here I divide the shareable object into three categories:

information, physical assets, and labor. Although many platforms share a combination of these objects, for most of them, one of these objects is more distinct, which in turn determines some important characteristics of the platform.

A.1. *Information*: Given the digital nature of modern sharing economy platforms, information sharing is often at the heart of how these platforms operate. In fact, the information intensity of a service or product is a strong predictor of its propensity to become a successful platform. We need, however, to distinguish between cases in which information is shared between the platform and its users, and those where platform-enabled information exchange among users is the main function of the platform. The first type of information sharing is ubiquitous among multisided platforms and serves two intertwined functions. Information shared with the platform by the users reduces various forms of transaction costs for other types of transactions; for example, data about users' locations, preferences, past transactions, and social networks can facilitate the search and matching process. This high-resolution data, provided voluntarily by the users to serve such functions, can then be used by platform owners to generate additional revenue, often in the form of direct or indirect advertisements.

Apart from this ubiquitous form of user–platform information sharing, information can be the main object of exchange in many multisided platforms such as LinkedIn (job-related information between employers and jobseekers), Yelp and Angie's List (information about business quality), and StackExchange (questions and answers [Q&A]). Whether all these companies can be classified as sharing economy platforms is not fully clear and depends on the breadth of the definition one uses for the sharing economy. I would argue that Q&A services such as StackExchange better satisfy the narrower definition of the sharing economy, compared to companies such as LinkedIn or Yelp. This is because, unlike Yelp or LinkedIn where information exchange is not targeted, transactions on StackExchange are targeted sharing that happens between two parties (questioner and responder) and are driven by differences in the ownership level of a resource (expertise in this case). In my classification, while I recognize the ubiquitous role of information sharing in all digital platforms, I only consider information as the main transaction object when platforms can be classified as sharing economy systems and are used primarily for exchange of information among users.[1]

A.2. *Physical Assets and Labor*: Although information can be the main article of exchange for some sharing platforms, the majority of these platforms are founded to facilitate the sharing of either physical assets or human labor, and some of the key characteristics of sharing platforms can be linked to the relative importance of these two different types of sharing articles.

The first generation of sharing platforms was mostly based on sharing unused *physical assets*, primarily in transportation (unused car seats in the early days of

[1] From this standpoint, we can consider the product Q&A feature of Amazon where previous buyers respond to questions by a prospective buyer as a form of sharing service.

BlaBlaCar) and lodging (Couchsurfing and the early version of Airbnb). The choice of physical assets (as opposed to digital assets) to identify the first generation of sharing economy is a conscious choice – to satisfy the standard definition of sharing economy platforms mentioned earlier. However, I acknowledge that virtual mechanisms such as digital right management or non-fungible tokens that can artificially introduce *scarcity* in digital assets can in theory enable forms of platform-based sharing of digital assets that are closer to how we define sharing economy platforms here.

B. Transaction Heterogeneity (and Uncertainty): Heterogeneity, also known as diversity in some contexts, is an important common feature of complex systems that creates a fundamental system-level trade-off, enabling adaptability, evolution, and resilience on the one hand, and making it harder to predict, manage, and change the systems on the other. Moreover, higher heterogeneity may result in higher uncertainty, making it more challenging to manage resources and predict their supply and demand. Much of the complexity management in complex engineering systems revolves around implementing an appropriate level of heterogeneity at various layers (e.g., products, agents, modes, and rules of interactions) to balance this trade-off. The dominant system design mechanism uses the principle of modularity, which works in two steps. It first maps a large number of possible realizations of heterogeneous attributes to a smaller set of modules. It then creates standard interfaces that facilitate interaction between different modules.

Managing transaction heterogeneity is a key differentiating attribute among various sharing economy platforms. These platforms face at least two layers of heterogeneity when it comes to transactions they enable: Spatiotemporal heterogeneity, and agent's type diversity. As I will discuss, while managing the former type has been instrumental in the success of most sharing platforms, the latter plays a major role in the governance schemes of the platforms.

B.1. Spatiotemporal Heterogeneity is the very basic form of heterogeneity and refers to the diversity relating to when and where the demand or supply for articles of transactions occur. Traditionally this type of heterogeneity was managed by creating spatiotemporal modules, for example, by creating stations and timetables for public transportation systems. This form of spatiotemporal heterogeneity was in fact a major barrier for peer-to-peer (P2P) platforms until recently, and a key value for on-demand platforms such as Uber and Lyft is their successful management of this aspect of heterogeneity, thanks to the prevalence of smartphone devices, accurate supply and demand prediction, and demand and supply shaping through different incentive mechanisms. These mechanisms make it possible to modularize the unit of transaction to a more or less standard product, such as a ride to the airport, or a standard bedroom on a second floor in the Alfama neighborhood in Lisbon in the second week of June. As we will see, such modularization becomes challenging as other forms of heterogeneity are added.

B.2. Agents Heterogeneity: Besides differences in the time and location of supply and demand, participating agents on a platform can be different in other aspects such as preferences, skills, and reliability. I refer to all these other aspects as agent type. Although this dimension of heterogeneity is also present in most sharing platforms, the associated complexity of this dimension and the consequent governance mechanisms can vary substantially across different platforms. On one end of the spectrum lie platforms such as Uber and Lyft for which differences in agents' types are either not large (e.g., driving skills), not of primary importance (e.g., make and model of the car, within a given vehicle category, or the personality of the driver), or can be ranked on a single dimension (e.g., safety and reliability). Mechanisms such as review help with standardizing the last group, since it is often expected that the reviews are not affected by heterogeneous, multidimensional preferences of platform users, and thus that much of the information about these attributes can be encapsulated in standardized review scores. As we move to the other end of the spectrum, agents' differences become wider (e.g., skill level of professionals on Upwork), preferences become more heterogeneous on a wide range of dimensions (e.g., preferences of Airbnb users for the type of a $150/night apartment in Berlin), and the weights they assign to those preferences increase (e.g., Airbnb host personality).

What are the consequences of this dimension on platform governance? Using principles of modularity in complex systems, I argue that smaller heterogeneity range, significance, and dimension, enables creation of more standardized modules, which in turn opens the door for a higher level of control by the platform owner over different aspects of transactions. Standardized modules can enable control over pricing, where, for example, a "6:00am ride from downtown to the airport in a sedan" can be considered as a standard transaction module that can be priced. Lower dimensions of complexity also eliminate the need for direct exchange of information between different sides of the transaction, which in turn can enable algorithmic matching between them, further leaving transaction control in the hands of the platform owner. This contrasts with a platform like Airbnb that falls towards the middle of the spectrum, where heterogeneity, especially on the demand side inhibits automated matching, allows direct communication and negotiations between different sides, and leads the way to delegate much of the pricing decisions to the landlord. An example of a platform that resides close to the other end of the spectrum is ebay in which both sides of the platform (sellers and buyers) experience large multidimensional heterogeneities, which in turn push the platform owner to delegate a large portion of control to the users and to market mechanisms such as auctions.

C. **Transaction Stakes**: Sharing platforms can have different levels of transaction stakes as a function of various forms of risks associated with those transactions. Besides financial and safety risks, higher stakes can be the result of concerns about opportunity cost, poor experience, reputation, discrimination, and privacy. I also expect that, everything being equal, transactions with longer time commitments show higher stakes (a few minutes of an Uber ride, compared to a few days of Airbnb stay). The difference in the level of transaction stakes is crucial for platform governance, since it directly affects trust, which is central to the success of sharing platforms. In general, platforms with higher transaction stakes need stronger governance mechanisms to ensure a sufficient level of trust between different sides of the platform. These mechanisms include prescreening of users, mechanisms to ensure participation and quality of reviews, mechanisms to promote trust as an emergent collective norm among platform users, and transparent, punitive measures to deal with special cases. This is why Airbnb, which exercises less governance control compared to Uber in pricing and matching dimensions, demonstrates stronger control when it comes to trust mechanisms.

D. Time Urgency: I define time urgency as the average time between the availability of supply and demand and the execution of the actual transaction. Based on this definition, ride hailing applications often have a high level of time urgency, on the order of minutes, due to their on-demand nature, although the time urgency is generally lower for long distance carpooling platforms such as BlaBlacar. Lodging platforms such as Airbnb and Homeaway have a medium level of time urgency on the order of days to weeks. Labor matching platforms such as TaskRabbit and Upwork, on the other hand, are highly heterogeneous in their time-urgencies, which can range from hours to months depending on the nature of the service.

As for the impact of time urgency on platform values and their governance, it interacts with the two types of heterogeneity mentioned earlier – spatiotemporal and agent type – in two different ways. Higher time urgency increases the role of platforms in managing spatiotemporal heterogeneities for the reasons described earlier, thus adding to their value from their users' perspective, while making it more possible for platforms to exert their control over on-demand transactions. As time urgency decreases, the overall value of the platform might decrease. This is because lower time urgency makes room for higher competition and creates the possibility of *multi-homing* where users simultaneously evaluate multiple platforms for the same type of transaction. Lower time urgency also increases the relative importance of agent type heterogeneities, which in turn forces the platform to relinquish some of its control.

E. Network Effect: Most sharing platforms owe most of their value to some form of network effect, at least in the earlier phases of their operation. In platform-mediated P2P markets, this network effect is often cross-sided, which means that users on one side are the source of value for users on the other sides, which in turn will increase the number of users on those sides, resulting in a positive feedback of constantly adding users – and value – to the platform. This increase in value as a result of positive cross-sided network effects manifests itself in the form of lower wait-time (e.g., for ride hailing passengers), lower idle time (e.g., for ride hailing drivers), wider geographical coverage (e.g., for Uber and Airbnb), and a more diverse set of choices. The network effect can be local or global, depending on the nature of what is shared on the platform and time urgency. In general, the network effect becomes more localized when transactions include physical assets and have higher time urgency. The scope of network effect is a key determinant of market competition forces and subsequent policy and regulations.

Although cross-sided network effect is often considered as one of the main reasons for the near-monopolistic behavior of sharing economy platforms, one needs to be cautious about its role as a barrier to entry in the long-run. One reason is that ironically, cross-sided network effect is technically not a *network* effect, since it often has little to do with the social network of users. This is in stark contrast to how network effect works for social media platforms where much of the value of the platform for users depends on the presence of the members of their social network on the platform. Switching to a different platform then requires a coordinated decision of social networks clusters, which is difficult to achieve in most cases. On the other hand, it is theoretically possible for a new ride-hailing platform to enter the market and establish the initial network by subsidizing rides and paying more to the drivers, similar to how Uber grew in its early days. Cross-sided network effects, however, can create barriers to entry for new platforms in the long run by enabling the economy of scale that is required to build certain physical and logistical infrastructures, favorable terms with other corporate partners, and public–private partnerships.

Sharing platforms can also demonstrate various degrees of same-sided network effect, where the value of the platform for users of one side is modulated by the number of other users on the same side. Some forms of same-sided network effects are more or less universal among most sharing platforms. For example, many platforms demonstrate negative effects related to short-term issues like congestion and competition (e.g., more passengers drive up the price and wait time on a Friday night). Other forms of same-sided network effects, however, can vary substantially across different platforms, depending on some of the characteristics discussed earlier. Reviews are one of the main mechanisms that create this same-sided network effect, where both the quantity and quality of reviews by other users can improve the choice quality for a user on the same side of the platform. Whether this type of same-sided network effect benefits from the social networks of users depends largely on the level of agent type heterogeneity. When agents are heterogeneous in type and in multiple dimensions, as discussed earlier, we can expect users to benefit more from structured same-sided network effect. For example, most people care little about who reviewed the Uber driver who is being matched to them, while learning that their friend enjoyed staying with a family-owned Airbnb in Barcelona would carry great weight. Consequently, platforms with higher agent-type heterogeneity could be more successful in establishing mechanisms for structured same-sided network effects as an additional barrier to entry. Regulators need to take on this often-neglected lens in addition to the commonly discussed cross-sided network effect.

2.5 CONCLUSION

Platform systems are touching various corners of our socioeconomic lives and are creating gray areas in many traditional dichotomies: Employees versus independent contractors, ownership versus access, external regulation versus self-regulation, public versus private, and competitive versus monopolistic markets. We can only benefit from the promise of sharing economy platforms, while addressing valid concerns about some of their negative consequences, by increasing our understanding of these grey areas, making choices among them, and understanding and quantifying the trade-offs between these choices. This chapter argued that this can best be achieved by establishing a sociotechnical ecosystem framework that includes a set of lenses borrowed from the sociotechnical approach towards complex systems, an ecosystem perspective that builds upon previous work on business and industry ecosystems, and a set of differentiating dimensions that can help with building classes of sharing economy platforms to create useful levels of modeling abstractions and enable transfer of insights across different platforms. However, more research and case-based studies must be conducted to take this framework to the next level, that is to fully operationalize it and better show its power vis-à-vis other existing frameworks in the literature. I leave this challenge for future research by the interdisciplinary community active in this area.

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3

The Sharing Economy and Environmental Sustainability

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3.1 INTRODUCTION

Sharing economy organizations advertise many types of benefits to users and society, including advancing environmental sustainability. A basic premise of sharing economy services is that they convert private, under-utilized assets into resources that are shared among a pool of users. From an environmental perspective, sharing is assumed to reduce private consumption and attendant energy use, resource demands, and emissions, thus allowing people to live 'low-impact' lifestyles. These benefits are influential, and the promise of efficient use of resources and environmental sustainability have been identified as important motivators for consumers' participation in the sharing economy (Bocker and Meelen 2017).

Meanwhile, the sustainability orientation of sharing economy companies varies dramatically. As manifested by the companies' taglines and branding, housing and mobility platforms have typically framed themselves in terms of economic opportunity: 'Airbnb: Earn money from your extra space', 'Uber: Get behind the wheel and get paid'. Among mobility platforms, Lyft stands out by investing in environmental sustainability through promoting hybrid and electric car rides and buying carbon offsets: 'Every Lyft ride is fully carbon neutral'. Interviews of free home-sharing companies such as 'Couchsurfing', 'Trustroots' and 'BeWelcome', Voytenko Palgan, Zvolska, and Mont (2017) found that environmental sustainability is a core value for these businesses, but that there was no explicit message of environmental sustainability motivation on these companies' websites. Instead, trust was emphasized as the core value.

On the other hand, goods sharing platforms are more often grounded in environmental sustainability, with taglines such as: 'Our mission: save the world and enjoy delicious food in the meantime' (https://medium.com/resq-club), 'OLIO can help create a world in which nothing of value goes to waste', 'Rent instead of buying. Hygglo is good for environment' (hygglo.se). These general observations have recently been confirmed by a systematic analysis of sustainability claims in the online and social media content of 121 sharing platforms (Geissinger et al. 2019), which found that all of the thirty-five identified sustainability-oriented platforms were focusing on goods sharing. In another study, 61 per cent of the food-sharing platforms in 100 cities made statements about environmental benefits. Yet, even in the goods-sharing sector, only a few platforms provided any evidence to substantiate achievement of these benefits (Davies et al. 2017).

As with many efforts related to environmental sustainability, in practice the reality is much more complicated than these straightforward claims suggest. The predicted environmental benefits are by no means assured and need to be researched carefully (Frenken 2017, Frenken and Schor 2019). Several observed consequences involve trade-offs between avoided consumption (e.g., from resources and pollution avoided in manufacturing) and increased use (e.g., energy use and emissions from traffic congestion). In some cases, preliminary estimates have been made to quantify such environmental sustainability trade-offs using tools such as life-cycle assessment (LCA) combined with real data from sharing economy platforms (Mi and Coffman 2019). Some estimates have also considered the rebound effect, where savings due to avoided purchases are actually applied to more consumption, which can be either less or more emissions-intensive than the original environmental savings (Plepys and Singh 2019).

This chapter will document the types of unintended consequences that have been observed for different sharing platforms, including for mobility, housing, and second-hand goods, many of which are mediated by the economic rebound effect. This chapter will also present the arguments and evidence to date on the question of how and whether the sharing economy is environmentally beneficial in its current manifestation, and what might be done to improve environmental outcomes. Section 3.2 will describe how sharing systems affect the environment, both directly and indirectly. Sharing systems are often characterized in economic terms; here the focus will instead be on physical consequences, such as shifts in consumption of materials and energy. Section 3.3 will review the nascent literature assessing the environmental sustainability of different sharing systems and identify patterns, both in terms of the methodologies underlying the studies as well as their findings. Based on past results and lessons learned from cases around the world, Section 3.4 will highlight further research opportunities and suggestions that have mitigated some unintended consequences and helped to advance environmental sustainability. Environmental sustainability is multi-factorial, encompassing many types of earth and environmental systems and resources. For simplicity, we will restrict the discussion of environmental sustainability to four aspects: material use and waste, energy use, and emissions.

3.2 THE PHYSICAL SHARING ECONOMY

One way to assess the environmental impact of sharing systems is to describe sharing transactions in physical terms by mapping their associated material and energy flows, to quantify unintended consequences and avoided emissions of manufacturing additional products, and to compare against conventional private consumption. The field of industrial ecology (IE) has long been applied to investigate these types of problems. From its founding, IE has used natural ecology as a metaphor for inspiring human systems of production and consumption, including the features of community, connectedness, and cooperation that describe many sharing economy activities (Ehrenfeld 2000). IE research is well developed in its investigation of shared *production*, particularly the inter-firm sharing of by-products or collective services, called 'industrial symbiosis' (Chertow 2000). Using by-products such as fly ash, for example, as a substitute for cement in concrete, avoids the need to dispose of the by-product and simultaneously reduces the amount of virgin production of cement. In physical terms, this means avoiding resources, energy, and emissions from quarrying, transportation of raw materials, cement production, transportation to the disposal site, as well as reducing burden on infrastructure such as roads, landfills, industrial equipment, and so on. Quantifying resource and emissions savings through avoided materials and energy is often done using the systems modelling tool of LCA, which is designed to capture environmental burdens of goods and services over their 'life cycles', that is including their production, use, and end-of-life (Eckelman and Chertow 2013). With the advent of large-scale, technology-enabled sharing economy platforms, IE and LCA are now being used increasingly to analyse shared *consumption*, again starting from the first principle of quantifying material and energy flows.

In transportation, the major physical flows associated with human mobility are the energy needed to move vehicles and the materials in the vehicles themselves. Shared transportation services can directly reduce these resource requirements in a number of ways. In terms of material resources, the availability and convenience of sharing services allows some people to forego the purchase of their own individual vehicles, which in turn avoids energy, water, and emissions associated with materials production and vehicle manufacturing. Shared transportation increases vehicle intensity of use and may cause vehicles to deteriorate faster. This can have both negative effects (physical vehicle must be replaced) as well as positive (new vehicle may be more efficient). For fuel, if each passenger is alone in a ride share vehicle all the way from origin to destination, then there is no clear energy advantage over using a private vehicle, assuming the two vehicles have comparable fuel economies; there may instead be a disadvantage due to additional driving in between hired rides. But, if the rideshare picks up or drops off additional passengers en route (as with UberPool), or if using a rideshare eliminates the need to search for parking at the destination, then some fuel use, associated emissions, and congestion may be avoided.

These shifts may have indirect benefits for health, particularly through reduced emissions and congestion that will be felt predominantly in urban areas, where the majority of ridesharing is occurring. Reduced emissions lower levels of hazardous urban air pollution, especially ozone to which automobile emissions are important precursors, with attendant health benefits from cleaner air. Reduced congestion has beneficial implications for pedestrian and bicycle safety, urban noise, road maintenance, worker productivity, and stress. However, unintended consequences may offset some or all of these direct and indirect benefits. Most notably, rideshare drivers who stay on the roads while waiting to respond to ride requests will contribute to fuel use, emissions, congestion, and ageing of their vehicles. This phenomenon would be the same compared to taxis trolling for fares but would not take place compared to private vehicles that remain in parking places when not in use. This raises the vital question of what transportation mode is actually being substituted by ridesharing. Is it taxi or private vehicle? Or (where available) is it public transit, bicycling, walking, or not taking the trip at all? When utilized at high capacity, buses and trains are much more energy efficient modes of transportation per passenger than private vehicles on a life-cycle basis (Chester and Horvath 2009), so a shift away from public transit toward ridesharing will likely increase energy use, in addition to reducing fare-based funding for infrastructure improvements.

Shared housing presents different physical flows and different types of direct and indirect consequences of sharing. Platforms such as Airbnb allow people to rent out a spare room or an entire apartment or home on a short-term basis, presumably substituting for staying in a hotel. In theory, this could lead to direct substitution of hotel goods and services, such as room air conditioning and lighting energy, consumables, and services associated with cleaning and turning over the room. However, these goods and services would be used in the shared housing instead, perhaps with lower efficiency due to smaller economies of scale. On a macro scale, shared housing could shift the market for hotels, leading to fewer being constructed, but the land parcels in question would presumably be used for other productive developments. Another potential direct physical effect relates to energy use: Hotels are frequently located in central, convenient locations, whereas shared housing is more spatially distributed, potentially leading to more transportation energy used when travelling to and from the shared housing site. Indirect environmental concerns are also primarily related to shifts in transportation. When many centrally located properties are used primarily for shared housing rather than residences, the people who previously lived there may move to locations outside of the city and become commuters, potentially increasing fuel use and congestion.

Finally, shared goods such as surplus food and materials represent another type of implicit environmental trade-off between direct and indirect benefits and costs. Surplus food or materials are themselves a physical flow whose sharing prevents their collection, saving fuel energy, and disposal in landfills or waste incinerators, saving valuable space and energy and avoiding landfill leachate and other types of waste management pollution. Goods sharing could contribute to the 3Rs (Reduce, Reuse, Recycle) principles of waste prevention by reducing packaging waste of new products and reusing products that are in good condition. Sharing is also a strategy under the Circular Economy concept that aims to maximize utility and value of the resources in use (Kalmykova, Sadagopan, and Rosado 2018). In addition, their sharing means that receivers do not have to purchase as much new food or materials, with savings of resources all the way up the supply chains of those goods. As with shared housing, the locations of the substituted and shared goods are a critical consideration. If the sharing location is closer than the primary store where goods would ordinarily be bought, then transportation energy could be saved. However, for food in particular, the variety that is available through sharing may not be adequate to cover dietary needs, and participants may end up making trips to primary stores anyway. So, while food and materials sharing appears to have clear avoided materials and waste management emissions benefits, the trade-offs associated with transportation are unclear and likely to depend on origin–destination locations, travel modes, and consumer shopping behaviour.

3.3 EVIDENCE OF ENVIRONMENTAL BENEFITS OR DISADVANTAGES

A bevy of new data-driven research has emerged recently on the environmental implications of sharing economy practices, supplementing the mostly small-scale, anecdotal or model-based studies in the existing literature. This Section will review findings to date that have been published in open literature (as opposed to studies conducted or commissioned by companies themselves) and how they incorporate (or don't) the relevant physical considerations outlined in Section 3.2.

3.3.1 *Transportation*

The most active research area on the sustainability of the sharing economy has been shared transportation. An early life-cycle impact study of car sharing (business-to-consumer, with fixed parking locations, as opposed to ride sharing) in the United States by Chen and Kockelman (2016) reported reduced car ownership, a decrease of vehicle-kilometres travelled (VKT) of 30–70 per cent, and reduction in greenhouse gas (GHG) emissions of approximately 50 per cent when compared to the car-sharing members' travel before joining the sharing service or in comparison to their non-sharing neighbours. Among other environmental benefits were reduction in parking space demand and increase in use of public transit and non-motorized modes of travel, such as walking and bicycling. The greater intensities of use of the shared vehicles also led to a faster turnover, and subsequently to better fleet fuel economy as more efficient models are adopted. Similar results were found in a study of hundreds of car-sharing participants in the Netherlands (Nijland and van Meerkerk 2017). Importantly, the US study also examined rebound effects, which offset approximately 40 per cent of the environmental benefits as household cost savings were spent on other energy- and emissions-intensive goods and services (Chen and Kockelman 2016).

In contrast, studies of ride sharing have mostly found environmental costs rather than benefits. Ride sharing has been connected to the decline in public transit system ridership (Graehler, Mucci, and Erhardt 2019) and increased congestion in cities (Erhardt et al. 2019). A major study of ride sharing by the Union of Concerned Scientists (UCS 2020) found an average increase in emissions of 70 per cent compared to the trips that ride sharing is replacing, mostly due to excess driving between hired rides. Pooled ride sharing was found to have approximately the same emissions as private vehicle use, but when pooled ride sharing is paired with public transit use, this option was found to decrease emissions to less than half that of private vehicle use. The report also notes that transitioning to electric vehicles will have major benefits for ride sharing and should be a priority. Ride sharing now greatly exceeds taxi ridership in the United States, but because of their decentralized ownership, ride-sharing systems cannot directly take the same fuel efficiency-oriented purchasing decisions as taxi companies or car-sharing systems. However, ride-sharing companies can incentivize their drivers to invest in high-efficiency or electric vehicles, through cash incentives, preferential pricing, and partnerships for vehicle charging. For their part, some governments have taken action through differential fees for pooled rides or rides in downtown areas that compete with public transit, or through direct regulation of ride-sharing emissions, such as California's Clean Miles Standard and Incentive Program (UCS 2020).

Sharing systems for other transportation modes such as bicycles and e-scooters have also been studied. Bike sharing is present in many urban areas around the world, and can include fixed station locations, demarcated parking areas, or no fixed locations at all. Bike sharing in the United States was found to decrease ridership on buses (for which bike trips substitute) but increase ridership on light and heavy rail, as commuters combine bicycling and trains in order to address the 'last-mile' problem often associated with public transit (Graehler et al. 2019). In terms of energy use and emissions, Zhang and Mi (2018) examined a large dataset from bike share trips in Shanghai and concluded that sharing programmes resulted in savings in fuel use and decreases in harmful air pollutant emissions in the city. Similar studies have investigated health benefits, both directly from increased exercise but more significantly indirectly from a decrease in vehicle emissions and pollution that benefits all surrounding residents (Mueller et al. 2018; Woodcock et al. 2014,). On the other hand, these sharing systems require collection and re-distribution or balancing of where bicycles and e-scooters are located, which is typically done with vans or trucks running on conventional fuel. Poor operational management or sprawling low-density systems have the potential to lead to overall increases in emissions which can occur when vehicle use from redistribution exceeds that which is being substituted by bike or e-scooter use (Fishman, Washington, and Haworth 2014, Hollingsworth, Copeland, and Johnson. 2019). Environmental and health benefits are largely predicated on the fact that users are switching away from driving, rather than from public transit, private bike use, or walking; benefits of bike or e-scooter sharing may then not materialize in cities where the share of car trips is already low, as was found for London (Fishman et al. 2014).

3.3.2 *Housing*

Home-sharing platforms are the least researched in terms of environmental impact, despite their popularity. Among different vacation housing options, home sharing has been assumed to cause no additional environmental impact in comparison to the option of staying at home, while an average of 20 kg additional carbon dioxide (CO_2) per person per night at a hotel room was estimated in several studies (Chenoweth 2009). The hotels impact is in part because hotel premises continue to be heated, cooled, and air-conditioned regardless of whether they are occupied or not, and these energy demands are higher than those of a typical home, which may or may not have mechanical ventilation. Airbnb produced a report claiming substantial energy and water savings, as well as reductions in CO_2 emissions and waste due to Airbnb stays instead of staying in hotels (Airbnb 2017), building on an earlier comparison commissioned from the Cleantech Group. The report found that Airbnb stays require substantially less energy (~80 per cent) and generate lower GHG emissions (~90 per cent) than conventional hotel stays. However, the full methodology with which environmental benefits were calculated has not been made available and the results have not been independently verified. Nevertheless, a subsequent report by the Nordic Council of Ministers used the same percentage reductions to approximate potential emissions reductions from home sharing in their region (Skjelvik, Erlandsen, and Haavardsholm 2017). These results are only meaningful if home sharing is substituting directly for hotel stays.

The other consideration is whether the convenience, choice, and typically lower costs of home-sharing platforms induce additional travel. Studies of the direct rebound effect of home sharing, namely whether it promotes more travel (including longer stays) entailing corresponding emissions, showed disparate results. A survey of 450 respondents with experience of using home sharing showed that use of peer-to-peer (P2P) accommodation expands destination selection (65 per cent positive responses) and may increase travel frequency (40 per cent positive responses) (Tussyadiah and Pesonen 2016). It should be noted that over 30 per cent of the respondents used home sharing only once, while 40 per cent of respondents have experience of up to five visits. In another questionnaire involving twenty-four users of a home-sharing platform, all but one user responded that they would conduct their travels independently of access to a home-sharing option (Voytenko Palgan et al. 2017).

3.3.3 *Goods*

It is often assumed that, as a consequence of using a sharing platform, the purchase of new products may be avoided or replaced by the sharing of products with the same functionality, thereby avoiding the environmental impacts of virgin production. Again, this simplistic assumption needs to be tested, as avoided production may not be the driving contributor and rebound effects may negate any potential savings. However, at the time of this review, there were few publications with comprehensive assessments of the environmental benefits of sharing goods such as surplus food, products, or building materials.

One of the most comprehensive was that of Martin, Lazarevic, and Gullstrom (2019), who assessed CO_2 emissions of durable-goods sharing and potential savings in emissions, compared to the baseline (no sharing) scenario, based on transactions from the sharing platform Hygglo.se. Hygglo.se facilitates transactions between the user and provider for P2P sharing of about 7,000 listed products and services. In order to investigate the benefits of this sharing platform, three scenarios were analysed for an urban district with a population of 25,000 in Stockholm, Sweden: (1) a baseline scenario that assumed that no sharing service was available and all products were purchased new by the residents; (2) a scenario of products sharing assuming patterns of Hygglo.se transactions during 2017; and (3) the same sharing scenario as (2) but supplemented with a lockers-and-delivery system in order to reduce transport emissions of transactions. The analysis considered environmental impacts of goods production (due to raw materials extraction and manufacturing), distribution (for example, transportation, retail operations, energy use, and impacts from digital infrastructure), and use (for example, energy consumption) but excluding impacts of goods disposal. The study found that sharing scenarios reduced GHG emissions by about 77–85 per cent, with the results varying according to the average roundtrip travel required to complete the transaction. In this case, environmental impacts associated with avoided goods production were in fact the dominant factor in reducing emissions, since there were fewer products circulating in the district through sharing, providing the same level of service that newly purchased products would have provided. The study also showed how introducing a system with lockers and delivery could additionally reduce the transportation emissions of sharing transactions, though other work has shown that such reductions depend on characteristics of the logistics system, demand, and locker locations.

The garment industry is another sector that has received recent criticism for its environmental impacts, particularly from the rise 'fast fashion', where garment use is extremely short-lived (Niinimäki et al. 2020). There have been calls to transform the industry toward a circular economy model, including mechanisms for sharing via platforms (Ellen MacArthur Foundation 2017), with the implicit assumption that such sharing will lead to environmental benefits such as reduced emissions. To test this hypothesis, Son et al. investigated different scenarios for garments, in which both second-hand purchases and sharing in the community were found to cause similar GHG emissions (1 kg CO_2/garment usage), lower than a new purchase or online/offline rental (2.5–4 kg CO_2/garment usage) (Son et al. 2019). In the case of rental, however, the impacts of cleaning and transportation brought the CO_2/usage above that of owning an item. Another study focused on waste reduction found that, operated under favourable conditions, sharing could potentially reduce household waste by 20 per cent overall (Demailly and Novel 2014).

In general, transportation mode and distance are critical considerations for assessing the emissions associated with product-sharing transactions. For example, for food products, which can have relatively low embodied emissions compared to durable goods, the transport emissions from travelling to and from the point of sharing may offset the environmental benefits of avoiding new food, but the balance depends on how and how far individuals must travel. Proximity and access to low-emission transport options led to favourable results for sharing models. In a study in the United Kingdom, based on records from the OLIO food-sharing app, it has been found that 92 per cent of transactions occur within 10 km and 76 per cent of transactions occur within 5 km (Harvey et al. 2019). For the Greater London area, with high population density and proximity of sharing pairs, Makov et al. found that food sharing through OLIO led to net environmental benefits for all transportation options, though the benefits were greatly reduced when a two-way dedicated car trip was used (Makov et al. 2020).

Emissions are just one measure of environmental performance. For many studies describing the environmental benefits of goods sharing, another common metric is quantity (mass) of the avoided waste. This trend is especially evident in the literature on food waste (Davies and Legg 2018). Two studies involving Craigslist, a popular US-based P2P sharing platform for second-hand goods, found an estimated mass reduction in solid waste generation by 2–6 per cent per capita annually (Dhanorkar 2019; Fremstad 2017). But in these studies, neither the benefits of saved methane emissions, landfill space, and transport for waste collection have been assessed, nor has the alternative of anaerobic digestion of food waste to produce fuel and fertilizer been considered. This indicates that the use of different environmental metrics to assess environmental benefits of goods sharing is far from comprehensive and there is significant scope for expansion in research in this area, as few studies take a life-cycle approach.

Goods sharing is also potentially susceptible to the rebound effects, where savings from avoided purchases are applied to more consumption. For example, usage of second-hand P2P platforms has been connected to buying unnecessary items, both new (due to the ability to easily resell them later) and used (because of the low price). In addition, the results of an empirical study on consumer behaviour pointed out that consumers with materialistic traits and environmental consciousness were both more likely to engage in impulse buying of unnecessary items on P2P platforms (Parguel, Lunardo, and Benoit-Moreau 2017). The suggested mechanism of such behaviour is moral self-licensing, since platforms offer numerous justifications for purchases, including the common belief that buying second-hand is virtuous in terms of savings and environmental benefits. It has also been shown that consumers' propensity to replace goods that are still in working condition has increased due to consumer participation in P2P platforms, thus potentially increasing the consumption of new goods. Unnecessary consumption of products shared for free may be even larger, leading to acquisition of products that are ultimately not used, but disposed of, negating any potential environmental benefits of their sharing.

3.4 OPPORTUNITIES AND CONCLUSIONS

The overall message of the research to date is that sharing is not an environmental panacea and should not be used as a heuristic for sustainability. Whether sharing produces environmental benefits or not depends on many factors, especially the quality of the item or service being shared, its intensity of use, the distances involved, and the severity of rebound effects. As seen in Section 3.3, research on the environmental sustainability of sharing platforms is uneven and there is much we don't know. Transportation continues to receive significant attention, in part because of the public data infrastructure available from detailed travel surveys. On the other hand, there is relatively little research to date on P2P sharing of accommodation and goods, and therefore ample opportunities for improving our understanding of potential benefits and disadvantages.

For all three sharing types considered in this chapter, research has identified opportunities for improvements, regardless of whether the baseline comparison was positive or negative. Such research has also made clear that pursuing these opportunities changes the overall calculus of whether sharing is environmentally beneficial. In general, recommendations have fallen into four major themes:

1. *Design algorithms to emphasize proximity*. For goods especially, the benefits or disadvantages of sharing were found to be highly sensitive to transportation considerations. This suggests that grouping or even restricting sharing to the neighbourhood level, as many platforms already do, may be an effective way to avoid unintended environmental emissions.
2. *Encourage low-carbon transportation options for sharing transactions*. In general, ride sharing was generally found to have higher GHG emissions than personal vehicles, but it could be lower if pooling and vehicle electrification were pursued aggressively (UCS 2020). For accommodation, home sharing was generally found to have lower GHG emissions than hotel stays, and especially so if located in public transit areas where additional car transportation could be avoided, such as city centres. For food, relying on bus travel or trip chaining with a personal vehicle greatly increased the environmental benefits of sharing (Makov et al. 2020).
3. *Model the system and mitigate unintended effects*. Sharing has large-scale implications for both private consumption and public infrastructure, with many knock-on effects that are poorly understood. For example, the emergence of home sharing in some city centres has caused rents to become unaffordable and forced long-time residents to move out of the city. These people must then commute back into the city for work, inducing additional emissions that can eclipse any environmental benefit of the home sharing itself. In response to turmoil in local housing and rental markets from home sharing, major cities such as Los Angeles have passed ordinances regulating home sharing, including by requiring registration of allowed locations, which may

enable the cities to shape where and what types of home sharing are allowed. Such policies could also include environmental motivations. Environmental economics and consequential LCA provide tools for examining the extent of rebound effects and the unequal distribution of benefits and costs.

4. *Focus sharing on transactions with the highest environmental benefit.* Items that are energy- or emissions-intensive to produce, such as like high-end tools or machinery, have a large benefit for avoided production when they are shared. If they are durable items and can be shared among a large group, these benefits will compound. Transactions can also have a large benefit because they avoid the environmental impacts associated with disposal, such as shared food avoiding the emissions from decomposition of food waste in a landfill. Estimating a ranking of sharing benefits by item type using tools such as LCA would be a useful area of future research.

While this chapter has focused on environmental benefits in physical terms, perhaps the most important sustainability opportunities afforded by sharing economy platforms are indirect, through the data that they can provide for consumption-related research and policymaking. For example, shared-ride information can be analysed by municipal transportation departments to identify demand for last-mile transportation, with the purpose of designing public infrastructure and services that operate synergistically with ride-sharing and can satisfy demand in an environmentally sound and safe way (Fishman and Schepers 2016). The levying of occupancy taxes on home-sharing by municipalities allows them to collect data on P2P supply and demand for accommodation that can be useful for urban zoning and development planning (Coles et al. 2018). Identifying the most commonly shared foods may help develop information campaigns for residents on best management practices as well as design of municipal organic waste management systems. Also, areas with food shortages may be identified and assisted. Knowledge about popular items for goods sharing and their end-of-life can inform design of more robust shareable goods by manufacturers (Wastling, Charnley, and Moreno 2018), thus further reducing demand for manufacturing through product lifetime extension. One example is high-quality durable clothing. The sharing economy may help in reaching several United Nations Sustainable Development Goals (SDGs), including SDG #11 (Sustainable Cities and Communities) and SDG #12 (Sustainable Consumption and Production). Enabled by collaborative consumption, reductions in emissions from goods production, long-range transport, and waste management could also contribute to achieving climate goals. If these potentials are found to be considerable, it may warrant political and legislative support of sharing initiatives.

As sharing economy platforms continue to evolve, there are numerous opportunities to improve their back- and front-end design in order to incentivize beneficial environmental outcomes. Thanks to their digital basis, sharing platforms are well suited for evaluation of their environmental costs and benefits at a transaction level using tools like LCA, though this opportunity that has been underutilized so far. Just as some airlines now show passengers the carbon footprint of their trips (and offer the opportunity to purchase carbon offsets), sharing platform algorithms can estimate the environmental benefits due to the avoided manufacturing and transportation, using positioning services or customers' addresses (Martin et al. 2019). Such a feature will allow users to make informed decisions on transactions, such as choosing a pool ride, instead of a single-person ride, or avoiding food pick-up that entails generating high transport emissions. Environmental characteristics of shared items could be communicated to users, such as embodied carbon or product durability. Encouraging sharing of the most robust goods will extend the lifetime of these products while further reducing demand for new goods manufacturing. Sharing economy platforms can also be engineered for the entire user base such that the objectives of the optimization routines they use include minimization of environmental impacts.

Finally, we can think of the design of the physical systems within which sharing economy companies operate, most notably by promoting urban design that enables the sharing economy. For example, what would an effective 'sharing district' look like? Is there a bundle of shared services that can be provided to the residents that would allow them to forego private consumption entirely? Several examples are already common, such as subscriptions to a shared ride service in lieu of private parking spaces, or shared appliances and tools instead of private storage spaces. Safety and security will always be important concerns for consumers; for some sensitive items, can a system of lockers for exchanged goods make transactions more trusted?

In conclusion, the rise of sharing economy platforms has upended many markets for goods and services. From an environmental perspective, there is growing quantitative evidence about the consequences of these shifts, both positive and negative. Many sharing economy participants cite environmental sustainability as a motivator for engagement, but as this chapter has shown, the scale of environmental benefits depends on operational circumstances such as travel distance, substitution, and rebound. This is still an emerging area of investigation, particularly for accommodation and goods, using LCA and other assessment techniques. Harnessing data collected by or in response to sharing economy platforms will enable a clearer picture of environmental benefits and disadvantages, which can in turn inform actions that the platforms and public authorities can take to incentivize more environmentally sustainable outcomes.

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4

Sharing Economy and Privacy

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4.1 INTRODUCTION

Information privacy has long been at the center of policy debates focusing on design and operations of online platforms (e.g., Karwatzki et al. 2017). According to the Centre for International Governance Innovation-Ipsos report (2018), nearly half of North American Internet users report that their privacy-related concerns have been increasing over time. Better understanding of the antecedents and elements of information privacy is particularly important in the context of sharing economy platforms, as participating in the services they facilitate often involves exchanging highly personal and intimate information, such as addresses, photos, personal items, phone numbers, and individual preferences (Lutz et al. 2018; Teubner and Flath 2019).

Previous examinations of privacy considerations in sharing economy platforms have been primarily focused on rights and regulations by legal scholars, resulting market power and competition outcomes by economists, privacy-centered systems design by engineers and underlying cognitive and emotion-based mechanisms by psychologists. Following the central theme of this book, the goal of this chapter is to provide a common comprehensive framework that would allow scholars and scientists coming from different backgrounds to bridge disciplinary silos and advance research on information privacy issues arising in sharing economy platforms.

The framework we propose consists of two conceptual models. The first model is concerned with exchange of information. We focus on describing various types of information exchange that arise on sharing economy platforms across different purchase stages. As the platforms serve as intermediary between providers and consumers (Ranzini et al. 2017), leading to a triadic relationship between the three types of actors (providers, consumers, platforms), it is important to understand how the dyadic information exchanges underlying this dynamically evolving relationship may vary, depending on which particular dyad is involved. Put differently, the first part of this chapter focuses on classifying all *possible* information exchanges on sharing economy platforms. Such complex information exchange is crucial for any functioning sharing economy platform (Lutz et al. 2018; Ranzini et al. 2017).

However, this exchange of information may raise privacy concerns among platform providers and consumers (Eckhardt et al. 2019; Teubner and Flath 2019). Consequently, possible information exchanges we describe in the next section may occur only if the platform users (individual providers and consumers) accept the risk that they may lose a certain degree of privacy in exchange for receiving certain benefits (Dinev and Hart 2006; Lutz et al. 2018). But how do the users trade off the relevant risks and benefits? In the second part of this chapter, we examine how platform users decide which of the possible information exchanges they choose to participate in (i.e., *accepted* information exchanges), using the privacy calculus framework.

4.2 Exchange of Information

In this section, we discuss three types of information exchange. First, we examine the exchange of information between platform users and the intermediating sharing economy platform. Then, we consider the exchange of information between providers and consumers. Finally, we discuss the exchange of information between platforms.

4.2.1 *Exchange of Information Between Platform Users and the Intermediating Platform*

The exchange of information between platform users and an intermediating platform includes the exchange of mandatory data, voluntary data, and behavioral data (Ranzini et al. 2017). Platform users exchange such data with the intermediating platform to participate in the sharing economy. The exact nature of the information exchanges can be different for providers and consumers, depending on the platform context (Lutz et al. 2018).

Mandatory data refer to information that platform users must provide to sign up on the sharing economy online platform such as real names, email address, and phone number. Such data are mainly collected through online forms (Ranzini et al. 2017) accompanying account registrations, or by asking new users to verify their identities by linking with existing Facebook or Google accounts. Providers and consumers may be asked to share different data (Lutz et al. 2018). On TaskRabbit, for instance, service providers are required to fill in quite a broad range of information fields necessary to create an account on the platform, including their name, email address, phone number, address, photo, and description of their applicable skills. By contrast, individuals seeking to onboard TaskRabbit platform as service consumers, are only required to share their name, email address, and zip code to create an account.

Voluntary data refer to information that platform users may provide to develop their profile further on the platform. Platform users may choose to share such information to appear more trustworthy and likeable, hoping to increase the likelihood of getting engaged in more transactions facilitated by the sharing economy platform (Ranzini et al. 2017; Teubner and Flath 2019). For this data type, providers and consumers may also choose to share different information items with the platform. On Airbnb, for instance, providers (hosts) can enrich their profile with more personal description and enhanced textual and visual descriptions of the property they would like to rent. Such information can make their profile (and their property) more appealing for potential consumers (guests). As for consumers, they can also choose to share more personal details, both in textual and visual (through their photo) formats, hoping that such additional information may enhance their likeability in the eyes of potential hosts (Lutz et al. 2018; Ranzini et al. 2017).

One of the key considerations related to the exchange of mandatory and voluntary data is that it is always *explicit*, meaning that platform users deliberately provide such information to access and engage with sharing economy platforms (Ranzini et al. 2017). The third type of shared information, comprising behavioral data, is fundamentally different in this respect. Specifically, sharing economy platforms often collect behavioral data *implicitly*, by tracking platform users' behavior (Fay et al. 2009). There are multiple purposes that such information can serve. First, platforms may use it to assess the effectiveness of the platform user interface by analyzing bounce rates (the percentage of website visitors who navigate away after viewing only one page) and mapping user journeys from the initial onboarding to submitting posttransaction feedbacks (Fay et al. 2009). Second, such data enable platforms to learn more about their users' preferences and personalize the user experiences on the platform accordingly (Bleier and Eisenbeiss 2015). Personalization refers to the ability to adapt content to individuals automatically, based on their inferred preferences (Chellappa and Sin 2005; Karwatzki et al. 2017). Personalization helps sharing economy platforms to recommend tailored content to platform users (Ranzini et al. 2017). While both platform providers and consumers may find some of these adaptations appealing, such data-driven personalization at scale may also backfire. Prior studies have shown that excessive personalization may result in platform users finding it too intrusive (e.g., Karwatzki et al. 2017).

Table 4.1 summarizes these three types of information exchange between platform users and the intermediating platform. In the next subsection, we discuss the information exchanges between platform providers and consumers.

TABLE 4.1 *Types of shared information*

Mandatory data	Voluntary data	Behavioral data
Aim: Getting access to the platform	Aim: Increase likelihood of participation	Aim: Analyze users' behavior on the platform
Means of collection: forms, linking with existing Facebook or Google accounts	Means of collection: forms	Means of collection: cookies, pixels
Examples: real names, email address	Examples: personal description, photos	Examples: visit frequency, bounce rates

4.2.2 *Exchange of Information Between Platform Consumers and Providers*

Once platform users establish their relationship with the platform (either by registering or subscribing), they can start interacting with other platform users. Following a commonly used classification of the different stages of the customer journey, in this subsection we use it to discuss information exchanges between platform consumers and providers that frequently occur at such stages: prepurchase stage, purchase stage and the postpurchase stage (Lemon and Verhoef 2016).

The prepurchase stage encompasses all interactions between consumers and providers that take place before the transaction or purchase occurs (Lemon and Verhoef 2016). Following registering or subscribing to the platform, consumers and providers typically exchange product information, related to the good or the service characteristics and delivery terms (Lemon and Verhoef 2016). For instance, consumers may have questions about products and may want to learn more details before deciding to book a service or purchase a good. On Airbnb, for instance, potential guests may contact hosts through the intermediating platform to obtain more information about the price or the amenities of the offered property before deciding to book a short-term stay. Providers typically respond to such requests by providing necessary information.

The purchase stage refers to all the interactions between consumers and providers that are directly related to the transactions (goods purchase or services booking) (Lemon and Verhoef 2016). At this stage, a typical information exchange is focused on payments and fulfillments. For example, Airbnb guests can exchange information with selected hosts to secure the property booking.

Finally, consumers and providers may exchange information during the postpurchase stage, which typically encompasses all posttransactional interactions (Lemon and Verhoef 2016). At this stage, they can exchange information related to exchanging or repairing the good or fixing service access issues (Ranzini et al. 2017). On TaskRabbit, for example, consumers and providers may contact each other through the platform to arrange their meeting place and time, and exchange information about required tools and job access. On Uber, drivers may call riders on their way through the platform if there is traffic, an accident or if they have trouble finding the rider at the requested location.

While consumers and providers exchange information mainly through the intermediating sharing economy platform, they can also do that outside the platform (Ranzini et al. 2017) if platform users are comfortable exchanging the contact means (typically their email addresses or phone numbers) necessary for such nonplatform information exchange. On Airbnb platform, for instance, hosts may share their private phone numbers so guests can contact hosts if there is any issue with the property during their stays.

4.2.3 *Exchange of Information Between Platforms*

In our current information-driven economy, data generate economic value for online platforms and offers a competitive advantage (Awad and Krishnan 2006). Online platforms always look to acquire new data to learn more about their current users or to identify and attract promising new ones. The access to such data helps them improve their targeting and personalization.

Unbeknownst to many platform stakeholders, many platforms share detailed information about their users with other online platforms to help them enrich their data and profit in the process (Kim et al. 2018). Moreover, online platforms may choose to share their users' data with some (but not all) of the partnering platforms strategically, to strengthen their strategic competitive advantage. For example, Facebook gave access to some of its data to Airbnb, Lyft, and Netflix (Satariano and Isaac 2018).

In sum, the advances in digital transformation enable sharing economy platforms and their key stakeholders (consumers and providers) to exchange rich data across different dyads through several consumer journey stages and for multiple purposes – we summarize these information flows in Figure 4.1. However, the sheer *possibility* of such information flows and its pervasiveness today may not necessarily indicate the expansion (or even existence) of such flows in the future, as this would require *acceptance* of such information flows by key platform stakeholders. Over past several years, many journalists and scholars have emphasized how the invasiveness of such information exchange could raise serious privacy concerns among platform providers and consumers (e.g., Kim et al. 2018). In the next section, we examine the privacy calculus framework and discuss its implications for the acceptance of various information exchanges in the sharing economy.

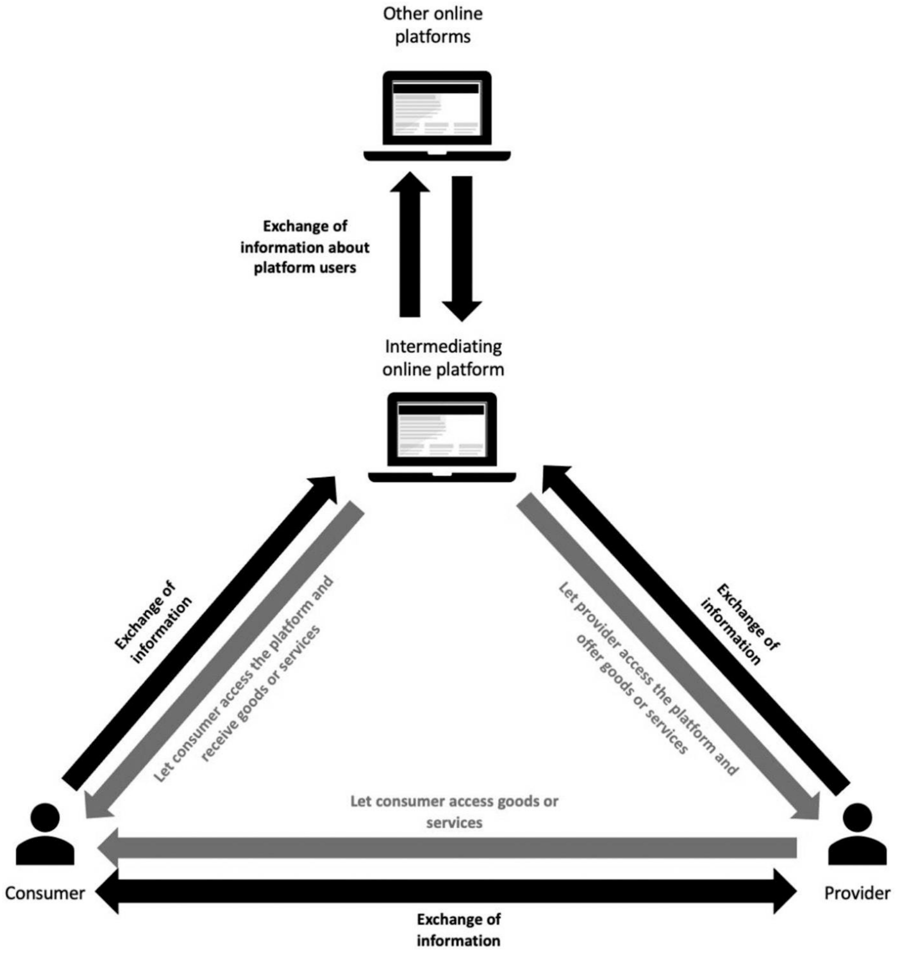

FIGURE 4.1 Exchange of information in the sharing economy.

4.3 PRIVACY CALCULUS

The information exchanges discussed in Section 4.2 may occur only if the platform users accept the risk that they may lose a certain degree of privacy in exchange for receiving certain benefits (Dinev and Hart 2006; Lutz et al. 2018). But how do the users trade off the relevant risks and benefits? We adopt the *privacy calculus* framework to shed light on these tradeoffs (Dienlin and Metzger 2016; Dinev and Hart 2006).

The *privacy calculus* is a rational analysis that focuses on the relative benefits and risks of disclosing information (Dinev and Hart 2006). In the context of the sharing economy, the privacy calculus implies an assessment of the risks of disclosing information versus an evaluation of the potential benefits derived from participation in the sharing economy. In this perspective, platform users accept losing a certain degree of information privacy if expected outcomes are worth the risks (Dienlin and Metzger 2016).

In the following subsections, we will explore the benefits and risks that could be potentially derived from participation in the sharing economy.

4.3.1 *Risks of Disclosing Information*

Yates and Stone (1992) define risk as "the possibility of loss." In the context of sharing economy platforms, users may decide against pursuing an access to a good or service due to the uncertainty associated with the required personal data disclosing (Ranzini et al. 2017). Such uncertainty generates concerns among platform users about information privacy practices (Bart et al. 2005).

Privacy concerns refer to the extent to which individuals are concerned about online platforms' collection and use of their data and worry about potential misuse (Hong and Thong 2013; Karwatzki et al. 2017). Such concerns relate to data collection, unauthorized secondary use of data, improper access, and errors (Malhotra et al. 2004; Smith et al. 1996). In the case of sharing economy, privacy concerns may also include considering potential physical privacy threats (Lutz et al. 2018; Teubner and Flath 2019). In the following discussion, we examine each of these risk dimensions.

4.3.1.1 Data Collection

Concerns about data collection are defined as "the degree to which a person is concerned about the amount of individual-specific data possessed by others relative to the value of benefits received" (Malhotra et al. 2004, p. 338). In the sharing economy context, the amount of data relates to the number of pieces of information that pass through the intermediating platform. Not only does it include the information that is required to access the sharing economy platform but also encompasses the information the users share on the platform afterwards. Sharing economy platforms where consumers and providers typically share a large amount of information are likely to generate such concerns (Lutz et al. 2018).

Let us illustrate the intrinsic data collection using TaskRabbit as an example. Platform providers are required to share their name, email address, phone number, physical address, photo, and skills description when they sign up. For their part, platform consumers are required to share their name, email address, and zip code to create an account. Then, service providers need to further detail their skills and price ranges, while service consumers need to describe the task that needs to be completed and the task options. Consumers and providers may also contact each other to organize their meeting. After the task is completed, consumers may post reviews on the platform and assess the reliability of the provider.

On other sharing economy platforms, the number of stages at which the information needs to be disclosed could be lower, but the information context could be potentially more invasive, such as geolocation information, necessary for facilitating real-time matching on sharing economy platforms. For example, on Uber, besides sharing basic personal information when registering to access the platform (such as name, email address, and phone number) and rating their experiences after each transaction, drivers and riders must also disclose to the platform their exact location, as it is required to connect and match drivers and users in real time (Thelen 2018).

As these examples illustrate, the amount of exchanged data may vary across intermediating platforms, depending on the sector in which they operate. For instance, the travel sector that requires the exchange of more personal information may generate more privacy concerns than in other sectors (Bart et al. 2005).

Moreover, the amount of exchanged information may vary across different types of platform users; for example, consumers and providers may need to share substantially different volumes of information. On Airbnb, for instance, while both hosts and guests are required to exchange information about themselves to sign up such as names, email addresses, dates of birth, and photos, hosts also need to post detailed information about their property such as location and amenities to attract potential guests (Ranzini et al. 2017). After booking, hosts may also need to share their personal contact details (such as phone number or email address) and information to access the rented property (such as key or door code) either through or outside the platform (Lutz et al. 2018; Teubner and Flath 2019). Overall, the amount of information expected to be shared by hosts is much greater, and the disclosure of information is more intimate and prejudicial for them (Lutz et al. 2018; Teubner and Flath 2019). Such asymmetry against hosts who must take on more risks when disclosing information may discourage some of them to participate in the sharing economy.

4.3.1.2 Unauthorized Secondary Use

Concerns about unauthorized secondary use refer to platform users' concerns that data collected for a defined purpose may also be used for another purpose without their consent. Secondary use of data may be internal or external (Malhotra et al. 2004; Smith et al. 1996).

Internally, the unauthorized secondary use may occur within the organization that initiated the data collection. For instance, the user data that was initially collected for research purposes may be used afterwards for marketing purposes (Cespedes and Smith 1993; Smith et al. 1996).

Externally, the secondary use of data is often associated with unauthorized sharing of the user data with other platforms. A typical example is the external sale or rental of data (Smith et al. 1996). As mentioned earlier, the exchange of data with external parties like other platforms is particularly perceived as unacceptable among platform users (Kim et al. 2018).

Overall, platform users that may share highly personal information (Lutz et al. 2018) may be particularly concerned about unauthorized secondary use.

4.3.1.3 Improper Access

Concern about improper access refers to the "concern that data about individuals are readily available to people not properly authorized to view or work with this data" (Smith et al. 1996, p. 172). Users may be concerned that intermediating platforms do not spend enough time and effort to prevent improper access and protect personal information (Malhotra et al. 2004). Sharing economy platforms that let platform members comment on their experience interacting with other members are particularly susceptible to such concerns.

4.3.1.4 Errors

Platform users may also be concerned that the protection implemented by the platforms against deliberate and accidental errors is not adequate (Smith et al. 1996). For instance, data coding in databases and files could be inaccurate (Malhotra et al. 2004). Such concern raises the question about the responsibility of the platform in spotting errors (Smith et al. 1996).

4.3.1.5 Physical Privacy Threats

Physical privacy refers to "individuals' sense of having a private space that others cannot enter against their will" (Lutz et al. 2018, p. 1475). In the sharing economy context, platform users often allow other users temporary access to their personal property (such as cars on Uber or homes on Airbnb), which can raise serious concerns about potential physical privacy threats. Such threats may include surveillance, discomfort, and intrusion through the sharing of physical spaces (Lutz et al. 2018; Teubner and Flath 2019).

4.3.2 *Individual Benefits of Disclosing Information*

We turn now to examining how platforms users may account for various potential benefits derived from the participation in the sharing economy in their privacy calculus. We focus on three main benefits for platform users: Economic, reputation and social capital benefits (Ranzini et al. 2017).

4.3.2.1 Economic Benefits

Participating in the sharing economy may provide multiple economic benefits to platform users (Belk 2014; Bucher et al. 2016; Hamari et al. 2016). Economic benefits represent not only earnings for the platform providers who can offer access to their goods or services to a large potential audience, but also savings for platform consumers who can benefit from accessing such services or goods at a much lower price point compared with prices for alternative options associated with the similar consumption experience (Lutz and Newlands 2018; Ranzini et al. 2017). For example, providers on ride-sharing platform earn money by driving local riders around cities, while consumers gain by obtaining a ride at a comparatively low price.

The economic benefits may extend beyond the pure financial considerations. Besides the tangible value component based on the core consumption experience (e.g., getting from point A to point B), consumers may derive additional value associated with the speed and convenience of obtaining the experience.

Another important aspect of evaluating economic benefits, especially on the provider side, is related to perceived audience size, which represents platform users' perception of the potential reach of the platform (Teubner and Flath 2019). The possibility of reaching a larger number of potential consumers is particularly important for providers who may derive higher economic benefits from the greater demand or higher prices associated with the higher number of potential consumers on the platform (Teubner and Flath 2019).

4.3.2.2 Reputation

Platform users may also benefit from interacting with reputational mechanisms embedded in many sharing economy platforms (Park et al. 2014; Ranzini et al. 2017). Reputation enables individuals to obtain and maintain a higher status within a community (Wasko and Faraj 2005). In essence, these mechanisms allow platform users to obtain greater value in the future (through attracting more demand and/or charging higher prices) from their better past behavior on the platform.

Disclosing certain mandatory personal information is essential for proper functioning of such reputation-based systems, as they require unambiguous and longitudinal (over time) platform users' identification based on such information. In addition, users may gain a better reputation by voluntarily disclosing more information. On sharing economy platforms, a more developed user profile (containing more information about the user and/or their platform-related assets and services) may signal higher trustworthiness (Ranzini et al. 2017; Teubner and Flath 2019). On Airbnb, for instance, guests tend to trust hosts with more developed and accurate profiles (Ranzini et al. 2017).

4.3.2.3 Social Capital

The possibility to connect with other individuals in a meaningful way is another important motivation to participate in online communities (Hamari et al. 2016; Ranzini et al. 2017; Wasko and Faraj 2005), such as sharing economy platforms. However, social interactions between users in the sharing community inside and outside the platform (Ranzini et al. 2017) typically involve informal information exchanges above and beyond the level of individual data disclosure required by the platform.

4.3.3 *Operating the Calculus*

As we posited at the beginning of this section, participation in the sharing economy involves a mental process called the privacy calculus (Teubner and Flath 2019). In the sharing economy context, it involves analyzing trade-offs between the perceived risks related to information disclosure, namely data collection, unauthorized secondary use, improper access, errors, and physical privacy threats (Lutz et al. 2018; Malhotra et al. 2004; Ranzini et al. 2017; Smith et al. 1996) and its main perceived benefits namely economic, social capital, and reputation derived from participation in the sharing economy (Hamari et al. 2016; Lutz et al. 2018; Teubner and Flath 2019).

This privacy calculus typically involves two stages: *before and during* interacting with the platform. In the first stage, potential platform users assess expected benefits and risks based on what they know about the sharing economy platform under consideration. If expected benefits are greater than expected risks, users would start engaging with the platform. Conversely, if risks are expected to overweigh benefits, users may decide that accessing the sharing economy platform is not worth it (Dinev and Hart 2006; Teubner and Flath 2019). For instance, users may learn that the amount or sensitivity of information required to access the platform is too high and decide that the expected platform benefits are not high enough to overweigh expected risks associated with sharing such information. It is no coincidence that sharing economy platforms primarily focus on explaining benefits to potential users, rather than discussing various risks associated with the required information exchanges. For example, at the recruiting stage, Uber focuses on showing potential drivers how they can increase their earnings by subscribing and participating in the platform, rather than explaining potential risks associated with mandatory and continuous geolocation data disclosure while on the job.

Figure 4.2 presents the privacy calculus and the intention to access the sharing economy platform. In the second stage, platform users assess benefits and risks during the use of the sharing economy platform. While platform users could only rely on their expectations about perceived benefits and risks associated with engaging with the sharing economy platform in the first stage, now they can evaluate their actual experience with the platform. Based on that evaluation, they decide whether perceived risks from the completed and ongoing information disclosures outweigh the perceived benefits associated with using the platform. If so, the users might decide to decrease their engagement or even to stop interacting with the platform (Dinev and Hart 2006; Trepte et al. 2017). Consequently, sharing economy platforms often emphasize and communicate to current users how they may gain more benefits by increasing their platform engagement, which is often accompanied by

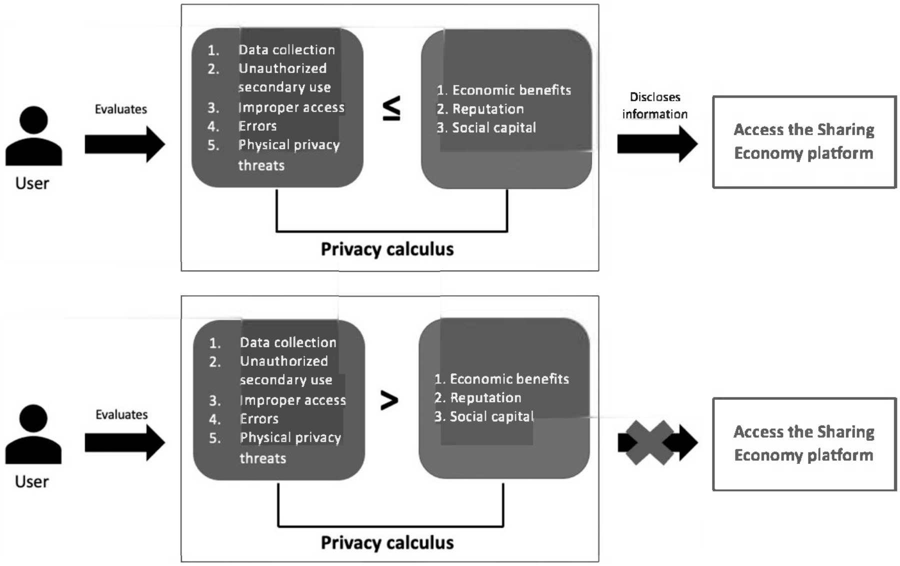

FIGURE 4.2 Privacy calculus before accessing the sharing economy platform.

additional information disclosures by the users. Such a strategy often features new, higher tiers to entice the users to follow that path. For example, Airbnb advertises an opportunity for hosts to receive the *superhost* title when they meet four requirements: Host at least ten stays a year, have an average rating at or above 4.8, maintain a 90 percent response rate and not allow their cancellation rate to exceed 1 percent (Airbnb, 2019).

Privacy calculus in both stages depends on trust, as it is an important internal factor behind overcoming uncertainty and increasing the likelihood of participating in the sharing economy (Ranzini et al, 2017). Moorman et al. (1993, p. 82) define trust as "a willingness to rely on an exchange partner in whom one has confidence." Trust includes three dimensions: Competence, reliability, and safety (Dinev and Hart 2006). Competence represents "the ability of the trustee to have the necessary expertise to perform the behavior expected by the trustor" (Dinev and Hart 2006, p. 66). Reliability reflects a trustor's perception that the trustee is honest and sincere, and safety refers to the trustors' belief that the trustee won't disclose their personal information to a third party (Dinev and Hart 2006).

In the context of triadic relationships underlying sharing economy platforms, it is important to distinguish between trust beliefs between platform users (providers and consumers), and trust toward the intermediating platform. Trust between platform users within a community is essential in a context where members share personal information with other platform users (Lutz et al. 2018). For instance, Uber explains on its platform how respect between drivers and riders is essential to build trustworthy social dynamics and provides practical tips. Trust toward the intermediating platform is also important. Platform users need to be sure that the intermediating platform will protect their data (Lutz et al. 2018; Ranzini et al. 2017) and will not disclose it to external parties without their explicit permission (Kim et al. 2018). Towards this goal, intermediating platforms may implement trust-building cues and submit to independent external data audits to signal to their users that their data is protected and will not get misused.

Finally, elements of individual's privacy calculus may get influenced by one's culture (Trepte et al. 2017). Privacy is a right that is shared all over the world but that is perceived differently depending on the culture (Altman 1977; Trepte et al. 2017). In their study, Trepte et al. (2017) show how cultural dimensions influence one's avoidance of privacy risks. Individuals from a collective culture appear to give more importance to privacy risks and tend to avoid them, compared to individuals from individualist cultures. In addition, cultures presenting higher uncertainty avoidance (such as in Germany or the Netherlands) tend to avoid privacy risks.

4.4 ROLES OF INFORMATION TRANSPARENCY AND PRIVACY LITERACY

While the framework we have outlined in this chapter describes models of both possible and acceptable information flows, many researchers and policymakers have been questioning the assumptions underlying these models: Information transparency (ensuring that all sharing economy participants can observe all possible information flows) and privacy literacy (ensuring that platforms users are able to make informed trade-offs inherent in operating the privacy calculus that determines all acceptable information flows).

Although the concept of information transparency has been studied in the general context of information privacy, the role of transparency in the sharing economy has been relatively understudied. Information transparency refers to "the extent to which an online firm provides features that allow consumers to access the data collected about them and informs them about how and for what purposes the acquired information is used" (Karwatzki et al. 2017, p. 372). Amidst growing privacy concerns, governments enact policies to protect online users' data. For instance, the European General Data Protection Regulation (GDPR) aims at delineating data protection for European individuals. It defines rules about the type of data companies can process, the time data can be stored and the way to communicate data collection and use to individuals (Kumar, 2018). This regulation renders data collection more difficult for online platforms and may have stronger overall impact on the sharing economy platforms that are more dependent on collecting personally identifiable information. For example, the more information Airbnb and Uber obtain about their users, the more efficient the matching is between hosts and guests, or drivers and riders (Teubner and Flath 2019).

Although prior research has shown how higher information transparency may reduce perceived consumer vulnerability in e-commerce and advertising contexts

(Aguirre et al. 2015; Martin et al. 2017), further research is needed to understand potential positive and negative impacts of information transparency on different types of sharing economy platform users. On the one hand, the presence of information transparency cues may provide platforms users with more control about the way their data are collected and used. However, higher platform transparency may also potentially negatively bias the individual private calculus outcomes, and this effect is likely to be moderated by privacy literacy.

Trepte et al. (2015, p. 339) define online privacy literacy as "a combination of factual or declarative ('knowing that') and procedural ('knowing how') knowledge about online privacy." In terms of declarative knowledge, online privacy literacy refers to the users' knowledge about technical aspects of online data protection, related laws and directives, as well as institutional practices. In terms of procedural knowledge, online privacy literacy refers to the users' ability to apply strategies for individual privacy regulation and data protection. It helps empower individuals engaging in practices that may affect their online privacy (Trepte et al. 2015). Prior research has shown the importance of online privacy literacy as a mediator to spending more time on social network sites (Bartsch and Dienlin 2016). However, since knowledge is an important dimension of perceived control, consumers who are high in online privacy literacy also have a higher willingness to control their online privacy and lower desire to disclose information (Awad and Krishnan 2006). From this perspective, educating and empowering users of sharing economy platforms to raise their privacy literacy may also lead to a higher sense of control of the way their data are collected and used, but, at the same time, could also reduce their willingness to disclose personal information on these platforms.

Finally, we encourage future research to examine both prevalence and impact of dark patterns in the context of sharing economy. In the online context, dark patterns are defined as "interface design choices that benefit an online service by coercing, steering, or deceiving users into making decisions that, if fully informed and capable of selecting alternatives, they might not make" (Mathur et al. 2019). Prior studies have documented how dark patterns may lead e-commerce consumers and mobile app users to share personal information when they ordinarily would not and described the mechanisms through which such patterns may influence user actions and perceptions (e.g., Hartzog 2018). It is important to understand how the potential presence of such dark patterns on sharing economy platforms may affect accepted information flows.

Overall, despite this high complexity and variety of factors underlying privacy considerations, we expect that future research bridging the disciplinary silos studying different aspects of privacy and sharing will deepen our understanding of how sharing economy platforms could optimally balance operational efficiencies against privacy concerns and rights of their users. We hope the framework detailing both possible and accepted information flows and related classifications we have introduced in this chapter would be helpful in these future endeavors.

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5

Reputation, Feedback, and Trust in Online Platforms

Steven Tadelis

5.1 INTRODUCTION

As a recent McKinsey article (Briedis et al. 2020) states, "digital marketplaces have been the buzz of the consumer industry for the past several years." Indeed, online marketplaces have grown dramatically over the past two decades and bring value across many areas of our lives. The recent forced lockdowns caused by the COVID-19 pandemic have accelerated the use of online marketplaces even further. Platforms such as eBay, Taobao, Flipkart, Amazon Marketplaces, Airbnb, Uber, Upwork, and many more match consumers and businesses to businesses and individuals and create gains from trade in efficient and effective ways by: (i) allowing businesses to market their goods or get rid of excess inventory; (ii) saving businesses the costs needed to establish their own e-commerce website to generate online consumer traffic; (iii) allowing individuals to get rid of items they no longer need and transform these into cash; (iv) allowing individuals to share their time or assets across different productive activities; and (v) allowing businesses to hire short- and longer-term contractors and employees to perform a variety of remote tasks.

Looking back at the success of these platforms, especially the sharing economy platforms where asset owners allow temporary asset usage by other users, a natural question arises: How is it that strangers who have never transacted with one another, and who may be thousands of miles apart, are willing to trust each other? Unlike a physical transaction in a store, where the buyer can touch and feel the good he or she is buying, this close contact is absent at the matching stage at multiple sharing economy platforms, which means that users may not be able to verify each other's identities in person when they commit to a transaction. Hence, to many, the rise of multisided online marketplaces, and sharing economy platforms in particular, was not foreseen.

This chapter is adapted from an article titled "Reputation and Feedback Systems in Online Platform Markets," which appeared in the *Annual Review of Economics* in 2016 and is being published with permission.

Indeed, basic economic theory would predict that these platforms should face an uphill battle. In his seminal article "The Market for 'Lemons'", Akerlof (1970) showed how hidden information in the hands of sellers causes markets to fail despite gains from trade. Intuitively, two sources of uncertainty can prevent markets from operating efficiently. First, uncertainty about the quality of a transaction may be inherent to the good or service provided like in Akerlof's adverse selection model, which means that users should be wary of purchasing access to assets they cannot inspect. For example, some hosts on Airbnb may know that the apartments they are offering for a short-term rent are defective, yet they may choose not to reveal the defect and misrepresent their items. Second, quality uncertainty may be a result of unobserved actions that determine the quality of the good or service, what is often referred to as "moral hazard." For example, a host on Airbnb may choose to skimp on cleaning between guest stays and increase the likelihood that the apartment will be in a bad shape when next guest arrives. Of course, both hidden information and unobserved actions might be present simultaneously.

It is therefore necessary that both sides of the market feel comfortable trusting each other, and for that, they need to have safeguards that alleviate the problems caused by asymmetric information. This is where new-world online platforms took a page out of an old-world playbook by creating feedback and reputation systems that became central to their operations. The need for reputation-based incentives to foster trust and guarantee successful market operation is an old idea that has been part of commerce for centuries. Just as digital transformation made possible instantaneous matching of users in modern sharing economy markets, the need to coordinate where and when market transactions took place was an important historical innovation. Take, for example, the introduction of trade fairs in medieval Europe (see Grief 2006) in which the successful trade between parties who had never met was supported by governance and reputation mechanisms that gave traders the faith to trade with strangers (see Milgrom, North, and Weingast 1990).

In this chapter, I explain how feedback and reputation systems work in practice, and how they support online markets. While most of the examples I use refer to the e-commerce marketplaces context, the key mechanisms behind interactions between buyers and sellers are similar to the mechanisms driving sharing economy markets (for example, interactions between hosts and guests on Airbnb or between drivers and riders on Uber). Section 5.2 presents the theory behind reputation mechanisms and how they support more efficient trade. Section 5.3 describes the actual working of typical online feedback and reputation systems while Section 5.4 presents findings from a host of empirical papers that explore how reputation works in actual online marketplaces. Section 5.5 highlights some shortcomings of reputation systems and Section 5.6 suggests some considerations for the future design of feedback and reputation systems that can augment their effectiveness. Section 5.7 offers some closing thoughts.

5.2 REPUTATION AND FEEDBACK: THEORY

The difficulty in supporting anonymous online trade can be explained using a relatively simple game-theoretic example.[1] Consider a buyer who finds an online product sold by an anonymous seller. The buyer values the product at \$25, the purchase price is \$15, and the seller has no use for the good, so the seller receives a net value of \$0 if it does not sell the good. The seller's costs of shipping and handling are \$5, so at a price of \$15 the seller will make \$10, and the buyer, paying \$15 for what he values at \$25, is left with a net surplus (or dollar-value utility) of \$10.[2] Further imagine that the buyer must first send money to the seller (as in clicking "buy" online) and then the seller can send the good to the buyer.

The standard assumption in economics is that people are selfish utility maximizers. This would imply that if the buyer clicks "buy" and pays, then the seller is better off just keeping the \$15 and sending nothing, thus saving the \$5 of shipping fees. But we know that many people care about being honest, and hence we need to capture a world where this is the case. To do this, imagine that the seller can be one of two types: one is an honest seller who makes good on promises, and the other is an opportunistic seller who only cares about their own profits. The buyer does not know the type of the seller but does believe that a seller is honest with some well-defined probability $p \in (0,1)$.[3] This simple game is shown in Figure 5.1.

Figure 5.1 describes the story above as follows: "Nature" determines whether the seller that the buyer faces is honest or opportunistic; the reason that both nodes are circled in a dashed ellipse is to indicate that the buyer does not know which type of seller they face, but they do know that the seller is honest with probability p. Hence, the buyer assigns probability p to being on the right side of the ellipse. If the buyer chooses not to trust the seller and not engage in trade, then regardless of the type of seller, there is no trade and both parties get zero. If instead the buyer chooses to trust, then if the seller is honest the game will end in a successful trade, while if the seller is opportunistic then it may go either way, depending on the choice of the opportunistic seller. In the jargon of economics, this game includes both "hidden information" (the type of seller is not known to the buyer) and "hidden action" (the opportunistic type has agency to act in a way that can harm the buyer).

Now ask yourself what would happen if this game is played only once? Naturally, the opportunistic seller would choose to abuse trust because it saves money and offers a higher profit. In turn, a rational buyer would anticipate this behavior and

[1] I understand that not all readers may be familiar with the tools of game theory and hence, I tried to keep this example as simple as possible and minimize the use of jargon.

[2] This scenario can be thought of as follows: If the buyer is offered to choose freely between two options, one is getting the good, and the other is getting \$25, then this buyer is indifferent between the options – they are equally good. Hence, if the buyer is offered to pay \$15 for the good, it is as if the buyer is getting \$10 worth of net value.

[3] You may wonder where p comes from. In game theory we assume that people have correct beliefs about the environment, possibly from their experience or possibly from trusted sources of information.

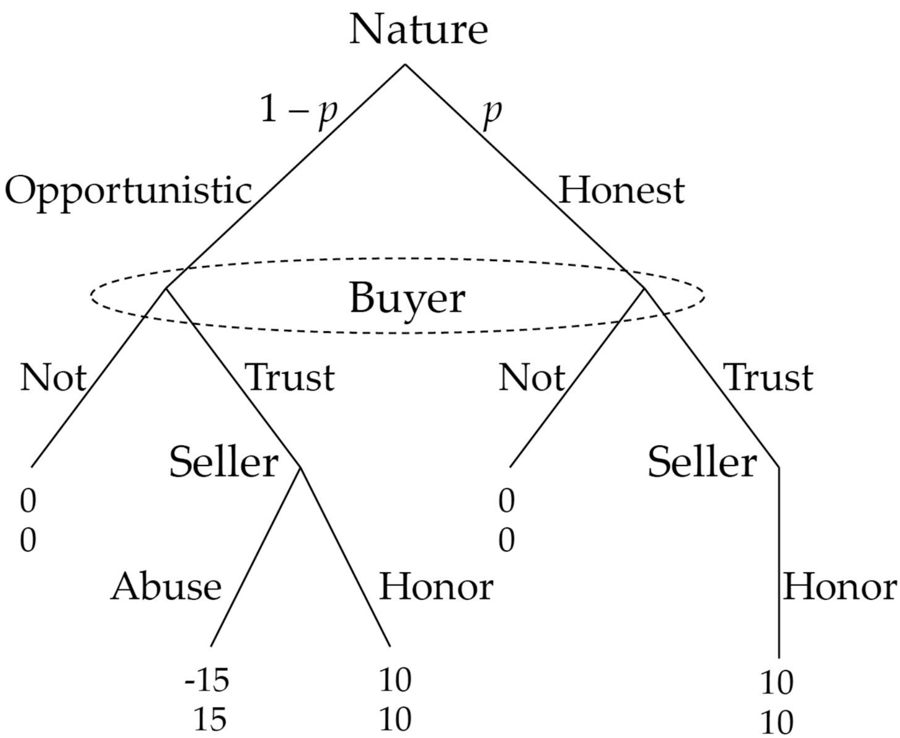

FIGURE 5.1 Trade game with asymmetric information.

will choose to trust the seller if and only if the risk is worthwhile. Assuming that the buyer is risk neutral (i.e., maximizes expected value), the risk is worthwhile if and only if the expected value from trusting the seller is larger than zero (the value of not trading), i.e., $10p+(-15)(1-p)\geq 0$ or $p\geq 0.6$. Intuitively, if the likelihood of an honest seller is high enough (greater than 60 percent) then the risk is worth taking.

Now assume that most people are known to be honest so that $p>0.6$ and any buyer would be happy to transact, and risk being cheated because the likelihood of successfully completing a trade is high enough. Imagine now that our seller will be able to transact with the buyer twice consecutively, across two periods – say in month 1 and month 2. An honest seller will always act honestly, while an opportunistic seller wishes to maximize its expected profits. Being forward looking, assume that at the beginning of month 1 the opportunistic seller discounts future profits in month 2 at a discount factor of $\delta\in(0,1)$. This means that \$1 in month 2 is worth \$$\delta$ at the beginning of month 1.[4]

It is clear that in month 2, when the opportunistic seller is facing its last transaction (there are no future trade opportunities), then it will choose to abuse trust just

[4] This is just like a business that can borrow today against future profits, but must pay some interest rate, making the amount it must pay back higher (it can borrow \$$\delta$ today and repay \$1 next month).

as it would when there is only one opportunity to trade as shown previously. The question is, what would an opportunistic seller do in month 1 when there is a future trade opportunity? As we will now show, if δ is not too small (the future is important enough), then an opportunistic seller will no longer choose to abuse trust in the first transaction and instead will want to "build a reputation" of being honest.

The argument is a bit subtle. Imagine that the buyer in month 1 believes that an opportunistic seller will abuse trust in the first transaction. The buyer is still willing to trust the seller because $p > 0.6$, but in month 2 the buyer will expect to update beliefs about the type of seller they face. If the buyer believes that an opportunistic seller always abuses trust, it follows that in month 2, the buyer can use the seller's performance in the first month to form updated beliefs about the type of the seller: If the first month's transaction was honored then the seller must be honest, and should be trusted again; if the first transaction failed then the buyer infers that the seller must be opportunistic, and hence would choose to not trust the seller in month 2. With these beliefs in place, however, if the future is important enough then an opportunistic seller would not find it beneficial to abuse trust in the first month. To see this, first note that abusing trust would result in a payoff of $15 for the opportunistic seller because they will receive $15 in month 1 from abusing trust once, and they will not be trusted a second time and receive $0 in month 2. If instead the opportunistic seller chooses to honor trust, then they receive $10 in the first month, and because the buyer will (incorrectly) infer that the seller is honest, then the buyer will trust the seller in month 2 allowing the seller to then abuse trust in the second transaction and acquire another $15. If the added value of $15 in the future transaction outweighs the loss of $5 in the first transaction, then pretending to be honest will pay off. This happens if and only if $\$10 + \$15\delta > \$15$ or $\delta > \frac{1}{3}$. Hence, if honesty is common enough ($p > 0.6$) and the future is important enough ($\delta > \frac{1}{3}$), then the opportunistic seller will choose to honor trust in order to get access to the money he can obtain from the second transaction.[5]

What is more interesting is that with such a two-period game, where early behavior of the seller influences future buyers to update their beliefs, trade can occur even when buyers are less optimistic about the seller's honesty ($p < 0.6$). To see this, imagine that the buyer believes that an opportunistic seller will abuse trust always, which are the most pessimistic beliefs a buyer can have. If the buyer trusts the seller in the first month, then with probability p, the buyer faces an honest seller and will obtain a payoff of $10, and then will know for sure that the seller is honest, and she'll obtain another payoff of $10 in the second month. If instead trust is abused in the first month, then the buyer will opt out of transacting again. Assuming that

[5] In fact, in the jargon of game theory, the unique sequential equilibrium (and the unique perfect Bayesian equilibrium) of this game with these assumptions has the opportunistic seller behaving honestly in the first period. For more on these concepts and for a more formal treatment of the material see Tadelis 2012 (Part V).

the buyer also uses δ as their discount factor, then with these beliefs the buyer will choose to trust in month 1 if and only if,

$$p(10+10\delta)+(1-p)(-15)\geq 0 \Longleftrightarrow p\geq \frac{15}{25+10\delta}$$

Note that if δ becomes infinitesimally small, then for the buyer to trust the seller it is necessary that $p \geq 0.6$ because it effectively becomes a one-time game for the buyer (as δ becomes infinitesimally small, it means that the payoffs from the second month become insignificant and can be ignored). If, on the other hand, the buyer is extremely patient so that δ approaches 1, then the buyer will trust the seller if $p\geq\frac{3}{7}$. The analysis performed earlier implies that the opportunistic seller would rather imitate the honest type and cooperate in the first month of trade. Hence, with a high enough discount factor we get "more trade" in the sense that trust is supported for lower values of p (a lower propensity of honest sellers). And if we add more potential trade periods in the future, then trade will occur for even lower likelihoods of the seller being honest.[6]

The key idea is that a seller's actions today will lead to future consequences, which keep him in check. This mechanism even works if the seller does not interact repeatedly with the same buyer as long as the seller understands that his current actions will be revealed to all future buyers and that his good behavior today will be rewarded by future business just as bad behavior will be penalized by a lack of future business. What's more, the value of the business itself will depend on the seller's past performance (see Kreps 1990; Tadelis 1999), an insight that sheds light on the powerful role that reputation and feedback systems play in fostering trust. A public reputation repository allows all future potential buyers to track a seller's past performance, and reputation becomes an important incentive mechanism that facilitates trust in anonymous markets.

There is a vast theoretical literature on the economics of seller reputation (see Bar-Isaac and Tadelis 2008 for a survey) with empirical implications that are rather intuitive. First, sellers with better reputations should attract more potential buyers, and command higher prices for their goods and services. Second, as sellers' reputations get better (or worse), their economic returns and growth will also get better (or worse). These simple yet powerful implications of reputation models can be put to empirical scrutiny and tested using market-level data. In fact, the recent rise of online platforms with "big data" on buyer and seller behavior have proven to be a fertile ground to test these implications.

6 This is an example of a game in the spirit of the seminal work by Kreps et al. (1982). For some values of $p \geq 0.6$ the equilibrium involves the seller using "mixed strategies" in the first stage (i.e., the seller randomizes between honoring and abusing trust), as well as mixed strategies for the buyer in the second stage (i.e., the buyer randomizes between trusting and not trusting). This is beyond what I wish to highlight here, as the key insight is that a potential future creates incentives to behave honestly and not abuse trust. See chapter 17 in Tadelis (2012).

5.3 REPUTATION AND FEEDBACK: PRACTICE

Many have attributed the success of eBay, the very first online marketplace that grew rapidly to mediate the trade of scores of transactions, to its reputation and feedback mechanism (see, e.g., Resnick et al. 2000 and Dellarocas 2003). Indeed, eBay exists as a successful business despite the complete anonymity of the marketplace. Following eBay's lead, practically every online marketplace, including modern sharing economy markets, has adopted some form of a reputation or feedback system. Herein I will describe in detail how eBay's feedback system works, which should give the reader an idea of how these kinds of systems work elsewhere.

A well-functioning reputation system provides future buyers with information about each seller's past behavior, information that is generally produced by the voluntary input of buyers. After completing a transaction on eBay, a buyer has sixty days to leave either a positive, negative, or neutral feedback score for the seller. On the Chinese marketplace Taobao.com, if a seller leaves positive feedback for a buyer but the buyer leaves no feedback then the platform's algorithm leaves automatic positive feedback under the assumption that silence is most likely a sign of buyer satisfaction.[7] As I explain in Section 5.5, this may be far from the truth. Also note that leaving feedback requires some time, so a buyer may selfishly choose to leave no feedback at all. Interestingly, back in 2016 about 65 percent of buyers left feedback on eBay, and an even higher fraction (more than 80 percent) left feedback in eBay's earlier days.[8]

Figure 5.2 shows how a seller's feedback, which I refer to as the reputation measure of the seller, is calculated and displayed on eBay. A new Apple MacBook is being sold by a seller with the username "electronicsvalley" with a Feedback Score of 21,814, which is the summed value of the number of positive feedbacks minus the number of negative feedbacks. The page also shows that 99.2% of this seller's feedback was positive, defined as the seller's number of positive feedbacks divided by the sum of his number of positive and negative feedbacks.[9]

To learn more about the seller's history, buyers can click on the feedback score (the number 21,814 in Figure 5.2), which directs them to a detailed feedback profile page that is shown in Figure 5.3, which displays how many positive, neutral, or negative feedback reviews the seller received in the past month, six months, or twelve months.[10] At the bottom of the page there is a rolling list of verbal comments left

7 See Li et al. (2020) for more on Taobao's reputation system.

8 This high fraction of feedback may be a surprise to many mainstream economists, but not to Pierre Omidyar, eBay's founder. On his personal profile page, it states that "Pierre created eBay in 1995 on the premise that people are basically good" (www.omidyar.com/people/pierre-omidyar).

9 Notice the "Top Rated Plus" badge at the upper right corner of Figure 5.2. This designation is bestowed on sellers that meet a series of criteria believed by eBay to be an indication of a high quality seller. See Hui et al. (2014) for a lengthy discussion of this feature.

10 While the feedback score is calculated using all past transactions, the percent positive only uses the last twelve months of a seller's transactions.

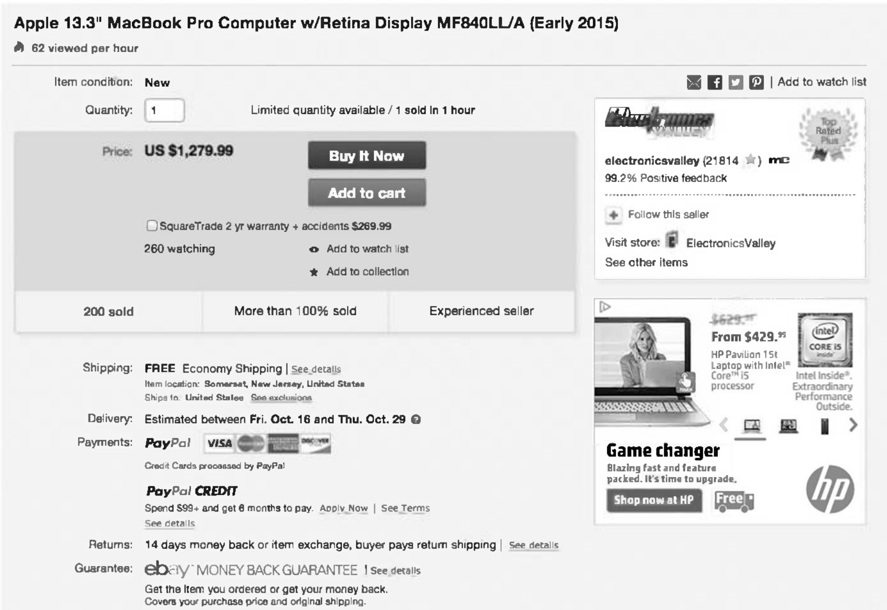

FIGURE 5.2 eBay's view item page displaying feedback.

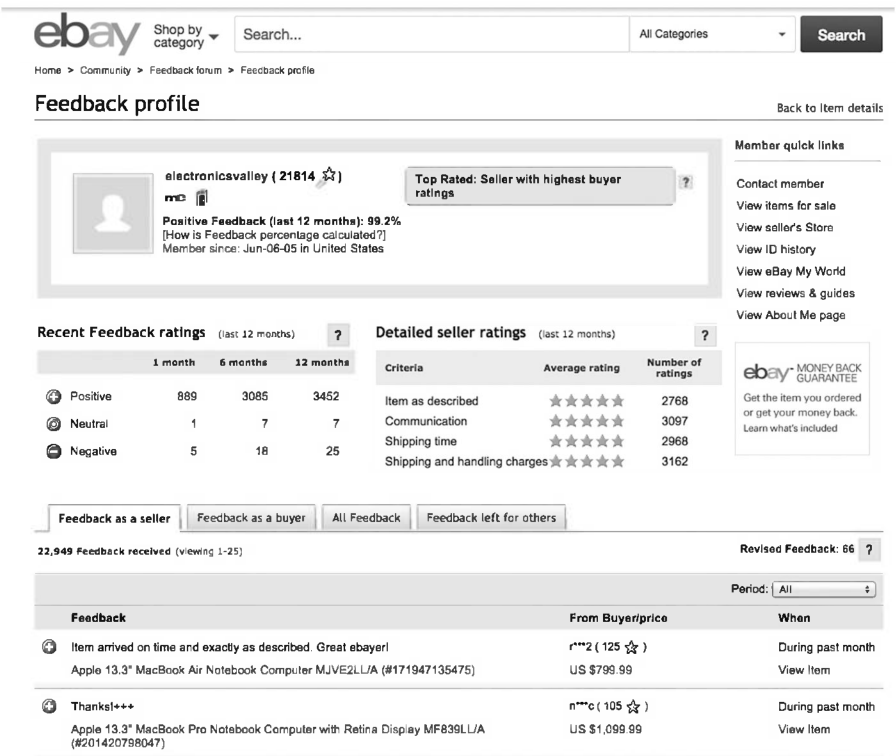

FIGURE 5.3 eBay's display of a seller's feedback profile.

by buyers, and to the right there are stars that indicate the Detailed seller ratings (DSRs), which buyers can leave only if they choose to leave feedback first.

Many ecommerce platforms use a star system (typically one through five stars). It is important to note that reviews may be about the product rather than the seller, a well-known example being the product reviews on Amazon. Platforms must be careful about distinguishing between product reviews and seller reviews in order to avoid confusion. Many online platforms offer at least one side of the market the ability to make choices that depend on the reputation of the other side of the market.

Before 2008, buyers and sellers on eBay could leave each other positive, negative or neutral feedback with comments. In 2008 eBay changed the feedback system limiting sellers to leave either positive feedback or no feedback at all. On Amazon's marketplace, sellers leave no feedback at all; on Airbnb both owners and renters leave feedback; on Uber both drivers and riders leave feedback, which is not made public, yet drivers see a rider's feedback before accepting a ride and riders see the driver's feedback after the ride was confirmed.

Whether reputation should be "two-sided," like it is currently on Airbnb, or practically "one-sided," like it is currently on eBay and on Amazon's marketplace, is an important design question. In essence, the platform benefits when feedback is informative and does not cause unnecessary friction as part of the user experience. For example, before eBay acquired PayPal's online payment system, buyers would send checks or money orders to sellers, meaning that buyers can abuse trust by not sending payment, just as sellers can abuse trust by not shipping the product. As a result, both buyers and sellers needed some guidance about which counterpart is trustworthy. After eBay acquired PayPal, however, it encouraged sellers to use PayPal as the only form of payment. By doing this, gone were the problems of buyers not sending checks and, for the most part, the problem of buyer abuse was solved, which in turn means that feedback left by sellers for buyers became a lot less valuable.[11]

Still, for some time eBay kept the two-sided feedback system, only to later learn that there is a weakness to two-sided feedback. In collaboration with eBay, Bolton, Greiner, and Ockenfels (2013) used data from eBay during the period when the reputation system was two-sided, and convincingly showed that sellers retaliated against buyers with their feedback. To illustrate their findings, consider pairs of feedback scores, $\left(FB_i, FS_j\right)$ left by a pair consisting of buyer B_i and seller S_j who constituted a transaction. For example, a transaction in which both buyer and seller left each other positive feedback is denoted $(+,+)$, while if the buyer left positive feedback and the seller negative feedback, it is denoted $(+,-)$. The data first showed that practically all transactions are either $(+,+)$ or $(-,-)$. They then showed that a vast majority of $(-,-)$ transactions are characterized by the seller leaving feedback on the same

11 Buyer abuse still persisted at a very low level: Some buyers would threaten to leave sellers negative feedback for no reason in order to get some partial refund, but the prevalence of this behavior was in the low single-digit percentages during the time I was at eBay.

day or the day after the buyer does, while the (+,+) transactions happen with less correlation between the buyer's and seller's day of leaving feedback. Hence, sellers' negative feedback scores were primarily retaliatory, which in turn made it painful for buyers to leave negative feedback (a point to which I return later).

This fear of retaliation was most likely a central cause behind the fact that almost all buyers left positive feedback on eBay, which in turn caused eBay to switch from the two-sided reputation system to a one-sided reputation system. This is not, however, a good prescription for all online marketplaces. Take the lodging marketplace Airbnb as an example. Even if payment is mediated by the site, as it is now, there is still a concern that abuse may occur from either side of the market. The dwelling owners can cause harm to renters in many forms, such as misrepresenting the dwelling, leaving it dirty, not giving the renters a key at the prespecified time, and more. At the same time, the renter's role on Airbnb is not just to pay like they do on eBay and wait for an item to arrive: they too can harm the dwelling owner by leaving the space dirty, causing damage, being very noisy, causing the owner trouble, and more. As such, it is imperative that Airbnb continues to keep a two-sided reputation system for trust to prevail in their marketplace. In fact, Airbnb even verifies the identity of all parties given the high stakes involved. Each marketplace, therefore, must weigh the relative costs and benefits of one- versus two-sided feedback systems.

5.4 HOW WELL DOES REPUTATION WORK?

The data made available by online marketplaces have enabled scholars to study how online feedback and reputation mechanisms work in practice.[12] Most studies used "scraped" data from marketplace webpages and explored whether sellers with higher reputation scores and more transactions receive higher prices and whether reputation seems to matter more for higher priced goods than for lower priced goods.

Early studies collected what are now considered tiny datasets. For example, McDonald and Slawson (2002) collected data from 460 auctions completed in 1998 of collector-quality Harley Davidson Barbie dolls. Because the closing price and the number of bids is bound to be correlated, they used an approach known as Seemingly Unrelated Regressions to simultaneously estimate the effect of reputation on both the number of bids and the closing price. Their results suggest that eBay's reputation score is positively correlated with both the closing price and the number of bids. However, the interpretation of McDonald and Slawson (2002), as well as similar studies, raises some concerns. First, good reputation may be correlated with a variety of omitted variables influencing the dependent variables. The authors themselves acknowledge unclear language and grammar as possibly confounding factors. Second, though statistically significant, the results are economically very small: for example, a one-point increase in reputation corresponds to four cents

[12] See Resnick et al. (2000) for a more detailed discussion of these studies.

increase in final price. With a median sample reputation score of twenty-one points, this means that increasing reputation from none at all to the median increases price by less than $1, a fraction of a percent of the median price of $275.

Jin and Kato (2006) took a different approach and studied the relationship between price, claimed quality, reputation, and true quality, using observational data of baseball card auctions on eBay. The true quality of cards was determined by purchasing actual cards from online auctions and having them examined by professional rating agencies. Jin and Kato (2006) collected data of the five most traded baseball cards on eBay for seven months, resulting in 1,124 auctions, of which 67 percent were graded. Of the full sample, 81 percent of auctions sold with at least one offer above the reserve price. Buyers in their sample have two signals for the quality of an ungraded card: the rating and claims made by the seller. The data indicate that claims of quality for ungraded cards seem suspiciously high, both when observing their distribution and when considering sellers' expected payoffs. The data also show that sellers who claimed extremely high quality had significantly lower ratings, but buyers were still willing to pay more for cards with higher claimed quality. Furthermore, an increase in claimed quality significantly raises the probability of an auction ending with a sale, but ratings do not seem to create a reputation premium, consistent with Livingston (2005). Perhaps the most interesting result in Jin and Kato (2006) is that reputable sellers (using eBay's ratings) are less likely to make extreme claims about their cards' quality. Moreover, reputable sellers are less likely to default or provide counterfeit cards. However, conditional on authentic delivery, higher reputation ratings are not correlated with higher true quality. This may explain why buyers are more willing to trade with reputable sellers but are not willing to pay more.

Cabral and Hortaçsu (2010) used a different strategy by collecting a series of seller feedback histories, thus creating a panel of seller histories, and proceed to estimate the effect of changes in reputation on a seller's sales rate. They find that when a seller receives his first negative feedback rating, his weekly sales growth rate drops from a positive rate of 5 percent to a negative rate of 8 percent. To overcome the fact that eBay does not provide information on how many past transactions a seller completed, Cabral and Hortaçsu (2010) make two assumptions and provide evidence that they are reasonable. First, they assume that a seller's frequency of feedback is a good proxy for the frequency of actual transactions, and second, that feedback correlates with buyer satisfaction.

An interesting question is what the impact would be of introducing a reputation system into a marketplace that did not have one. To answer this question, Cai et al. (2014) study the case of Eachnet, a Chinese auction cite that had about a 90 percent share of the Chinese market during its years of operation (1999–2003). Unlike eBay, exchange of products and money was done offline, and this face-to-face exchange may create less uncertainty at the time of the transaction. In 2001 Eachnet introduced a feedback system that enabled buyers to rate sellers after each transaction. Cai et al. (2014) received a large amount of data from the platform, containing a random sample of 125,135 sellers who posted almost two million listings throughout Eachnet's years of operation. Because sellers' feedback scores are obviously not available prior to the introduction of centralized feedback, their prefeedback reputation is approximated with the cumulative number of successful listings each seller had since joining Eachnet. Cai et al. (2014) examined how a seller's reputation, as approximated by cumulative success rates, affects the seller's behavior and outcomes, and how things changed after feedback was made available. First, an increase in the cumulative success rate of a seller is correlated with a larger fraction of repeating buyers, but the effect weakens after making feedback available. This is intuitive: centralized feedback is a substitute to the trust built in relationships. Second, centralized feedback leads sellers with higher cumulative success rates to sell more products in more regions, suggesting that formal feedback helps reputable sellers expand into new markets. Last, a higher cumulative success rate is generally correlated with a lower hazard rate of exiting the market, an effect that diminishes after feedback centralization. Though prices appear to be lower for reputable sellers, they do enjoy more listings and higher success rates, in line with the results of Cabral and Hortaçsu (2010).

A shortcoming of observational studies, like those just described, is the possible "endogeneity" concern from potential selection or omitted-variables biases. In other words, it is possible that sellers with higher reputation scores exhibit other information that causes buyers to be more interested in their products, so that it is not the reputation score per se that is accountable for the observed outcomes. Two ways around this are either a randomized controlled experiment, where similar goods and experiences are sold by sellers that are the same but for their reputation, or some source of exogenous variation in reputation scores that are not correlated with other important drivers of outcomes.[13] Resnick et al. (2006) ran a controlled field experiment by offering a series of sales of identical items (collector's postcards) where they vary reputation by randomly assigning items to either an established seller's account with a good reputation, or to a new account with little reputation history. They estimated an 8 percent price premium to having 2,000 positive and 1 negative feedback over a reputation of 10 positive and no negative feedbacks, which is quite sizable.

Klein, Lambertz, and Stahl (2013) cleverly took advantage of a change in the way that eBay reported feedback, together with the fact that feedback for sellers has two components: the nonanonymous simple feedback of positive, negative, and neutral ratings, and the anonymous feedback of Detailed Seller Ratings (or DSRs, as seen in

[13] This relates to the problem of distinguishing causation from correlation, as described in detail in Angrist and Pischke (2008). A randomized controlled experiment controls for all but one variable of interest, and creates two groups where only the variable of interest differs and all else remains the same. This allows the researcher to measure the causal effects of changes in the variable of interest without the concern that other important variables may also differ across the two groups. Exogenous variation refers to cases where there was no carefully designed experiment, but where for other reasons the researcher can be confident that the changes in the variable of interest are not correlated with other important variables that determine outcomes.

Figure 5.3). In May 2008, after realizing the problem of seller retaliation (recall the discussion of retaliation in Section 5.3), eBay removed a seller's ability to leave the buyer negative or neutral feedback. The belief was that this change will encourage buyers to report negative feedback following a poor experience, which can cause sellers to respond in two ways. First, some really bad sellers may leave eBay following a series of negative ratings. Second, sellers may work harder to improve buyer satisfaction. Klein et al. (2013) scraped data containing monthly information on feedback from about 15,000 eBay users between July 2006 and July 2009, a period that included both the introduction of anonymous DSR ratings (May 2007) and of one-sided feedback (May 2008). They found that the change to one-sided feedback led to a significant increase in buyer satisfaction using the DSR reviews but did not lead to a change in the exit rate of sellers from the market.

5.5 BIASES IN ONLINE FEEDBACK SYSTEMS

The studies just discussed suggest that reputational forces are at work in online marketplaces, but a question remains: How accurately does feedback capture variation in performance? As suggested earlier, retaliation on eBay may have caused feedback to be biased, as buyers chose to refrain from leaving negative feedback for sellers. A recent literature has demonstrated that user-generated feedback mechanisms suffer from bias. Dellarocas and Wood (2008) conjectured that the extremely high percent-positive reputation measures on eBay may be because many buyers who suffered poor experiences chose not to leave feedback at all.[14] They derive implications from the fact that eBay's reputation system was two-sided (buyers and sellers leave each other feedback) and use these implications to develop an econometric technique that uncovers the true percent of positive transactions. However, because eBay switched to one-sided feedback after 2008, their proposed approach no longer works.

Nosko and Tadelis (2015) use internal eBay data to directly show how biased reputation measures really are. Their data show that the percent-positive measure has a mean of 99.3% and a median of 100%. The distribution of feedback from their study is described in Figure 5.4, which displays the histogram of seller percent-positive measures from a dataset containing close to two million sellers who completed over fifteen million transactions between June 2011 and May 2014. One naive conclusion is that the reputation system works exceptionally well because bad sellers (below the high 90s) leave the platform. This is not the case: the data show that there are three times as many complaints to customer service as there are negative feedback scores.

[14] Li (2010) proposed a mechanism designed to solve the problem of missing reports and positive bias. The mechanism provides the sellers with an option for giving rebates to rating buyers. Li and Xiao (2014) extended the model and conducted a laboratory experiment to test the main hypotheses. The lab results suggest that higher reporting costs decrease buyers' willingness to review sellers, leading to a decrease in buyers' trust and sellers' trustworthiness, but these results are not statistically significant. Additionally, since the research design lacks a fear of retaliation, reports are negatively biased.

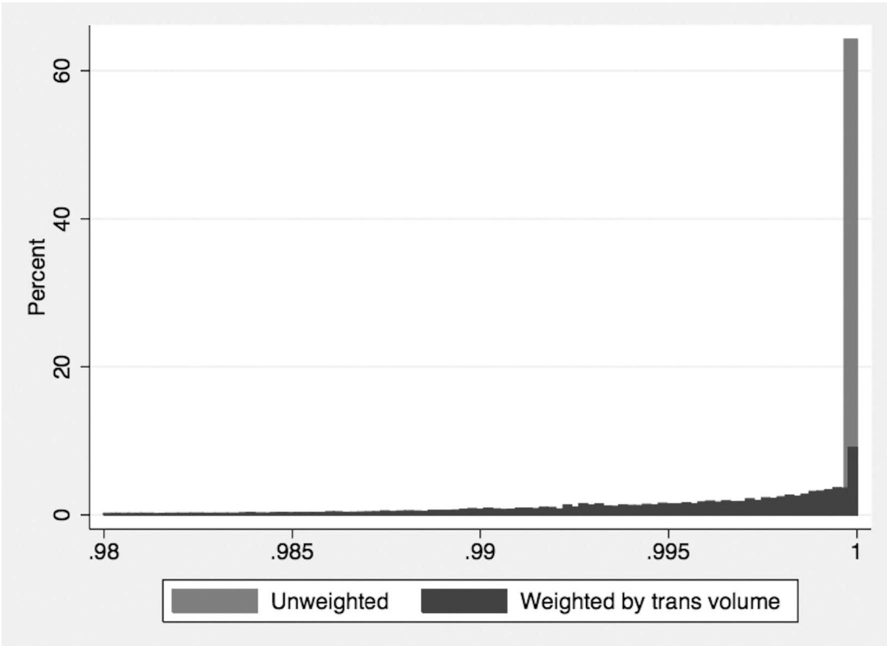

FIGURE 5.4 Percent positive of sellers on eBay.

The findings in Bolton et al. (2013) described in Section 5.3, that sellers retaliated towards buyers who left them negative feedback, and the evidence described in the study, suggest that for buyers, leaving different types of feedback entails different consequences. In particular, buyers find it more "expensive" to leave a negative review than a positive one, which in turn means that with a given propensity to leave feedback, this asymmetry between leaving positive versus negative feedback inherently creates upward bias. Nosko and Tadelis (2015) suggest a new quality measure, "effective percent positive" (EPP), which is calculated by dividing the number of positive feedback transactions by the total number of transactions. This penalizes sellers who are associated with more transactions for which the buyers left no feedback, based on the insight that no feedback includes in it a measure of negative outcomes.

The distribution of the EPP measure is described in Figure 5.5 using the same set of sellers for which the percent-positive scores were described in Figure 5.4. EPP has a mean of 64 percent, a median of 67 percent, and exhibits significantly more variation than percent positive. But can this be verified as a better measure of quality?

To demonstrate this, Nosko and Tadelis (2015) use a "revealed preference" approach to study the effect of a seller's EPP on a buyer's propensity to continue buying on eBay after that transaction. This distinguishes their paper from the papers that collect scraped data and cannot track the behavior of buyers on the site and

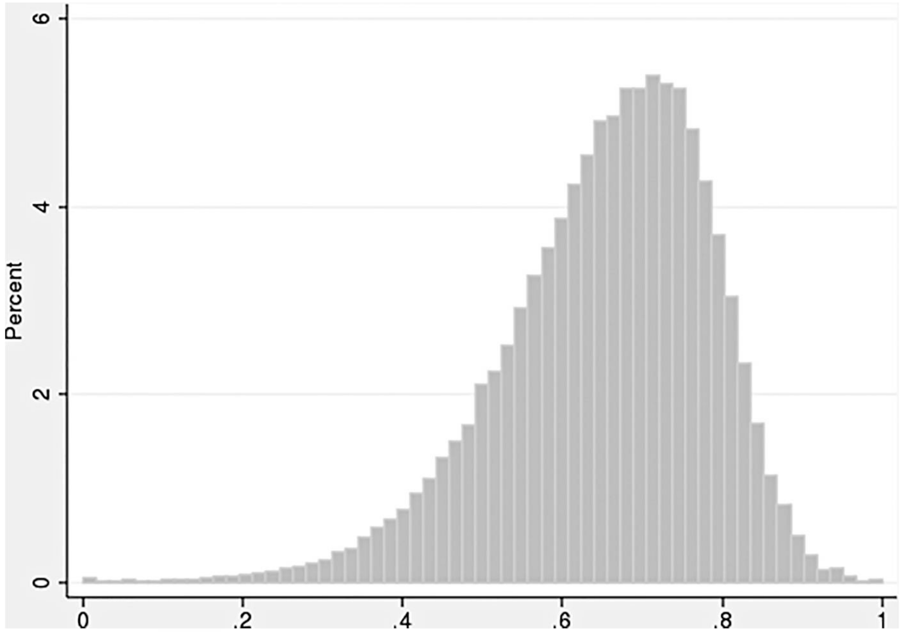

FIGURE 5.5 Histogram of sellers' effective percent-positive scores.

allows them to get to the heart of the question of whether reputation mechanisms help buyers avoid low quality sellers. Importantly, eBay does not display the total number of transactions a seller has completed, and buyers cannot therefore compute a seller's EPP score.

Nosko and Tadelis (2015) show that a buyer who buys from a seller with a higher EPP score is more likely to continue to transact on eBay again in the future, which by revealed preference suggests a better experience. They also report results from a randomized controlled experiment on eBay that incorporated EPP into eBay's search-ranking algorithm. The treated group was a random sample of eBay buyers who, when searching for goods on eBay, were shown a list that prioritized products from sellers with a higher EPP score compared to a control group. The results show that treated buyers who were exposed to higher EPP sellers were significantly more likely to return and purchase again on eBay compared to the control group. Jaffe et al. (2019) use data from Airbnb to further explore the revealed preference approach of Nosko and Tadelis (2015) and find similar results. Further implications about the design and engineering of feedback systems are discussed in Section 5.6.

Mayzlin, Dover, and Chevalier (2014) exploit different policies about who can leave feedback across several travel sites and show biases in ratings for hotels from the online travel sites that are consistent with strategic feedback manipulation by sellers. What makes that paper particularly clever is that they do not attempt to categorize which reviews are fake reviews versus those that are not, which on the face of it is impossible because fake reviews are designed to mimic real reviews. Instead, they take advantage of a key difference in website rating systems where some websites accept reviews from anyone while others require that reviews be posted by consumers who have purchased a room through the website. If posting a review requires an actual purchase, the cost of a fake review is much higher. The upshot is then that they measure the differences in the distribution of reviews for a given hotel between a website where faking a review is expensive and a website where faking a review is cheap. The results in Mazylin et al. (2014) indeed show greater bunching at the extreme ratings for hotels on the sites where posting reviews is cheaper, and this is exacerbated by local competition (more local hotels). Hence, for reviews to be less biased it is critical to impose some kind of cost to prohibit fake reviews by nonpurchasers.

Fradkin et al. (2015) study the bias in online reviews by using internal data from Airbnb, and like Nosko and Tadelis (2015) report results from field experiments conducted by the online marketplace. In one experiment they offer users a coupon to leave feedback and show the users who were induced to leave feedback report more negative experiences than reviewers in the control group, suggesting that otherwise they would have probably been silent. In a second experiment they disable retaliation in reviews, similar to what eBay did in 2008, and find that retaliation (or rewards for positive feedback) causes a bias, but that the magnitude of this bias is smaller than that caused by a lack of incentives to leave truthful feedback. Interestingly, using data on social interactions between buyers and sellers on the site, they show that such interactions result in less negative reviews. This result suggests that a challenge for online marketplaces is the potential loss of information following the social interaction of buyers and sellers on the site.

Another form of bias is grade inflation. Horton and Golden (2015) document substantial levels of "reputation inflation" on the online labor marketplace, oDesk, that uses a five-star feedback system for freelance employees who bid on jobs that are posted by potential employers. The data show that from the start of 2007 to the middle of 2014, average feedback scores increased by one star. Like Bolton et al. (2013), Horton and Golden (2015) conjecture that giving negative feedback is more costly than giving positive feedback due to retaliation. They further argue that what constitutes harmful feedback depends on the market penalty associated with that feedback. The paper argues that these two factors together can create a race of ever-increasing reputations. Zervas, Proserpio, and Byers (2015) demonstrate that grade inflation is also severe on Airbnb, where ratings are overwhelmingly positive, averaged at 4.7 out of 5 stars with 94 percent of property ratings with 4.5 or 5 stars.

One more channel through which bias in reputation may occur is by sellers trying to fraudulently "buy" a reputation that they do not deserve. Brown and Morgan (2006) show some cases in which this practice happened on eBay's marketplace. Xu et al. (2015) document and explain the rise of a centralized marketplace for fake reputations for sellers on the Alibaba marketplace in China. Hence, it may be possible for sellers to fraudulently acquire a reputation that they do not deserve, and marketplace designers must be aware of such practices and make every effort to detect and punish this kind of behavior.[15]

5.6 ENGINEERING REPUTATION SYSTEMS

Economic theory takes the view that market participants understand the equilibrium they are playing, and correctly infer information from signals and actions. In practice, however, buyers may not correctly interpret the feedback information they are presented with. Naively, in some sort of absolute scale, a score of 98 percent is considered excellent. But, as Nosko and Tadelis (2015) show, on eBay this score places a seller below the tenth percentile of seller feedback, and it is unclear whether the more informative EPP measure constructed by Nosko and Tadelis (2015) would be interpreted correctly by buyers. For this reason, Nosko and Tadelis (2015) propose not to reveal effective measures to buyers, but instead choose to run a controlled experiment that incorporated the EPP measure into eBay's search-ranking algorithm.

This approach offers a new direction for improved marketplace performance. Instead of showing buyers information on seller quality, platforms can benefit from a more paternalistic, or regulator-like approach, that does not rely on participants correctly deciphering information. In this sense I very much advocate for the view expressed in Roth (2002) that market designers "cannot work only with the simple conceptual models used for theoretical insights into the general working of markets. Instead, market design calls for an engineering approach" (p. 1341). Trust can therefore be engineered by way of a process in which recommendations rely on underlying data that is not made visible to buyers. Of course, this requires buyers to trust that the platform is operating in their best interest, a trust that I believe is justified. Just as the motivation of repeat business is at the heart of the value of a good reputation, so does future business motivate platforms to offer buyers a positive experience every time they purchase on a marketplace platform.

Marketplaces can rely on a variety of internal data to infer the quality of sellers. For example, many marketplaces allow buyers and sellers to exchange messages before and after a transaction occurs. Masterov, Mayer, and Tadelis (2015) showed that text-mining these messages could reveal unhappy buyers even if they chose not to leave negative feedback. This information could also be used to rank sellers by quality, and manipulate the consideration sets of buyers. More advanced implementation of Natural Language Processing can offer deeper insights into how messages translate to experience and buyer satisfaction. Marketplace platforms can then

[15] Not all attempts to purchase a reputation may be fraudulent. Signaling theory suggests that high-quality sellers may pay for honest feedback knowing that the feedback they receive will bode well for them. See Li et al. (2020) for a study of such behavior in Taobao's marketplace.

create engineered measures of seller performance that aggregate both what is seen publicly (past feedback) and what is not (messages or customer service complaints), to create better measures of seller quality. Search algorithms can be engineered to promote better quality sellers for the continued health of the marketplace, alleviating buyers from deciphering what a certain rating means.

User-generated feedback will continue to be an important signal that marketplaces will use to match buyers with high quality sellers, and the challenge of engineering ways to procure more accurate feedback remains. The experiments described in Fradkin et al. (2015) suggest that a challenge for online marketplaces is the potential loss of information following any social interaction of buyers and sellers on the site. As such, marketplaces may choose some sort of incentives to motivate more truthful feedback from buyers, such as the use of coupons to motivate feedback as described in Fradkin et al. (2015) and similarly, the use of rebates for feedback described in Li, Tadelis, and Zhou (2020).

One last issue warrants discussion, especially because of tension it raises with the common belief that a drive for transparency is likely to be central to any regulatory oversight, as well the discomfort it creates for the fundamental approach of game theory. As mentioned earlier, Nosko and Tadelis (2015) propose not to reveal effective measures to buyers to remove the burden to interpret what feedback really means. However, they discuss a second reason not to make new measures of reputation transparent: transparency can reduce the quality of information that the platform can generate from these measures. Take for example the effective percent-positive score developed by Nosko and Tadelis (2015), which counts silence as a negative mark against a seller. If sellers learn that this is part of the way they are evaluated, then they would harass buyers who do not leave them feedback, which in turn can both generate positive feedback when it is not warranted, as well as drive buyers to abandon the platform. This suggests that transparency is not necessarily the best policy. Indeed, Google's famous "Quality Score" is used by the company to rank sponsored search links, and though the company does give guidance on ways to improve the score, they do not reveal the exact way in which it is estimated. This allows them to control the user experience for quality of ads because, after all, the main reason so many people use Google is because of the quality of the search engine and the relevance of ads.

As for the discomfort with game theory, note that at the heart of "equilibrium" analysis is that every player has correct beliefs about everything relevant to their environment. But in the case of platform quality, it may be in the best interest of the platform (and its buyer-side) that sellers are left in the dark about some aspects of how they are evaluated, and only given coarse feedback about how to improve. If the exact formula of evaluation relies on hidden biases in the data, then revealing these hidden biases may cause behavior that will undermine the value of the current formulas, effectively causing the platform designers to play a cat-and-mouse game with abusive sellers. Even though I agree with eBay's founder, Pierre

Omidyar, who was famously quoted saying that "People are basically good," platforms need to safeguard against the few who try to take advantage of others, and this seems to require making sure that bad actors do not have insight into the ways they are being detected.

5.7 CONCLUDING REMARKS

Reputation and feedback systems are critical to foster trust and trustworthiness in online marketplaces. The rise of these platforms and their penetration to practically every household owes much of its success to reputation and feedback systems.

In the past few years there has been a lot of scrutiny by regulators who question whether and how to protect customers from a variety of hazards on sharing economy platforms. The rapid growth of such platforms suggests that feedback and reputation systems do a reasonably good job at policing bad behavior, possibly eliminating the need for onerous rules and regulations. At the same time, several studies described in this chapter document biases in feedback and reputation systems that can be improved upon.

There is still much to explore in order to deepen our understanding of how feedback and reputation systems can be improved. It is clear that the design and engineering of feedback and reputation systems will continue to play an important role in the broader area of market design as it applies to sharing economy platforms.

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6

Labor and the Platform Economy

Juliet B. Schor and Steven P. Vallas

6.1 INTRODUCTION

A defining feature of twenty-first century capitalism has been the rapid growth of platform work, which allows firms to use digital technology (websites or apps) to mediate economic transactions between service providers and customers. Though platform work as yet accounts for a small proportion of the labor force – estimates typically lie in the low single digits (Collins et al. 2019) – many scholars are convinced that the ranks of the platform labor force will grow significantly in coming years (Sundararajan 2016), exercising potentially far-reaching effects on the nature of work and employment, perhaps even reconfiguring what is conventionally meant by a "job." Mindful of the stakes, academic researchers have generated a flood of studies of platform work (Calo and Rosenblat 2017; Ravenelle 2019; Schor et al. 2020b; Wood et al. 2019). Yet this research has provided little clarity or consensus on any number of important questions. How does "algorithmic management" reshape the exercise of power and authority over labor? How will firms in the conventional economy be affected by the rise of platform work? What adjustments are needed in regulatory policy and welfare-state provisions, given the disruptive power that platform firms have shown? Will the availability of crowd-working sites such as Upwork and Mechanical Turk encourage firms to outsource their staffing systems? Or will platforms instead foster a more inclusive economy, enabling workers in marginalized regions or those with disabilities to gain greater access to income earning opportunities? Finally, how are legal and political struggles over platform workers' rights likely to evolve? Which groups will succeed in shaping the narrative that defines platform work in the years to come?

In this chapter we can hardly aim to resolve these questions. Our goals are more modest, aiming to outline the main lines of contention in the literature, to identify major gaps in our knowledge, and to suggest some of the most important areas for future research as nations struggle with the structural upheavals unfolding across the contemporary capitalist landscape.

The chapter begins by sketching three dominant lines of analysis that have opened up in recent years: First, a hopeful view, in which platforms help to expand the range of freedom and autonomy that income earners enjoy; second, a technology-centered approach, in which algorithms and systems of digital surveillance and evaluation are used to establish greater company control over labor; and third, a view in which platforms accelerate a trend toward more precarious forms of work, with workers classified as independent contractors who are ineligible for statutory protections and welfare-state benefits. The chapter then points to one source of complexity in the field, which helps account for the continuing contention: Heterogeneity in the platform workforce itself, with varying segments of labor differentially positioned with respect to the platforms themselves. We end by briefly alluding to the regulatory struggles and forms of worker mobilization that platforms have provoked and then speculate about possible paths that might lead toward more humane yet innovative uses of the platform paradigm.

6.2 DOMINANT APPROACHES IN THE LITERATURE

The rise of digitally mediated economic transactions has generated tremendous interest from scholars in a wide range of fields – from economics, sociology, and geography to law, management, engineering, and computer science. In part as a result of this range, as well as differences within disciplines, the literature on labor and the sharing sector is quite diverse. Indeed, even the terms scholars use to capture this phenomenon differ, with such terms as the sharing, on-demand, or platform economy competing for attention.[1] Here we focus on three of the main approaches that have dominated the literature – those emphasizing how the digital technologies of the sharing economy yield efficiencies and enhanced opportunities for entrepreneurship for workers; those that focus on how these technologies are used to surveil and control workers; and the third, largest group, which emphasizes the precarity of sharing labor as a result of platform policies and workers' employment status. We discuss them in turn.

The first approach is mainly found in economics, management, engineering, and related fields, as well as some sociological accounts. It centers on the ways in which the major technological affordances of the sharing sector enable new efficiencies and economic relationships. These come from two major innovations – the use of matching and search algorithms to pair buyers and sellers and the crowdsourcing of reputational information and ratings from users. These technologies are at the heart of most platforms, or what economists have termed "two-sided markets," (Rochet and Tirole 2003), as they facilitate transactions among unknown users by reducing search costs and providing some reputational security. As a result the sharing

[1] For the sake of simplicity, this chapter uses the terms "platform" and "sharing" economy interchangeably, referring to firms operating in two-sided markets, using apps or websites to govern transactions between peers, that is, buyers and sellers. We make no assumptions that "sharing" is a valid descriptor of platform goals (Ravenelle 2017; Schor and Attwood-Charles 2017).

economy is thought to reduce transaction costs and make self-employment more feasible for individuals (Einav, Farronato, and Levin 2016). Some scholars also emphasize the freedom to set schedules and working hours that is typical of platform work (Sundararajan 2016). Equally important are claims that digitally mediated work (especially crowd-working sites) can include members of the workforce who might otherwise be excluded, owing to geographic barriers, caregiving obligations, or ethno-racial bias (Bennhold 2017; Mays 2018; Zanoni 2019). This perspective focuses on the new opportunities created by the sector and the benefits it can provide. In contrast to the two other approaches, it does not recognize issues of power between labor and sharing companies, nor does it acknowledge the possibility of negative outcomes for platform workers, especially as firms initially devoted to peer-to-peer sharing among users evolve into giant firms with operations across the globe.

The second perspective also views digital technologies as the central and unique feature of sharing platforms, but emphasizes their dark side, in particular their ability to control workers using digital means such as algorithms. While the particulars vary across services, nearly all for-profit sharing apps include certain core elements that these scholars argue expand corporate control over the performance of service providers. One such element is the use of surveillance technologies, whether they are locational, as in driving and delivery, or visual observation and accounting in the case of digital tasks. In addition, the use of customers to rate worker performance – a phenomenon Maffie (2020) describes as the "laundering of managerial control" – provides another type of surveillance, and one that may create what has been termed "algorithmic insecurity" (Curchod et al. 2019; Wood and Lehdonvirta 2021). In this view, ratings metrics that are visible to all customers and are used to shape workers' job prospects impose a disciplinary effect on workers that far transcends what predigital forms of supervision are able to achieve. Moreover, because they typically individualize the workforce, foregoing socially shared workplaces, platforms reduce the opportunity for labor to informally negotiate the terms and conditions of employment, as was long true of traditional work organizations. Hence, "algorithmic control" scholars see a digital panopticon in which workers cannot escape the discipline and punishment of the app. In contrast to the efficiencies approach, scholars in this tradition emphasize the superior informational position of the platform and its ability to exercise power over workers (Calo and Rosenblat 2017; Rosenblat and Stark 2016). Examples of information asymmetry include withholding destination information or the prices paid by customers from drivers or delivery couriers. Another theme in this literature is gamification – the ability of the platform to offer bonuses and incentives in order to keep earners on the app, and to seamlessly change those conditions in order to achieve the objectives of the platform, rather than satisfy the desires of the worker – a power that is established in legally binding terms of service that all users must accept (Bearson, Kenney, and Zysman 2020; van Doorn and Chen 2021). Another theme is the use of algorithms to dispense discipline and punishment, including "deactivation," that is, worker termination. While it is important to recognize the control dimensions of these technologies as well as the power imbalance between platforms and their workers, this approach can at times display a similar, albeit inverse, weakness to the efficiency approach, which is that it can overstate the ability of the technology to control labor. There is growing evidence of the ability of workers to evade, outsmart, and resist algorithmic control (Chen 2018; Cameron 2018; Shapiro 2018; Wood et al. 2019). Strategies are commonly shared on social forums uniting platform workers on Uber, Lyft, and many delivery apps, which may help foster collective actions aimed at pressuring firms to alter the workings of the app. The algorithmic control perspective can also exaggerate the novelty of this type of control, given that technology, and even algorithms have been used to structure the labor process long before the advent of the current platform model.

The third perspective emphasizes the precarity of this type of work. Virtually all platforms engage their workers as independent contractors, rather than employees. However, while independent contractors do nominally retain control over many aspects of their work, some precarity scholars argue that financial need obviates de facto control as these workers are either forced into very long hours or to work whenever there is customer demand (Ravenelle 2019). The precarity approach also calls attention to the risk shift associated with platform work. These earners are responsible for providing the capital goods necessary to do the work, and responsible when customers engage in malfeasance or nonpayment. Furthermore, they are denied the standard protections and benefits of employment such as a minimum hourly wage, unemployment benefits, and compensation for workplace injuries (Dubal 2017; Vallas 2019). Legal scholars have argued that most platform workers are misclassified as independent contractors, since key decisions concerning prices, work rules, and other practices are set unilaterally by the platform. As a result, there are ongoing judicial, regulatory, and legislative challenges to these platform policies. The precarity perspective departs from the previous two in that it sees precarious platform labor as part of a trend that predates the sharing economy by decades (Kalleberg 2011; Kalleberg and Vallas 2018), and which is propelled by policy choices of employers rather than the exigencies of technology. In addition, because precarity is a larger trend throughout the economy, these scholars tend not to focus on the novelty or uniqueness of the sharing economy, in contrast to the previous two approaches. The major weakness of the precarity approach, in our view, is that it pays insufficient attention to the technological innovations of the sharing sector, while also ignoring the heterogeneous composition of the platform workforce, (significant portions of which may view platform work as a solution to precarity rather than a source of it). As we discuss in the next section, the platform workforce is uniquely diverse in ways that do not always support the precarity narrative.

This overview raises a number of issues that warrant discussion. First, although we have emphasized the differences among the three approaches, there are important instances in which scholars have combined elements from each approach.

For example, Davis (2016) suggests that platforms use digital technology to control labor algorithmically while also transforming the employment relationship in far-reaching ways. In this view, platforms enable for-profit companies to reconfigure employment, completing a trajectory that leads work from the career, to the job, to the "task." This view essentially combines the second and third approaches sketched earlier. A second example is that of Schor et al (2020b), who argues that the "sharing" feature of the platform economy has largely been coopted ("hijacked") by large corporations, but that social movements and progressive policies make it possible to reclaim the logic of reciprocity that informed the sharing economy at its birth.

A second point concerns recent efforts to transcend the three approaches we have sketched earlier, developing frameworks that better capture the distinctive features of labor platforms. One example is that of Vallas and Schor (2020), who see platforms as heralding a new organizational form, in addition to that of markets, hierarchies, and networks. The argument here is that platforms combine elements of these prior economic structures but do so in ways that achieve an institutional form that is qualitatively distinct. In this view, two key features that platforms exhibit are their reduced barriers to entry (which generates greater heterogeneity in their workforces) and a general "retreat from control" (which delegates practical decisions and the labor of evaluation to platform participants). In this view, platforms achieve their power precisely by relaxing elements that had figured prominently during industrial capitalism. A similar formulation is that of Watkins and Stark (2018, see also Stark and Pais 2021), who also see platforms as a distinct organizational form that operates by coopting the resources and assets of the entities that surround them. Both these views emphasize the instability of the platform economy, whose reproduction rests on political and regulatory inputs to manage the tensions and conflicts that platforms themselves create. We discuss these tensions in our concluding section.

6.3 RECENT TRENDS IN PLATFORM LABOR

An important issue that has emerged in research on labor platforms concerns the heterogeneity that characterizes the platform work experience. Though the tendency in early studies was to generalize about the work situations that platform activity fosters, scholars have acknowledged important variations in the experience of platform working conditions. While many workers do appreciate the scheduling flexibility and relative autonomy from supervision that much app-based work provides, other workers bemoan the job's inability to provide a living wage or other sources of security. We contend that this difference issue is not merely a matter of contrasting orientations toward platform work but is instead a structural attribute, rooted in both labor market institutions and the platforms, the consequence of which is to stratify the platform workforce in socially and politically significant ways. This phenomenon holds obvious importance for any effort to support worker mobilization or platform regulation, but it remains poorly understood.

One question that has bedeviled researchers is how best to categorize the differing positions that platform workers occupy. The most common approach is to distinguish platform workers on the basis of their temporal engagement with the work – a simple approach that typically distinguishes between part-time and full-time platform workers (Robinson 2017; Rosenblat 2018). Though virtually all studies report that part-timers constitute the majority of platform workers on apps such as Uber, they also indicate that longer hour workers perform a disproportionate amount of the work (Parrott and Reich 2018, 2020). To better understand this division, researchers have begun to characterize workers in more differentiated ways, hoping to better understand the context in which platform work is done. In her multiplatform study, for example, Ravenelle (2019) develops a threefold typology that distinguishes between "strugglers," who try to make a living entirely from their platform earnings; "strivers," who use their platform earnings to supplement income from their primary jobs; and "success stories," who use their app-based experience to accumulate wealth, forming small businesses in catering or real estate management. The thrust of Ravenelle's argument – platforms have multiplied the precarity of platform workers – is based only on the first of these types, overlooking the complexity she herself reports.

One effort to capture the stratified nature of the platform workforce emerges in the multiplatform study conducted by Schor and her colleagues (2020a), which emphasizes the degree to which workers depend on their platform earnings to pay their basic expenses. At one end of this continuum are "dependent earners," who primarily or fully rely on the platform for their livelihoods. At the other end are "supplemental earners," who can rely on their primary jobs for income, and whose platform work is largely discretionary. In between are "partially dependent" earners, who either work on multiple platforms or who have several jobs. Because the most dependent earners are compelled to accept whatever tasks that are thrown their way, they face a harsher and more coercive work situation. By contrast, supplemental earners can afford to be more selective, accepting only tasks that offer relatively generous returns. Such disparities become all the more pronounced in light of the income inequalities evident across different platforms, in which some platforms (those requiring higher levels of capital goods or skill) provide higher earnings and greater autonomy than do others. Lower income individuals are more likely to participate in labor or gig platforms, while those with higher income are increasingly able to participate on more lucrative capital platforms, such as short-term accommodation sites. The implication, supported by survey research recently conducted in Denmark (Ilsøe, Larsen, and Bach 2021) is that the platform economy reproduces preexisting tendencies toward segmentation rooted in the conventional economy. Moreover, the emergence of platform work may help privileged workers claim income-earning opportunities previously accessed by working-class earners, in effect crowding out the most vulnerable members of the workforce (Schor 2017). Overlapping these sources of inequality are racial and ethnic dynamics, which scholars are only beginning to explore. Dubal (2021) has argued that the disproportionate presence of Black and Latinx earners in the platform economy amounts to a new racial wage code, as platforms have attempted to create a third, implicitly racialized employment status between independent contractor and employee, with lower wages, fewer benefits, and substandard protections. Her analysis shows that platform firms have invoked racial justice language (i.e., the inclusion of ethnic and racial minorities), but have acted in ways that reduce these workers' access to equal employment opportunity. Whether, where, and how gig work becomes racialized is an important matter that labor market analysts must address.

Two issues emerge at this juncture, both centering on the relations that exist among the disparate strata of platform workers. The first concerns the ability of platforms to evade the provision of benefits and other job rewards that conventional firms must offer. The notion here, emphasized by Schor et al. (2020a), is that labor platforms function as "free riders" – that is, when they grow, they do so partly by operating parasitically, avoiding the employer contributions to unemployment insurance, social security, and health insurance that conventional firms must pay. This issue has become more visible in the United States during the COVID pandemic. Because platform workers were not covered by unemployment insurance, providing them with income support during COVID required the federal government to subsidize costs that would normally have been paid by employers. Here the costs of operation were socialized, but the profits (where firms were profitable) remained in private hands. Pressure on the companies to treat their workers better has also led the companies to respond with the creation of a "third category" of worker, between independent contractor and employee. This category offers some workers small monetary benefits for healthcare, and the illusion of a statutory minimum wage, but also permanently bars them from employee status (Dubal 2021). Such a category was created in California in 2020 via the passage of Proposition 22 and Uber, Lyft, and Doordash are currently trying to expand this model throughout the United States.

A second issue that has emerged again concerns relations among the various strata making up the platform workforce. The argument here, as developed by Rosenblat 2018 (see also Robinson 2017; Robinson and Vallas 2020), is that the stratification of the platform workforce is a vital element in the labor control systems on which labor platforms rely. In this view, the ready availability of occasional workers – those who have alternative sources of income – "reduces pressure on employers to create more sustainable earning opportunities" (Rosenblat 2018: 52–53). In other words, part time or supplemental earners serve as an industrial reserve army in modern dress, providing platforms with a workforce that is "tolerant of working conditions that are anathema to occupational drivers trying to support their families" (Rosenblat 2018: 54). Supporting this view is Robinson's study of Uber drivers in Boston (Robinson 2017), which found that occasional drivers were significantly less aware of their actual costs of operation than longer hour or full-time drivers, and thus were more easily exploited by the platform. However, this view stands at odds with the logic of Schor et al.'s argument (2020a), in which occasional or supplemental earners are able to enjoy higher wages than their fully dependent counterparts. If this were true, it would be hard to see how supplemental earners could undermine the labor market position of more dependent workers. Clearly, much more research is needed on the origins and consequences of labor market stratification among the platform workforce, especially as platform companies face investor demands for profitability, or at least smaller quarterly losses. The latter pressures have seemed to generate a downward trajectory in platform working conditions, though it remains unclear which sectors exhibit this trend, and whether regional or institutional influences mediate its effects.

Beyond the question of stratification among platform workers, a host of broader questions have emerged regarding the relation between the platform economy and the work structures it seems to disrupt. A key question here concerns the relation between platform work and the professions. Research has suggested that the "golden age" of the professions has long since passed (Gorman and Sandefur 2011), as autonomous professional occupations have tended to splinter into more specialized forms of "knowledge work," supplying expertise via arrangements that are shaped more powerfully by the demands of markets and firms than by professional norms. Though this pattern unfolds in varying ways across the different sectors of professional work, the question is how the platform economy will affect the work and employment situations that professionals face in such fields as health care, journalism, legal services, and other traditionally autonomous occupations. In many of these fields, task-based, independent contracting arrangements have grown, ratings metrics have assumed a newfound importance, and an emphasis on commercialism increasingly conflicts with professional autonomy. A kindred issue here concerns the relation between crowd-working sites such as Upwork and Fiverr and the conventional bureaucratic contexts in which professionals have often been employed. Does the availability of crowd working encourage organizations to outsource professional work through digital means, as seems to have unfolded in journalism, legal services, and computer science (Christin 2020; Osnowitz 2010)? In her study of crowd-working sites, Berg (2016) notes that the single largest user of Amazon mTurk is an editing and publishing firm that relies on Turkers for its entire workforce. Though some have envisioned the growth of such a trend (Scholz 2016), little systematic research on these substitution dynamics has yet been conducted. Arguably, the pandemic, which has fostered much wider acceptance of "working from home" arrangements, may encourage firms to explore new forms of work organization, not only reversing the historical trend toward spatial agglomeration but also fostering a greater reliance on the crowdsourcing of projects and task-based compensation. This raises the prospect of the degradation of pay and conditions, long-recognized attributes of piece-rate systems (Dubal 2020), for middle-class work.

One of the characteristic features of many platforms has been their strategic emphasis on growth, rather than profitability. In effect, platforms have sought to use first-mover advantages and/or network effects – in which the value of the firm's services grows in proportion to its adoption – as a glide path to monopoly status, capturing markets that will only later support profits. The best example of such a strategy is of course that of Uber, which has incurred massive losses in its effort to establish market dominance. As Srnicek (2016) has noted, such a strategy presupposes the ready availability of patient capital from investors. Yet as firms go public, pressures to turn a profit are likely to rise, leading unprofitable firms to tighten their labor and compensation practices, generating a downward trajectory in working conditions (Vallas 2019; Schor et al 2020b). We have already seen this from a number of platforms, particularly in ride-hail and delivery. Without embracing a mechanistic approach linking austerity to resistance, it seems that this downward trajectory has exacerbated the labor relations tensions that platforms often provoke, prompting regulatory agencies, legislators, and courts to reexamine the practices in which platform firms engage, potentially reconfiguring their treatment of workers as independent contractors (Dubal and Schor 2021).

6.4 CONCLUSION: THE FUTURE FOR PLATFORM LABOR?

Not surprisingly, then, tensions between platforms and their workers have intensified in the past few years. The deterioration of earnings in ride-hail and food delivery (Farrell, Greig, and Hamoudi 2018) has led to increased union organizing and periodic flash strikes. Contestation continued through the 2020–2021 lockdown, spurred by questions of protective personal equipment, exposure to the virus, and over-hiring on some platforms. The pandemic itself scrambled demand across platforms, with ride-hail collapsing and package, food, and grocery delivery all growing dramatically. At the same time, regulatory activity has accelerated, raising many questions about the future of labor in the platform economy. Beginning in 2018, municipalities began more serious attempts to control the platforms (Schor et al. 2020b). In San Francisco, new regulations to reduce Airbnb activity began. New York City instituted a minimum wage for ride-hail drivers. Seattle began a process to do something similar. The State of California passed AB5, which made gig workers employees, in a dramatic departure from the independent contractor model that dominates. While Uber, Lyft, and Doordash were able to carve out their workers from that statute in a bitter electoral fight in 2020, the viability of this arrangement has come under increasing scrutiny. In London, Uber was forced to transform its workers into employees. In the European Union, tolerance for platforms' attempts to evade labor laws is likely to end soon.

These developments suggest that the future of platform labor remains uncertain. One possibility is that in North America and Europe, pressures to convert workers to employees will mount, especially where progressive governments are in power (though even conservative governments have begun to consider applying antitrust statutes to digital behemoths, potentially widening their vulnerability to industrial and economic reform). The other possibility is that the gig model will entrench itself and expand, providing a powerful model for the organization of work, leading conventional firms to convert their expensive workforces into independent contractors. Another option is one in which employment law and regulations institute a "third category" of gig workers, giving them some of the benefits typically associated with employment, but not many of its privileges and conditions. While we cannot foresee which of these pathways the sector will take, what we can predict is that, like its first decade of its existence, the second is likely to be characterized by heterogeneity, conflict, and continuous change, as the platform and conventional economies grow ever more intertwined.

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7

Contemplating the Next Generation of Sharing Economy Regulation

Rashmi Dyal-Chand

7.1 INTRODUCTION

As with any new and disruptive market force, the sharing economy has posed a significant regulatory challenge. Indeed, it is fair to say that the first generation of regulations of the sharing economy exhibits confoundment over basic definitional questions. What are the best legal analogies for sharing economy platforms? What are the goals and interests at stake? And how do the participants in the sharing economy view the need for, or value of, regulation? These definitional struggles have obscured equally important questions that remain unanswered. Significantly, it remains unclear how different sharing industries will develop, and this unknown continues to make regulation extraordinarily challenging.

Yet, as we consider the next generation of regulations of and for the sharing economy, we do have at least some of the benefit of hindsight. We have now seen the values held by platform proprietors, consumers, and workers in the sharing economy as such values are expressed through market practices. For example, we have seen the extent to which Uber and Lyft have replaced busses and subways as an essential form of transportation, and we have seen the increased access they create to areas that are inaccessible by public transportation. These developments redefine values such as convenience and accessibility in ways that the first generation of sharing economy regulations did not anticipate. We have even experienced the extremes in need, usage, and access dictated by a global pandemic. We know, for example, that while platform proprietors tend to portray platforms as attractive online alternatives to consumer marketplaces for accessing products and services, an increasing number of consumers view some forms of sharing economy businesses as basic necessities.

This chapter reviews the first generation of sharing economy regulations and proposes an approach for developing the second generation of regulations. In Section 7.2, I argue that first-generation sharing economy regulations rely on legal categories and assumptions that have been used to address business operations that have developed

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over decades (sometimes centuries), but that such legal approaches are at times ill-suited to regulation of the sharing economy.[1] In Section 7.3, I argue for a new regulatory approach that directly addresses core principles or values in the sharing economy. I focus in particular on four core principles that ought to serve as foundations for the next generation of sharing economy regulations.

7.2 FIRST GENERATION REGULATIONS

7.2.1 *Safety and Consumer Protection*

Some of the earliest and most important regulations of the sharing economy were those responding to safety and other consumer protection concerns raised by users of sharing platforms, especially those who used home- and car-sharing services such as Uber and Airbnb. Such concerns included reports of sexual assault, harassment, and other forms of unsafe behavior by drivers.[2] While renters also raised similar concerns with respect to home-renting services, some of Airbnb's most prominent troubles were raised by hosts whose homes were burglarized or misused by renters.[3]

The first generation of regulatory responses to such safety concerns was either to ban sharing businesses from operating, to sanction them, or to require them to obtain the same permits required of their competitors in the non-sharing economy for rooms, rides, and other services. Thus, for example, London recently banned Uber citing safety concerns, and California fined the company $59 million for failing to turn over information on sexual assaults.[4] These and other car-sharing services also faced repeated efforts by states to require some level of permitting.[5] Similarly,

[1] Portions of this section were originally published in 90 *Tulane Law Review*, 241 (2015).

[2] US Safety Report 2017–2018, 50, 57, 58 (Uber Technologies, Inc., 2019); Jennifer Schaller, Lyft Sexual Assault Claims Consolidated for Pre-Trial Proceedings, *National Law Review*, Feb. 10, 2020, www.natlawreview.com/article/lyft-sexual-assault-claims-consolidated-pre-trial-proceedings; Sara Ashley O'Brien et al., CNN investigation: 103 Uber Drivers Accused of Sexual Assault or Abuse, *CNN Wire*, April 30, 2018, https://money.cnn.com/2018/04/30/technology/uber-driver-sexual-assault/index.html.

[3] Biz Carson, Airbnb is Fixing its Safety Problems After California Shooting Leaves 5 Dead, Forbes.com, Nov. 6, 2019, www.forbes.com/sites/bizcarson/2019/11/06/airbnb-to-verify-all-listings-after-orinda-shooting/?sh=7156096ee49a; Olivia Carville, Airbnb Is Spending Millions of Dollars to Make Nightmares Go Away, *Bloomberg Business Week*, June 15, 2021, www.bloomberg.com/news/features/2021-06-15/airbnb-spends-millions-making-nightmares-at-live-anywhere-rentals-go-away.

[4] Knowledge at Wharton, Can Uber Overcome its Regulatory Obstacles?, *Fair Observer*, Dec. 3, 2019, https://knowledge.wharton.upenn.edu/article/can-uber-overcome-regulatory-obstacles; Suhauna Hussain, Uber Faces $59-Million Fine, License Threat, *Los Angeles Times*, Dec. 16, 2020, https://enewspaper.latimes.com/infinity/article_share.aspx?guid=750229ad-fbc6-41a0-b9ca-22837db84ca8.

[5] Meera Joshi et. al., E-Hail Regulation in Global Cities (NYU Rudin Center for Transportation, 2019); Paul Nussbaum, PUC Approves UberX for State, Not Philadelphia, *Philadelphia Inquirer* (Business), Nov. 14, 2014, at A15; Andy Vuong, Likely Ride-Sharing Nod would be a First, *Denver Post*, Apr. 30, 2014, at A10; Public Service Commission of South Carolina Commission Directive, No. 2014-372-T, http://dms.psc.sc.gov/pdf/orders/5A23B2F8-155D-141F-23C07EAA18BA1E64.pdf. (ordering Uber to cease and desist operations in South Carolina until a regulatory determination has been made); Katherine Driessen, Ride-Share Operators Gain Access to Houston Airports; City Becomes Third in U.S. to Adopt Rules for App-Based Services, *Houston Chronicle*, Nov. 13, 2014, at A1.

Airbnb became entangled in disputes about the legality of its business operations in New York City, Paris, and other cities.[6]

Sharing economy businesses typically fought these regulatory measures by arguing that they were not hotels, rental agencies, or taxicab companies.[7] Rather, they claimed they were only the providers of software that facilitates online markets.[8] They also developed their own internal measures for assuring customers about safety and product efficacy, many of which increased the transparency of their measures as a means of transferring the burden of safety assurance to their customers.[9] For example, Uber claimed to screen criminal and driving records and to provide a transparent system for reviewing driver profiles and the anonymous ratings of other users.[10] In 2019, in partnership with the National Sexual Violence Resource Center, the company released its own safety report detailing the number of accidents and assaults that occurred during Uber rides.[11] Airbnb went considerably further by providing hosts with a "host guarantee."[12] In 2019, after five people were killed at an Airbnb property, the company pledged to verify all its listings and provide a hotline for neighborhood complaints.[13]

More recently, regulators at especially the municipal level in some cities have begun to think about safety and consumer protection from a broader perspective,

[6] Tim Logan, Boston's Tough Rules Governing Airbnb Rentals are Finally in Full Effect, *Boston Globe*, Nov. 28, 2019, www.bostonglobe.com/business/2019/11/28/boston-tough-rules-governing-airbnb-rentals-are-finally-full-effect/qGyipfGarsWFPfcMmmrvyM/story.html; Sam Schechner and Matthias Verbergt, Paris Confronts Airbnb's Rapid Growth, *Wall Street Journal*, June 25, 2015, www.wsj.com/articles/airbnb-still-has-stoops-to-conquer-paris-takes-to-airbnb-like-a-croissant-1434999730?tesla=y; David Streitfeld, Airbnb Listings Mostly Illegal, New York State Contends, *New York Times*, Oct. 16, 2014, at A1; John Lichfield, Beware Airbnb If You're A Tenant Looking For A Quick Euro, *Independent* (World), May 23, 2014, at p. 32.

[7] These arguments have regularly arisen in the context of disputes with workers over employment status. See, for example, Noam Scheiber, Uber and Lyft Drivers Win Ruling on Unemployment Benefits, *New York Times*, July 28, 2020, www.nytimes.com/2020/07/28/business/economy/lyft-uber-drivers-unemployment.html; Tyler Sonnemaker, Court Rules Uber and Lyft Must Face Worker-Misclassification Lawsuit from Massachusetts' Attorney General, *Business Insider*, Mar 25, 2021, www.businessinsider.com/uber-lyft-massachusetts-attorney-general-misclassification-lawsuit-proceed-court-2021-3.

[8] Lori Aratani, A 'Balancing Act' for Ride-Sharing Service, *Washington Post*, May 12, 2014 at B01 (Uber and Lyft argue "that they are not transportation companies but rather go-betweens that link drivers who have vehicles with customers who need a ride."); Brief for Defendants-Appellees, Anoush Cab, Inc. v. Uber Technologies, Inc., No. 19-2001 (1st Cir. Aug. 25, 2020).

[9] See, for example, Michael Liedtke, "Sharing Safety Program": Uber, Lyft Team Up on Database to Expose Abusive Drivers, *USA Today*, Mar. 11, 2021, www.usatoday.com/story/travel/news/2021/03/11/uber-lyft-team-up-database-expose-abusive-drivers/4654902001/.

[10] Uber Background Checks, Uber, http://blog.uber.com/driverscreening (visited Aug. 11, 2014).

[11] Leidtke, "Sharing Safety Program"; US Safety Report 2017–2018, 50, 57, 58 (Uber Technologies, Inc., 2019).

[12] Ron Lieber, A Liability Risk for Airbnb Hosts, *New York Times*, Dec. 5, 2014, www.nytimes.com/2014/12/06/your-money/airbnb-offers-homeowner-liability-coverage-but-hosts-still-have-risks.html.

[13] Carson, Airbnb is Fixing its Safety Problems; David Yaffe-Bellany, Airbnb to Verify All Listings, C.E.O. Chesky Says, *New York Times*, Nov. 6, 2019.

including traffic safety and congestion, neighborhood safety and preservation, and environmental protection.[14] Some cities have even begun responding to concerns about loss of permanent housing and neighborhood gentrification.[15] While most, and arguably all, consumer protection regulation is justified on the grounds that it forces the internalization of negative externalities,[16] these more recent regulatory moves seem to recognize the breadth of the negative externalities that have proliferated in some sharing economy sectors. Though reactive, such regulation implicitly acknowledges the enormous extent to which network effects drive the development of the sharing economy. However, the piecemeal manifestation of these regulatory acknowledgements does not really comprehend the systemic relevance of both positive and negative externalities in the sharing economy.

7.2.2 *Discrimination*

A significant interdisciplinary literature has captured the proliferation of racial and other forms of discrimination across sharing economy industries. One well-known analysis, by Nancy Leong and Aaron Belzer, described the differing experiences of White and Black Uber customers, wherein the former were able to obtain Uber rides quickly and easily, while the latter had more difficulty obtaining Uber rides. Leong and Belzer traced the differing experiences partly to discrimination by Uber drivers, and particularly the rating system pursuant to which the drivers gave lower ratings to Black passengers.[17] But multiple studies have also traced discrimination to the very algorithms used by Uber.[18] In the United States, these algorithms incorporate geographical and other data that reflect residential racial segregation resulting from redlining and other hallmarks of structural racism.

The proprietors of platform technologies argue that the product features that have contributed most straightforwardly to discrimination on their platforms have other claimed benefits. For example, Uber's ratings system is intended to increase transparency for both drivers and passengers, which Uber claims makes its ridesharing service safer for all involved and "includes steps to mitigate racial bias."[19]

[14] See Chapter 8 (Behroozi) and Chapter 9 (Katsoupolos et al.).

[15] See Chapter 10 (O'Brien et al.). See also Josh Bivens, The Economic Costs and Benefits of Airbnb, The Economic Policy Institute, 2019.

[16] Joshua D. Wright, The Antitrust/Consumer Protection Paradox: Two Policies at War With Each Other, 121 *Yale Law Journal*, 2216 (2012).

[17] Nancy Leong and Aaron Belzer, The New Public Accommodations: Race Discrimination in the Platform Economy, 105 *Georgetown Law Journal*, 1271 (2017).

[18] Donna Lu, Uber and Lyft Pricing Algorithms Charge More in Non-White Areas, *New Scientist*, June 18, 2020.

[19] Details on Safety, *Uber News*, http://newsroom.uber.com/2015/07/details-on-safety (accessed April 22, 2021); Josh Eidelson, Uber Sued for Using 'Biased' Rider Ratings to Fire Drivers, *Bloomberg*, Oct. 26, 2020, www.bloomberg.com/news/articles/2020-10-26/uber-sued-for-using-biased-customer-ratings-to-fire-drivers.

Airbnb and other home-sharing services make similar claims about their ratings system.[20]

With some important recent exceptions, the first generation of regulations has barely addressed these forms of discrimination. While algorithmic bias is the subject of intense scholarly attention by legal experts, it has not translated into many lawsuits or much law reform.[21] Moreover, to the extent they have resulted in legal redress, successful claims have relied largely on existing laws that are not well-tailored to addressing algorithmic bias or other forms of discrimination that result from the industry norms of platform operation. Thus, for example, current regulation has failed to address the lack of transparency in the development of algorithms or the extraordinary extent to which intellectual property rights shield discriminatory behavior.[22]

7.2.3 *Workers Rights*

Some sharing economy firms, especially Uber, have also come under attack for their treatment of the workers who provide services through their platforms. Several lawsuits have claimed that these individuals are not really independent contractors or businesses that contract with companies such as Uber; rather, they are employees.[23] This distinction has significant consequences, because some states (such as the Commonwealth of Massachusetts) provide extensive protections to employees, including requiring employers to provide unemployment and health benefits.[24] Lawsuits in Massachusetts and California also defeated Uber's restrictions on the

20 Airbnb (n.d.), How Do Reviews Work?, www.airbnb.com/help/article/13 (accessed April 17, 2021); Emily Badger, Racial Bias in Everything: Airbnb Edition, *Washington Post*, Dec. 12, 2015.

21 See Leong and Belzer, The New Public Accommodations; Anne-Marie Hakstian et. al., The More Things Change, the More They Stay the Same: Online Platforms and Consumer Equality, 48 *Pepperdine Law Review*, 59 (2021); Allyson E. Gold, Redliking: When Redlining Goes Online, 62 *William. & Mary Law Review*, 1841 (2021); Sonia K. Katyal, Private Accountability in the Age of Artificial Intelligence, 66 *UCLA Law Review*, 54, 56 (2019); Anupam Chander, The Racist Algorithm?, 115 *Michigan Law Review*, 1023 (2017); Frank Pasquale, *The Black Box Society: The Secret Algorithms that Control Money and Information*, Harvard University Press, 2015.

22 Leong & Belzer, The New Public Accommodations; Rashmi Dyal-Chand, Autocorrecting For Whiteness, 101 *Boston University Law Review*, 191 (2021).

23 Healey v. Uber Techs., Inc., 2021 Mass. Super. LEXIS 28, 2021 WL 1222199; Kate Conger and Noam Scheiber, California's Contractor Law Stirs Confusion Beyond the Gig Economy, *New York Times*, Sept. 11, 2019, www.nytimes.com/2019/09/11/business/economy/uber-california-bill.html?utm_source=Triggermail&utm_medium=email&utm_campaign=Post%20Blast%20bii-transportation-and-logistics:%20Uber%20faces%20more%20regulatory%20woes%20%7C%20Trucking%20telematics%20-looks%20poised%20for%20takeoff%20%7C%20Amazon%20brings%20offline%20Alexa%20functionalities%20to%20the%20car&utm_term=BII%20List%20T%26L%20ALL; Michael B. Farrell, Suit Claims Uber Exploits Drivers, *Boston Globe*, June 27, 2014, at B7; Uber Technologies, Inv. v. Berwick, Case No. 11-46739 (CA Labor Commissioner, June 3, 2015); O'Connor v. Uber Techs., Inc., No. C-13-3826 EMC, 2013 U.S. Dist. LEXIS 171813 (N.D. Cal. Dec. 5, 2013).

24 In Massachusetts, these protections are buttressed by a very strict statute enacted to classify many of the people working as "independent contractors" instead as employees. See M.G.L. c. 149, s. 148B.

ability of drivers to request and retain tips.[25] These regulatory moves are another example of the growing recognition that negative externalities are also proliferating on the supply side of the sharing economy.

Of course, these companies dispute such claims, arguing instead that they have a much more limited role in these networks. However, the tide has begun to turn against them, opening a path for at least some sharing economy workers to have the benefits of true employment, including perhaps even unionization. The first generation of sharing economy regulations has left a significant open question, though, about the appropriate legal perspective on workers in platforms that are more genuinely peer-to-peer in their operation.[26]

Recent scholarship has also begun to capture the racial inequalities among workers that are perpetuated by such platforms. In her analysis of a recent survey of platform workers, Daria Roithmayr noted: "Because workers of color have fewer options than their white counterparts, they are less free to refuse precarious work, and are more likely to form the core component of motivated workers on which the on-demand economy relies."[27] Thus far, this form of discrimination on platforms has not resulted in much regulatory intervention.

7.2.4 *Anticompetitive Behavior*

A prominent form of first-generation regulatory interventions was aimed at preventing perceived anticompetitive behavior by businesses involved in the sharing economy. These claims were generally raised by traditional businesses, such as hotel or taxicab companies, that competed with sharing networks. Such businesses argued that by avoiding the costs associated with obtaining permits and complying with other regulations, sharing businesses were able to operate at lower costs.[28] Taxicab companies in Maryland even claimed antitrust violations on the grounds that Uber engages in price-fixing.[29]

25 Uber Drivers: Don't Sign Away Your Rights, http://uberlawsuit.com/ (visited Jan. 23, 2015); Lauren Weber and Rachel Emma Silverman, "We Are Not Robots" – Is Technology Liberating or Squeezing The New Class of Freelance Labor?, *Wall Street Journal*, Jan. 28, 2015, at B1 (describing a number of lawsuits filed by workers in the sharing economy to claim more benefits).

26 See Rashmi Dyal-Chand, Regulating Sharing: The Sharing Economy as an Alternative Capitalist System, 90 *Tulane Law Review*,241 (2015).

27 Daria Roithmayr, Racism is at the Heart of the Platform Economy, *Law & Political Economy Project*, https://lpeproject.org/blog/racial-capitalism-redux-how-race-segments-the-new-labor-markets/ (accessed April 17, 2021).

28 Ill. Transp. Trade Assn v. City of Chi., 839 F.3d 594, 2016 U.S. App. LEXIS 18285; Zeninjor Enwemeka, Boston Taxi Group Files Federal Lawsuit Over State's New Ride-Hailing Law, *WBUR*, Sept. 23, 2016, www.wbur.org/bostonomix/2016/09/23/boston-taxi-group-sues-massachusetts; Lori Aratani, Taxis Paralyze Downtown Traffic to Protest Ride Sharing Services, *Washington Post* (Metro), June 26, 2014, at B5; Boom and Backlash; The Sharing Economy, *Economist*, Apr. 26, 2014, at 61.

29 Parveer S. Ghuman, Analysis of Competition Cases Against Uber Across the Globe, CUTS International, 2017; Aratani, Taxis Paralyze Downtown Traffic.

The regulatory responses to these claims of anticompetitive behavior generally involved revising state or local anticompetition and permitting laws to apply to sharing networks. For example, Chicago considered an ordinance imposing permitting requirements on car-sharing services.[30] Similarly, New York City radically limited the extent to which people could work as hosts through Airbnb. Both in their narrower focus on anticompetitive behavior and in their implicit recognition of the effects on neighbors of Airbnb hosts and other third parties, such regulations are yet another example of first-generation regulatory efforts to address negative externalities.

7.2.5 *Taxation*

Finally, and not surprisingly, regulatory authorities have puzzled over the question of how to tax the first generation of sharing economy businesses. One pair of prominent scholars described Congress and the Internal Revenue Service as cycling between a "Proactive Approach," whereby they "change existing regulations to encourage the growth of new industries," and a "Neutrality Approach" in which they "cut back on regulatory benefits all around."[31] Meanwhile another pair of prominent scholars concluded that current tax law largely is capable of "tax[ing] sharing" and that the application of tax doctrine to sharing businesses is "not particularly novel."[32] They did, however, caution that some sharing businesses have behaved opportunistically in exploiting regulatory ambiguities in the tax arena.[33] Indeed, this observation seems to be shared by many tax law experts. More generally, these and other commentators have noted that, as is the case with other first-generation regulations, much of the regulation in this arena is reactive, piecemeal, and less than ideal.

7.3 GOVERNING PRINCIPLES FOR THE NEXT GENERATION OF REGULATION

The next generation of regulations must transition from reactive regulations that seek a rudimentary level of stability in the face of the upheaval of industry norms to proactive regulations that recognize the longer-term goals, expectations, and strategies of all relevant constituencies in sharing economy industries.

[30] Jon Hilkevitch, Uberx Caught Illegally Sharing; Company Directed Drivers to Airports, Violating Ordinance, *Chicago Tribune*, May 7, 2014, at C1; Kip Hill, Lyft, Uber Drivers Will Have to Pay New Fees, Follow New Rules under Spokane City Council Proposal, *Spokesman-Review*, Dec. 10, 2018, www.spokesman.com/stories/2018/dec/10/lyft-uber-drivers-will-have-to-pay-new-fees-follow/; H.R. 1093 Relating To Transportation Network Companies, 30th Leg., 2019 (Hi. 2019).

[31] Jordan M. Barry and Paul L. Caron, Tax Regulation, Transportation Innovation, and the Sharing Economy, 82 *University of Chicago Law Review*, Dialogue 69, 82–83 (2015).

[32] Shu-Yi Oei and Diane M. Ring, Can Sharing be Taxed?, 93 *Washington University Law Review*, 989, 994 (2016).

[33] Ibid.

Perhaps the first and most basic regulatory transition that is required is a transition from substantive regulatory silos to regulation that directly addresses core principles or values in the sharing economy. This is not to say that the trend toward more robust treatment of platform workers as employees, for example, is wrong or ineffective. But it is to argue that current regulatory systems, and the assumptions on which they have been built, are not the best basis for approaching the next generation of regulation. In making this argument, I take issue with some prominent legal commentators who claim that the sharing economy is not really that new or different as a market phenomenon,[34] at least to the extent that such claims lead to the conclusion that the same regulatory approaches we have used with other seemingly disruptive technologies will suffice for regulating the sharing economy. Instead, I am more convinced by Pollman's and Barry's observation that platform proprietors are very effectively taking advantage of regulatory gaps and conflicts to innovate their business models in new directions to avoid regulations that they disfavor.[35] This sophisticated (and Legal Realist) understanding of the regulatory landscape has allowed some sharing economy businesses to attenuate traditional legal categories to the near breaking point, as the increasingly frequent queries about the future of work in the "gig economy" reveal.[36]

Thus, policymakers would be better served by regulating on the basis of the core principles that they seek to promote in the next generation of sharing economy businesses. Returning to the example of platform workers, rather than trying to analyze whether Uber drivers or Airbnb hosts are employees or independent contractors according to the laws of any given jurisdiction, it will be more efficacious for policymakers to regulate in recognition of the actual roles such platforms play as a source of work and income. This in turn requires recognition of who exactly participates as workers in various sharing industries.

In this section, I review four core principles that have emerged essentially as consensus principles that ought to govern sharing economy practices. These are

34 Orly Lobel, The Gig Economy and the Future of Employment and Labor Law, 51 *University of San Francisco Law Review*, 51, 56 (2017) (asserting that the sharing economy is an expansion on previously existing contingent workforces); Valerio De Stefano, The Rise of the "Just-in-Time Workforce": On-Demand Work, Crowdwork, and Labor Protection in the "Gig-Economy," 37 *Comparative Labor Law & Policy Journal*, 471, 480–481 (2016) (relating modern gig-workers to a broader trend of casualization and demutualization in the workforce that predated the modern platform-based sharing economy); Derek Miller, The Sharing Economy and How it is Changing Industries, *The Balance Small Business* (Jun. 25, 2019), www.thebalancesmb.com/the-sharing-economy-and-how-it-changes-industries-4172234#:~:text=The%20sharing%20economy%20is%20an%20economic%20principle%20that,share%20value%20from%20an%20under-utilized%20skill%20or%20asset.

35 Elizabeth Pollman and Jordan M. Barry, Regulatory Entrepreneurship, 90 *Southern California Law Review*, 383, 392, 398–399 (2017).

36 Robert Reich, Why the Sharing Economy is Harming Workers – And What Must be Done, RobertReich.Org, https://robertreich.org/search/sharing+economy, Nov. 27, 2015; Juliet Schor, Debating the Sharing Economy, *Great Transition Initiative*, Oct. 2014; Charlotte S. Alexander and Elizabeth Tippet, The Hacking of Employment Law, 82 *Missouri Law Review*, 973, 1000–1001 (2017).

principles that scholars across disciplines have argued should govern continued development in the industry. Such scholars have argued, for example, that sharing economy businesses must optimize for more than profit.[37] They must optimize for values such as equity.[38] I argue here that these principles also should anchor the next generation of sharing economy *regulation*. The four principles on which I focus here are by no means a closed list. To the contrary, this list ought to be developed, expanded, and edited as the sharing economy continues to mature.

However, this list does serve several crucial functions for policymaking moving forward. First, it provides a model for policymaking that is a compelling alternative to the piecemeal, reactive, and often ill-fitting regulatory approaches that have thus far dominated the landscape. Second, it serves as a powerful basis for regulation of the sharing economy *at this point* in time, capturing a phenomenon that has established itself as a ubiquitous market force that significantly disrupted prior market practices and has yet to assume its ultimate (and perhaps more stable) form. Third, it forcefully reminds us that regulation that "leaves to the market" the opportunity to optimize just for profit *is in fact regulation*. Said another way, the perceived absence of regulation is a form of regulation that tips the balance of legal power and privilege precipitously in favor of platform proprietors. By providing regulatory support for optimizing for values other than profit, policymakers can and must acknowledge the reality that they have already been regulating the sharing economy. Moreover, and crucially, lawmakers can be more proactive in regulating the profit-making and economic behavior of sharing economy businesses in such a way as to enable greater innovation and ultimately competition among businesses in any given sector. In short, lawmakers must take active responsibility for regulating forward.

7.3.1 *Principle 1: The Sharing Economy as Infrastructure*

Our experience with the pandemic has starkly revealed the extent to which some platforms, including some sharing economy businesses, have begun to serve as essential infrastructure for many individuals, especially those in urban locations. For example, many of us have been utterly dependent in our work lives on platforms such as Zoom and Microsoft Teams, with all the attendant dependencies

37 Alexiomar D. Rodríguez-López, Trust Me, I Share Your Values, 10 *University of Puerto Rico Business Law Journal*, 44, 50–51 (2019) (arguing that the sharing economy could address economic problems in Puerto Rico, but only if implemented with a pool of shared values between the business and the clients in mind). Nestor M. Davidson and John J. Infranca, The Sharing Economy as an Urban Phenomenon, 34 *Yale Law & Policy Review*, 215, 268–269 (2016).

38 Orly Lobel, The Law of the Platform, 101 *Minnesota Law Review*, 87, 163 (2016) (stating that equity issues should be addressed as platform companies continue to expand). *See also* Vanessa Katz, Regulating the Sharing Economy, 30 *Berkeley Technology Law Journal*, 1067–1112 (2015); Abbey Stemler, The Myth of the Sharing Economy and Its Implications for Regulating Innovation, 67 *Emory Law Journal*, 197, 223n (2017).

such as handing over our private lives for data collection by these platforms during the many hours in which we use these platforms for meetings.[39] Such dependencies extend to other core sharing economy sectors. Many of us have come to rely even more extensively on cloud technology to store both business and personal materials. Many of us have relied on ridesharing services both to get ourselves to workplaces, medical appointments, and grocery stores (during times when subways and busses have operated on much more limited capacity) and to provide additional income. Many of us have used sharing economy platforms to order products and services that are essential to our daily living, thereby also relying on last-mile delivery systems and other attendant services. And the list goes on.

These examples reveal that sharing economy businesses have directly replaced those things that we explicitly label as infrastructure, including modes of communication, transportation, storage, and essential equipment. Equally basically, such businesses have replaced – and displaced – those things that our federal, state, and local governments have built as public works. This basic reality dictates qualitatively different regulation. It is a given that policymakers develop fundamentally different rules for overseeing the operation, management, and maintenance of infrastructure.[40] Even when such infrastructure is privately owned, policymakers do not – and cannot afford to – leave the owners and managers of such infrastructure to their own devices for maximizing profit and efficiency. The stakeholders of such businesses include more constituencies than just their shareholders. The role of regulation is to

39 See, for example., Jane Wakefield, Zoom Boss Apologises for Security Issues and Promises Fixes, *BBC News*, April 2, 2020, www.bbc.com/news/technology-52133349 (reporting on Zoom's response to widely criticized security breaches at the beginning of the coronavirus pandemic); Kate O'Flaherty, Zoom's Security Nightmare Just Got Worse: But Here's the Reality, *Forbes*, June 5, 2020, www.forbes.com/sites/kateoflahertyuk/2020/06/05/zooms-security-nightmare-just-got-worse-but-heres-the-reality/?sh=34b456592131 (reporting on the anger users expressed upon learning that end-to-end encryption was for paid users only). See also Celine Castronuovo, EU Privacy Regulator Proposes $425M Fine Against Amazon, *The Hill*, June 10, 2021 https://thehill.com/policy/technology/557863-eu-privacy-regulator-proposes-425m-fine-against-amazon (reporting on charges against Amazon for alleged privacy data invasions that violate EU law); Barbara Ortutay, Record Facebook Fine Won't End Scrutiny of the Company, *AP News*, June 24, 2019, https://apnews.com/article/technology-business-facebook-privacy-scandal--ap-top-news-ca-state-wire-47f5f7fd9e0941a880b929af081a37a0; Jordan Valinsky, 4 Companies Affected by Security Breaches in June, *CNN Business*, June 26, 2021, www.cnn.com/2021/06/26/tech/cyberattacks-security-breaches-june/index.html (reporting on data privacy breaches from platforms including Electronic Arts and Peloton).

40 Ganesh Sitaraman, Morgan Ricks, and Christopher Serkin, Regulation and the Geography of Inequality, 70 *Duke Law Journal*, 1763, 1830–1832 (2021) (noting that transportation and communications resources are foundational to economic growth and development, and analogizing high speed internet to the modern postal service as necessary to bring infrastructural equity to marginalized communities); Sofia Ranchordás, Innovation Experimentalism in the Age of the Sharing Economy, 19 *Lewis & Clark Law Review*, 871, 889 (2015) (relating the regulation of the modern gig-economy to earlier efforts to regulate infrastructure-based activities such as telecommunications and energy). See also, Lobel, The Law of the Platform, at 163 (raising questions of equity in whether platform companies serve poor and marginalized communities and arguing that platform companies should include such considerations as they expand); Stemler, The Myth of the Sharing Economy, at 239 ("For performance standards to be effective, they must be monitored").

ensure that the public has the right to access and use such infrastructure, regardless of whether it is publicly or privately owned.[41]

Perhaps more than anything, this qualitative difference boils down to a recognition that the line between "public" and "private" in these sharing economy sectors is illusory in meaningful respects. Across a range of legal fields, the illusoriness of the public/private distinction has been the subject of more than a decade of robust legal scholarship, and much of this critique is directly applicable to the sharing economy.[42] Thus, for example, the argument by a platform proprietor that it is a private entity with the right to treat its workers as independent contractors, ought to be of little consequence in this arena. It may be an apt argument that Uber should be forced to internalize the negative externalities it produces by not treating its drivers as employees. But it is an equally realistic argument that Uber's operations should be regulated in ways that other forms of infrastructure are regulated because it is now providing an essential service. Thus, just as regulations protect subway drivers and electrical service technicians by prioritizing their ability to work safely and for fair wages,[43] so too must regulations protect sharing economy workers so that they

[41] For an insightful treatment of this subject, see Nik Guggenberger, The Essential Facilities Doctrine in the Digital Economy: Dispelling Persistent Myths, *Yale Journal of Law & Technology*, 2021. See also, Frank Pasquale, Dominant Search Engines: An Essential Cultural & Political Facility, in *The Next Digital Decade*, 401–418 (Berin Szoka and Adam Markus, eds., 2010, Washington, DC: Tech Freedom).

[42] See, for example, Brian Jason Fleming, Regulation of Political Signs in Private Homeowner Associations: A New Approach, 59 *Vanderbilt Law Review*, 571, 573–574 (2006) (noting that homeowner associations take up an ambiguous legal space as private governing bodies whose jurisdiction overlaps with federal and state governing bodies). Gillian E. Metzger, Privatization as Delegation, 103 *Columbia Law Review*, 1367, 1371–1373 (2003) (discussing the blurred line between the public and private sectors in constitutional law); Michael P. Vandenbergh, Private Environmental Governance, 99 *Cornell Law Review*, 129, 171–172 (2013) (discussing the emergence of private–public environmental governance); Matthew A. Shapiro, Delegating Procedure, 118 *Columbia Law Review*, 983, 998 (2018) (arguing that three significant aspects of civil litigation have been delegated by the federal government to private parties); Benjamin Zhu, A Traditional Tort for a Modern Threat: Applying Intrusion Upon Seclusion to Dataveillance Observations, 89 *New York University Law Review*, 2381, 2389 (2014) (claiming the digitization of public documents has given access and intrusive power to private data collection agencies); Orly Lobel, The Renew Deal: The Fall of Regulation and the Rise of Governance in Contemporary Legal Thought, 89 *Minnesota Law Review*, 342, 345 (2004) (discussing the emerging governance model of transferring governing responsibilities to states, localities, private businesses and nonprofit organizations); Robert C. Hockett and Saule T. Omarova, Public Actors in Private Markets: Toward a Developmental Finance State, 93 *Washington University Law Review*, 103, 122 (2015) (arguing public and private sectors are "inseparable and deeply interconnected parts of the nation's economic organism"). See also, Tabrez Y. Ebrahim, National Cybersecurity Innovation, 123 *West Virginia Law Review*, 483, 494–495 (2020) (noting that the private and public sectors are interconnected and co-mingled, thus requiring similar treatment in cybersecurity regulation).

[43] Ross Barkan, New York's Transit Workers Keep Getting Sick, *The Nation*, April 9, 2020, www.thenation.com/article/politics/mta-transit-driver-covid/ (discussing the high rate of COVID-19 infection among public transit workers in New York and efforts to protect essential workers in public transit); Rachel Burgaris, Why Electrical Safety Should be a Priority in Post-COVID Planning, *Occupational Health & Safety*, June 1, 2020, https://ohsonline.com/articles/2020/06/01/

can continue to provide essential services without work interruption. The value of recognizing such platforms as infrastructure is that it forcefully creates more space for a broader range of regulatory interventions.

What regulatory possibilities might flow, then, from the recognition of at least some (perhaps many) sharing economy sectors as infrastructure? Consider the possibilities that such a perspective could have created during the coronavirus crisis. There should have been little question that Uber drivers should have received the same treatment as other essential workers in receiving personal protective equipment and early vaccinations. On the consumer side of the equation, the safety of consumers of such services should also have received more sweeping consideration. Meanwhile, just as we have enhanced rights of privacy from governmental surveillance,[44] so too should companies like Zoom and Microsoft have been regulated more strictly to protect the privacy of their many users.

Indeed, the pandemic has clarified the real role and value of such businesses, and it has also provided a basis for gaining much-needed regulatory perspective. Out of the many regulatory possibilities, three seem particular efficacious. First, and most basically, public monitoring of such sharing businesses is imperative. Just as the Consumer Financial Protection Bureau, the Consumer Product Safety Commission, and a robust list of other federal and state agencies monitor and oversee a very broad range of consumer products and services, so too must sharing economy businesses receive the same careful scrutiny for safety, accessibility, value, and basic fairness.[45] Indeed, while monitoring is appropriate across all sharing economy sectors, it should be more extensive for those that serve as infrastructure.

why-electrical-safety-should-be-a-priority-in-postcovid-planning.aspx (discussing the safety concerns and protections unique to electrical safety practices, including COVID-19 precautions); Heidi Groover, Masks, Driver Shields, Artificial Intelligence: How Do We Make Public Transit in the Puget Sound Area Safe Amid COVID-19, *Seattle Times*, Aug. 23, 2020, www.seattletimes.com/seattle-news/transportation/masks-driver-shields-artificial-intelligence-how-do-we-make-public-transit-in-the-puget-sound-amid-covid-19/ (reporting on high death rates of transit workers and on the rules in place to protect them from COVID-19); *What Have Platforms Done to Protect Workers During the Coronavirus (COVID 19) Crisis?, Organisation for Economic Co-operation and Development*, Sept. 21, 2020, www.oecd.org/coronavirus/policy-responses/what-have-platforms-done-to-protect-workers-during-the-coronavirus-covid-19-crisis-9d1c7aa2/ (reporting on the unique risks to platform workers during the pandemic and protections governments have taken to protect workers from the financial and health risks of the virus).

44 Deborah Pearlstein, Before Privacy, Power: The Structural Constitution and the Challenge of Mass Surveillance, 9 *Journal of National Security Law & Policy*, 159, 166–168 (2017) (outlining the history of bulk surveillance and the regulations that limited the ability of the National Security Agency to monitor certain data from US citizens); Ieuan Jolly, Data Protection in the United States: Overview, *Practical Law*,(law stated as of June 8, 2020), https://1.next.westlaw.com/Document/I02064fbd1cb611e38578f7ccc38dcbee/View/FullText.html?contextData=%28sc.Default%29&transitionType=Default (a question and answer guide to privacy regulation in the United States).

45 *See* Dodd-Frank Act 12 U.S.C.A. § 5491 (2010) (establishing Consumer Financial Protection Bureau); Consumer Product Safety Act 15 U.S.C.A. § 1261 (1972) (current version at 15 U.S.C.A. § 1261 [2008]) (establishing the Consumer Product Safety Commission).

Second, those sharing businesses that provide services that directly replace public infrastructure could be regulated as public utilities. Such regulation could take the form of treating some platforms as "essential facilities," a possibility that Nikolas Guggenberger discusses as efficacious as a means of limiting monopoly power. As Guggenberger notes, "[t]o define the suitable remedies and to open the digital economy for competition, we can learn from the past. In the early twentieth century, the railroads controlled critical infrastructure and excluded competitors from crucial markets."[46]

Finally, it ought to be a routine option for public agencies at the federal or state level to consider investing in both research and development as well as the operation of government services that compete with and service as a public alternative to private sharing economy businesses that provide critical infrastructure. We have seen exactly this form of investment proposed by local governments such as New York City and the Biden Administration with respect to broadband access.[47] This form of regulatory investment has also been proposed in the ridesharing context, as is discussed by Behroozi in Chapter 8. It provides an intriguing opportunity for rebalancing and democratizing technological access that could contribute enormously to closing the digital divide and preempting some of the injustices that have proliferated as a result of the extreme emphasis on profit that we have seen in first-generation sharing economy businesses.

7.3.2 *Principle 2: Protect Resilience*

The pandemic has also helped to clarify the importance of a second principle – resilience – that I argue should define the next generation of regulatory approaches to the sharing economy. Indeed, the value of resilience is closely related to the recognition that some sharing economy sectors have become part of the infrastructure of modern society. However, I have separated resilience out as an independent core principle that must be promoted through regulation across *all* sharing economy sectors, even those that do not provide goods or services that can be deemed as essential facilities or infrastructure. Such a regulatory prioritization acknowledges that even

46 Nik Guggenberger, Essential Platform Monopolies: Open Up, Then Undo, *Promarket*, Dec. 7, 2020, https://promarket.org/2020/12/07/essential-facilities-regulation-platform-monopolies-google-apple-facebook/.

47 Andrew Duehren, Kristina Peterson, and Sabrina Siddiqui, Biden, Senators Agree to Roughly $1 Trillion Infrastructure Plan, *Wall Street Journal*, June 24, 2021, www.wsj.com/articles/biden-senators-agree-to-roughly-1-trillion-infrastructure-plan-11624553972?mod=searchresults_pos3&page=1(noting that increased broadband access is a priority of legislators under the Biden administration); Stacie Sherman, Cuomo Signs New York Bill Requiring Low-Cost Broadband Access, *Bloomberg*, April 16, 2021, www.bloomberg.com/news/articles/2021-04-16/n-y-to-require-all-internet-providers-offer-low-cost-broadband (discussing new legislation in New York that mandates that Internet providers ensure access to high-speed internet services at an affordable rate for all New York families).

niche markets, contexts, and consumer clusters can rely heavily on platforms, and concomitantly, that these consumers deserve protection also.

Returning again to the nature of work during the pandemic, Zoom glitches literally could mean hours of missed work, which had to be somehow made up, excused, or explained. When workers that our society labeled "essential" started catching COVID-19 in clusters, policymakers were forced to quickly discern the protections that were required in order to keep them at work. They also had to develop regulations that forced employers to provide such protections on an ongoing basis. Because the essential nature of some sharing economy sectors was invisible to policymakers, however, they did not have the information, nor often the motivation, to protect workers in those sectors who often were just as essential. Meanwhile, on the consumer side of the picture, prices of essential consumer goods fluctuated wildly, at times triggering price gouging laws,[48] as a result of problems with supply chains and delivery systems.[49]

These lived experiences of crisis-generated disruption have taught new lessons about the importance of regulation that motivates and supports the development of resilient systems. Part of the function of regulation is to ensure that such lessons are not short-lived. The pandemic, and the range of economic and social crises that have surrounded and preceded it, have revealed a great deal about the fragility of many of the systems on which we rely. Our job now is to plan forward in building resilience for the crises we currently face and that we inevitably will face, including climate-related, health, financial, racial, and other disruptions and crises. Resilience can serve as a touchstone that clarifies both the need for regulation and the regulatory choices that ought to be made. In the realm of sharing economy businesses, one commonality across many sectors may be that sharing businesses have the capacity to rapidly and efficiently allocate resources for a very broad range of consumer needs. This makes them enormously attractive and useful in times of crisis.[50] Without regulation,

48 See COVID-19 Price Gouging Prevention Act, H.R. 6472, 116th Cong. (2d Sess. 2020) (a bill proposed in response to price gouging in the COVID-19 pandemic); see also Ky. Rev. Stat. Ann. § 367.374 (West 2021); 73 Pa. Stat. Ann. § 232.2 (West 2007); N.Y. Gen. Bus. Law § 396-r (McKinney 2020) (examples of statutes designed to protect against price gouging; Kentucky's and New York's laws appeared after the COVID-19 pandemic).

49 Michael Levenson, Price Gouging Complaints Surge Amid Coronavirus Pandemic, *New York Times*, Mar. 27, 2020, www.nytimes.com/2020/03/27/us/coronavirus-price-gouging-hand-sanitizer-masks-wipes.html; Danielle Wiener-Bronner, Everything at the Grocery Store is Getting More Expensive, *CNN Business*, Aug. 5, 2020, www.cnn.com/2020/08/05/business/grocery-prices-rising/index.html (reporting on the disrupted supply chains due to the pandemic); Lisa Baertlein, COVID-19 Delivery Surge Strains FedEx Service, Opening Doors for UPS, *Reuters*, June 30, 2020.

50 Kentaro Toyama, The Sharing Economy Will Survive the Pandemic. Is That a Good Thing?, *World Politics Review*, July 7, 2020, www.worldpoliticsreview.com/articles/28893/what-the-coronavirus-pandemic-means-for-the-sharing-economy-business-model; Josh Whitney, Rebuild 'Sharing Economy' Post-Virus to Prepare for Climate Change, *Bloomberg Law*, May 1, 2020, https://news.bloombergtax.com/coronavirus/insight-rebuild-sharing-economy-post-virus-to-prepare-for-climate-change (arguing that companies such as Uber's and Airbnb's services to healthcare workers in the early stages of the pandemic are examples of how the sharing economy can nimbly respond to future crises such as climate change).

however, such businesses may have little incentive to ensure that their allocation choices are equitable, accessible for all, and built to last.

Again, a rich array of regulatory options is available to optimize for resilience in the sharing economy. One important consideration is to ensure consistent consumer access by actively monitoring, and at times capping, prices. Uber's and Lyft's surge-pricing schemes taught important lessons about the predation that can easily occur when a business both monopolizes a market and is free to set its own prices.[51] While price caps seem particularly relevant during times of crisis, as evidenced by price gouging laws which typically only apply during states of emergency,[52] such caps should be in consideration more broadly as a means to ensure accessibility to all. Thus, for example, just as utility companies are constrained from "turning off" a service if individuals are unable to pay,[53] so too should at least some sharing sectors be subject to broader regulations on pricing. This is not to say that all forms of dynamic pricing are problematic. To the contrary, the reasonable use of such pricing can help to ensure temporally efficient supply during times when demand suddenly spikes. However, regulation has a role to play in establishing the parameters of what is reasonable in this context.

As I have discussed, a second area for regulation is in the realm of worker protections. While all workers deserve fair treatment and wages, the need to develop resilient systems within a range of sharing economy sectors should serve as an independent basis for considering regulations relating to workers and workplace conditions.

[51] Fran Spielman, Alderman Accuses Uber, Lyft of 'Predatory Fares,' Wants Price Cap Imposed, *Chicago Sun-Times*, May 24, 2021, https://chicago.suntimes.com/city-hall/2021/5/24/22451667/uber-lyft-ride-share-hailing-surge-pricing-cap-city-council-ordinance-alderman-reilly-taxi-cabs#:~:text=They%20would%20be%20free%20to%20use%20%E2%80%9Csurge%20pricing%E2%80%9D,and%20other%20ride-hailing%20companies%20would%20limit%20surge%20pricing; Michael Sainato, Uber and Lyft Fares Surge as Pandemic Recedes – but Drivers Don't Get 'Piece of Pie,' *The Guardian*, June 21, 2021, www.theguardian.com/technology/2021/jun/21/uber-lyft-fares-surge-drivers-dont-get-piece-of-pie (reporting on the reemergence of surge pricing following the pandemic, but noting that drivers are not receiving the financial benefit of surge pricing and neither customers nor drivers have transparency about how surge prices are allocated).

[52] See, for example, Price Gouging Prohibited, 73 PA. Stat. Ann. § 232.4 (prohibiting price gouging in Pennsylvania during states of emergencies); Price Protections During the COVID-19 Recovery Period, Del. Code Ann. tit. 6, § 2528 (2020) (prohibiting price gouging during the state of emergency precipitated by COVID-19). See also, 8NewsNow Staff, Surge Pricing Cap on Uber Stems from 2015 Nevada Law, *8News Now*, Apr. 14, 2021, www.8newsnow.com/news/local-news/surge-pricing-cap-on-uber-stems-from-2015-nevada-law/ (reporting that Uber blamed Nevada's declaration of emergency for preventing the company from charging surge prices).

[53] See, for example, Prohibition on Discontinuance or Disconnection of Utility Service During the Winter Heating Season; Minimum Payments; Payment Plans; Exceptions, N.M. Stat. Ann. § 27-6-18.1 (protecting low-income New Mexican citizens from having essential utilities turned off during inclement weather and ensuring access to government energy assistance programs); Limitations on Termination of Utility Service, Wash. Rev. Code § 54.16.285 (prohibiting Washington utility companies from terminating heating services during the winter months).

Finally, and more broadly, it will be important for policymakers to consider regulating in favor of redundancy in sharing sectors. This broad objective still leaves open many regulatory possibilities. For example, regulators could choose to develop their own publicly operating platform, as described above, or they could choose to regulate in such a manner as to promote competition within a sharing economy sector. Though radically different, both possibilities could avoid the fragility that results from over-dependence on a single provider of an essential platform service.

7.3.3 *Principle 3: Create Equity*

While the coronavirus pandemic has highlighted the importance of regulating to optimize for resilience, another ongoing crisis has shone a harsh light on the need for regulations across sharing economy sectors to address the imperative of equity. The murder of George Floyd has activated a long-overdue and more sustained reckoning with systemic racism and violence than has occurred in some time. While the almost weekly police killings of Black individuals demonstrate the urgency of such a reckoning in the area of criminal justice practice and regulation, no sector is immune from scrutiny. Indeed, that is one of the most important lessons from the recent dialogue about the nature of structural racism in US society.

Moreover, compelling research has revealed the extent and depth of racism in the sharing economy. The combination of individual decision making, such as the choice of Airbnb hosts not to rent to Black guests, and machine learning, namely the rampant nature of algorithmic bias, has resulted in tremendous inequities. Uber drivers have consistently given lower ratings to Black passengers. Gig workers who rely predominantly on gig work are also predominantly people of color. Platform technologies are configured in such a way as to exhibit algorithmic bias by race and other traits.[54] Here again, the list is almost endless.

Such inequities are not just racial, but include bias about gender, sexuality, disability, and many other identities and traits.[55] They also include economic inequalities, which have resulted in predation by platform proprietors – of lower-income consumers and workers.[56] The need for lower-income workers to access ridesharing

[54] See, for example, Benjamin G. Edelman, Michael Luca, and Daniel Svirsky, Racial Discrimination in the Sharing Economy: Evidence from a Field Experiment, 9 *American Economic Journal: Applied Economics* 1 (2017), https://dash.harvard.edu/bitstream/handle/1/33045458/edelman,luca,svirsky_racial-discrimination-in-the-sharing-economy.pdf?sequence=1. See also Stemler, The Myth of the Sharing Economy, 222–223.

[55] See, for example, Naomi Cahn, June Carbone, and Nancy Levit, Discrimination by Design?, 51 *Arizona State Law Journal*, 1 (2019) (discussing how the platform economy reflects and exacerbates gender disparities in the workforce by relegating women to low-paying gig jobs such as clutter organization rather than high-paying jobs such as moving furniture).

[56] Virginia Eubanks, *Automating Inequality: How High-Tech Tools Profile Police and Punish the Poor*, Macmillan, 2017, 111–115 (defining modern algorithms that monitor poor and minority

services to reach their workplaces during the pandemic serves as a compelling example here. When such services were priced too expensively to be accessible to essential workers, the resulting inequities cried out for regulatory intervention.[57] Indeed, both the speed and extent of the proliferation of bias across sharing industries has been breathtaking. Especially given the failures of first-generation sharing economy providers to self-regulate to eliminate discrimination, it is imperative for policymakers to intervene.[58]

While the creation and preservation of equity in the sharing economy will require a range of regulatory interventions, the threshold intervention that seems inescapable in this arena is the involvement of government agencies in monitoring the development and operation of sharing platforms. Simply put, it can no longer be a right of sharing economy businesses to hide behind claims of trade secrecy or other intellectual property rights as a way of avoiding scrutiny by public agencies to determine the existence or extent of differential impact by platforms on their consumers and workers.[59]

Relatedly, it will be imperative for policymakers to develop a range of interventions when bias is discovered. These can and should occur at the federal and state level and should be driven by both legislatures and courts. They should include expanded rights of action for consumers to claim racial and other forms of discrimination. But especially when promulgated by legislatures, such regulations should also adopt a broad view of the imperative of equity, moving beyond the definitions of and tests for discrimination and the categories of protected classes traditionally determined by civil rights laws. Instead, lawmakers should consult the extensive literature on the benefits of equitable access to technology to define broad rights of equitable access to sharing economy systems and platforms.[60]

communities as the "digital poorhouse" and describing how as a result of these facially neutral algorithms, marginalized groups are subjected to practices such as predatory lending and reverse redlining).

57 See Community Rides: UTA Essential Workers, *Utah Transit Authority News*, Aug. 18, 2020, https://rideuta.com/news/2020/08/Community-Rides-UTA-Essential-Workers (discussing how essential workers continued to use Utah's public transportation services throughout the pandemic); Matt McFarland, Traffic Deaths Jump for Black Americans Who Couldn't Afford to Stay Home During Covid, *CNN*, June 21, 2021, https://edition.cnn.com/2021/06/20/economy/2020-traffic-deaths-black-americans/index.html (discussing how nonwhite pedestrians have much higher fatality rates than white counterparts, and reporting on the sharp rise of pedestrian deaths during the pandemic, especially in minority and low-income communities); Christine Roher and Randy Mac, Rideshare Prices Soar: Here's What's Going On, *NBC Los Angeles*, May 19, 2021, www.nbclosangeles.com/investigations/rideshare-prices-increase-uber-lyft-pricing/2598627/.

58 *See* Rashmi Dyal-Chand, Autocorrecting for Whiteness, 101 *Boston University Law Review*, 191, 250–251 (2021).

59 Ibid., 253–254. See also Pauline T. Kim, Data-Driven Discrimination at Work, 58 *William. & Mary Law Review*, 857, 921 (2017) (explaining how algorithm creators often escape liability for bias by claiming their algorithms are proprietary information).

60 Ifeoma Ajunwa, The Paradox of Automation as Anti-Bias Intervention, 41 *Cardozo Law Review*, 1671, 1733–1735 (2020); Stephanie Bornstein, Antidiscriminatory Algorithms, 70 *Alabama Law Review*, 519,

Finally, the troubling extent to which Black, Indigenous, and People of Color (BIPOC) and other historically marginalized individuals are represented among the ranks of sharing economy workers mandates far greater regulatory attention to ensure equity in the sharing economy workplace. Such attention will require regulators to break through some of the traditional legal structures, including labels such as "independent contractor," and rhetorical slogans such as freedom of contract, that have been used (and attenuated) by platform proprietors to avoid regulation. Just as the pandemic-induced rules allowing for gig workers to file for unemployment recognized the true nature of sharing economy work from the perspective of those workers, so too will more permanent regulations have to recognize the precarity that has resulted from the current imbalance of power between platform proprietors and their workers.

7.3.4 *Principle 4: Develop Democracy*

The fourth core principle that I wish to discuss here builds on the prior three principles, abstracting a crucial basis for governance of the sharing economy going forward. While the prior three principles provide foundations for regulations that shape rights and remedies for categories of participants in the sharing economy as a means of correcting the imbalance of power and providing stability, this fourth principle addresses the instability and imbalance of power by providing a foundation for *governance* as a form of regulatory intervention. The imperative to develop democratic institutions for governance within the sharing economy recognizes that platforms today are a powerful means of organizing and controlling social interactions and behaviors. This powerful role dictates ongoing access by the public not only to the goods and services provided but also to the right to determine *how* such platforms operate.

Currently, the governance of sharing economy platforms is controlled almost exclusively by their proprietors, who set the rules for participation in such platforms. The resulting governance failures are numerous. Rather than enumerating examples, the best demonstration of such failures may be simply to contrast Wikipedia, which is arguably a governance success,[61] with Uber, which has repeatedly disregarded the voices and participation of consumers, workers, and really anyone (other than its owners) who has a stake in the company's operations.

534 (2018); Kim, Data-Driven Discrimination at Work, 919–921. See also Matthew Adam Bruckner, The Promise and Perils of Algorithmic Lenders' Use of Big Data, 93 *Chicago-Kent Law Review*, 3, 18-19, 23, 26 (2018); Ifeoma Ajunwa, Algorithms at Work: Productivity Monitoring Applications and Wearable Technology as the New Data-Centric Research Agenda for Employment and Labor Law, 63 *St. Louis University Law Journal*, 21, 44–45, 50–51 (2018).

[61] Yochai Benkler, Coase's Penguin, or, Linux and the Nature of the Firm, 112 *Yale Law Journal*, 369 (2002).

Extreme examples such as this have generated a developing consensus that, like home-owners associations[62] and bowling societies[63] a generation earlier, some platforms are developing into institutions that substitute for public institutions. It is not an exaggeration to describe such platforms as forums in which private forms of government have developed. As with predecessor institutions that have developed in this manner, one of the roles of regulation is to provide scaffolding that promotes their democratic growth and development.

Thus, policymakers should investigate the regulation of home-owners associations and other similar institutions as models for developing democracy in the sharing economy. They should also draw strategies from Wikipedia and other truly "open access" platforms. Indeed, one basic assumption that may well be both an appropriate starting point for such work, as well as a basis for further investigation, is that genuinely peer-to-peer sharing platforms are a home-grown, internally generated form of governance within the sharing economy.[64] Assuming such investigations bear out the validity of this assumption, then policymakers can and should investigate ways in which to incorporate some of the operational strategies of peer-to-peer platforms more broadly into sharing economy sectors, particularly those that serve as crucial infrastructure today.

7.4 CONCLUSION

While regulation of the sharing economy has thus far been a reactive process, exhibiting very little attention to priorities such as consistency and the development of

[62] Paula A. Franzese and Steven Siegal, The Twin Rivers Case: Of Homeowners Associations, Free Speech Rights, and Privatized Mini-Governments, 5 *Rutgers Journal of Law & Public Policy*, 729, 752–753, 767 (2008) (discussing the rise of home-owners associations as governing bodies).

[63] Robert D. Putnam, *Bowling Alone: The Collapse and Revival of American Community*, Simon & Schuster, 2000 (discusses the rise and fall of social capital in the United States, explaining that once-common civic participation in clubs and other social activities complemented state and federal governance).

[64] Daniel H. Kahn, Social Intermediaries: Creating a More Responsible Web Through Portable Identity, Cross-Web Reputation, and Code-Backed Norms, 11 *Columbia Science & Technology Law Review*, 176, 199-200 (2010) (discussing Wikipedia's success in creating a code-of-conduct-based governance system); Molly Cohen and Arun Sundararajan, Self-Regulation and Innovation in the Peer-to-Peer Sharing Economy, 82 *University of Chicago Law Review: Dialogue*, 116, 129 (2015) (arguing peer-to-peer platforms have tremendous grassroots potential, and that the platforms themselves should be included in developing needed regulatory solutions to governance issues in the sharing economy); Kasey C. Tuttle, Embracing the Sharing Economy: The Mutual Benefits of Working Together to Regulate Short-Term Rentals, 79 *University of Pittsburgh Law Review*, 803 (2018) (arguing local governments should work together with peer-to-peer property sharing platforms, such as Airbnb, and home owners themselves to develop regulations to govern property sharing); Bryant Cannon and Hanna Chung, A Framework for Designing Co-Regulation Models Well-Adapted to Technology-Facilitated Sharing Economies, 31 *Santa Clara High Technology Law Journal*, 23, 55, 91 (2015) (using the example of California's Occupational Health and Safety Administration's collaboration with management and existing labor unions to develop a co-regulation strategy that could be applied to sharing economy regulation models).

core regulatory principles, it need not be going forward. We now have a much greater level of knowledge about the sharing economy as well as interdisciplinary tools for regulating it. Moving forward, it is incumbent upon policymakers to use the regulatory tools available to them in support of the optimization of a more just sharing economy.

PART II

Sharing in Context – Domains, Applications, and Effects

PART II-A

Ride Sharing, Mobility, and Lodging

PART II-B

Applications of Tomorrow

8

Understanding the Impact of Ridesharing Services on Traffic Congestion

Mehdi Behroozi

8.1 INTRODUCTION

The advance of GPS technologies and the swift adoption of smartphones has enabled the rapid growth of on-demand ride services. People, being connected to the network anywhere anytime, started to see the benefits of having on-demand access to a ride from multiple competing providers. It was a convenient system for all involved parties. Moreover, not adapting to the new network-based system meant missing out on benefits for the riders and losing the market share for the ride-hailing companies. As a result, as Figure 8.1 illustrates, even traditional street hailing services adopted e-hailing systems quite quickly. On-demand ride-hailing platforms, such as Uber and Lyft, have grown rapidly in the last decade in almost all countries; in some markets, they doubled the number of riders each year. It is fascinating to see a service that did not exist just ten years ago become so significant. It is now the fastest-growing transportation mode, has gained a larger market share than taxis in many cities, and has provided another transportation option and much more flexibility to passengers. It has altered the urban mobility landscape in a significant way. However, just like any other disruptive technology in its early years, it has brought some problems too. Municipal officials are concerned about congestion and pollution, drivers complain about their working terms (as evident in the forum [1]), taxi companies are enraged about unfair competition, and passengers are often agitated with sudden spikes in fares, all suggesting that this new experience is far from being stabilized.

One of the primary questions about ridesharing services is whether they decrease or increase traffic congestion (and relatedly carbon dioxide [CO_2] emissions). Traffic congestion is a serious and growing concern in modern life in metropolitan areas. The 2019 Urban Mobility Report of the Texas Transportation Institute [3] shows that the national congestion cost in the United States has risen from \$75 billion in 2000 to \$179 billion in 2017 (both in 2017 dollars), a whopping 139 percent increase in less than two decades that signifies the urgency of addressing this issue. Due to the rapid expansion of ridesharing services in urban areas in the last decade, the question of their impact on traffic congestion and carbon emissions has gained

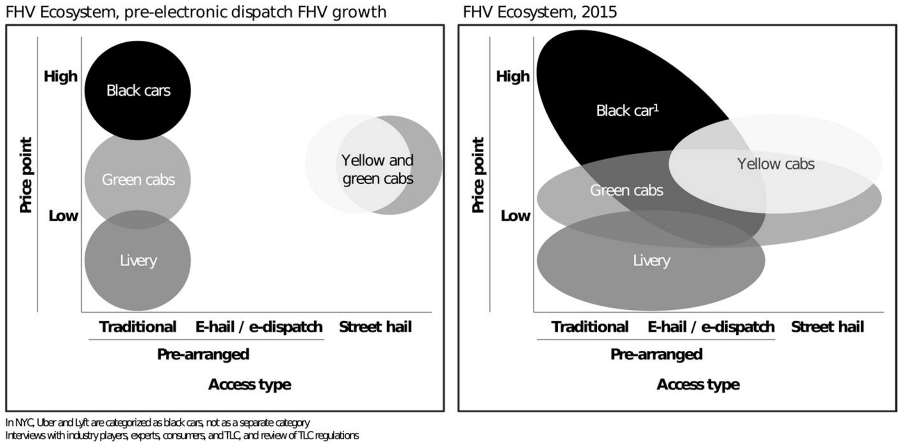

FIGURE 8.1 The figure shows the categories of for-hire vehicles (FHV) in New York City and the fact that they all adopted e-hail/e-dispatch systems by 2015 [2].

considerable interest among researchers and policymakers. Researchers are clearly split between advocates and critics of ridesharing services. On the one hand, these platform-enabled ride-hailing services may decrease traffic by increasing capacity utilization and reducing ownership/use of private cars. On the other hand, this type of ride-hailing may increase traffic congestion and pollution by replacing carpooling and nondriving modes such as mass transit, biking, and walking with separate and nonshared platform-initiated rides or motivating a new trip that would have not been made otherwise. These latter findings have surprised many observers since these services were expected to help mitigate traffic congestion.

This chapter reviews the literature and analyzes different perspectives on this debate,[1] describes key policy measures, and determines the future research opportunities that could help to settle this debate. The remainder of this chapter is organized as follows. Section 8.2 provides a historical overview of ridesharing services. Section 8.3 details the arguments on each side of the debate concerning ridesharing and traffic congestion. Section 8.4 reviews some policy measures for mitigating the negative impact of ridesharing services on congestion. Finally, Section 8.5 identifies the research gaps in this area for future research.

8.2 RIDESHARING – A HISTORICAL OVERVIEW

The idea of ridesharing (people sharing a trip in the same vehicle) is as old as the history of transportation and human traveling. Additionally, the negative externalities

[1] Note that other social impacts of ridesharing services such as their impact on equity (as surveyed in e.g., [5]) or accidents and cases of driving under the influence (as investigated in e.g., [6]) are not the focus of this chapter.

and challenges that appear to be associated with ridesharing services are similar to the negative externalities brought with any other disruptive technology throughout history. In the field of urban mobility, when the first hackney coach/carriage, the ancestor of modern days taxis [4], was introduced in London in 1605, everybody was excited and pleased with the service. However, the number of hackney coaches grew very fast, brought great nuisances to the streets of London, and raised fierce competition and bitterness between hackney coaches, wherries, barges, and sedan chairs (the popular urban transportation modes of that time) [4]. By 1635 Charles I, the king of England, issued a proclamation[2] banning and limiting the usage of hackney coaches in specific regions [7]. Hackney coaches had a bumpy road with many ups and downs until the 1660s, when finally the Hackney Carriages Act of 1662 recognized the hackney carriages as one of the modes of transportation and regulated their usage concerning fares, crawling, days and hours of operation, licensing, the permissible number of licensed coaches, and specifications of horses used [4]. The current questions and debates about ridesharing services and some of the policy responses are remarkably similar. As Mark Twain famously said: "History doesn't repeat itself, but it often rhymes."

By the end of the twentieth century, ridesharing became a necessary and inseparable part of modern life. Because of the rapid expansion of technologies and inventions in recent decades and the complexities of modern societies, current app-based ridesharing services are conglomerates of different features of older ridesharing services, each having a different history. It is useful to learn these histories to understand their impact on current transportation systems. The rest of this section briefly reviews the histories of dial-a-ride transit, carpooling, and carsharing as the predecessors of modern ridesharing options, and then it reviews the history of platform-based services.

8.2.1 *Dial-a-Ride Transit*

The paratransit system, commonly known as Dial-a-Ride, is a door-to-door or curb-to-curb transportation service for people with special needs, including seniors and people with disabilities, who cannot use the standard fixed-route transit systems. People can request this service for commuting to work or school, going to a hospital, visiting

[2] "That the great numbers of hackney coaches of late time seen and kept in London, Westminster, and their suburbs, and the general and promiscuous use of coaches there, were not only a great disturbance to his Majesty, his dearest consort the Queen, the nobility, and others of place and degree, in their passage through the streets, but the streets themselves were so pestered, and pavements so broken up, that the common passage is thereby hindered, and made dangerous; and the prices of hay and provender, &c. thereby made exceeding dear — Wherefore we expressly command and forbid, that no hackney or hired coaches be used or suffered in London, Westminster, or the suburbs thereof, except they be to travel at least three miles out of the same. And also that no person shall go in a coach in the said streets, except the owner if the coach shall constantly keep up four able horses for our service, when required."

FIGURE 8.2 World War II posters promoting carpooling for work commute.

a friend, or just shopping or doing groceries, typically trips constrained within a geographic zone. The establishment of the service in the United States dates back to 1970 when it started in Mansfield, Ohio in a collaboration project with Ford Motors. Two years later it was followed by a similar service in the United Kingdom in the town of Abingdon [8]. The service is technically an on-demand service, but in reality most often it must be prescheduled. There is a spectrum of services in different paratransit systems where on the one end the service could be an on-demand ride-sharing service that would go through a fixed route and on the other end, it could be a fully responsive transport system providing door-to-door service from any origin to any destination within a city or a specified service area. The vehicles are usually specialized cars, minivans, vans, or minibuses well-equipped to handle passengers with wheelchairs or other special needs. The passengers are pooled together to share a ride based on their origin–destination (OD) pairs and requested time intervals.[3]

8.2.2 *Carpooling*

The concept of carpooling (and vanpooling) goes back for decades and in the United States it became very common during World War II with efforts to save fuel for the war (see Figure 8.2). It again became popular during the oil crisis in the 1970s, due to the high cost of gasoline, before gradually declining in the years that followed [10, 11]. Carpooling can occur in three different ways: 1) *commute carpooling*, where people arrange their commute on a long-term basis and commit to mutually agreed and predetermined pick-up and drop-off locations and times; 2) *long-distance carpooling*, where drivers and riders match for a potentially one-time long-distance trip with advance scheduling and typically with an abundance of flexibility; and 3) *casual carpooling* (also known as "slugging") [12], where drivers and riders start a one-time relatively short rideshare trip on the spot similar to hailing a taxi on the street.[4]

[3] There is a rich body of literature on the scheduling and routing optimization of dial-a-ride trips that is beyond the scope of this chapter and the reader is referred to the survey paper [9].
[4] For more discussion on carpooling the reader is referred to the survey papers [9, 13, 14].

8.2.3 *Carsharing*

Carsharing typically refers to short-time car rentals, often for less than an hour, for a single trip within the city. The fleet usually is comprised of small electric/hybrid cars and is geographically distributed in different parts of the city. The members of a carsharing club can see the location of the closest car on a map in the car-share provider's mobile application. Depending on city regulations, sometimes they have specific parking places, and sometimes they can be parked at any free curb-side parking spot. Notable providers of this service in the last fifty years include Witkar, Communauto, ZipCar, FlexCar, City Car Club, and City CarShare. In recent years peer-to-peer carsharing is also becoming popular through services such as RelayRides and Getaround.[5]

8.2.4 *Application-Based Ridesharing Services*

It is difficult to pinpoint the first app-based or peer-to-peer ridesharing service. Neither Lyft nor Uber gets the credit, as many other platforms started offering ridesharing services ahead of them. These platforms include Craigslist Ride Board, CarPoolWorld, BlaBlaCar, GoLoco, PickupPal, Avego (currently Carma), ZimRide, Flinc, SideCar, and Tickengo (currently Wingz).

Among these platforms perhaps SideCar is the most notable. It was the first ridesharing service that started operation in San Francisco in 2011, and its purchase by General Motors in 2015 was very well-publicized [16, 17], bringing more attention to app-based ridesharing services. SideCar could also be credited as the inventor of platform-based, on-demand, short-distance, intracity ridesourcing, as Chief Executive Officer (CEO) Sunil Paul's 2002 patent suggests [18]. Another notable platform is ZimRide. ZimRide is a long-distance, intercity ridesharing service initially targeting college students and was founded in 2007 after one of its founders observed strangers to each other sharing a ride in Zimbabwe. ZimRide connected drivers and riders through Facebook to ensure security.

The currently dominant ridesharing services were born through these early experiences. Lyft was started as a side project within Zimride to provide intracity ride services and initially launched in San Francisco in May 2012. Since the market was extremely asymmetric in favor of Lyft, the founders offloaded the intercity carpooling section of the company and sold ZimRide to the car-rental giant Enterprise in 2013 to focus more on developing Lyft. Uber was founded in 2009 and officially launched its service in San Francisco in 2011 as a limousine or luxury black car service for more affluent customers. Later, in the summer of 2012, it developed into the ridesharing service as we know it now by launching Uber X, which allows individuals to be Uber drivers with their own cars. This was about the time of Didi's

[5] For a review on the literature of research on carsharing see [15].

TABLE 8.1 *Some of the non-United States platform-based ridesharing companies*

Company	Country of Origin	Operation Started in
BlaBlaCar	France	2006
Carma (formerly Avego)	Ireland	2007
Flinc	Germany	2010
Ola	India	2010
Gett	Israel	2010
Cabify	Spain	2011
Yandex	Russia	2011
Didi	China	2012
Grab	Singapore	2012
Careem	UAE	2012
Via	Israel	2012
Bolt (formerly Taxify)	Estonia	2013
Snapp	Iran	2014
Gojek	Indonesia	2015
FreeNow	Germany	2019

inception in China, which later became the second largest ridesharing service in the world, as Lyft and Uber also started to expand globally. Many other similar services were developed in other countries; see Table 8.1 for a short list.

Initially, neither Lyft nor Uber had a carpooling or ridesharing option leading many transportation experts to use the term "ridesourcing" for their service instead of any term that would include "pooling" or "sharing." It could be the case that the adoption of the term "ridesharing" by many of these platforms in the early years of their operation when they were essentially operating as de facto taxi companies, was to avoid regulations surrounding taxis. To finally remove the ambiguity, in 2013, a new category of mobility service was defined in the United States as transportation network companies (TNCs) to distinguish the operation of these services from taxis, chauffeured car services, and other for-hire vehicles [19].

Eventually, in 2014 Lyft Line and Uber Pool were introduced, where multiple passengers could "share" a ride [20]. Later in 2015 and 2016, new services such as Uber Commute, Uber Destinations, and Lyft Carpool were launched, where drivers were assumed to have a predetermined destination towards which they would pick up those passengers heading in that same direction. This was very similar to classical commuting carpooling and casual carpooling [21, 22, 23]. Uber also launched Uber HOP in 2015 [24, 25], which appears to have morphed into Uber Express Pool in late 2017 and early 2018 [26], in which riders have to walk to an efficient pickup location, in exchange for a cheaper fare, and share the ride with other passengers to drop off locations that are close to (but not exactly) their destinations. It was followed by a similar service by Lyft called Shared Saver in early 2019 [27].

It is important to keep in mind the above chronology of events in the development of ridesharing services when reviewing the literature in the next section, as some of the studies span a certain period of time.

8.3 IS RIDESHARING A SOLUTION OR A CONCERN?

Early studies about ridesharing platforms mostly promoted ridesharing services as having the potential to improve the overall efficiency of the transportation system by reducing the idle capacity of vehicles. Data from the National Household Transport Survey (NHTS) [28] show that during the period April 2016 to March 2017 about 94 percent of personal vehicles in Massachusetts were idle (parked) 94 percent of the time (see Figure 8.3). Platform-based ridesharing held the promise of using some portion of this idle capacity, thereby contributing to the overall economy. These early studies also proposed the idea that app-based ridesharing services may reduce road congestion and carbon emissions in metropolitan areas, primarily by increasing capacity utilization in each trip [29, 30]. These studies showed that a significant level of ridesharing adoption would have considerable benefits for reducing traffic and CO_2 emissions.

However, as the early fascination faded and people experienced the new system, some reports suggested that ridesharing services such as Uber may be actually contributing to congestion instead of decreasing it [31], while other reports were inconclusive [32]. These studies, and highly publicized challenges such as the feud between Uber and New York City [33, 34] and the lawsuits that Uber

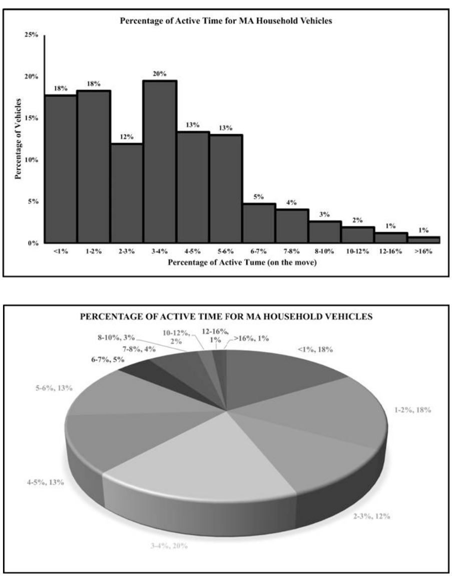

FIGURE 8.3 Distribution of active time percentage of personal vehicles in Massachusetts from April 2016 to March 2017.

faced in recent years which resulted in bans on Uber's operation in many cities and countries around the world [35, 36], initiated the idea of regulating the industry. Policymakers around the world considered a broad range of regulations, including a cap on the number of operating vehicles, a limit on the growth rate of these platforms in a city, a ceiling on surge pricing,[6] as well as zoning restrictions and congestion pricing. These almost contradictory studies, along with the regulatory efforts and legal challenges backed by municipal and governmental administrations and taxi companies around the world, sparked a debate on the true impact of ridesharing services on urban congestion and the necessity of further regulations and policies.

This section summarizes the arguments and research findings that either claim ridesharing services have helped mitigate congestion and pollution problems or suggest that instead they are contributing to these problems.

8.3.1 *Ridesharing as a Solution*

The main argument claiming a positive impact from ridesharing services is based upon the notion that modern ridesharing at its core is a way of carpooling or carsharing. Indeed, before the rise of app-based ridesharing services, the concepts of carpooling and ridesharing were almost synonymous. Thus, consistent with the generally positive understanding of the impact of carpooling[7] and carsharing,[8] it was expected that ridesharing services should also provide some savings in vehicle miles traveled (VMT),[9] CO_2 emissions, travel time, and travel/fuel cost.

[6] Surge pricing is a feature that the ridesharing platforms use to charge higher fares during busy periods.

[7] There is a body of literature studying the environmental and economic benefits of carpooling. For example, the paper [37] shows the economic benefits of carpooling such as reduced VMT, higher vehicle speed, and reduced fuel cost. Similarly, the paper [38] studies the impact of carpooling on reducing the negative environmental effects such as congestion and carbon emissions in Ireland in 2006 when only 4% of total morning peak commute were carpooling trips. They implemented a logistic regression model and concluded that the promotion of carpooling could lead to a significant reduction in CO_2 emissions.

[8] A similar generally positive body of literature exists for carsharing. For example, a 2011 study [39] conducts research on the question of whether carsharing reduces or adds to greenhouse gas emissions. Similar to ridesharing services, one could easily make an argument on both sides. The study demonstrates that carsharing services/clubs actually help to reduce the overall greenhouse gas emissions of their members. An earlier study [40] shows that the benefits of carsharing go beyond lowering VMT and reducing emissions. It reduces the need for private parking spaces, reduces car ownership, and reduces per capita gasoline consumption. Furthermore, it helps increasing non-driving modes such as mass transit, biking, and walking.

[9] Vehicle miles traveled (VMT) is one of the most common metrics for congestion. Throughout this chapter for measuring congestion, different metrics such as vehicle miles traveled (VMT), vehicle kilometers traveled (VKT), vehicle hours traveled (VHT), travel time index (TTI), commuter stress index (CSI), vehicle hours of delay (VHD), average travel delay, average vehicles speed, passenger miles traveled (PMT), and the ratio PMT/VMT, are mentioned.

Not surprisingly, early studies of what we now recognize as app-based ridesharing services were a natural progression from carpooling studies. Most such studies assumed a *dynamic* ridesharing system in which trips could be coordinated between people with similar itineraries and scheduled on *short notice* (a few hours to a few minutes in advance) or even in the course of the trip [41–45]. For example, Agatz et al. [43] propose an optimization approach for the problem of matching drivers and riders in *real-time*.[10] The appearance of the concept of dynamic ridesharing coincided with the rise of app-based services and created a new branch of research in the quest for designing more efficient transportation systems regarding different criteria including congestion.

Another classic body of research on platform-based ridesharing services is the well-known pickup and delivery problem (PDP). In PDP, a single vehicle, or a fleet of them, has to visit pickup locations to pick up goods or people and drop them off at delivery locations while minimizing the total distance or cost of all the routes. PDPs have many different varieties. The dial-a-ride transit service discussed earlier is a special example of this problem. Dynamic one-to-one multiple vehicle PDPs relate directly to ridesharing services. Here, the service is provided by a fleet of vehicles serving customers' requests that are initiated on a dynamic basis, originated at one location, and destined for another.[11] Most studies of PDPs focus on logistics and cost minimization rather than on congestion-related aspects. Among the relevant studies, Wang et al. [50] show that in the presence of congestion and high occupancy vehicle (HOV) lanes and existing policies of discounted toll rates on HOVs, taking detours to pick up additional passengers, that is, sharing the ride, and using HOV lanes can reduce the cost of a ride as well as the travel time (thereby reducing congestion and emissions).

The true shared services such as Uber Pool and Lyft Line were built upon this rich literature of PDPs. Uber's then CEO Travis Kalanick once described Uber Pool as a major evolution of Uber's business model:

> Two people taking a similar route are now taking one car instead of two. And when you chain enough of these rides together, you can imagine a perpetual trip — the driver picks up one customer, then picks up another, then drops one of them off, then picks up another. [51]

Because of this pooling and sharing of rides, initially, there was great hope and expectation for ridesharing services, as a revolution in urban mobility, to reduce congestion in addition to increasing consumer welfare. To analyze this, Li et al. [29, 30] conduct a difference-in-difference (DID) analysis[12] with travel time index

[10] See the tutorial [46] and survey papers [14, 47] for an overview on optimization models for dynamic ridesharing problems.

[11] For a review on this category of PDPs, see the papers [48, 49].

[12] DID is a statistical method that tries to measure the differential effect of an independent variable on a treatment group versus a control group by comparing the average change over time in the outcome variable of both groups.

(TTI),[13] commuter stress index (CSI),[14] and delay as primary dependent variables to measure the impact of Uber on congestion in 101 urban areas. They conclude that Uber's entry into these urban areas significantly reduced congestion. Hall et al. [52] also use a difference-in-difference analysis on a data set of transit ridership in U.S. metropolitan areas from 2004–2015 to show that Uber has had a complementary effect to public transit, suggesting a potential to reduce congestion, and that its effect on the increase in mass transit ridership grows over time. They also conclude that Uber's biggest complementary effect is on the public transit system that had the smallest ridership before Uber's entry. The article, while having a generally positive view on ridesharing services, does not directly study Uber's impact on congestion but raises a speculative concern that an increase in ridership might lead to increased traffic and suggests that it needs further investigation. Furthermore, a study [2], conducted by the Office of the Mayor of New York City, shows that most of the increase in app-initiated rides in New York City during 2014 and 2015 were substitutions for rides in yellow cabs and thus did not contribute to the observed increase in total VMT (or VHT) and congestion during that period. Similar to the study in New York City, a study using data from Boston [53] found that under moderate to high adoption rate scenarios, ridesharing is likely to result in a noticeable decline in urban traffic and congested travel times. These studies make the case for supporting policies that promote the use of ridesharing services to reduce congestion.

8.3.2 *Ridesharing as a Concern*

Despite the expected positive effects of ridesharing services on congestion, more recent studies have suggested that there might also be some rebound effects, that is, the reemergence of congestion in another form. These rebound effects include modal shift,[15] induced traffic,[16] deadheading,[17] encouraging car usage, and relocation of people further within metropolitan areas. While it is expected that ridesharing reduces the number of vehicles on the road, as well as total VMT and CO_2 emissions, it may also make people more accustomed to car usage and result in mode switching from public transit or other nondriving modes to cars in the short-term. In the long-term, ridesharing could cause people to relocate further away from metropolitan centers, thereby adding to congestion and pollution. It was mentioned in the last section that the New York City's report [2] exonerated the app-based

[13] The TTI is the ratio of the travel time during the peak period to the time required to make the same trip at free-flow speeds.

[14] The CSI is the same as the TTI but is based only on peak direction travel in each peak period.

[15] Modal shifts can increase congestion if passengers switch to ridesharing services from other modes of transportation such as public transit, biking, and walking that cause less traffic.

[16] Induced traffic happens when passengers of ridesharing services would not start the trip had they not have these services available.

[17] The term "deadheading" refers to the movement of a TNC car or taxi while searching for a customer.

ridesharing services from contributing to the observed increase in traffic congestion during 2014 and 2015. However, it warned against the potential of rapid growth in e-hailed rides in the future, leading to a decrease in public transportation trips, which in turn would increase total VMT (or VHT). A ride switched from a yellow cab to a ride-hailing service has a chance of being a shared ride; therefore, generally, this type of switch will decrease congestion and pollution. However, a switch from public transportation to ride-hailing would have a detrimental impact on congestion; the report suggests that a switch in less than 1 percent of public transit rides is enough to offset the congestion mitigation earned by an 11–13 percent switch in yellow cab trips.

The studies that suggest ridesharing services contribute to congestion usually focus on one or some of these rebound effects and try to analyze their offsetting or negating impact on the savings gained by shared rides. For example, Yin et al. [54] use an integrated land-use transport model to investigate the environmental impact of carpooling in the Paris region taking into account the impact of rebound effects. They conclude that under long-term scenarios for 2030 the rebound effects of ridesharing decisions will cut the expected CO_2 emission savings of carpooling substantially. For short-term scenarios, similar results are obtained by a study [31], which conducted an intercept survey[18] in three spots in downtown San Francisco during May and June of 2014 mostly concentrated on nighttime and social trips. Among the results are observations about induced travels and transportation mode substitution where passengers were asked if they would make the trip and how would they do it had they not used the ridesharing services. The survey shows that if ridesharing services were not available, about 8 percent of the respondents would not have made the trip. Among the rest, about 39 percent would have taken a taxi, 33 percent would have used public transit, 8 percent would have walked, 2 percent would have used a bike, 8 percent would have used their own car, and 1 percent would have shared a ride with a friend or family member. This means about half of the respondents would have either not taken the trip or would have used a nondriving mode for their trip. This is also confirmed by a recent longitudinal analysis[19] using monthly transit ridership data from twenty-two transit agencies and four modes of transportation (commuter rail, heavy rail, light rail, and motorbus) across major U.S. cities that shows that in fact, ridesharing services after entering a market draw passenger from heavy rail services by 1.3 percent per year and bus services by 1.7 percent per year [55].

Similarly, a survey of nearly 1,000 ride-hailing passengers in the Boston metropolitan area in late 2017 [56], conducted by Boston's Metropolitan Area Planning Council (MAPC), finds some concerning facts. It indicates that if ride-hailing services had not been available, approximately 42 percent of passengers would have

18 This is a surveying method used to collect top-of-mind feedback from an audience through on-site interviews.

19 This is a research design that involves repeated observations of the same variables over short or long periods of time.

taken a train or a bus for their trip, 12 percent would have walked or biked, 5 percent would not have made the trip at all, and the remaining 41 percent would have used a personal vehicle or taken a taxi. This means 59 percent of all ride-hailing trips in this survey were contributing to the total VMT and thus overall congestion. The 42 percent substitution from public transit trips is particularly alarming! A similar study [57] considers seven major U.S. cities from 2014 to 2016. The results show that if TNC services were not available, 49 percent to 61 percent of TNC trips either would not have been made at all or would have been made using a nondriving mode (transit, bike, walk). It also suggests that ridesharing services reduce the ridership from bus and light rail services but have a complementary effect on commuter rail services. Confirming these results, a 2018 study [58] shows that ridesharing services have added 2.6 new vehicle miles on the road for each mile of personal driving removed, a 160 percent increase in driving on city streets of nine large, densely populated metropolitan areas (New York, Los Angeles, Chicago, Boston, San Francisco, Miami, Philadelphia, Seattle, and Washington DC). In these cities, about 60 percent of users of ridesharing services would have taken public transportation, walked, biked, or not made the trip if these services had not been available, while 40 percent would have used their own car or a taxi. The study suggests that in most cases, the ridesharing services are targeting the same customer base as public transportation, just as the New York City warned in 2015.

There are also other studies that suggest an increase in congestion without delving into the reasons behind it. For example, a report [59] prepared by the London Assembly, names ridesharing services as one of the factors contributing to congestion in London. The report shows that there has been a 70 percent increase in the number of registered ridesharing vehicles between 2012 and 2017. In 2017, private hire vehicles, with a sharp increase since 2013, accounted for 38 percent of total car traffic volume in London's congestion charging zone; this is roughly double the proportion of taxis, which is a remarkable growth in less than five years for an already congested city. Likewise, Schaller [60] presents the results of a study on TNC ridership data in New York City from June 2013 to June 2016. Most notably, he shows the following: 1) the introduction of pool options such as Uber Pool and Lyft Line in TNCs helped ridership to grow faster than the number of licensed vehicles (i.e., higher utilization for TNC cars); 2) the net increase in ridership of hire vehicles due to the growth of TNCs in three years was 52 million passengers, 31 million trips, and 600 million miles; and 3) the net mileage increase due to the ridesharing services was 3.5 percent of the city's total VMT while this percentage of total VMT for Manhattan was more than two times larger. This is a significant increase in VMT in an already congested area.

A similar report about New York City, Shcaller [61] illustrates a 59 percent increase in hire vehicle hours in the central business district (CBD) between 2013 and 2017. The increase in weekday mileage of these vehicles in the CBD in the same period was lower at 36 percent due to slower vehicle speed – the overall traffic speeds declined by 15 percent. As passenger trips with taxis declined, the trips with ridesharing platforms increased but at a higher pace; the net increase in passenger trips with hire vehicles was 15 percent during this period. It is also notable that the unoccupied hire vehicle hours increased by 81 percent versus a 48 percent increase in occupied hours during these four years. Similarly a study of Denver, Colorado [62] surveys 416 rides of 311 passengers of Uber and Lyft and performs a before-and-after analysis.[20] Among the various results, it demonstrates that with the introduction of ridesharing services the ratio PMT/VMT has dropped from 112.3 percent to 60.8 percent and the overall VMT increased by 84.6 percent, both suggesting an increase in congestion.

More recently, a 2019 study [63] claims that TNCs are the biggest contributor to congestion in San Francisco. The study conducted a before-and-after analysis and was based on a data set scraped from the application interface of Uber and Lyft in 2016 and was combined with San Francisco's travel demand model, SF-CHAMP, to control for background factors that may also impact congestion. The study shows that the average speed decreased from 25.6 miles per hour (mph) in 2010 to 22.2 mph in 2016 and that the vehicle hours of delay (VHD) increased by 63 percent over the same period. A 2020 study in Santiago, Chile [64] uses a Monte Carlo simulation method and shows that ride-hailing services increase the total vehicle kilometers traveled (VKT) unless the average occupancy rate is significantly increased by actually sharing/pooling the rides.

All these studies were conducted while the ridesharing services were present in the regions of study. Among them, some relied on a before-and-after comparison to obtain a better understanding of their impact on congestion after they entered those regions. However, even such before-and-after analyses may not be adequately conclusive as the comparison is done over a long period, usually several years. A very recent study [65] takes an interesting and different approach, and yet suggests similar conclusions. It focuses on the city-wide strikes by drivers for these services as exogenous shocks in three major Indian cities (Mumbai, New Delhi, and Bangalore). It implements a regression analysis to study the impact of ride-hailing services on traffic congestion. It suggests the conclusion that congestion was reduced during these strikes as much as 40–53 percent of the reduction observed during a typical holiday. It also reports a public transport substitution effect suggesting that ride-hailing services were drawing passengers from mass transit.

8.3.3 *Analysis of the Discrepancies in the Results*

As has been demonstrated in the previous sections, the existing studies on the question of whether TNCs contribute to congestion have conflicting results. Because these studies are mostly empirical, statistical, or simulation-based, they naturally inherit some degree of uncertainty due to the methodologies. However, as the

[20] A type of statistical analysis focusing on the change in trends before and after a particular event.

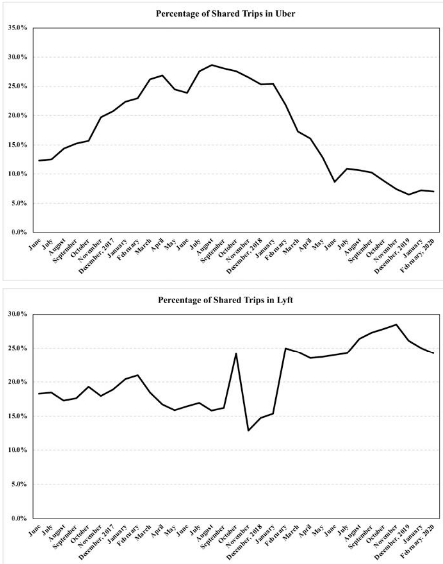

FIGURE 8.4 Percentage of shared trips in New York City for (a) Uber, and (b) Lyft.

remainder of this section discusses, several avoidable factors are contributing to the inconsistency of the results.

Missing Factors: The studies discussed earlier are not always comprehensive in terms of the factors they consider. For example, in Schaller's report [61], a fraction of the reported 15 percent net increase in passenger trips with hire vehicles could be associated with other factors such as population growth, replacement of personal car usage, and deadheading. Although it is clear from the metrics used in this report alongside those in his earlier report [60] that ridesharing services had contributed to the overall traffic volume in the CBD during 2013–2017, the magnitude of this contribution could be different if one would include those factors in the study. The New York City's report [2], on the other hand, accounts for the TNC rides that are replacements of the use of private vehicles, but this report also does not account for the population growth or deadheading. The exclusion of certain critical factors from these studies could be the source of some of the disparities between the results.

The Scale of Truly Shared Rides: Another factor that leads to inconsistent results is the misunderstanding of the true scale of sharing in different cities. An advocate of ridesharing services may argue that the studies that view ridesharing services as a source of congestion are not fully capturing the full effect of sharing rides, and if we properly account for all shared and pooled trips the conclusion might be different. However, according to a recently published data set [66], on average, only about 13 percent of Uber rides in New York City in 2019 were actually shared; the number for Lyft was 24.7 percent. Figure 8.4 shows the monthly percentage of shared trips in New York City for Uber and Lyft – as the two currently dominant ride-hailing companies there. The charts show that the maximum percentage has never exceeded 30 percent for either of them (28.6 percent for Uber and 28.5 percent for Lyft). They also show a divergence between the two service providers which could be due to their different ride options and pricing schemes. The fact that Uber's percentage is declining is a matter of concern as Uber had more than three times as many rides as Lyft in the same period. The weighted average of their combined percentages of shared trips in 2019 was just 15.7 percent of all trips. Misunderstanding the real scale of shared rides in the ridesharing services, which may lead to wrong assumptions, or missing to control for this factor can explain some of the inconsistencies between the results in different studies.

Adequacy of Data: Availability of data, the type of available data, and the sample size can have an enormous impact on the way these studies are conducted and on their results. For instance, the data used by Erhardt et al. [63] does not capture shared trips, and in any sequence of pickups and drop-offs, it only takes into account the first pickup and the last drop-off and none of the stops in between. Moreover, the first pickup location is not exactly the passenger's location but rather the point at which the driver accepts the new order. This is because the data were collected by a tracing system that would only track out-of-service TNC vehicles. The study's dependence on this data set may skew the results towards the conclusion that ridesharing services contribute to congestion, as it leaves the main congestion reducing force of these services, namely shared rides, out of the analysis.

Choice of Congestion Metric: It appears that the choice of the congestion metric has a big impact on the result of the study. For example, TTI and CSI are used by Li et al. in [29, 30]. Both TTI and CSI are very good at measuring commuting-related congestion but may not be accurate measures for the overall ridesharing-related congestion observed in a city as they are merely based on two snapshots of peak time and free-flow time. As another example, Clewlow et al. [57] mention that 49 percent to 61 percent of "trips" would have been either avoided or made by a nondriving mode such as walking, biking, or transit. However, it does not study the translation of this increase in the number of car-based trips into actual additional VMT or VHT, thus making it hard to realize the significance of this change.[21]

Availability of Services: Availability and the existing usage levels of public transit, carpooling, carsharing, and shared bikes in a city might have a considerable impact on the type of service that riders would receive from TNCs. For example, a high level of carpooling adoption in a city may shift TNC rides more towards nonshared ones. Consider two studies focusing on two cities, one with a high level and another with a low level of public transit and carpooling. Assuming that there are no modal shifts, the rides in the latter are expected to have a higher percentage of shared rides. This combined with a choice of congestion metric like the ratio PMT/VMT could

[21] This could also explain some of the discrepancies seen in the results of the above-mentioned studies. Therefore, everything else being the same, we may have a study suggesting an increase in congestion based on one metric and another study suggesting a decrease in congestion concerning another metric.

give us inconsistent conclusions on the congestion contribution of ridesharing services in these two studies. This would also lead us to the next attribute, that is, the spatial differences of these studies.

Spatial Differences: Most existing studies are limited locally while making conclusions globally. A local study may not give us the overall picture of the impact on traffic congestion in a country. Further and more comprehensive studies would be required to find out the global impact of ridesharing services on congestion. However, when making policies, as will be discussed more in the next section, it is generally better to rely on local studies with local conclusions. The results from a dense and populous city may not translate to a small town or vice versa, as both supply and demand sides of a ridesharing market in a large city are vastly different from that of a small city. The number of active ridesharing services in a city and the number and percentage of people using them can have a tremendous impact on the number of shared rides. Moreover, many other factors such as accessibility of public transit, demographics, and geography also play a role and force policymakers to rely mostly on local data and analyses. Therefore, the locational differences in cities that were the subject of the existing studies could help explain the difference in their results.

Temporal Differences: Similarly, collecting data or surveying trips at different times of the day or different days of the week may skew the analysis. For instance, the intercept survey used by Rayle at al. [31] is heavily weighted towards Downtown San Francisco's social hot spots, where parking for a personal vehicle is a big problem, and in the evening when public transit is less frequent and people are more inclined towards taking a TNC vehicle to avoid driving under the influence. Furthermore, the effect of TNCs on congestion could vastly differ from one year to another. Consider four studies that rely on data from the following periods (as some of the studies discussed above do): 2014,[22] 2014–2015, 2015–2016, and 2016. One should not expect consistent results from these four studies as the industry evolved dramatically during this period. For example, New York City's report [2] suggests that TNCs did not contribute to the observed increase in congestion in New York City during 2014 to 2015 but could contribute to congestion in a significant way in the future if they draw passengers from public transportation. One year later, Schaller [60] suggests that the net mileage increase due to the ridesharing services from 2013 to 2016 is 3.5 percent of the city's total VMT. The exponential growth of TNC services during 2015–2016 could explain these seemingly different results. When the underlying subject is doubling in size every year, it would not be surprising if these studies come to different conclusions.

8.4 POLICY MEASURES TO REDUCE CONGESTION

As mentioned in the previous section, the answer to the question of whether ridesharing services have a positive or negative impact on congestion depends on the

[22] Uber was forced in 2014 to release some of its data.

location and the time. If at the local level in a certain region and a certain period a negative impact is observed, it is necessary to devise policy measures for controlling or mitigating this impact. This section reviews some of these measures, focusing just on policy responses that can directly mitigate congestion caused by ridesharing services. Despite some overlaps, other sources of traffic congestion may require different measures.

Infrastructure Expansion: Adding more roads, tunnels, bridges, subway/bus lines, and bike lanes can provide a long-term solution for the congestion problems caused by ridesharing services, as can expansion of the city towards the outskirts. However, these options require an increase in taxation to finance infrastructure projects, which is not always politically popular. Also, in many cases cities may face geographic barriers for expansion, and even if the expansion is possible it may not resolve the congestion issue in downtown areas and business districts. This pushes the cities to rely on more short-term solutions such as designing restricted traffic zones and congestion pricing [67, 68].

Restricted Traffic Zones: Restricted/limited traffic zones (RTZs or LTZs) are areas within a city where entry to these zones requires permission and may be subject to a fee. Entry to such zones could also be limited to certain hours of the day or certain days of the week, or for certain types of vehicles or groups of people (such as residents, public workers, and disabled motorists). LTZs are very common in Italian cities such as Rome, Florence, and Milan. In many cases, LTZs are complemented with either pollution charges or congestion charges. Odd-Even Zones (OEZs) apply similar restrictions to odd or even license-plate numbers during the weekdays. Tehran and Beijing are notable examples of the implementation of this policy. Tehran is particularly interesting, as its use of this practice dates back to late 1979 and it implements concentric layers of OEZs and RTZs together [69].

Zero-emission Vehicles Zones and Pollution Charges: To promote electric and environmentally clean vehicles in congested urban areas, cities can design zero-emission zones (ZEZs) or low-emission zones (LEZs) in which only electric vehicles or ultra-low emission vehicles could travel. An alternative for cities with medium congestion or pollution levels is to impose a pollution charge in specific areas of the city on vehicles that fail to meet certain standards. This would reduce pollution as well as the traffic volume in such areas. Milan's Ecopass System [70] is a prime example of this policy.

Congestion Pricing: Congestion pricing is the practice of charging a flat or variable rate fee to vehicles that drive in a specified zone within a city to reduce traffic and pollution in that zone. There are multiple successful cases of this policy around the world. A report prepared by the Center for City Solutions [71] reviews the results of congestion pricing in Singapore, London, and Stockholm. With its Area Licensing Scheme (ALS) designed in 1973, and updated with an Electronic Road Pricing (ERP) system in 1998, Singapore is perhaps one of the leading cities in the world in designing a congestion pricing scheme to solve traffic issues caused by rapid economic development and geographic restrictions. Singapore's congestion pricing scheme resulted in a 24 percent decrease in inner city traffic, 6 mph increase in average vehicle speeds, 15 percent increase in public transit ridership, and 10–15 percent reduction in greenhouse gas emissions in the inner city. In London, congestion pricing resulted in a 9.9 percent reduction in traffic between 2000 and 2015 despite a 20 percent increase in population; it also added 30 percent to average vehicle speeds and 8.5 percent to the city's transportation revenue. In Stockholm, despite population growth, the traffic volume decreased by 22 percent, VMT declined by 16 percent and 5percent for the inner and outer city respectively, and the government had net earnings of $143 million per year. Milan's Area C program is another successful example of congestion pricing that within two months of implementation delivered a 36 percent decline in commercial and private traffic, a 50 percent decrease in accidents, an 11 percent increase in average vehicle speed, and a 24–45 percent cut in greenhouse gas emissions [72]. Despite the lack of a successful case in the United States, the concept of congestion pricing or zone pricing is not new to U.S. cities, as there have been multiple attempts to establish such systems in cities such as New York and San Francisco [73]. New York is set to be the first city in the United States to adopt a congestion pricing policy. In 2017, Governor Andrew Cuomo announced his plan to impose a fare on traffic in Manhattan's CBD (south of 60th street) to both reduce traffic and raise funding to fix New York City's failing public transit system [67]. A similar attempt in 2008 led by Mayor Michael Bloomberg to charge $8 on entries to the most congested parts of Manhattan failed to gain the support of other boroughs [74]. The new three-phase plan was finally approved by the state in 2019 [75] and the first two phases are already implemented, including $2–5 per trip surcharges for for-hire vehicles in the congestion zone. The third phase, which involves congestion pricing for all entries to the CBD, was scheduled to be implemented in January 2021. It is now scheduled for late 2023. If the initial estimates of entry fees – $11.52 for cars and $25.34 for trucks [76] – are implemented, it is expected that the annual revenue from the plan will exceed $1 billion, which could be spent for the revival of public transit infrastructure. The plan's third phase is pending approval from the Federal Highway Administration (FHA) [77]. However, it is unclear how much this program would reduce the congestion caused by TNCs in Manhattan, as about half of their trips in the CBD zone start and end within that zone [60].

Capping Number of Hire Vehicles and Limiting Zones of Operation: In some cities, limitations on the number of taxicabs and their operation areas are already in place. For example, in New York City, restrictions on the number of yellow and green (Boro) taxicabs and service zone limitations for green cabs have been in place for many years. Green cabs are only allowed to operate in upper Manhattan and the outer boroughs [78]. This helps cities in many ways, including by ensuring equity and access to reliable transportation in underserved areas of the city, facilitating fair competition and leveling playing fields, making the urban transportation sector economically sustainable while keeping fares affordable, and mitigating congestion in certain areas. Similar measures can be applied to ridesharing services by defining areas of operation for each TNC or putting a cap on the number of TNC vehicles in the entire city or certain areas within the city.

Learning from the Popularity of TNCs: It might be the easiest approach for policymakers to suppress TNCs with different measures or to impose outright bans on them to mitigate the congestion caused by them. However, policy choices ultimately boil down to satisfying customers' needs one way or another. As mentioned in the historical review section, water wherries would have had a better outcome if they had focused on improving their service rather than fighting with hackney coaches. This is why the National Association of City Transportation Officials recommends encouraging taxi companies to adopt new technologies for staying competitive [79]. Focusing on the reasons that made platform-based ridesharing services very popular and mimicking them in other ride services such as taxis, buses, and trains can immensely improve the quality of rides passengers receive from those services. These reasons include, but are not limited to, providing additional information to the rider on the app and thus reducing uncertainties, enhancing the convenience of paying fares, providing broader spatial and temporal access to TNC vehicles, charging attractive prices relative to the convenience of the trip, reducing wait times, increasing the convenience of leaving a review for the ride experience, and more generally satisfying a younger and more technology-friendly generation by providing a more technology-friendly experience. For example, the additional information provided by a TNC app, such as GPS data, origin–destination route, estimated time of arrival, and travel time, can significantly reduce the uncertainties of a trip. One could imagine the stress and anxiety associated with making an appointment and relying on public transportation without too much buffer time. City transit authorities can incorporate many of these features into other modes of transportation, making them more popular and efficient. This can particularly reduce the number of riders that switch from public transport (the least convenient experience) to TNCs (the most convenient experience), thereby mitigating congestion.

8.5 RESEARCH GAPS & FUTURE DIRECTIONS

A complete answer about the impact of ridesharing services on traffic congestion requires more comprehensive, multifaceted, multidisciplinary research. This section discusses some of the research gaps, opportunities, and directions for further investigation of this question.[23]

[23] Other research opportunities, such as the impact of cruising for parking, the role of autonomous vehicles in the future of ridesharing, the impact of the size of a city, e-commerce and its impact on congestion, and the utility of integrated mobility systems, are not directly tied to the policy measures discussed in the last section. However, they could help to settle the debate faster and also have the potential to introduce novel policy responses.

Traffic Zoning: One important research opportunity concerns the design of optimal RTZs, OEZs, ZEZs, and LEZs. For example, there is a lack of research on the use of geographic optimization methods to reduce congestion. Computational geometric approaches when combined with optimization methods could be very helpful to policymakers in designing such zones in a city and solving the related utility optimization problems. Geographic optimization methods can find the optimal boundaries of the zones and the optimal pricing for permit fees in each zone and can balance the traffic between the zones.[24]

Congestion Pricing: If New York City's congestion pricing plan goes into full implementation, it may soon be followed by San Francisco, Los Angeles, Chicago, and other big cities in the United States. This provides a research opportunity for helping especially urban policymakers to find the optimal entry fees and surcharges for ridesharing services as a mechanism to control traffic volumes generated by these services.[25]

Micromobility Services: One of the policy measures discussed in the last section was the expansion of transportation infrastructure, which includes bike lanes and shared bike terminals. This could be generalized to almost all micromobility services. City bikes and shared electric scooters can be efficient and green alternatives to private cars and ridesharing services, despite shortcomings such as the seasonal nature of these options. Their relatively low costs (in both initial investment and usage fare), high accessibility, and ease of use makes them strong competitors to the currently dominant modes of urban mobility. The significance of these services can also be seen in the rapid growth of micromobility companies such as Lime and Bird in the last three years and the recent focus of ridesharing companies such as Uber and Lyft on offering these services. However, many cities are not ready for this new trend: Public bike-sharing stations and the allocation and reallocation of bikes between the terminals are not well-optimized; many cities do not have an adequate number of dedicated lanes for bikes and scooters; and scooter businesses are not regulated. A comprehensive and interdisciplinary study of micromobility systems is necessary and urgent. This necessity and urgency can be seen by, for example, the big surprise and chaos that communities, city officials, and transportation authorities faced by the sudden emergence of electric scooters in the technology-friendly cities of San Francisco and Los Angeles [82, 83].

Elimination of Cruising for Parking: An aspect missing in current studies on the impact of ridesharing on congestion is the impact of cruising for parking by personal vehicles. As Shoup [84] suggests, on average and over the long term, approximately 30 percent of traffic is due to such cruising. If a TNC trip replaces a trip that would have been made by a personal vehicle, it not only replaces the personal vehicle mileage for the distance between the origin and destination of the trip but also

[24] See [80] for a review on application of these methods in geographic districting and zoning problems.

[25] For a review on previous practices in congestion pricing see [81].

removes the potential need to cruise for parking and its additional VMT (VHT). This could reduce congestion and thus warrants further study.

Self-driving/Autonomous Vehicles: It is notoriously difficult to achieve an equilibrium in a dynamically changing two-sided market and even harder to maintain it. Any such equilibrium state will be short-lived, as the supply (drivers) and demand (riders) are steadily changing. It will also be very sensitive to any change in the decision-making parameters such as ride fare, waiting time, and travel distance. Moreover, the whole system is also prone to short- and long-term exogenous events such as sports events, gas prices, local mass layoffs, and new regulations. Therefore, the platforms inevitably have to move towards reducing the uncertainty on the side they have more control over, which is the supply side. This leaves TNCs with three options: 1) using significant incentives to make the supply side more predictable; 2) hiring a fraction of drivers as employees with a predetermined working schedule, adding a layer of certainty to the supply side; or 3) deploying a fleet of self-driving/autonomous cars to constitute a fraction of the supply. The first option is currently being implemented with much difficulty and very little success for a variety of reasons including competition with other platforms that may provide better incentives or the unpredictability of human behavior when faced with incentives. The second option is unlikely to be followed, as the currently active ridesharing platforms such as Uber and Lyft have gone through many legal challenges to avoid the costs of treating their drivers as employees. However, the third option appears to be promising. A simulation model by Fagnant and Kockelman [85] shows that each shared autonomous vehicle can remove up to 11 conventional vehicles from the streets while adding only up to 10 percent to the VMT due to more deadheading. This could simultaneously make the planning easier for TNCs and mitigate the congestion issue for cities,[26] More studies are required to better understand the magnitude of its mitigating impact on congestion.

Large Cities versus Small Cities: Due to network effects and the large population in major cities, it is expected that a significant number of people use ridesharing services just because people in their social network use them and not necessarily out of a need. This could have an immense impact on congestion. Moreover, due to the large market size in big cities, competitor companies have more time to enter the market and gain a share after the first TNC's entry and to enjoy the network effect in their growth. Soon there will be several TNCs active in the city competing with each other in a race to the bottom by providing more and more incentives for the drivers. This may lead to an oversupply of drivers deadheading or offering very cheap fares to customers, thereby encouraging mode switches and causing induced traffic. Ultimately, these effects could contribute to congestion from both sides of

[26] This third option also matches the image of future urban mobility that TNCs are envisioning as one day, people would give up car ownership or using their cars for most urban mobility purposes and instead rely on their services. A fleet of autonomous vehicles moving around and providing ride services can make that vision a more likely scenario.

the market. In contrast, small cities are more likely to have a monopoly or something close to that as the first TNC can grab the entire market quickly after its entry, making it extremely hard for any competitor to enter that market or efficiently compete there. Any new competitor would have to reach a critical mass or a significant number of drivers and riders to remain operationally sustainable. A monopoly in the ridesharing market in small cities could lower the congestion by reaching equilibrium more efficiently and increasing the number of shared trips. A game-theoretic approach might be fruitful in analyzing these two different situations.

Impact of E-commerce on Traffic Congestion: A meaningful portion of the recent increase in congestion observed in metropolitan areas could be due to the massive increase in the movement of commercial trucks after the boom in e-commerce. It is worth investigating the impact of e-commerce on traffic congestion. It appears to have a sizable impact (maybe bigger than that of ridesharing) on congestion, especially during the COVID-19 pandemic as people tended to do most of their shopping online. There has been very little attention in the literature to control for this significant factor. Studying the congestion impact of ridesharing services and e-commerce activities together could be very valuable, leading to more accurate conclusions.

Integrated Urban Mobility Systems: It is notable that the complementary effect that ridesharing services have on public transit, by improving first and last mile access especially for the longer distance services such as commuter rail [86], has not gained much research attention. A similar statement can be made about the impact of ridesharing services on parking spaces. To prevent ridesharing services from taking public transit's market share, we may find interesting solutions in measures such as integration of ridesharing databases with that of public transit, putting a quota for each ridesharing company or a limit for all of them combined, data-driven and geographic-based pricing, and taxation of rides originating in the vicinity of transit routes excluding those trips to or from a transit station. An interdisciplinary approach to develop a framework, along with models and methodological tools for analyzing problems arising in this field, could be a powerful approach to tackling this and other similar research questions, leading to more effective policies.

Comprehensive Study: A negative externality such as congestion (pollution) is just a small piece of a big puzzle. Policymaking in this area requires a holistic view. No matter how harmful ridesharing might be in one aspect, such as congestion, it may have greater benefits for society in other aspects. For example, a collaborative study between Uber, the University of Oxford, and the University of Chicago [87] shows that in 2015 Uber X in San Francisco, Los Angeles, New York, and Chicago rendered a total of $2.9 billion in consumer surplus. More independent research is needed to understand the overall socioeconomic impact of ridesharing services better.

It would be ideal if future research could address the root causes of traffic congestion by designing comprehensive studies that control for more factors, ensure the adequacy of data, compare the most suitable (and possibly multiple) congestion metrics, and take into account the spatial and temporal differences.

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9

Increasing Shareability in Ride-Pooling Systems

Opportunities and Empirical Studies

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9.1 INTRODUCTION

The last few years have seen a tremendous growth of mobility companies, referred to as Transportation Network Companies (TNCs), such as Uber, Lyft, and Via, that have introduced a variety of on-demand services. TNCs have grown exponentially. It took Uber six years to reach its first billion rides but only six months to reach the next billion [1].

The popularity comes with concerns about the impact of these services on congestion and traffic conditions in general. In 2018, there were 42,201,375 TNC rides starting in the Boston municipality, with an average of 68.3 rides per habitant. According to the Massachusetts Department of Public Utilities (DPU), rides increased by 21 percent from 2017 [2]. The San Francisco County Transportation Authority (SFCTA) reports that TNCs were responsible for half of the increase in congestion in San Francisco from 2010 to 2016 (while employment and population growth contributed the other half). The report also finds that TNC trips account for an estimated 25 percent of the total congestion in the city and 36 percent of delays in the downtown area. On a typical day, they add 170,000 vehicle trips and more than 570,000 vehicle miles traveled (VMT) (20 percent of all local daily VMT). TNCs contribute to congestion at all times of the day, especially in the evenings [3, 4]. Furthermore, in general, the fraction of rides that are actually shared is small, meaning that TNC services are operating, in principle, as taxi services with a ride arranged through apps. This actually adds extra mileage rather than reducing traffic, considering the mileage driving to pick up passengers. Schaller [1] reported that the non-shared ride TNC services (UberX, Lyft) put 2.8 new vehicle miles on the road for each mile of personal driving removed, for an overall 180 percent increase. The increased congestion brings other negative externalities as well, for example, reduced safety. According to a study [5], the rise of TNC services has increased traffic deaths by 2–3 percent in the United States since 2011, equivalent to as many as 1,100 fatalities a year.

TNC services also compete with sustainable modes of travel such as public transport, walking, and biking, while they are, in general, less competitive with personal automobiles. The main factors impacting mode-choice, such as price, speed, convenience, and comfort, result in shifting passengers to TNCs from public transport and nonmotorized modes rather than cars. Many surveys show that if TNC services were to disappear, about 60 percent of current TNC users would switch to public transport, walking, and biking (or not make the trip), about 20 percent would use their own car, and 20 percent would use a taxi [1]. Many traditional public transport services have been recently experiencing a reduction in ridership, especially buses. This decline is partially attributed to direct competition from TNCs [6]. The Chicago Transit Authority (CTA), for example, is reporting that the decline in ridership is partly caused by competition from TNCs, like Uber and Lyft. Equally alarming is the decline in student ridership. The Metropolitan Transportation Authority (MTA) in New York reported a 12.7 percent decline in student ridership in buses in 2018 [7].

Despite their popularity and large market, on-demand mobility services are far from profitable. Uber reported an operating loss of $8.5 billion in 2019 after losing more than $3 billion the previous year [8]. This lack of profitability seems to be a characteristic of the on-demand mobility service industry. Currie and Fournier [9] compiled a database of 120 systems, including traditional dial-a-ride, demand-responsive transit (DRT), and Microtransit, from nineteen countries since the 1970s. They found that most of the systems eventually failed (for example, 67 percent in the United Kingdom), and 40 percent lasted fewer than three years. High operating costs are the main contributor to their failure. The use of new technologies, such as apps and the mobile internet that enabled the recent developments, has not helped, with profitability, at least not yet. Results also show that services with simpler operations (for example, "many-to-few" systems, where trips may have many [any] origin locations but all go to one or very few destinations and vice-versa providing economies of scale) have lower failure rates, compared to the complex all-to-all services (where requests can have any origin location and can go to any destination location). Enoch et al. [10] also concluded that systems are often not properly designed and there is a tendency to offer too much flexibility, which increases costs.

Ride-pooling is a strategy that can address all of these concerns, regarding societal impacts (on congestion, traffic, and competition with public transport) and TNC profitability (operating costs and overall efficiency). Using taxi-trip data from New York City, for example, Santi et al. [11] concluded that even if trips are shared by only two passengers, a significant reduction in total VMT can be achieved in dense metropolitan areas, such as Manhattan. Alonso-Mora et al. [12] showed that, if all trips are shared, 25 percent of active taxis in NYC can satisfy 98 percent of the ride requests with an average waiting time of 2.8 minutes and mean trip delay of 3.5 minutes. This represents a significant reduction in required fleet size and hence, improvement in efficiency.

Because of the potential of ride-pooling to improve operating efficiency and, at the same time, reduce the impact of TNCs on congestion, experts have begun developing approaches to increase the number of shared trips. These approaches include alternative operating models on one hand, and long-term strategic partnerships with other service providers, such as public transport operators, on the other, which can result in simpler operations and economies of scale [10].

This chapter discusses opportunities for on-demand mobility services to improve sharing performance as a means to improve not only operating efficiency but also environmental sustainability. It explores, empirically through a large TNC dataset, the potential of these approaches to reduce on-demand mobility impacts, especially from a sustainability point of view using metrics such as VMT (a good surrogate of congestion and environmental impacts). It examines the impact of various factors (such as the fraction of requests known in advance, the percentage of shared requests, and the level of service expectations). It also reports on the experience with field tests and other experiments of coordinated public transport/TNC services and highlights lessons learned.

9.2 BACKGROUND AND DEFINITIONS

The concept of on-demand transportation services is not new. The first experiments were carried out in Atlantic City, New Jersey, in 1916 and some form of on-demand, shared-taxicab services have existed in US communities since at least the 1930s. By 1974 there were approximately twenty systems operating in North America, often referred to as dial-a-ride, demand-responsive, and paratransit systems [13] used to complement regular transit services. Dial-a-ride was introduced as a form of shared transport where passengers make reservations (typically a day in advance). Requests are organized in itineraries satisfying a certain level of service constraints (for example, maximum wait time from desired departure time). Vehicles do not have a fixed route or timetable. Systematic research into dial-a-ride started in the 1960s by researchers at the General Motors Research Laboratories, Massachusetts Institute of Technology (MIT), and Northwestern University. The federally funded project Computer-Aided Routing System (CARS) at MIT focused on all (operating) aspects of dial-a-ride from all points of view, including the development of computerized algorithms for optimal routing and scheduling [14]. Wilson et al. [15] were among the first to explore the potential of computers to plan and control dial-a-ride systems. Their efforts resulted in algorithms to assign requests to the most appropriate vehicles. They also investigated the problem of integrated dial-a-ride and fixed route public transport services and coordinated dial-a-ride systems. They aimed to design effective hybrid systems, in which dial-a-ride serves low volume and short trips, fixed-route public transport serves high volume trips, and a coordinated fixed-route/dial-a-ride system serves long but low-volume trips [15]. Today dial-a-ride, referred to as paratransit or demand responsive, services are mainly offered by public transport agencies in order to comply with the 1990 Americans with Disabilities Act (ADA). Qualified individuals can make reservations through a centralized system to use the service to access medical facilities as well as locations of other activities.

Today's mobility on-demand services (for example, Uber, Lyft, Via) are fundamentally app-based dial-a-ride services with centralized dispatching and flexible driver arrangements [9], with most of the requests placed in real-time. These new services appear under various names; however, the terminology used to define them is often inconsistent. For this discussion, we mainly use the terminology introduced by the Society of Automotive Engineers, SAE [16] as summarized by:

1. *Shared mobility* refers to the shared use of a vehicle, scooter, bicycle, or other travel modes. Users have short-term access to the travel mode on an as-needed basis [17, 18]
2. *TNC services* (also called *ridesourcing* or *ridehailing* services) are prearranged or on-demand transportation services for compensation, in which drivers and passengers connect via digital apps that support booking, electronic payment, and ratings of the services.
3. *Ridesharing* is the formal or informal sharing of rides between drivers and passengers with similar origin-destination pairs. Ridesharing may include carpooling and vanpooling, where several passengers share the cost of using a vehicle, and in some cases, driving responsibility.
4. *Ride-pooling*, also known as *shared TNC* services that are organized on-demand, enables people to share a vehicle ride with others. UberPool, UberExpressPool, and Lyft Line are examples of ride-pooling services [19].
5. *Microtransit* is a privately or publicly operated, technology-enabled public transport service, that typically uses vans to provide on-demand or fixed-schedule services with either dynamic or fixed routing.
6. *Demand-responsive transit* (DRT), also known as *demand responsive transport*, *flexible transport*, or *Dial-a-Ride Transit* (DART), is a form of public transport where vehicles can alter their routes based on demand rather than using a fixed route or timetable [20].

9.3 INCREASING SHAREABILITY

Recognizing the need for and potential of ride-pooling, TNCs are adjusting their technology and operating models to deliver more shared rides. They increasingly focus on ways to promote ride-pooling, with services such as UberPool, UberExpress, and Lyftline, offered at reduced prices. In the first two months of LyftLine's service in San Francisco, one-third of all Lyft rides were LyftLines [21]. Lyft recently redesigned its app and is developing strategies to improve ride pooling [22]. New operational models to increase ride-pooling opportunities have also been proposed in the literature, such as meeting points at origins and destinations [23] and transfer points to switch vehicles [24].

Studies in the literature also show that coordination and integration of TNC operations and regular public transport services [25–28] has the potential to be beneficial to both parties involved. For example, Fan and Zhang [28] concluded that there are financial benefits in the integrated operation of public transport and shared mobility services in Santa Clara, through increased economies of scale. As a result, not only does TNC operating efficiency improve, but also there is a positive impact on the demand for public transport. There is strong evidence that public transport agencies and TNCs are interested in exploring the coordination between public transport and TNCs. Uber and Lyft have recently added public transport directions and fares to their apps [29, 30]. In Denver, riders can purchase public transport tickets via the Uber app [31]. Google has plans to show in Google map the multimodal trip options that combine public transport and TNCs [32]. The service already provides directions to walk or drive to public transport. By adding on-demand services, the app can also support the option of using a ride to a public transport station. At the same time, various public transport agencies, such as the Greater Richmond Transit Company, are pursuing an integrated design of public transport and TNC services that can be mutually beneficial [33].

Although TNCs have been heavily investing in improving and promoting their shared services, such as UberPool, ExpressPool, and LyftLine, the majority of trips are actually singly served. For example, Uber reported that only 20 percent of Uber trips are shared/pooled trips in the major cities where UberPool service is provided. Lyft estimates that 37 percent of the users in cities with a LyftLine option request a LyftLine trip, but the actual rides being shared is substantially lower (22 percent in New York City in February 2018) [1]. Even in a shared ride, some portion of the trip may involve just one passenger (for example, between the first and second pick-up).

Several studies explore the factors impacting the potential for shared trips using real-world data. Tachet et al. [34] present a simple index that measures the potential for ride-pooling as a function of trip generation rates, the amount of trip delay time that is acceptable to passengers, average traffic speed, and city size. They show that various metropolitan areas (New York, San Francisco, Singapore, and Vienna) exhibit similar behavior in terms of shareability potential, indicating that the same operating strategies to increase shared rides could work in different metropolitan areas.

In general, the factors impacting the ability of ride-pooling services to attract and match ride pooling requests are both demand and supply related. Demand-related factors include customers' willingness to share (demand for ride-pooling) and level of service (LOS) expectations (extra ride time, waiting for a vehicle, etc.). They also include spatiotemporal distribution of requests, which determines the opportunity to match ride pooling requests. Supply-related factors include market fragmentation (various mobility service providers operating independently), which impacts the sharing of information and service resources (leading to inability to match requests across TNCs). They also include operating strategies and partnerships to facilitate ride-pooling and take advantage of the available opportunities for pooling requests to the full extent (request matching, vehicle dispatching and rebalancing, etc.). The remainder of this section reviews these factors.

9.3.1 *Customer Willingness to Share and LOS Expectations*

Passenger willingness to share and tolerance for increased waiting and trip detour times (additional time due to sharing a trip compared to a direct trip) affect ride-pooling opportunities [11, 12, 34–35]. While several existing studies explore the factors affecting the adoption of TNC services and the frequency of use [36–39], studies on the types of TNC services customers use and the factors impacting these choices are rather limited. In a recent TNC survey [40], respondents were asked about their TNC use frequency, the characteristics of their most recent TNC trip, and their willingness to share rides with others, wait for service, walk to a pick-up/drop-off location, and place requests in advance. The results show that 54 percent of the respondents prefer using the pool/shared services (for example, UberPool, LyftLine). Of the responders, 83 percent indicated that they would choose to walk to/from a pick-up/drop-off location for a discount, with 57 percent willing to walk more than 5 minutes. Furthermore, 75 percent of the respondents would also place requests in advance (at least 15 minutes ahead of their desired departure time). Users with higher income, age, and bike and car ownership tend to use TNC services less frequently. They also use pool services less. Lower-income, age, and no bike/car ownership groups, as well as groups with membership in sharing services (car/bike sharing), use TNCs more and also preferred pool services more than other groups [40].

9.3.2 *Spatiotemporal Distribution of Requests*

Current ride-pooling systems aim at pooling passengers with similar origin-destinations (OD) and departure times. In addition to the complexities of assigning a vehicle to several requests and designing a route plan that serves them most efficiently, pooling of trips with similar OD pairs and time frames, at its core, suffers from the spatiotemporal sparseness of real-time requests that could actually be matched [1]. The spatiotemporal distribution of requests for shared rides and their destinations determines the potential that two or more requests could be matched and served efficiently by a single vehicle, given their pickup/drop-off time windows and locations. Requests with similar paths and time windows can be assigned to the same vehicle. Trip origins and destinations are generally spread over numerous OD pairs which makes it difficult to find passengers who have compatible OD pairs. Moreover, potential ride-pooling passengers should also have compatible departure times. The likelihood of finding passengers who are willing to take a shared ride and are heading in the same direction at the same time is rather low and has hindered the effectiveness of real-time ride-pooling. To increase the likelihood of shared rides, the radius of matching passenger origins or destinations could be increased, or the time window of the departure time could be more flexible. In such cases the scheduling of the trips has to be sensitive to the level of service, as passengers may experience longer travel and waiting times. If the level of service deteriorates this may discourage passengers from choosing a shared ride in the future and hence, reduces the demand for shared services.

9.3.3 *Market Fragmentation*

Market fragmentation refers to multiple service providers/platforms, typically operating independently (except for some drivers working for multiple platforms). Multiple platforms fragment demand and myopically optimize their systems to serve their own customers. This may potentially result in a higher cost to society (pollution, fuel consumption, congestion), customers (fare, time), and their own services (fleet, crew). Séjourné et al. [41] analyzed the impact of competition among on-demand mobility companies on operating costs. Their analysis sheds light into the benefits of aggregating pickup and drop-off locations, increasing the flexibility of pickup times, and allowing drivers work on multiple platforms (also known as multihoming). Pandey et al. [42], using New York City taxicab data, conclude that competition among service providers degrades the level of service compared to a centralized model. Integrating all service providers is clearly not practical. However, mechanisms such as multihoming partially mitigate the efficiency loss and increase shared trips. Multihoming has the potential to provide a more flexible supply of labor, which not only increases ride pooling opportunities but also reduces costs, for example, by minimizing the need for rebalancing [43].

9.3.4 *Operating Strategies and Partnerships*

Various studies have proposed and evaluated novel service models for the purpose of facilitating trip matching in order to increase its likelihood. These strategies have the potential to provide more opportunities to share rides by seeking broader consolidation opportunities (in terms of space and time) to efficiently group travelers, while maintaining a high level of service. Several examples follow.

Advanced requests [44]. In this scenario, requests are placed ahead of time with desired pickup and drop-off time windows. In general, the service can accommodate passengers with different advanced request intervals and different price sensitivities. Advanced requests are expected to increase the likelihood of sharing trips while reducing operating costs for TNCs. Pricing the service accordingly can be the means of incentivizing passengers to make requests in advance. Uber recently added a similar function to incentivize travelers to depart later than their desired departure times. For example, users can get a $1 Uber cash back if they are willing to depart in ten minutes and $2 if they depart within twenty minutes.

Dynamic waiting [45]. In this scenario, requests are placed in real-time with desired pick-up times. As with advanced bookings, requests wait to be matched to a driver for a period of time (waiting time window). The waiting window is dynamic, depending on market conditions. For example, it increases when the supply of vehicles is constrained. The waiting window is used to increase the opportunities to pool together requests whose origin and destination locations are close to each other (within walkable distance).

Meeting points [23]. In this scenario, requests are placed in real-time with desired pick-up times. Passengers walk to pick up locations and share a ride with other passengers. After alighting, passengers may have to walk from the drop-off spot to their destination. The meeting points are determined dynamically, given the request location and expected LOS of passengers already on-board.

Intermediate transfer points [46, 47]. In this scenario, requests are placed in real-time with desired pick-up times. Users that are picked up may change vehicles during their trip. A transfer can occur at pre-specified locations in a static manner or can happen dynamically based on how trips are pooled together. Transfers increase the opportunity of matching rides as users from different origins can be pooled together at the transfer locations to a common destination.

Partnerships with other service providers [48, 49]. In this scenario, on-demand TNCs and public transport agencies work in partnership. For example, hybrid on-demand and public transport services allow passengers to place requests with desired pickup times and origin/destination information. Passengers can be picked up at their origins by on-demand services and dropped off at an "optimal" public transport station. Alternatively, they can take a bus or metro, and then either walk or take another TNC to their destinations, or they can be directly served (door-to-door) by TNC services.

9.4 ASSESSING OPPORTUNITIES

Successful outcomes with respect to increasing shared trips probably require a combination of approaches. We focus the discussion on two promising strategies for their potential to improve shared trips and reduce impacts such as VMT: a) advanced requests and b) partnerships with public transport agencies.

The advanced requests strategy is representative of the first three operating strategies discussed earlier. It relies solely on the TNCs to adopt alternative operating models by adding options to their services. Advanced requests can be viewed as a more formal way to extend some of the current offerings, for example, dynamic waiting. Therefore, from an implementation point of view, it represents incremental changes that are more likely to be adopted by companies and users. By contrast, strategies such as meeting points and intermediate transfer points may require significant changes to the digital infrastructure and deviate quite substantially from the core operating models currently deployed.

The second strategy we focus on, partnerships, is quite different from pure operating strategies, as it requires collaboration between TNCs and traditional public transport agencies. It represents an opportunity to take advantage of natural synergies that exist between TNCs and public transport services and has the potential to benefit both stakeholders. Public transport and TNCs both offer shared rides but with different degrees of flexibility. Partnerships between the two help address the weakness of one through the strength of the other.

9.4.1 *An Empirical Evaluation of Advanced Requests*

Given the on-demand nature of most requests, from a scheduling point of view, the short time between the placing of a request and the initiation of the service limits the ability of customer matching and vehicle scheduling algorithms to take full advantage of the shareability opportunities. A number of studies point out this inefficiency of the on-demand nature of TNC services. Alonso-Mora et al. [35] show that predicting future demand accurately could improve the efficiency of TNC operations. Using TNC ride data from three US cities (San Francisco, New York, and Los Angeles), Chen et al. [50] reported that ride-pooling with approximated future requests can yield significant benefits by reducing total fuel consumption (by 15 percent) and fleet size (by 30 percent). Various surveys indicate that TNC users report optimal waiting times for their ride to be five–eight minutes. In one study [40], it is reported that 68 percent of the TNC users in the survey actually waited more than four minutes for their service to arrive. Even more importantly, 75 percent of the users are willing to place requests more than fifteen minutes in advance, in return for a fare discount.

Given the inefficiency introduced by real-time requests and also the expressed willingness of users to place requests in advance, at the right fare, we examine in detail the potential of an advanced requests operating model for TNCs. Advance knowledge of future requests gives TNCs more flexibility to schedule trips and identify opportunities to match requests. We evaluate the performance of an advanced requests system relative to current practices using a large-scale dataset from the operations of a major on-demand ride-hailing company in China. In addition to the overall potential of such a strategy in reducing VMT (directly related to energy consumption and emissions) and operating efficiently, the impact of various design aspects of the advanced requests system (for example, advanced requests horizon, vehicle capacity) on its cost and performance is also of interest, as well as the sensitivity of the results to user preferences in terms of level of service (time to be served and excess trip time) and willingness to share.

The advanced requests system that we examine follows the one proposed by Ma et al. [44]. Requests are placed ahead of time with desired pick-up time windows. Let H be the advanced reservation horizon (how far ahead requests for service should be placed). Scheduling decisions are made every Δt seconds (decision epoch), with $\Delta t \leq H$. That means every Δt seconds, utilizing all available information on advanced requests and vehicle status, all requests are processed. At each decision epoch, all advanced requests within the advanced reservation horizon H are known. The decisions respect requests that have already been assigned to trips and, either assign pending requests to an existing trip, or start new trips.

TABLE 9.1 *Experimental design parameters.*

Dimension	Parameter	Settings
Operating model	Advanced requests horizon	$H \in \{0, 5, 15, 30\}$ minutes
	Decision epoch	$\Delta t \in \{30, 60, 120\}$ seconds
	Vehicle capacity	{2, 4, 7, 10} passengers per vehicle
User preferences	Willingness to share	% of customers requesting shared service ∈ {0, 25, 50, 75, 100}
	LOS	Strict users <=2 min, =5-min>
		Neutral users <=5 min, =10 min>
		Flexible users <=7 min, =15 min>
	User groups	All customers are strict
		All customers are neutral
		All customers are flexible
		Mixed <20% strict, 60% neutral, 20% flexible>
Traffic conditions	Travel time	Traffic conditions ∈ {low congestion, normal congestion, heavy congestion}

The above model is quite general and can represent alternative operating models. For example, for $H = 0$ the model represents existing, on-demand, ride-pooling services, where passengers make requests expecting immediate service. Existing on-demand ride-pooling services are reactive with requests collected during a short time window, for example, thirty seconds, after which they are assigned to different vehicles and the service stops (pickup and drop-off locations) are scheduled accordingly.

We analyze performance metrics with respect to mobility (VMT) and level of service (LOS) that passengers experience (waiting time and trip delay time). We consider different operating characteristics of the ride-pooling service in terms of the advanced requests horizon and the decision epoch. We also consider different user preferences and traffic conditions. The overall experimental design is summarized in Table 9.1.

A large-scale on-demand trip request data set from Chengdu, China from November 01–30, 2016, provided by DiDi Chuxing, a TNC in China, is used in the analysis. To assess the impact of various factors on the performance of ride pooling services, we use requests with pickups and drop-offs within the third ring of the city (20 km × 20 km area, covering 85 percent of all requests). For each trip, the dataset contains a request ID, vehicle ID, and the time of the request and pickup and drop-off locations (approximately 7 million trips). Figure 9.1 shows the heatmap of the distribution of pickups and drop-offs for a morning period (7.30–8:.0 a.m.). The pick-up and drop-off locations are scattered throughout the network, with drop-offs relatively more concentrated in the city center.

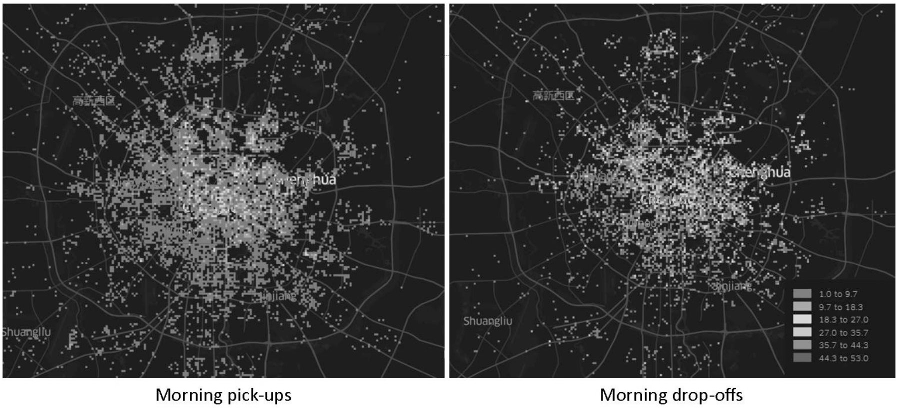

FIGURE 9.1 Distribution of TNC pickups and drop-offs for a morning peak period 7.30–8.30 a.m.

We evaluate the performance of the system for all possible combinations of the above experimental design resulting in 2,880 cases. Requests are scheduled with the objective of minimizing vehicle miles traveled (VMT). The scenario with advanced requests horizon $H = 0$ and decision epoch $\Delta t = 30$ sec represents (as close as possible) current operations of various TNC services (for example, Uber, Lyft). For the model with advanced requests, the vehicle schedule is optimized every decision epoch, for example, thirty seconds, given vehicle states and real-time and advanced requests within the time horizon, for example, fifteen minutes. The scheduled requests are kept in the request pool until picked up and can be reassigned if a better schedule is found before pickup. The base case is the scenario where all requests are for single trips. If all requests are for single trips, 30,000 kilometers are required to serve all requests (7,500), for the period 7.30–8.30 a.m.

Figure 9.2 shows the impact on VMT of passengers' willingness to share, for different user types and advanced request horizons. As expected, VMT decreases with the increase of the percentage of passengers willing to share trips. Compared to the base case, VMT is reduced by 14 percent, 25 percent, and 35 percent, when the sharing percentages are 50 percent, 75 percent and 100 percent respectively, for services with an advanced request horizon of fifteen minutes, vehicle capacity of four, and normal traffic conditions. Interestingly, no significant difference is found for the VMT to serve neutral, flexible, and mixed users (given the same settings on other variables in Table 9.1), while it consistently requires more VMT to serve strict users than the other user types. This suggests that, from the perspective of users' preferences, most of the VMT reductions could be achieved if passengers are willing to wait for five minutes maximum or can tolerate a trip delay of ten minutes maximum.

Operating models with advanced requests perform better than operating models with no advanced requests (advanced request horizon 0) from a VMT standpoint without deteriorating the level of service. Advanced requests facilitate a better

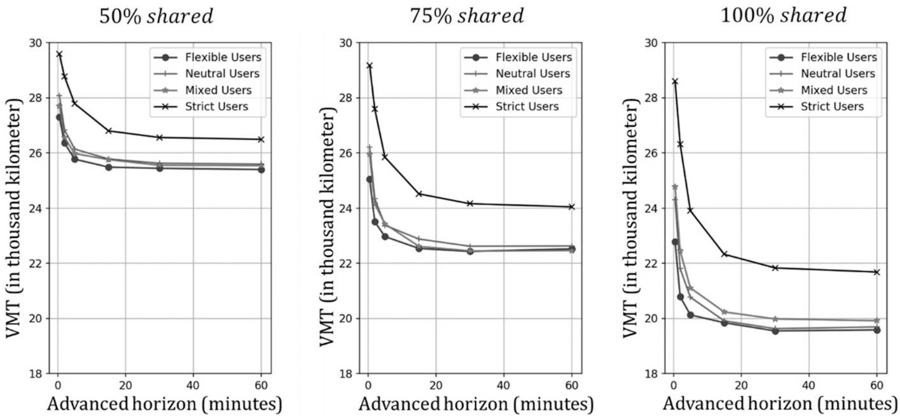

FIGURE 9.2 Impact on VMT of willingness to share (vehicle capacity four, normal traffic).

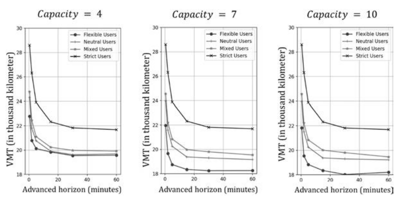

FIGURE 9.3 Impact on VMT of vehicle capacity (all shared, normal traffic).

matching of requests to vehicles as more information is available for decision making. For example, the operating model with an advanced requests horizon of fifteen minutes reduces the base case VMT (all requests are for single trips) by 35 percent, while the current practice model (with no advanced requests) saves 19 percent of the base case VMT if all requests are for shared trips. It is also interesting to note that even a short advanced requests horizon (for example, five to fifteen minutes) provides most of the benefits in terms of VMT reduction.

Figure 9.3 shows the impact on VMT of vehicle capacity for different user types and advanced request horizons. Higher capacity vehicles increase the sharing opportunities as more users can be assigned to the same vehicle and thus decrease the total VMT to serve all the requests. However, there are diminishing returns when the capacity exceeds seven. For example, if all passengers are willing to share, the operating model with advanced requests horizon fifteen minutes saves 35 percent, 40 percent, and 40 percent of the base case VMT for vehicle capacity of four, seven, and ten, respectively. The operating model with no advanced requests reduces the base case VMT by 19 percent, 23 percent, and 24 percent for vehicle capacity of four, seven, and ten, respectively.

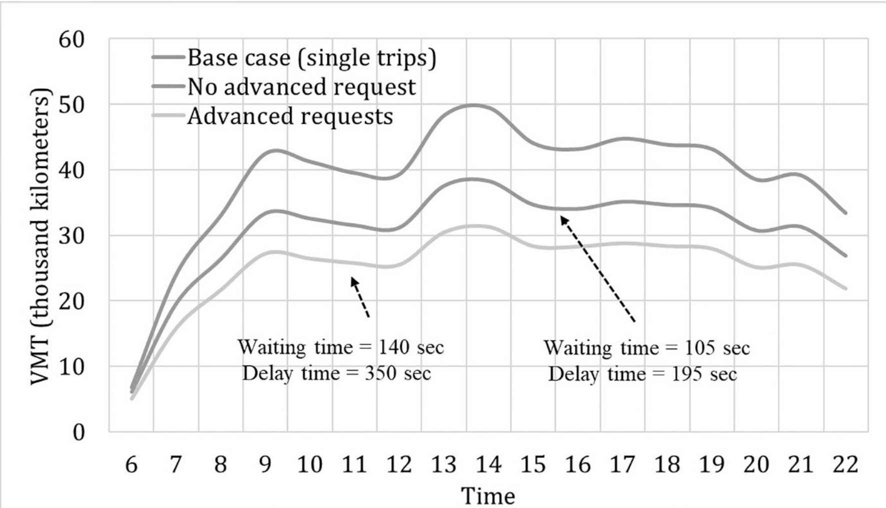

FIGURE 9.4 Comparison of VMT over the course of a day for different operating models: no advanced requests, advanced requests with, $H = 15$ min 100 percent willingness to share, mixed user preferences, decision epoch thirty sec, vehicle capacity four, and normal traffic.

Figure 9.4 compares the performance of the operating model with advanced requests, assuming a fifteen minutes advanced request horizon and a thirty seconds decision epoch, to the performance of current services (for example, no advanced requests). It is assumed that all passengers are willing to share and have mixed preferences. Vehicle capacity is four and traffic conditions normal. The base case of only single trip requests is also shown. The results are based on the application of the model over the entire day.

The advanced requests operating model performs consistently better than a system with no advanced requests across different time periods of the day. Compared to the base case when all requests are for single trips, on average, if all passengers are willing to share, a system with no advanced requests will reduce VMT by 20 percent, while the operating model with fifteen minutes advanced requests will save 35 percent of the total VMT. The 35 percent VMT reduction represents not only a reduction in congestion but also in environmental impacts. In terms of the LOS for the passengers, the no advanced requests system yields an average waiting time of 1.8 minutes and trip delay time of 3.3 minutes, while the advanced requests model has an average waiting time of 2.3 minutes and trip delay time of 5.8 minutes.

In conclusion, operating strategies based on requests in advance have the potential to improve shared rides and reduce the environmental footprint of TNC services. Even short advance request horizons offer substantial benefits at the cost of a small increase in waiting and travel delays. Furthermore, survey data indicate that users are actually interested in using such services.

9.4.2 *Partnerships with Public Transport*

Recently, there has been a growing interest in exploring partnerships between public transport agencies and TNCs. Such partnerships have the potential to increase shareability opportunities. Many commuting trips for example, take place at the same time and could use the same rail station. This increases the chances of pooling requests that go to the same public transport station (many-to-few case), providing economies of scale for the TNC and also feeding potentially new users to public transport services. In general, public transport agencies may partner with TNCs for various reasons, such as improving mobility where public transport is scarce or cutting down on costs and attracting new customers. TNCs on the other hand, view such partnerships as a means to increase revenue by serving markets with favorable spatio-temporal characteristics. Various studies indeed suggest that TNC and public transport services can be used collaboratively [48]. Uber data, for example show a strong relationship between the origin and destination of the rides and the location of public transport stops. Almost 40 percent of Uber rides in London either start or end near a Tube stop [49]. Uber reported a 22 percent increase in the number of its trips that began within 200 meters of a Tube stop after London launched a limited nighttime Tube service in 2016 [49]. In Portland, Oregon, 25 percent of Uber trips occur within a quarter-mile of a public transport station [51]. Lyft rides follow the same pattern, with 25 percent of Lyft riders using the service to connect to public transport. In Boston, 33 percent of Lyft rides start or end near a public transport (MBTA) stop [52].

The initial partnerships emerged due to safety concerns. The goal of the partnerships was to motivate people to use public transport to attend social and entertainment activities and, later in the night, when public transport services are not available, help them get back home safely with subsidized TNC rides. The Dallas Area Rapid Transit (DART) partnered with Uber on St. Patrick's Day to reduce drunk driving casualties during one of the deadliest holidays [53]. In 2014, the University of Florida proposed a pilot to complement late-night circulatory bus services with subsidized Uber trips to discourage late night-driving [54]. The success of these trials triggered a wider interest in partnerships between TNCs and public transport agencies. The experience with such emerging partnerships however, varies among agencies, ranging from failures such as Bridje in Kansas City, which attracted only a total of 1,452 rides in a year (2016) and was terminated, to the successful Uber partnership with the city of Innisfil, Ontario, with 8,000 rides per month.

In general, three main types of partnerships are observed between public transport and TNCs: First/Last Mile connections, paratransit, and bus route replacement.

First/Last Mile connections: Providing on-demand rides that connect riders to public transport options is the most common partnership. Schwieterman and Livingston [55] reviewed twenty-nine agencies in North America and found that since 2016, at least six offered discounted TNC rides to/from public transport rail stations [55]. The Pinellas Suncoast Transit Authority (PSTA), for example, became the first public transport agency in the United States to partner with a TNC to provide first/last mile services. "Direct connect" was a pilot service that used public funds to subsidize Uber rides that would allow riders to get to and from a bus stop. "Direct Connect" replaced underperforming, low-frequency bus routes that were carrying less than five passengers per stop per day [54]. The pilot showed promise to reduce costs and the city allocated additional funds to expand the service to ten times the number of bus stops originally served [54]. European cities are also forming similar partnerships, such as BerlKonig in Berlin, Germany [56], and ViaVan in Espoo, Finland [57].

Some partnerships in this group however, experienced poor results. Centennial, Colorado, terminated a partnership with Lyft that offered free trips to light rail stations (Go Centennial). The city had to spend more (compared to the traditional paratransit service they offered, known as Call-n-Ride service), while serving fewer rides [58]. A report on the "Go Centennial" program blames lack of systematic integration between regional public transport services and the Lyft service for the poor results. Trips were not synchronized with the light rail schedule and alighting riders had to wait for Lyft to arrive. The same report also acknowledges the presence of parallel services (from other demand responsive services) that caused inefficiencies and limited the benefits that come from economies of scale [59].

Paratransit (dial-a-ride): It is typically very expensive to operate traditional paratransit services, which are often mandated by the Americans with Disabilities Act. The Brookings Institute estimates that in 2013, 12.2 percent of the operating costs of public transport agencies (approximately $5.2 billion) went to paratransit. Contracts with TNCs to provide paratransit services are particularly interesting, as agencies are under pressure to find innovative solutions to deal with the ever-growing paratransit costs. The experience from partnerships between public transport and TNCs to offer paratransit services is promising. Agencies, such as in Boston (MBTA) and Las Vegas (RTC), use TNCs as platforms to provide paratransit services that are easier for passengers to use and at a lower cost for the agency [60, 61]. In Boston, the MBTA recently renewed a three-year contract with Uber and Lyft to supplement their paratransit services [62], even though the TNC-based service may have problems serving some wheelchair users who have to be accommodated through other means [63]. In Las Vegas, RTC aimed to reduce the $32 per ride cost for traditional paratransit services by outsourcing the trips to Lyft. The public transport agency estimates that each Lyft ride costs about $15 [64].

Bus route replacement: Another type of collaboration is using TNC services to replace bus routes. The town of Innisfil, Ontario, decided to partially subsidize TNC trips in place of the traditional public transport system operating in the city. The average subsidy of $5.62 per passenger is lower than the subsidy for a typical bus ride [55]. Uber reports that the partnership is saving Innisfil $8 million a year [65].

In Arlington, Texas, the town's entire bus service was replaced by services provided by Via, making Arlington the largest US city without a typical public transport system [66]. The Via rides cost between $3 and $5, depending on distance and origin/destination of the trip. The customer is notified of the expected pickup time but, in general, waiting time is less than ten to twelve minutes, which makes the service particularly attractive. The program has been successful, and the contract was renewed with expanded service from 30 percent coverage to 100 percent coverage [67].

In summary, partnering with TNCs can have benefits for public transport authorities. Connecting riders to public transport, replacing inefficient bus routes, and providing cost-effective paratransit services are the most promising areas of collaboration. Collaboration can also be beneficial to TNCs. As mentioned earlier, TNCs are more cost-effective when trips are concentrated (for example, many-to-few). Partnerships with public transport favor and greatly facilitate such operations. The lessons learned from the current efforts suggest that service design, business models, demand spatio-temporal characteristics, marketing, and demographics are important for the success of public transport-TNC partnerships. The degree of complementarity (TNCs working together with public transport agencies) and substitution (TNC trips replacing public transport trips) between TNCs and public transport varies. The substitution effect is expected to be larger for example, in cities or areas where public transportation LOS is low (for example, high travel times, low frequency of service) compared to places with a strong public transport system.

9.5 CONCLUSION

TNC services have seen significant growth in recent years. While they play an important role in supporting urban mobility, they may also introduce negative externalities. Increasing ride pooling has the potential both to reduce the negative societal impacts and to improve operating efficiency (which is of great concern to TNCs). Although increasing the number of shared trips is a desirable goal, experience suggests that shared trips are currently only a small fraction of all trips. The chapter summarized the factors impacting ride-pooling and synthesized the main approaches that can be deployed to increase ride pooling. Two representative approaches to increase the number of shared trips discussed in detail, operations where requests are required to be known in advance (with short time horizons), and partnerships with public transport agencies for providing multimodal services, have shown promising results.

A case study with data from a large TNC showed that significant benefits (VMT savings) can be realized when advanced requests are combined with an increased willingness to share. Even short, advanced request intervals (five to fifteen minutes) can capture the majority of the benefits of advanced requests. The VMT savings are realized at the expense of a small reduction in LOS.

Partnerships between public transport and TNCs can be beneficial to both sides, in terms of reducing costs, improving level of service, and potentially increasing demand. Three main types of partnerships are observed: offering first/last mile connections, providing paratransit services, and substituting for unproductive bus routes. The discussion suggests that service design, business models, consumer attitudes, and demographics, are important for achieving increased ride pooling.

However, the success of these strategies depends on many factors that can play a key role in shaping the future role of TNCs as an integral part of a sustainable urban mobility system, especially considering that public transport should and will always be the backbone of urban transportation.

Pricing is an important lever that TNCs can use to drive demand for various services. Pricing, properly differentiated by service type, impacts consumer choices (along with level of service). Currently, prices for the typical TNC service (ride alone) are rather low, set aggressively to increase market share. Fares are subsidized by the venture capital the companies have attracted and do not always reflect the true cost of the trips. As a result, given this low ceiling (price for the single trips), there is currently limited room to set prices appropriately for the other products. Price differentiation is not strong enough to incentivize users to switch to the more sustainable options, such as ride-pooling.

Policy can play an important role in guiding TNCs to offer more sustainable services. A recent study proposes a number of financial instruments, including surcharges to help cities recover TNC-associated costs and externalities (management, curb utilization, congestion, and pollution), fees designed to penalize inefficient routes, and rewards for shared trips and trips that are complementary with public transport [68].

Integrated fare platforms, providing fare bundles for trips involving public transport/TNC connections is a logical next step in the development of partnerships between public transport and TNCs. Such integrated fare platforms eliminate the obstacle and inconvenience of separate payment means for customers, facilitate revenue allocation among stakeholders, and promote multimodal trip searching and recommendations.

Finally, it should be pointed out that, currently, data sharing between TNCs and public transportation agencies and city authorities is rather limited. Data sharing and greater transparency are important to further develop integrated, inclusive, multimodal services that promote sustainable mobility and accessibility in urban areas.

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10

How the Sharing Economy is Reshaping the Dynamics of Neighborhoods

A Theoretical Presentation and a Test Case

Daniel T. O'Brien, Babak Heydari, and Laiyang Ke

10.1 INTRODUCTION

The "sharing economy" has been lauded for decentralizing commercial transactions, allowing individuals to directly transfer products and services. Less often discussed is how it has precipitated a parallel geographic decentralization. Whereas historically the industries being disrupted by these platforms have been concentrated in downtown centers and business districts, the same transactions are now spreading throughout cities and towns. Uber and Lyft drivers make many more pick-ups and drop-offs in residential areas than traditional taxis(Lam & Liu, 2017). Airbnb listings offer short-term lodging in residential neighborhoods that have never had hotels. When this is discussed, it is often done in terms of supply and demand. First, some describe it as a boon to both the seller and the buyer as it expands the opportunity for each to deliver and receive services in locations that are more convenient to them. Second, there is sometimes concern, especially in the case of Airbnb, that these new transactions are removing products (for example, housing) from existing markets, shifting their balance. This market-oriented perspective, however, fails to engage the more fundamental implication of sharing economy platforms for neighborhoods: By shifting the geographic distribution of commercial transactions, they have the potential to alter who is in a neighborhood at a given time and what they do – whether residents or visitors – while they are there. This could lead to pervasive impacts to the social and behavioral dynamics, going beyond questions of supply and demand.

Here we present a generalized theory of how sharing economy platforms can and do impact neighborhoods. Our rhetorical focus is on urban neighborhoods, and we draw heavily from literature on cities, but the argument is relevant to suburban and even rural areas as well. After articulating this model more fully, we apply it to Airbnb, treating its incursion into the neighborhoods of Boston, MA as a test case. Along the way, we discuss some of the conceptual challenges that must be taken into account in such analyses.

10.2 A FRAMEWORK FOR HOW SHARING ECONOMY PLATFORMS CAN IMPACT NEIGHBORHOODS

The sharing economy has enabled private citizens to directly exchange services and products. This "peer- to-peer" construction has also changed the places where such transactions are likely or even possible. We propose a three-step framework for how these shifts in the commercial landscape of the city can affect the social and behavioral dynamics of neighborhoods (see Figure 10.1). Throughout, we use Airbnb and ride-sharing services (Uber and Lyft) as illustrative examples as they are the most common sharing economy platforms. That said, we go deeper into the implications of the model for Airbnb in the next section.

First, the sharing economy alters the traditional geographic distribution of service supply. Many services have historically been concentrated in business districts because of the incentives of agglomeration and access to consumers and the relatively high cost of serving areas with low expected demand. Sharing economy platforms have disrupted these mechanisms by lowering the transaction cost of offering services, thus enabling producers and consumers to find each other in less densely populated areas. This can be seen in both Airbnb and ride-hailing services. In terms

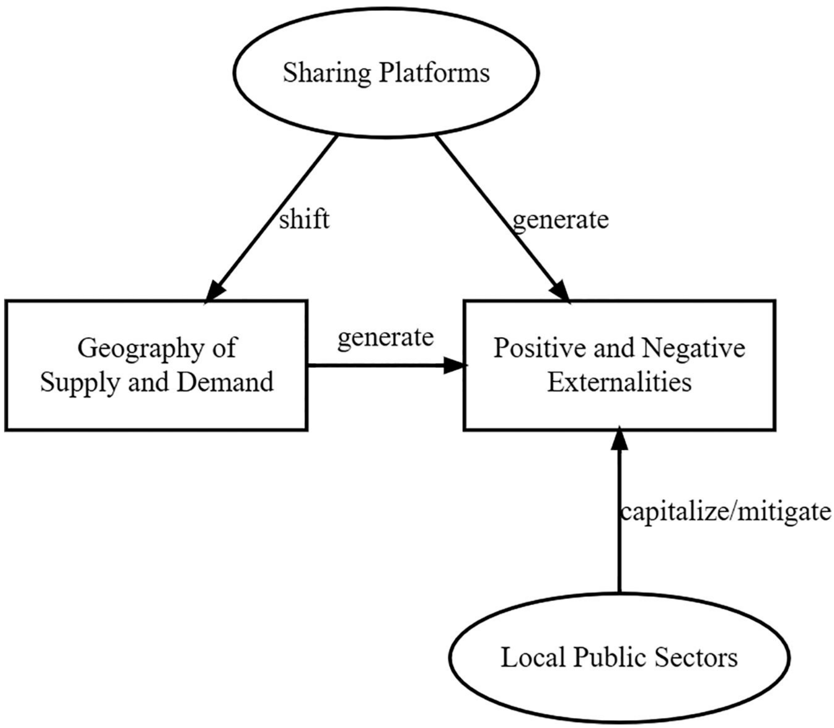

FIGURE 10.1 Three-step model of the sharing economy.

of the former, researchers examining New York City, Boston, San Francisco, and Barcelona have found that Airbnb listings are common in neighborhoods that did not previously have hotels (Benítez-Aurioles, 2017; Horn & Merante, 2017; Koster, van Ommeren, & Volkhausen, 2021). Likewise, much has been written about how ride-sharing has increased access to taxis in residential neighborhoods, especially in New York City, where taxis notoriously concentrate in Manhattan and rarely venture out to the other four boroughs (Correa Diego, 2017).

Second, these geographic shifts in supply and demand can generate unexpected positive and negative externalities for communities. Oftentimes the impacts of the sharing economy are articulated in terms of city- or region-wide industry patterns, like drops in overall hotel revenue (Dogru, Mody, & Suess, 2017; Zervas, Proserpio, & Byers, 2017). We are concerned here with more local impacts at the neighborhood level as the introduction of services brings in people and activities that were not there previously. These impacts might be economic in nature, but they also could arise from the social interplay between these visitors, the services themselves, and the local community. Such effects might be positive. For example, a sharing economy platform can stimulate economic development by increasing access to flexible jobs and foot traffic by outsiders who will frequent local establishments. For instance, one study in New York City found that neighborhoods with more Airbnb listings saw an increase in business, as reflected by expanded staff hiring (Alyakoob & Rahman, 2019). On the other hand, the increased activity might bring nuisances, like unpleasant guests or burdensome traffic, or, as has been seen, lower the supply and in turn raise prices for rental units in the community. We find the example of Airbnb leading to additional crime intriguing, in fact, as it might implicate either of two mechanisms instigated by a density of short-term rentals. As tourists begin to spend more time in the neighborhood, they might commit crimes, create disorder, or be targets for those who might do so themselves (Biagi & Detotto, 2014; Brunt, Mawby, & Hambly, 2000; De Albuquerque & McElroy, 1999; Harper, 2001; Ryan, 1993; Schiebler, Crofts, & Hollinger, 1996; Stults & Hasbrouck, 2015). Alternatively, the replacement of stable (or at least semi-stable) renter households with short-term rental units can create gaps in local social networks, potentially undermining a community's natural ability to prevent crime (Kawachi, Kennedy, & Wilkinson, 1999; Sampson, 2012; Sampson & Groves, 1989).

Third, local governments are tasked with designing policies and regulations that capitalize on the positive externalities of the sharing economy while minimizing the negative externalities. This third component of the model is a response to the first two factors we have described, they also will create a feedback loop, reshaping the distribution and consequences of both the sharing economy activity and its consequences. For instance, regulatory and legislative approaches to Airbnb and ridesharing have often focused on specific (and, at times, anecdotal) concerns about the impacts of these platforms on neighborhoods. In the case of New York City's negotiations with Uber and Lyft, the emphasis was primarily on increased traffic. For Airbnb in Boston, it was gentrification and displacement of the incumbent community. It is not to say that these considerations were incorrect, but that a more extensive science of the kinds of externalities we suggest here will be critical to developing fully informed policy. In the work we present here, our goal is not necessarily to critique current policy strategies for regulating the sharing economy, but to recommend a scientifically informed process for designing such regulations. That said, it is likely that in many cases the latter will give rise to the former.

Our three-part framework lays the groundwork for various research questions and practical implications for the sharing economy. In terms of the first component of the model, to what extent do sharing economy platforms shift the geographic distribution of a given service? Which neighborhoods see the greatest change? Are these changes correlated with demographic factors? As we progress to the second part of the model, what are the externalities arising from the geographic shifts resulting from a given sharing economy platform? To what extent are they consequential? Do they affect certain communities more than others? Critically, answers to these questions make it possible for policymakers to take action at the third stage of the model. They will be better equipped to determine which policy tools are most effective in managing the externalities surrounding the sharing economy. How do we design them to best effect and which neighborhoods most need attention? We thus encourage researchers and policymakers to partner under the perspective that these three components – the geography of supply and demand, localized social and behavioral dynamics, and public policy – are deeply intertwined in determining how the sharing economy contributes to the ongoing evolution of neighborhoods. With luck, such partnerships will provide the depth of knowledge necessary to design and advance "next-generation" regulatory approaches that move past traditional policy tools.

10.3 AIRBNB AND URBAN NEIGHBORHOODS

Airbnb and other peer-to-peer rental platforms make an ideal test case for our framework on how sharing economy platforms can impact neighborhoods. Per the first component of our model, travelers are no longer limited to districts with hotels, which are often concentrated around downtown neighborhoods with commercial and industrial zoning. Instead, they are now able to stay in apartments, houses, and condominiums in residential neighborhoods. This newly introduced commercial activity and the visitors it brings with it can have a variety of externalities, as stated in component two of our model. These can be both positive and negative, thereby impacting the character and trajectory of a neighborhood. An understanding of these externalities should in turn influence the regulation of short-term rentals, which have been the subject of much public discourse and policy debates in cities around the world. This is the culmination and third piece of our model.

To date, most research on the impact of Airbnb rentals on communities has centered on two main outcomes, each related to patterns of supply and demand – the revenue of the hotel industry and the price of housing. The former line of inquiry has found that Airbnb draws potential customers away from hotels and thus lowers their revenue, especially for middle- and low-end hotels (Dogru et al., 2017; Zervas et al., 2017). This work, however, has been more about the way that Airbnb disrupts the hotel industry in a city or broader region, and not about how Airbnb impacts neighborhoods. Meanwhile, research on the relationship between Airbnb and housing values works off the assumption that many Airbnb listings are for units that would otherwise be owner-occupied or rental properties. By lowering this supply, Airbnb in turn leads to increases in housing value and rental prices, a result that has been found in multiple cities in North America and Europe (Ayouba et al., 2019; Barron, Kung, & Proserpio, 2018; Horn & Merante, 2017; Garcia-López et al., 2020; Sheppard & Udell, 2016).

Less attention has been paid, however, to the ways that the prevalence of Airbnb in a neighborhood might impact other aspects of a neighborhood. This is important scientifically and practically, as it allows us to better understand how short-term rentals interact with local social dynamics and can provide guidance for policies and regulations that balance their costs and benefits for local residents and businesses. In order to enumerate these possibilities, we must first consider what it means to have tourists in a residential neighborhood. First, tourists tend to frequent local establishments, especially for food and drink, which could increase economic activity in "main street" districts that serve local communities. For example, Alyakoob & Rahman (2019) found that New York City neighborhoods with a greater presence of Airbnb listings experienced more growth in restaurant employment. They attributed this effect to visitors using Yelp reviews data. Likewise, Schild (2019) identified a positive impact of Airbnb usage on the number of firms in the entertainment sector.

Although they might contribute to the local economy, Airbnb users might not have an exclusively positive effect on neighborhoods. Tourists can potentially be disruptive by keeping different hours than locals and possibly partaking more avidly in alcohol or other disruptive activities. They also are more vulnerable to property crime than locals as they lack protective relationships and have money and valuables with them. Criminologists have regularly found that neighborhoods with more tourists tend to have greater crime (Boakye, 2010; Harper, 2001; Schiebler et al., 1996). No one has yet directly tested, however, whether the presence of Airbnb in a neighborhood leads to rises in crime and disorder via this mechanism.

Additionally, as we stated earlier, there is also the possibility that the tourists themselves are not responsible for rises in crime, but that the diminished number of stable households in the neighborhood interrupts the function of local social networks, which are known to be crucial in the management of crime and disorder (Sampson & Groves, 1989). To illustrate, if a sufficient number of units throughout a community have been converted to short-term rentals – the most transient form of occupancy possible – fewer neighbors are present to sustain a strong social network, also referred to as the social organization (Sampson, 2012), and establish the "social capital," including trust, reciprocity, and social cooperation, known to be crucial to communities (Coleman, 1988). Regardless of the specific terminologies used, researchers have found these processes to be active in diminishing crime (Kennedy et al., 1998; Sampson, 2012). There is also evidence in the network science literature that demonstrates the positive effect of enhancing the community structure of social networks on their collective prosocial behavior. The strength of the community structure in network science is often measured by *network modularity*, which measures the ratio of intensity of ties within and across a set of nodes that are identified as a community. Emergence of prosocial norms can then be studied by allowing nodes on a network to play some strategic games with their network neighbors and update their behaviors by occasionally mimicking their successful neighbors. The final status of the collective behavior is then related to the structural features of the network, such as modularity, degree distribution, and other standard network measures. The games are chosen in such a way to model various social dilemmas (for example, prisoner's dilemma or ultimatum game), in which players can either act selfishly for short-term gains, or take prosocial actions that have long-term benefits for them and the network as a whole. Several studies using this framework have demonstrated that how players resolve such dilemmas depends on the structure of the social network and have shown a strong impact of network modularity – that measures the intensity of community structure based on ratio of link density within and across communities – on population-level attributes such as cooperation, fairness, and stability (Gianetto & Heydari, 2015, 2016; Heydari, Heydari, & Mosleh, 2019; Mosleh & Heydari, 2017).

A corollary question is how the presence of Airbnb and tourists might impact the behaviors of local property owners. As listings increase in a neighborhood, they act as a tangible representation of the attractiveness and marketability of housing there. This might then inspire property owners to invest in their buildings, potentially accelerating increases in property values, rental prices, and more generalized gentrification.

Here we leverage our three-component model of sharing economy and neighborhoods to examine outcomes in Boston, MA, which has been the site for early work on how Airbnb impacts property value. It has also been one of the cities that has led the way in developing policy interventions that seek to limit the negative impacts of Airbnb on neighborhoods. Specifically, we analyze how the longitudinal growth of Airbnb across the neighborhoods of Boston, MA is associated with: (1) the increase in food establishments; (2) levels of crime and disorder; and (3) the tendency of property owners to invest in parcels across the city.

10.4 AIRBNB'S PRESENCE IN BOSTON

To examine the impact of Airbnb on Boston neighborhoods, we downloaded listings and reviews from InsideAirbnb.com, an independent, noncommercial website that scrapes and publishes data sets of Airbnb listings for cities across the world.

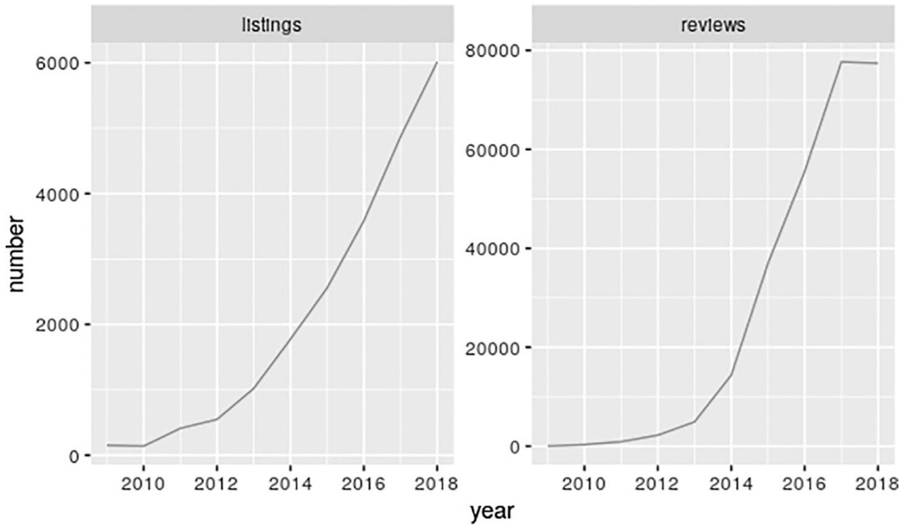

FIGURE 10.2 Airbnb's expansion in Boston: 2009–2018.

InsideAribnb.com has published these data annually since 2015, but Airbnb entered Boston in 2009. In order to overcome this limitation, we leveraged the "host since" field, which indicates the date a property became an Airbnb listing, to estimate which Airbnb listings were present in each year 2010–2014. Koster et al. (2021) took a similar approach using the date of a listing's first review, but we found that the "host since" variable more consistently had a value and would be more precise in any case.

As shown in Figure 10.2, Airbnb had limited presence in Boston in the early years, with a negligible number of listings and reviews. There was rapid growth, however, between 2014 and 2018, over which time the number of listings more than doubled from 2,558 to 6,014. There were also nearly 80,000 total reviews by 2018. Our focus here, though, is not the city as whole, but how the increased prevalence of Airbnb was distributed across neighborhoods. We examine this by joining each listing to the containing census tract, which we use to approximate neighborhood (avg. population = 4,000; 168 with meaningful population in Boston). A major challenge, though, is determining how best to measure Airbnb's presence in a neighborhood, particularly in terms of how we would expect that presence to have impact on local behavioral and social dynamics.

Airbnb listings are a "naturally occurring" data set, meaning they were not originally constructed for research purposes. The upshot is that it is incumbent upon researchers to determine how to operationalize the measures of interest (O'Brien, 2018). As such, previous studies have proposed several ways of measuring Airbnb's presence in a community. Some have focused on the number of listings, either as the percentage of total housing units in a census tract (Wegmann & Jiao, 2017) or relative to the number of buildings, being that many buildings contain multiple apartments of condos (Koster et al., 2021). Others have focused on the number of reviews, either as a pure count (Schild, 2019) or relative to the number of households in the neighborhood (Alyakoob & Rahman, 2019), arguing that reviews are a better reflection of the number of tourists brought to the neighborhood by the platform. There is no consensus as to whether one of these is superior to others, however, for which reason we use three measures of Airbnb presence here. First, we measured the *density* of Airbnb as the number of Airbnb listings in a neighborhood divided by the number of housing units (as accessed from American Community Survey 2011–2017 estimates). Second, we measured the *penetration* of Airbnb as the number of unique addresses with listings divided by the number of parcels (lots that contain one or more units, per the City of Boston's Assessing Department) in the census tract, thereby approximating the share of buildings with at least one Airbnb listing. Third, we measured *usage* of Airbnb as the number of reviews divided by housing units in a census tract. For the sake of brevity, we use these three terms – density, penetration, and usage – throughout.

The reason for adopting three measures of Airbnb's presence is because none of them captures the whole picture of Airbnb's impacts on neighborhood on its own. For example, if most listings in a neighborhood are concentrated in a few condo buildings, the potential positive or negative effects generated by Airbnb-related activities might be limited to the immediately surrounding areas, leaving the rest of the community unaffected. On the other hand, if the census tract is a sprawled suburban neighborhood filled with single family houses, the same number of Airbnb listings would be spread more evenly, having a wider impact across the neighborhood. In addition, per the advice of Schild (2019), Airbnb reviews more directly reflect the volume of usage by tourists as a higher density or penetration of Airbnb listings is not always accompanied by more visitors. There is of course, though, the potential for substantial measurement error in this last measure as leaving reviews for hosts is not a mandatory policy of Airbnb, hence many visitors choose not to do so. Also, a party with multiple visitors can only leave one review for a listing, inevitably fewer than the people who were present. As a consequence, this measure underestimates the total volume of tourists produced by Airbnb, and analyses using it must assume that these undercounts are consistent across neighborhoods; that is, the tendency to undercount is not exaggerated in some neighborhoods more than others. Another benefit of using these three different measures is the ability to potentially differentiate between those impacts caused by the sheer number of tourists (quantified with usage), versus those created by listings (quantified with penetration and density). As we noted earlier, this is specifically relevant to our discussion of Airbnb might lead to elevated crime in a neighborhood: Tourists could attract or perpetrate crime, or the conversion of units to short-term rentals could lead to weaker ties and relationships within the community.

Our first task is to determine whether we are justified in treating each of these three measures as a separate indication of the presence of Airbnb in a neighborhood.

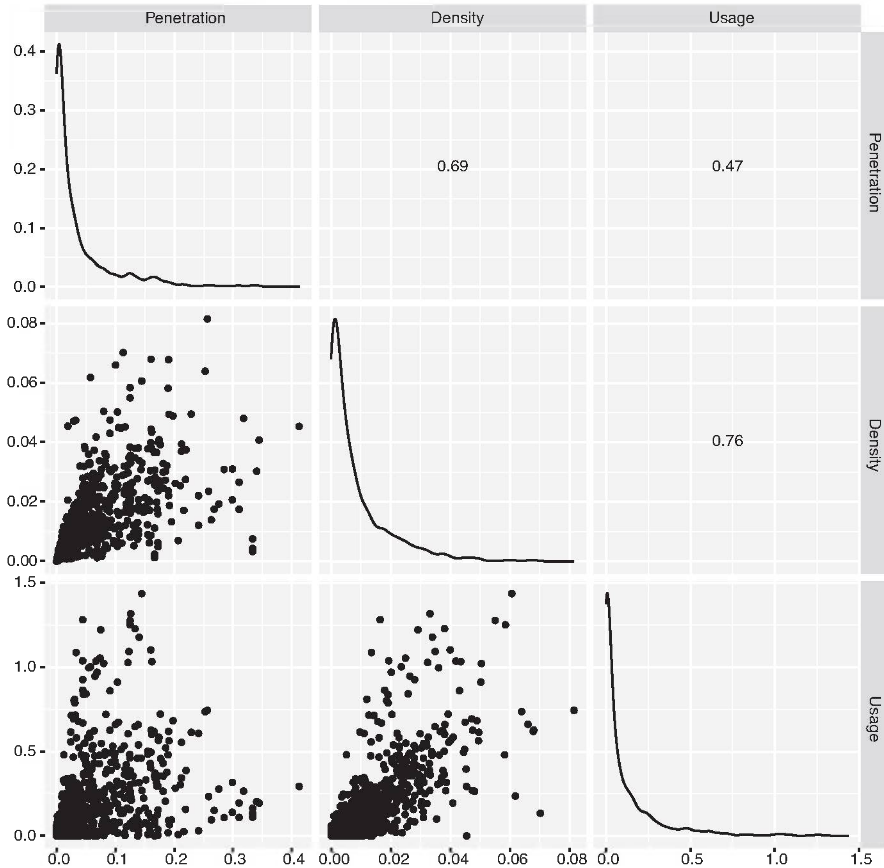

FIGURE 10.3 Correlations between three measures of Airbnb's presence in Boston.

While they are semantically and computationally distinct, it is completely possible that they are too strongly correlated to be analyzed independently. Figure 10.3 presents the correlations among the three measurements for census tracts, showing that they are substantially correlated (r = .47 – .76), but not so much to suggest that they cannot be analyzed separately. The strongest correlation is between density and usage, which is unsurprising being that they are calculated using the same denominator. Meanwhile, the weakest correlation is between penetration and usage. As one can see in the scatter plot at the bottom left corner of Figure 10.3, there are numerous neighborhoods with a high level of Airbnb usage (that is, many reviews per housing unit) but a low level of Airbnb penetration (that is, number of parcels with at least one listing); meanwhile there are others with low Airbnb usage but high penetration. Given this, we move forward analyzing all three measures.

In Figure 10.4 we can see that Airbnb density, penetration, and usage all increased over time and across census tracts in Boston. That is not to say that this growth

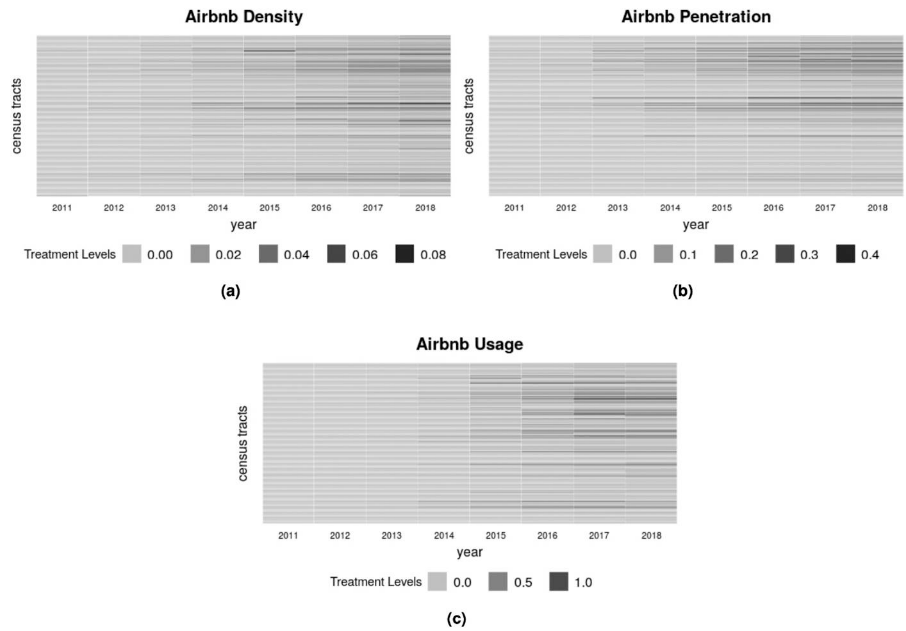

FIGURE 10.4 Airbnb's presence in Boston. Note: Each row represents a census tract from 2010 to 2018. The darker the color, the higher the Airbnb presence. Tracts are in the same position in each panel, meaning we can compare panels to confirm that most tracts with high level of presence on one measure scored similarly on the other measures.

was uniform. Certain census tracts were the first to have a measurable presence of Airbnb and then proceeded to have high levels of Airbnb by all three measures. The highest were tracts with as many as 8 % of units and 40 % of buildings featuring at least one listing. Even more striking, our measure of Airbnb usage is as high as 1.5 reviews per housing unit in the tract. In contrast, in many other tracts the presence of Airbnb was limited and even absent throughout the study period. Meanwhile a handful of tracts started with very low Airbnb presence and then witnessed rapid growth of Airbnb-related activities.

Before proceeding, it is worth noting which neighborhoods have high and low presence of Airbnb. Figures 10.5–10.7 map the spatial distributions of the three measures over time, demonstrating that the measures indeed tell different stories about Airbnb's expansion in Boston. In Figure 10.5, we notice that as the number of listings increases, Airbnb penetrations were most significant in census tracts that are located in the downtown urban center (in the northeast of the city). However, in Figure 10.6, although census tracts in urban centers still show relatively high Airbnb presence measured by Airbnb density, the tracts with highest level of Airbnb density are scattered surrounding the downtown areas. This divergence can be explained by

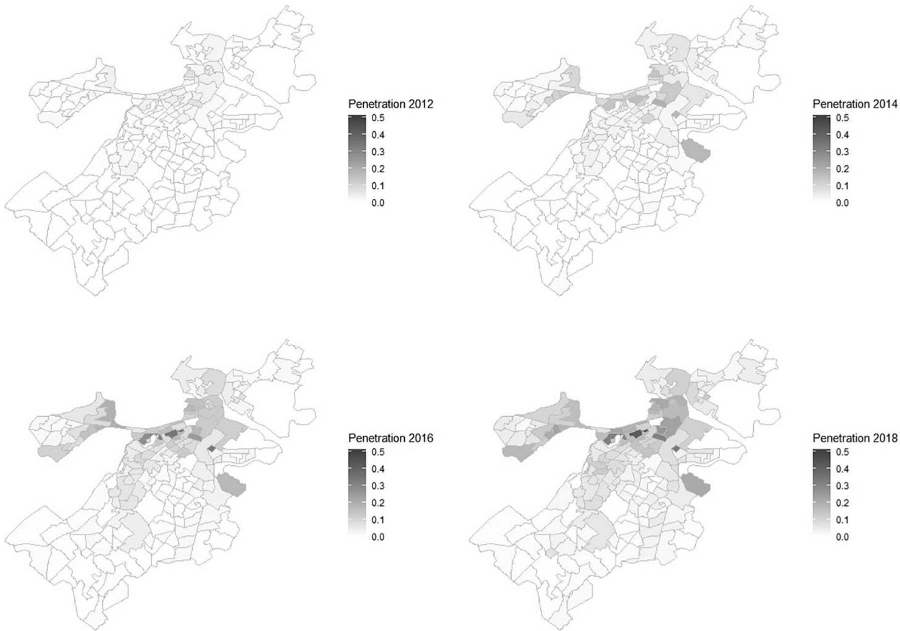

FIGURE 10.5 Airbnb penetration.

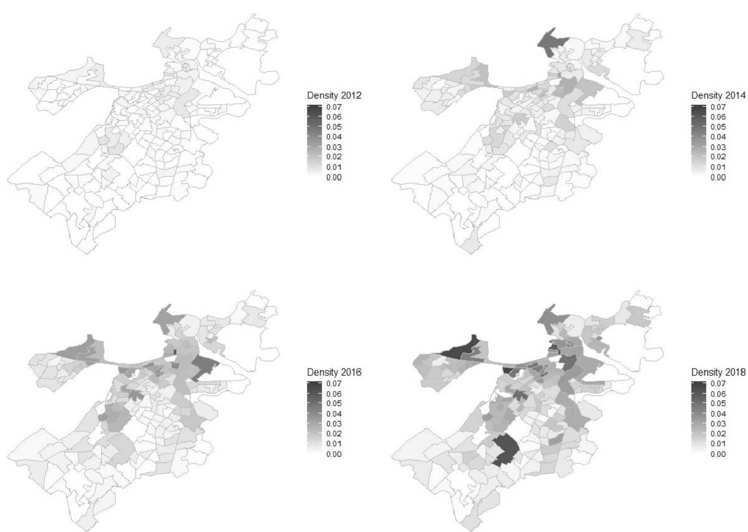

FIGURE 10.6 Airbnb density.

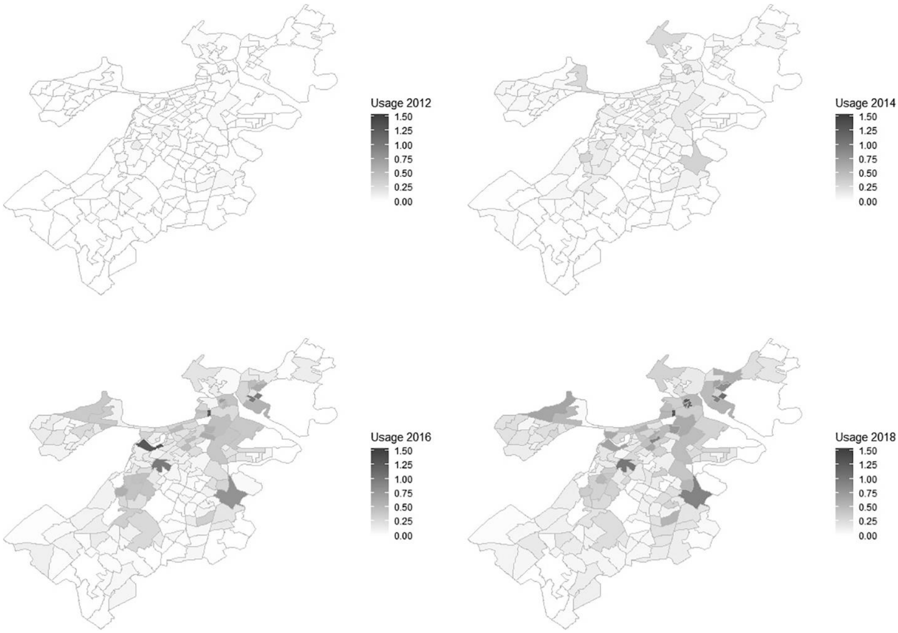

FIGURE 10.7 Airbnb usage.

population density in different urban neighborhoods. Urban centers usually have more people and less land while surrounding neighborhoods are somewhat less dense. Hence, Airbnb penetration might be high in an urban center, but its density is dwarfed by the immense number of housing units there. Owing to their strong correlation, Airbnb usage displayed a similar pattern to density (see Figure 10.7). Whereas the downtown and the first ring of neighborhoods around it share the distinction of highest presence of Airbnb depending on the measure used, neighborhoods located further out are consistently low in all three measurements. In the next section, we estimate Airbnb's impacts on neighborhood's investment and quality of life using the three measurements.

10.5 EVALUATING AIRBNB'S IMPACTS ON BOSTON NEIGHBORHOOD

10.5.1 *Methods*

To estimate Airbnb's impacts on Boston neighborhoods, we return to the three hypotheses from above: (1) Airbnb might encourage property owners to invest in their buildings; (2) the presence of tourists will support expansion of the local restaurant industry; and (3) the increased prevalence of tourists will lead to elevated disorder and crime. In order to test each of these hypotheses, we draw from indicators

TABLE 10.1 *Description of variables*

	mean	sd	min	max	Observations
Permits for Property Alteration (%)	0.19	0.09	0.04	0.61	1,176
Number of Licenses for Food Establishment	1.03	2.32	0.00	24.00	1,344
Airbnb Density (%)	0.01	0.01	0.00	0.08	1,344
Airbnb Penetration (%)	0.04	0.06	0.00	0.41	1,344
Airbnb Usage (%)	0.12	0.20	0.00	1.44	1,344
Events of Private Conflict (per 1,000)	11.13	6.18	0.00	32.97	1,344
Events of Guns (per 1,000)	4.21	4.52	0.00	25.79	1,344
Events of Violence (per 1,000)	28.10	21.84	1.33	172.54	1,344
Events of Social Disorder (per 1,000)	7.51	8.67	0.00	75.82	1,344

collected or developed by the Boston Area Research Initiative (BARI). First, BARI releases measures of investment and growth annually based on building permits approved by the City of Boston (O'Brien & Montgomery, 2015; O'Brien et al., 2019). The most relevant such indicator is alteration to existing buildings, calculated as the percentage of parcels in a census tract undergoing an addition or renovation in a year (excluding newly constructed buildings).[1] Second, we calculated the number of new food establishments from the records of new food establishment licenses approved by the Health Division of the Department of Inspectional Services (ISD).[2] Third, we obtained three indicators of social disorder and crime based on 911 dispatches (Ciomek & O'Brien, 2019): Public social disorder, such as panhandlers, drunks, and loud disturbances; private conflict arising from personal relationships (for example, domestic violence); and public violence that did not involve a gun (for example, fight). Each of these measures was based on a combination of case types in the 911 system, divided by the population of the census tract (to form a rate). We also access demographic measures from the American Community Survey as control variables, particularly measures of socioeconomic status (for example, income, poverty rate), as they are closely related to many of the variables here. Table 10.1 provides a summary of the variables.

Each of the variables was measured annually throughout the study period, making for a panel design. Thus, we analyze the impacts of Airbnb on a neighborhood using a set of generalized difference-in-difference (DID) fixed-effects models with multiple periods and continuous treatments (Lechner, 2011):

[1] Permits were first aggregated to the parcel level, and parcels were categorized as undergoing either a new construction, addition, or renovation. These categorizations were then the basis for calculating the census tract-level measure. Data were available from 2011 to 2018.

[2] Using the location of restaurants and the dates licenses issued, we aggregated the number of issued food establishment licenses to census tracts for each year since 2011. This variable represents a larger construct of commercial investments in a neighborhood.

$$Y_{i,t} = \alpha + \eta_i + \beta_t + \text{AirbnbPresence}_{i,t-1} + \delta C_{i,t} + \varepsilon_{i,t}$$

where i represents the census tract, t represents the year. $Y_{i,t}$ are the dependent variables: alteration to existing structures, growth in food establishment licenses, and indicators of social disorder and crime. γ is the estimated causal effect of Airbnb presence.[3] The key independent variables are lagged for one year to avoid reverse causal effects. η and β are the tract and year fixed effects, respectively, capturing both time-invariant characteristics of tracts and spatially invariant characteristics of years (for example, a city-wide increase in Airbnb prevalence or property investment). $C_{i,t}$ is the vector of control variables including log of median home values, median household income, and population density, among others.[4] Note that we run the models three times for each outcome variable, independently testing the impact of each aspect of Airbnb prevalence.

10.5.2 *Results*

The results from the DID models supported one of our three hypotheses of how Airbnb can impact neighborhoods. As shown in Table 10.2, increases in the prevalence of Airbnb predicted increased property investment in the following year. This was true whether we measured Airbnb in terms of density ($\beta = 0.004$, $p < 0.01$), penetration ($\beta = 0.001$, $p < 0.001$), or usage ($\beta = 0.000$, $p < 0.01$). The coefficients indicate that a one percentage-point increase in Airbnb density was associated with a 0.4 percent increase in property alteration and that a 10 percentage-point increase in Airbnb penetration was associated with 1 percent increase in building permits qualified as housing investments. This effect seems practically small but presents a reasonable ratio of 10:1 between properties listing on Airbnb and properties pulling building permits for improvements. It is worth noting that these are not necessarily the same properties, but it would seem reasonable to assume there is at least some overlap. Further, a 1 percent increase in property alteration is nontrivial, considering that the average census tract has just below 10 percent of properties apply for permits in a given year. In summary, Table 10.2 provides evidence that the prevalence of an Airbnb market in a neighborhood contributes to a greater percent of property investment. This joins existing evidence that Airbnb presence leads to higher housing property value, but we found no evidence to suggest that residential property investment is the intermediate factor through which Airbnb density affects housing values.

Table 10.3 shows no clear relationship between Airbnb prevalence in Boston neighborhoods and the expansion of food establishment licenses, regardless of which measure of Airbnb prevalence we used. Table 10.4, however, shows that

3 Most of our variables are continuous variables so we use an identity (linear model) link, but the number of new food establishment license is a count, requiring a logit (Poisson) link.

4 The specific combinations of control variables for each model can be found in the notes of each regression result table.

TABLE 10.2 *Fixed-effects models on property alterations*

	(1)	(2)	(3)
Airbnb Density (%)	0.386**		
	(0.162)		
Airbnb Penetration (%)		0.108***	
		(0.039)	
Airbnb Usage (%)			0.017**
			(0.008)
Tract FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	1,126	1,126	1,126
F	6.742	6.417	6.841
R^2	0.940	0.941	0.940

Note: clustered standard errors are displayed in parenthesis. All independent variables are lagged for one year. Control variables include median home value (log) and events of violence, social disorder, guns, and private conflicts
Significance levels: * p<0.00; ** p<0.01; *** p<0.001.

TABLE 10.3 *Fixed-effects Poisson regressions on new food establishment licenses*

	(1)	(2)	(3)
Airbnb Density (%)	–0.040		
	(0.047)		
Airbnb Penetration (%)		–0.012	
		(0.008)	
Airbnb Usage (%)			–0.003
			(0.003)
Tract FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	1,196	1,196	1,196
Chi^2	63.089	64.386	63.863

Note: clustered standard errors are displayed in parenthesis. All independent variables are lagged for one year. Control variables include median home value (log) and events of violence, social disorder, guns, and private conflicts.
Significance levels: * p<0.00; ** p<0.01; *** p<0.001.

neighborhoods with a higher level of Airbnb penetration saw rises in violent crime in the following year ($\beta = 0.546$, $p < 0.001$), and notably to a greater extent than the concurrent measure of penetration. There was still no corresponding effect on public social disorder or private conflict, however. Airbnb density in the previous year

TABLE 10.4 *One-year lagged independent variables*

	Events of Private Conflict			Events of Social Disorder			Events of Violence		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Airbnb Penetration (lag 1)	0.041			−0.115			0.546***		
Airbnb Density (lag 1)	(0.039)			(0.118)			(0.133)		
Airbnb Usage (lag 1)		−0.112			−0.426			1.407*	
		(0.227)			(0.293)			(0.614)	
			0.001			−0.011			0.037
			(0.009)			(0.016)			(0.021)
Tract FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,004	1,004	1,004	1,004	1,004	1,004	1,004	1,004	1,004
F	0.62	0.16	0.04	0.8	1.32	0.79	8.7	2.69	1.56

Note: clustered standard errors are displayed in parenthesis. Control variable is median household income. Significance levels: * $p<0.05$; ** $p<0.01$; *** $p<0.001$.

was also associated with higher levels of violent crime, albeit at a lower significance, and thus magnitude, relative to penetration ($\beta = 1.407$, $p < 0.05$). Airbnb usage had no effect on any of the three measures in the following year. We also performed a two-year lagged analysis, and the results are in general agreement with those with one-year lag in terms of the impact of Airbnb penetration on events of violence. There, Airbnb penetration not only predicted increased violence at this time scale, but also showed a moderate impact on events of private conflict, an effect that was not present in the one-year lagged analysis. The effects of Airbnb usage and density also concurred with the one-year lagged analysis (Ke et al., 2021).

10.6 DISCUSSION

We have used the expansion of Airbnb across the neighborhoods of Boston, MA to illustrate an overarching framework for considering how sharing economy platforms can impact neighborhoods. Airbnb has epitomized the way that such platforms have changed the geographic locus of certain commercial transactions, often by expanding them from business districts into more residential communities. In turn, cities like Boston have seen Airbnb listings direct more and more tourists to residential areas. Many have expressed concerns at the externalities that this unexpected influx of visitors might create. Here we articulated and tested three specific hypotheses for what these might be: (1) encouraging greater investment in property; (2) expanding the local hospitality industry; and (3) increasing crime and social disorder.

The empirical test provided support for our first hypothesis as well as some suggestive evidence for our third. Neighborhoods with increasing prevalence of Airbnb listings saw more investment in property, as measured through building permit applications approved by the City of Boston. Meanwhile, we saw mixed evidence for the other two hypotheses. Part of this might be limitations from the outcome measures we used. In particular, counting new restaurants is a constrained approach that requires that the hospitality industry expanded sufficiently to support entire new businesses. Researchers using the more nuanced measure of restaurant employment in New York City did find that Airbnb led to localized growth in the industry (Alyakoob & Rahman, 2019). Meanwhile, we see some initial evidence that Airbnb listings in a neighborhood are associated with increases in public violence in a neighborhood.

The suggestion that Airbnb might be associated with increases in public violence is intriguing, if preliminary. Admittedly, we sought here to illustrate a generalized framework for pursuing hypotheses on the externalities of sharing economy platforms. As such, this analysis and finding does not fully engage the more nuanced set of relationships between Airbnb and crime that we proposed earlier. To reiterate, Airbnb might impact crime through either of two pathways. First, tourists could directly raise crime, either by perpetrating crimes or acting as attractive targets for criminals. Alternatively, a density of Airbnb listings may undermine local social dynamics that mitigate and prevent crime. A seminal concept in criminology known as social disorganization theory posits that communities with high residential turnover will have difficulty creating and sustaining the relationships and norms necessary for limiting crime (Sampson, 2012). Consistent with this model, Airbnb is the most transient type of household possible, literally "turning over" every few days. To this end, the listings may leave gaps in the social fabric off the neighborhood that could permit crime to increase. Adjudicating between these two hypotheses requires a targeted conceptual approach and methods that attend to the nuanced differences between them. We conduct such a test in a recently published study in a separate venue (Ke et al., 2021). We do indeed find evidence that Airbnb listings lead to increased crime in neighborhoods by undermining the local social organization – not because they attract tourists, as one might assume. By undermining a neighborhood's social organization, higher Airbnb penetration diminishes the natural ability of a neighborhood to counteract and discourage crime, specifically violent crime.

Our goal in presenting this study is to highlight three important considerations, one conceptual, one methodological, and one practical. Taking the conceptual first, the framework here provides a guide for examining how other sharing economy platforms might be impacting neighborhoods. The study of each will first need to determine if and how the platform in question is in fact shifting the geographic distribution of commerce. It then will need to proceed to reasoning how those transactions might be altering existing behavioral or economic dynamics. In the current case, we reasoned that Airbnb highlights the value of local housing stock, thereby stimulating investment by property owners. We also discussed how the introduction of tourists might lead to more patrons at local restaurants, but also more disorder and crime. Similar logics would need to be developed for each sharing economy platform and might reveal that certain platforms would be more likely than others to have tangible impacts on communities.

Working through the first two steps of our conceptual process raises a crucial methodological consideration. How does one quantify the presence of a sharing economy platform in a neighborhood? In order to maintain brevity and avoid ambiguity, most scientific studies present and justify a single measure for a quantity of interest. This is a truism for science in general, and has become pronounced in recent years with the use of naturally occurring data sets, including but not limited to the data generated by sharing economy platforms (O'Brien, Sampson, & Winship, 2015). In contrast, we have taken the opportunity here to detail our own struggle to identify a single measure for the presence of Airbnb in a neighborhood, revealing that multiple measures are possible and that they are neither statistically nor conceptually equivalent. This highlights the challenge faced by researchers in this space and makes clear that the measures themselves need to be developed with care. Further, researchers need to be clear on the interpretation of the measure or measures they select. To illustrate this latter point, there are clear differences between the meaning of our three measures. Whereas high density could be created by a few large buildings with many units listed, penetration reflects a more general distribution of listings throughout a neighborhood. The latter might better reflect the exposure of many parts of a neighborhood and their residents to Airbnb. Meanwhile, the usage measure, which estimates the total number of visitors to the neighborhood, might be most relevant for hypotheses regarding the volume of impact of individual tourists.

Last, it is important to consider how this framework might be a useful tool as local governments look to manage and regulate the sharing economy. Presumably, the goal of such regulations is to maximize the benefits generated by the sharing economy and minimize the negative impacts. Research of the sort presented here will inform policymakers to the specific positive and negative externalities that should be taken into account when designing such regulations. Here we see that Airbnb is leading to more investment in neighborhood properties, which might be argued as a positive outcome. It joins, however, a wealth of evidence that the expansion of Airbnb listings can lead to increases in housing and rental costs and gentrification more generally. Municipal leaders need to weigh these costs and benefits alongside each other when determining how a regulation will impact neighborhoods.

Meanwhile, combining the results here with our further analysis elsewhere (Ke et al., 2021), we see that Airbnb can also lead to elevated levels crime and disorder in a neighborhood. But the crucial question of measurement returns, this time highlighting how intervention requires not only an understanding of the externalities of the sharing economy, but also of the mechanisms by which these externalities occur. Comparing different ways of measuring the presence of Airbnb in a neighborhood, the increase in crime appears to have been instigated not by the arrival of tourists, as many have assumed. Instead, the listings themselves create a transience that can undermine local social networks and the community's ability to prevent crime. There have been arguments that these sorts of effects are nonlinear and are only visible as they reach certain thresholds (Clear et al., 2003). Fittingly, the same has been demonstrated for gentrification (Hwang & Sampson, 2014), which is the potential concern arising from increases in building permits.

With information like that provided by our analysis, cities might be able to develop more informed regulations. Complete bans of Airbnb listings are a blunt tool that foregoes any of the possible benefits they might offer, like stimulating local businesses. Cities like Boston, MA, should be applauded for pursuing a middle ground, but the question is whether they were designed to best support communities. Boston, similar to other locales, has placed the focus on limiting property owners to renting out only one unit in an owner-occupied building at a time. This does limit the overall number of listings, but it has its weaknesses. At the extreme, it could lower density of short-term rentals in the neighborhood while permitting maximal penetration across its parcels. The results in studies based on the suggested framework here (Ke et al., 2021), would suggest that the negative externalities of the listings could still take hold in such a situation. Policymakers might instead consider quotas of parcels within a neighborhood that can have one or more short-term rentals. In conclusion, this framework can support well-crafted empirical research that then can be translated into well-designed policies. This is critical as it becomes increasingly clear that sharing economy platforms will be a major component of the commercial landscape for the foreseeable future.

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11

Sharing in Future Electric Energy Systems

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11.1 INTRODUCTION

Engineering advances have been opening new possibilities for sharing electric energy. Technological and social innovations in the electric energy sector may allow consumers to become more actively engaged in producing and managing the generation, distribution, and use of their electricity, which could shift the locus of organizational decision making and control away from traditional utilities. These innovations also have potential to diversify and restructure who is included and excluded from energy sector benefits (Stephens, 2020).

The transition toward a "sharing economy" in the transportation and lodging sectors, and in other emerging sharing economy systems, can be understood as a process of separating rights of use from the other rights of ownership for goods that had previously not been as easily divisible in this manner. For example, app-based short-term lease platforms have disrupted the lodging sector by enabling owners to create new value by more easily assigning the rights of use of their dwellings, and consumers now have new options of affordable unique rentals as an alternative to owning a vacation home. In the current traditional deregulated energy system, ownership of energy generation infrastructure is centralized along with allocation of rights of use. Generally, consumers did not own energy assets and had little power to consume the type (for example, traditional vs clean and renewable) or price (for example, fixed rate, time-of-use) of energy that aligned best with their economic and social motives. Sharing economy ideas combined with new technology promise to decentralize energy generation thus increasing ownership and opening broader markets (for example, demand response, community generation, and resilient microgrids).

Sharing economy innovations in the electric grid, including community solar and energy blockchain systems, are expanding the role of assets owned by consumers. These innovations are transitioning the role of generation and management from large corporations and utilities to consumers. This restructuring has potential to democratize energy systems depending on how policy and regulations guide the development of a more distributed renewable-based society (Stephens, 2019). As households and businesses become prosumers, they are producing and sharing surplus energy with the grid and other users, creating what some are referring to as "locavolts" linked in microgrid systems to enhance electric energy resilience and to leverage local financing. Prosumers who can "share" their electricity may also be empowered to change the rules that have governed their relationships with utilities for the past century.

At the same time, technological innovations related to renewable electric energy generation, distribution, and demand-side management may enable new types of energy sharing with the potential to disrupt and transform the current electrical energy industry. In the same way that Uber and Airbnb have disrupted existing transport and hospitality industries, we suggest that the electricity energy sector may also be trending toward large-scale system reconstruction by way of innovations for energy sharing. In recent years, one outcome of these energy sharing innovations has been the rise of a new group of energy platform operators (for example, thermostat companies and other third parties) acting as "energy services providers" that position themselves as the electricity sharing economy platforms facing consumers. Many have identified the "death spiral of the utilities' business model" in which the traditional fee for energy delivery that utilities charge to customers fails to provide adequate revenue from prosumers who use the grid only for short periods of peak power (Felder and Athawale, 2014). These periods of peak power, for example, in the early evening when the solar resource diminishes and residential demand increases, drive infrastructure costs. Energy platform operators may enter the power sector as new market players that aggregate small amounts of distributed energy resources (DERs) provided by each user into megawatts that can be traded in the traditional regional energy, capacity, and ancillary services markets.

Future energy systems are likely to integrate a regionally appropriate mix of renewable electricity generation that is dispatched, stored, and distributed through platforms that enable sharing at multiple scales, from milliseconds to decades (Stephens, 2019). The potential for sharing in electricity systems is expanding as energy systems around the world are transitioning from centralized large fossil fuel power plants to distributed renewable-based power generation at multiple locations (Stephens, 2020). Such flexibility in time scale and locations is critical, as the success or failure of any organization or individual operating in the sharing economy is determined by its ability to effectively manage an elastic match between resource supply and demand. Sharing in future electric systems has the potential to disrupt relationships governing utilities, energy consumers, and distributed electricity generation at the individual and household levels, at the community and organizational levels, and at the regional, state, national and even international levels.

This chapter reviews the range of institutional models for electricity generation and distribution; considers how electrical energy systems are undergoing a transformation toward more distributed, renewable-based configurations; and explores the multiple evolving mechanisms for energy to be shared among generators, distributors, and consumers. We present a typology of sharing economies in electric energy systems and identify the technological and sociopolitical potential for sharing electrical energy as systems evolve. The chapter also explores policy considerations that flow from such large-scale transformations in the energy sector. The chapter concludes with opportunities for future research and questions about the implications of energy sharing for energy justice.

11.2 BACKGROUND ON THE ELECTRIC SYSTEM STRUCTURE, BUSINESS MODELS, AND REGULATORY FRAMEWORKS

Over time, a wide range of institutional models, shaped by both technological and sociopolitical factors, have emerged for provisioning energy for households and industry (Stephens et al., 2015). Regulatory frameworks have evolved in parallel with transformations of technology and business models. It is important to understand how these transformations evolved over the last century, and the sociotechnical factors that led to them, to understand the disruptive potential of sharing economy innovations in the electric power sector.

Traditional utilities are structured as regulated monopoly providers of electrical power and grid services for a specific geographic area (Kiesling, 2014). The role of utilities is to deliver power to satisfy consumer demand, which may require the utility to generate, transmit, store, and/or purchase power and regulate its frequency and/or voltage. Early on, utilities faced steep barriers to market entry, because power plants and transmission lines were very expensive. Consequently, when household electricity was introduced in the United States in the early 1880s, it was available only in larger cities for wealthy homeowners and almost 90 percent of rural homes were without electricity in the first decades of the twentieth century (Velaga et al., 2019). Over time, growth in household energy demand drove down the average cost of delivered power. This combination of economies of scale and high barriers to entry led to the three dominant utility business models that operate in the United States today: (1) state-operated not-for-profit consumer-owned electric cooperatives, (2) local publicly run or managed utilities (POUs), and (3) investor-owned utilities (IOUs). Although there are relatively few investor-owned utilities, they tend to be very large, serving over 75 percent of utility customers nationwide.

Across the world, electric power markets operate in a variety of forms that lie on a spectrum from monopolization to democratization. The evolution of energy systems and markets around the world has been very heterogeneous. In some countries, deregulated markets were established through the restructuring of some of the existing utilities, with the intent to disrupt energy generation monopolies by increasing competition. In deregulated electric grids, electric energy, capacity, and reserves are each traded on a wholesale market, which must meet customer demands while satisfying any constraints of the transmission system (for example, line limits). Finally, in

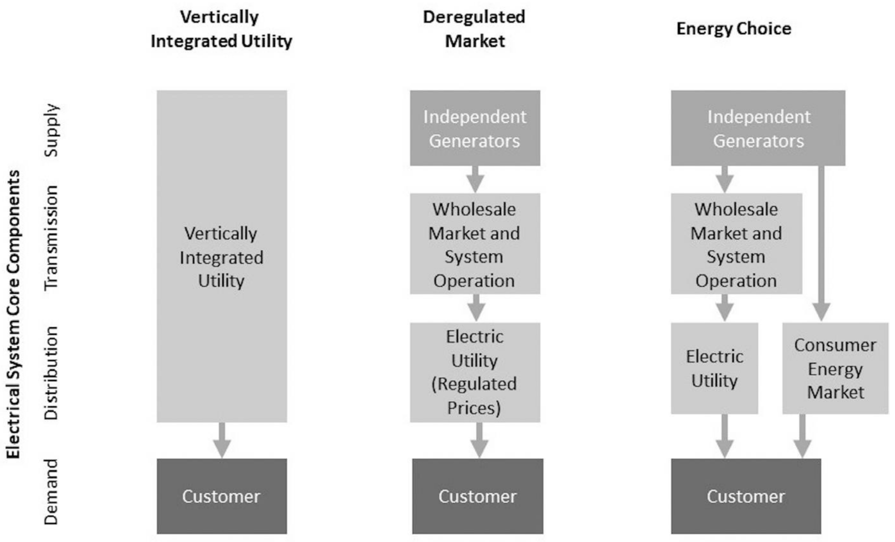

FIGURE 11.1 Three different systems for electricity generation, transmission, and distribution.

energy choice systems, energy users have the opportunity to select among multiple energy providers based on rates and energy generation options (see Figure 11.1).

In the twenty-first century there have been considerable advancements in technologies for household electricity generation with renewables. These affordable distributed generation technologies are beginning to challenge the stability of the centralized electricity system (McKenna, 2018). There is a growing embrace of distributed energy resources enabled by new information and communications technologies such as blockchain technology, which enables trusted peer-to-peer distribution; and internet-of-things (IOT) devices, which enable real-time response to changes in supply and demand. These technological changes have precipitated the rapid growth of sharing economy businesses (Hamari et al., 2016). A primary argument in favor of the sharing economy model is that collaborative effort among participating actors leads to more efficient, sustainable, and resilient outcomes than centralized decision making (for example, by utilities).

Continued global population growth and resource-intensive consumption practices have increased energy demands, contributing to the global climate crisis. In response, a growing number of consumers are beginning to look for opportunities to participate in alternatives to the current electric energy systems that promise improved efficiency, reduced fossil fuel emissions, and more local control over energy system decision making. There is tremendous disruptive potential associated with sharing economy innovations that will enable a broader group of actors to produce, transmit, store, and consume electric power with each other.

11.3 TAXONOMY OF ELECTRIC ENERGY SHARING

In this section we explore key trends in sharing of electric energy, looking at forms of sharing that have emerged based on market structures and services being provided.

At face value, electric energy may appear to be a perfectly fungible commodity that can be produced by a variety of methods, transmitted across nations, and consumed and billed through meters. In reality, electric energy markets face unique challenges compared to most other sharing economies, in that the product being traded is not discrete (compared with a ride between two points provided by a ride-hailing service or two nights in short-term rental), cannot be easily stored (generation must match consumption at every instant in time, unless expensive batteries or other storage systems are utilized), and transferring the commodity requires specialized infrastructure (for example, wires and transformers) that have limited capacity (for example, circuit breakers on distribution lines can trip if a large load overheats a transformer).

To facilitate the discussion of the sharing economy in the electricity sector, it will be helpful to classify various types of "sharing" by the market structure: Top-down, in the form of a vertically integrated utility, or bottom-up, where individuals govern the market forces. Additionally, it is important to identify what is being bought and sold in different arrangements of energy sharing: Energy (for example, kilowatt-hours), ancillary services (that is, voltage and frequency control, generator dispatch, operating reserves), storage, and/or transmission.

Figure 11.2 represents a framework and taxonomy of sharing economy approaches in the electric grid along two dimensions – market structure and services provided.

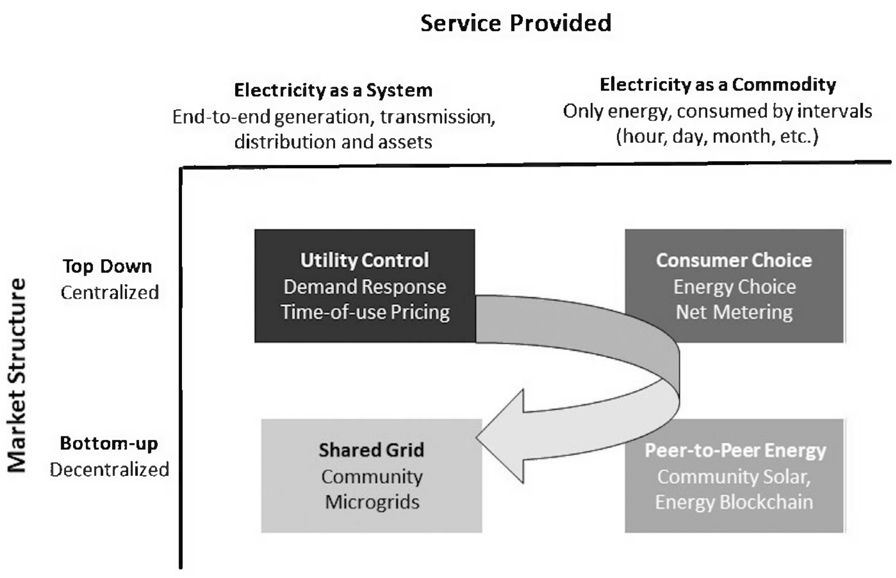

FIGURE 11.2 Taxonomy of sharing economy approaches in the electric grid.

The services encompassed by a sharing economy may only include energy, or all of the services required to operate an electricity system (including energy, voltage and frequency control, and asset management). Along the other dimension, the prices and availability of services may depend on the market structure.

In traditional *utility-control* approaches to energy sharing, consumers do not generate electricity; instead, they provide value through their flexibility to change demand. This is realized through demand response programs that ask users to modify behavior, or automatically adjust electric loads, for example, by turning off large energy loads such as air conditioners during times when the grid might overload. Similarly, time-of-use pricing enables users to shift their energy use to the times when low-cost, sometimes renewable, energy is available and can be easily transmitted to the consumer. However, such demand-side management approaches have limited capabilities since electricity demand is relatively inelastic to price.

Recent advances in regulatory structures and technology allow *consumer choice* in which consumers can choose which wholesale provider they buy their power from or generate power themselves. They then sell the excess energy (calculated over hourly, daily, or monthly periods) back to the grid through the wholesale power agreement of their distribution utility. Energy choice legislation in the form of the Energy Policy Act of 1992 enabled consumers to choose who they purchased their energy from, even specifying that only renewable energy be provided. As far back as 1983, consumers with the ability to produce electricity, primarily through rooftop solar, could share any excess, and receive the market value of that energy through net metering.

More recently, *peer-to-peer energy* sharing uses decentralized ledgers (energy blockchains, such as LO3 Energy) that track energy consumption, storage, and generation through a digital platform and enable users to choose who produces or consumes energy, and when, how and for how much the electricity is produced or consumed. The challenge in the future of the electric energy sharing economy is how to share all aspects of operations, safety, and management of the electric energy system.

Community microgrids promise to realize this future through breakthroughs in automation, machine learning, and digital platforms with both digital and physical aspects that enable sharing of distribution systems, or a fully *shared grid*. Community microgrids rely heavily not just on shared generation, including large amounts of renewables, but also on shared services through distributed energy resources (DERs). These DERs may include energy storage in parked electric vehicles, smart thermostats that run only when energy is available, and smart solar inverters that can help stabilize voltage and frequency on the shared wires. This sharing of the responsibility to balance supply and demand reduces costly peaks and transmission costs and creates a more resilient electric energy supply that can continue operating even when the larger grid suffers a blackout (Poudel & Dubey 2018).

The following sections describe in more detail these four approaches to sharing economies in electric energy systems, moving clockwise around Figure 11.2 from the status quo utility control to future shared grids.

11.4 UTILITY CONTROL – DEMAND RESPONSE AND TIME-OF-USE PRICING

Utility control describes top-down (centralized) management of grid services and reserves. In this arrangement, utilities are responsible for all grid services, including managing capacity of transmission lines and ancillary services that may include energy storage or controlling the readiness of power plants to begin producing energy to match demand.

Demand response innovations give some responsibility to energy consumers to help manage the electric grid. For example, during a time of high energy demand that might historically have led to a temporary partial shut off the grid (brownout), consumers can instead respond to signals from the energy provider and suspend operation of nonessential appliances, such as air conditioning units or pool pumps. This enables energy service to be maintained for essential functions and reduces total peak electrical load, reducing the need for costly increases in electric grid capacity. Such demand response (DR) may be fully automated with smart appliances (such as Google Nest) that adjust operation schedules based on signals from the utility or can simply take the form of utilities sending customers texts or other communications to encourage reducing energy use at specific times to avoid overloading the grid (for example, "Shave the Peak!").

Time-of-use pricing involves changing the electricity rate based on current demand, more closely reflecting real-time energy prices on the wholesale market. For example, customers might be charged a much higher rate to use energy during times of the day when aggregate demand is at its peak. This time-of-use pricing incentivizes consumers to adjust their energy consumption for more efficient operation of the grid. Time-of-use pricing enables users to shift their energy use to the times when low-cost, sometimes renewable, energy is available *and* can be easily transmitted to the consumer.

Since electricity has become an integral and necessary part of modern life, electricity demand is largely inelastic, therefore limiting the impact of pricing policies on demand (Lee and Chiu, 2011). Furthermore, price elasticity is nonlinear and asymmetric, complicating the efficient implementation of such dynamic pricing approaches (Haas and Schipper, 1998).

11.4.1 *Role of the Users*

In these examples of utility control energy sharing, innovations enable consumers to share the value of their flexibility to change aggregate demand in real time. Both demand response and time-of-use pricing can work automatically or by active participation of consumers. Consumers can potentially benefit from sharing by avoiding situations where electrical power would otherwise be interrupted and by reducing their electrical energy bill by adjusting their behavior based on signals from the utility service provider. These utility control sharing mechanisms can be a considerable benefit to customers who have the flexibility and information access necessary to vary their energy usage in response to market signals. However, since the average household spends only 2 percent of its income on electric energy, and various consumption-specific social and behavioral factors make household-level flexibility difficult, the elasticity of energy consumption is low (Drehobl and Ross, 2016; Wilson and Dowlatabadi, 2007). Further, as low-income households may spend up to 30 percent of their income on electric energy, demand response and time-of-use pricing may place an inequitable burden on the already disadvantaged if they lack technology or flexibility necessary to adjust energy usage in response to market signals (Drehobl and Ross, 2016).

11.4.2 *Role of the Platform*

For utility control of energy sharing, the utility, whether a private company, consumer-owned cooperative, or state-owned public company, functions as the platform for coordinating all sharing activities. Alternatively, demand response providers may be third-party commercial entities that aggregate the load flexibility of their customers into bids for the wholesale market. This motivates these third parties to help customers with strategies or technology to adjust their electricity consumption in response to market signals.

11.4.3 *Notable Examples*

Most US utilities offer both commercial and industrial customers options for centralized energy sharing in the form of demand response. Each of the nation's independent system operators/regional transmission organizations (ISO/RTOs) sponsor demand response programs (Department of Energy [DOE], 2019). The Federal Energy Management Program (FEMP) helps federal agencies and other organizations identify opportunities for energy project incentives and demand response programs, execute these opportunities, and fully capture their benefits (DOE, 2019). Most utilities offer time-of-use pricing options as well: These program structures include simple time-of-use rates, where prices change at set times through a 24-hour cycle to reflect afternoon peak electricity use, overnight off-peak hours, and the shoulder periods in the morning and evening hours. Other variations of time-variable pricing include real-time pricing in which customers' rates reflect the wholesale electricity market or the utility's cost of production; day-ahead hourly pricing, where the utility sets prices to reflect the cost of acquisition or production for the coming day; and block-and-index pricing, in which the customer can lock in set energy prices for part of their energy use and pay current market price for additional usage.

11.5 CONSUMER CHOICE – ENERGY CHOICE AND NET METERING

In the context of top-down (centralized) management of energy, without the complexity of real-time control of the grid, various forms of *consumer choice* energy sharing are possible on hourly, daily, or monthly timescales. These are distinct from what we have described in the previous section in that they engage the consumer in financing *distributed energy resources* (DERs), either on-site or remotely. DERs are decentralized because they rely on energy sources other than the utility to provide energy, and such sources can and often do include consumers themselves. DERs are not an innovation whose primary purpose is to manage constraints on the electrical grid. Instead, their primary benefits are to allow prosumers to buy energy from their preferred source (for example, renewables), reduce their bills through efficiency upgrades, and/or sell excess renewable energy they generate back to the grid at favorable prices.

Energy choice programs enable consumers to choose who they buy their energy from. For example, they might pay a premium for renewable electricity from wind turbines in another state. While this choice doesn't directly affect the "source of electrons" transmitted to the household user, the arrangement directly finances clean energy production. In these wholesale markets, consumers are buying from a corporate producer of energy, such as a large wind farm aggregator or financial entity specializing in trading energy.

As far back as 1983, consumers with the ability to produce electricity, primarily through rooftop solar panels, could share any excess, and receive the market value of that energy through *net metering*. In net metering, consumers have the opportunity to produce energy locally and use their energy first, selling any excess back to grid, typically averaged over the day or the month. Sometimes energy sales back to the grid are managed on a yearly basis, and very rarely on an hourly basis. These systems give consumers the option to choose renewable energy for their own consumption and reduce dependence on the utility provider, thus leading a transition toward renewable energy generation. Electricity consumers who generate their own energy on-site, sell a portion of that energy back to the grid, and store energy or otherwise control their load, are called *prosumers*. Figure 11.3 depicts a generalized scheme for how energy choice and net metering systems interface with traditional utility businesses.

11.5.1 *Role of the Users*

The act of producing energy locally and sharing it back to the grid transforms "energy consumers" to "energy prosumers." A growing body of research explores prosumers' behavior and interactions with the electrical energy system. A survey of prosumer perceptions found that prosumers are motivated to collaborate with utilities to contribute to the societal goal of creating more renewable energy (Silva et al., 2012). Information sharing and communication innovations are key to the successful management of energy sharing in prosumer engagement systems (Zafar et al., 2018). However, since

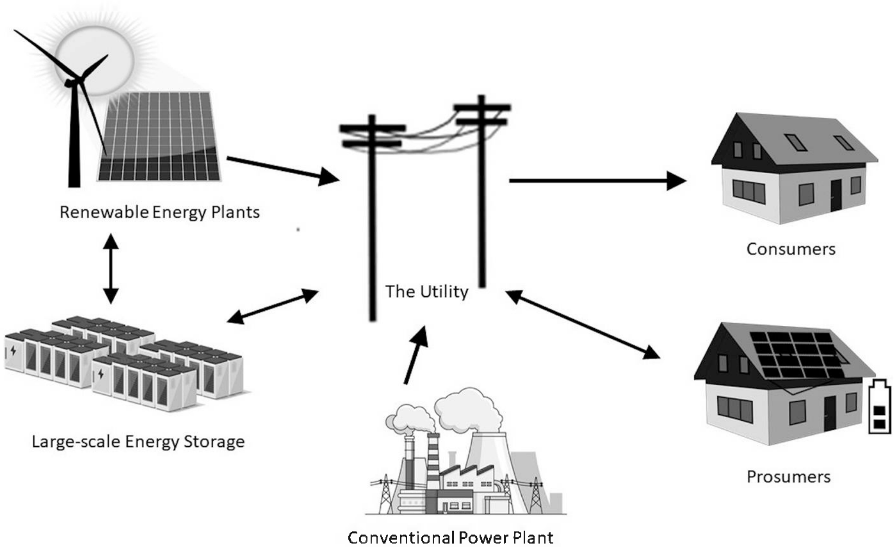

FIGURE 11.3 How energy choice and net metering systems interface with traditional utility businesses. Adapted from Potter, 2019.

prosumer systems that require the individual to own an asset (for example, rooftop solar) are in general limited to those individuals that own their home, renters and other low-income citizens find it difficult to benefit from prosumer engagement, aside from energy choice.

11.5.2 *Role of the Platform*

In the case of the prosumer systems based on energy choice markets and net metering, traditional utility companies maintain all physical hardware and assets of the energy distribution system and real-time controls, while prosumers begin increasing their share of ownership or investment in energy generation assets. Energy choice and net metering programs do not specifically address the challenge of managing the electrical load on the grid to match supply with consumer demand. A growing body of research focuses on the problem of peak shaving, that is, reducing the maximum points of electricity demand. An index termed the *sharing contribution rate* (SCR) quantifies users' contributions to energy sharing and peak shaving (Wang et al., 2019).

11.5.3 *Notable Examples*

Globally, a broad array of programs for energy choice and net metering are emerging. In the United States, over a dozen states have deregulated electricity markets, meaning that electricity providers can compete to sell energy to consumers. One example of a platform that provides individual energy consumers with the opportunity to invest in solar energy projects is Mosaic, a solar lending platform. Traditionally, only individuals with sufficient starting capital could invest in household solar panels. However, new technologies have improved the efficiency and lowered the cost of manufacturing, installing, and permitting solar energy. Solar lending companies enable consumers to become prosumers by financing their initial solar panel installation, and then collecting back the loans over time with interest as these prosumers sell energy back to the utility. New platforms have emerged to connect investors with borrowers seeking financing for solar power projects.

11.6 PEER-TO-PEER – COMMUNITY SOLAR AND BLOCKCHAIN

Recent advances in regulatory structures and technology have enabled *community solar* programs in which solar panels or other DERs are installed on shared land, while dividends for the energy produced are paid out to the community. Even more recently, *energy blockchains* have emerged, functioning as decentralized ledgers that track energy consumption, storage, and generation through a digital platform and enable energy consumers and producers to choose when, how, by whom and at what price their electricity is purchased and sold.

Community solar and blockchain-based energy sharing are examples of peer-to-peer electricity sharing that integrates decentralized management of energy systems and does not directly address the technical considerations associated with real-time control of the electrical grid. In these systems, transmission lines and distribution infrastructure are still managed by the traditional utility. Because there are substantial costs to operating the grid, such as controlling voltage and managing storage, electricity consumers in these types of peer-to-peer arrangements continue to pay utilities for use of their infrastructure (but not for the generation of electricity).

11.6.1 *Role of the Users*

When prosumers and consumers trade self-produced energy in a peer-to-peer manner, they can both profit, and this could provide incentives for different kinds of investments. Previous research indicates that compared to traditional peer-to-grid models of energy sharing, peer-to-peer electricity sharing may confer economic benefits to consumers and environmental benefits in the form of carbon footprint reduction (Secchi and Barchi, 2019).

11.6.2 *Role of the Platform*

In peer-to-peer sharing, the utility still manages (although, may not own) the physical assets to satisfy real-time needs. Recent research explores the potential for blockchain-based microgrid energy markets that do not require central intermediaries to facilitate transactions between producers and consumers, thus reducing costs associated with these traditionally labor-intensive markets.

11.6.3 *Notable Examples*

Examples of peer-to-peer sharing include community choice aggregation programs, as well as more sophisticated electricity trading platforms. One example of an electricity trading platform is Vandebron, a startup in the Netherlands that allows people to buy energy from independent producers (Vandebron, 2020). The mission of this company is to connect people who have surplus renewable energy with energy consumers who are not producing their own electricity. Utilities are not involved in the transaction. Functioning as an "Airbnb for electricity," this platform allows energy consumers to search for producers. For example, a consumer could share their information on the platform to arrange for the purchase of their power from a farmer in a neighboring community who has wind turbines or solar panels in their fields. Such business models may be easier to implement in deregulated energy markets, such as the Netherlands, in contrast to other countries and many states in the United States (Schiller, 2014).

While the case has been made that blockchains are an effective technology to decentralize the energy system, to date there are only limited examples of blockchain-based, local, peer-to-peer energy sharing operating in practice (Mengelkamp et al., 2018; Noor et al., 2018). The Brooklyn Microgrid project (BMG) is one such example (Brooklyn Microgrid, 2020). Note that this example differs from true shared grid systems described in detail later, because while consumers are able to trade and share energy with fellow consumers in the BMG project, the energy distribution infrastructure is owned and managed by a centralized utility. The network connects prosumers and consumers by enabling people to buy and sell locally generated renewable energy through a Brooklyn Microgrid mobile app, which gathers and records energy data for users. Through blockchain technology, BMG developed *Exergy*, a data platform that creates localized energy marketplaces for transacting energy across existing grid infrastructure. The BMG also acts as an educational and community engagement initiative: For example, the organization facilitates workshops in partnership with public schools in New York City to teach community members about the technology behind electric microgrid systems and encourage broader participation in energy sharing.

11.7 SHARED GRID – COMMUNITY MICROGRIDS

When shared ownership of electricity generation infrastructure is combined with shared ownership of distribution and energy management infrastructure, these systems can be classified as a *shared grid*. Shared grid systems are characterized by decentralized management of real-time energy generation and advanced grid controls, made possible by breakthroughs in automation and machine learning. They promise improved physical reliability and resilience to cyber threats, opportunities to improve energy system sustainability, reduce reliance on fossil fuels, and improved economic efficiency. These innovations help scale and reduce the costs associated with the hundreds of people required to run a regional grid, to a handful of contractors to operate a microgrid.

Community microgrids rely heavily not just on shared generation or renewable energy, but also on shared grid management services provided by distributed energy resources (DERs). These DERs may include energy storage in a parked electric vehicle, smart thermostats that run only when energy is available, and smart solar inverters that can help stabilize voltage and frequency on the shared wires. Thus, DERs represent a pathway for sharing the responsibility to balance supply and demand among all participants in the system. When integrated into a community microgrid system, these technologies have the potential to reduce costly peaks in energy demand as well as transmission costs. Many researchers also argue that community microgrids are a viable solution for more resilient local electric energy systems that can continue operating even in instances when the larger national or regional electric grid suffers a blackout (Jiménez-Estévez et al., 2017; Marnay et al., 2015; Wu et al., 2016).

11.7.1 *Role of the Users*

In a shared grid system, all users contribute to the cost of grid management. There are various ways that such cost sharing might be structured in real-world shared grid systems. For example, third-party platforms, decentralized algorithms, and/or self-governed user decisions can determine how the resources are managed.

11.7.2 *Role of the Platform*

In shared grid systems, the role of a traditional utility significantly diminishes. When energy generation, assets, and management of the grid are controlled by third-party platforms and decentralized algorithms that integrate a system of DERs, electrical energy systems can potentially function without any involvement of a centralized utility. A market of third-party platforms may even operate simultaneously in the same way that Uber and Lyft both operate in the same city. This future vision for shared grid systems requires, however, new technologies for information sharing between users in the system. For example, the algorithms needed to control millions of household-scale renewable energy generators and the load at millions of homes is very different than the algorithms that control load and generation in the traditional centralized generation system.

In addition to developing information sharing technologies to facilitate operation of shared grid systems, some scholars regard resource optimization technologies to be critical for continued innovation of smart grids. For example, Zafar et al. (2018) discuss linear and nonlinear optimization programming in the context of prosumer-based energy management and sharing. Other researchers present the optimization technique in a two-stage approach. For instance, Cui et al. (2019) argue that the bi-level optimization problem could be transformed into a single-level mix integer linear programming problem through proper linearization techniques. In the second stage, an online optimization model is proposed for each prosumer to make the energy schedule according to the latest system situation and prediction error (Cui et al., 2019). Alternatively, Long et al. (2018) present a nonlinear programming optimization in the first stage with a rule-based control to update the control set-points through real-time measurement in the second stage.

11.7.3 *Notable Examples: Community Microgrids*

To date, most examples of shared energy generation and grid management can be found in institutional microgrids. The best examples of shared grid systems can be found at US military bases, where there are systems in place for coordinated management to govern when and how system users produce and consume energy (Hossain et al., 2014; Prehoda et al., 2017). Shared grid examples also exist in hospitals and corporate landscapes. For example, East Boston has a microgrid network made up of institutions that share renewable electricity generation and backup generators among the buildings (Sheehan, 2015).

Looking ahead toward the possibility of more shared grid systems being implemented throughout the US and globally, there is considerable potential for increased production of renewable energy and efficient management of supply and demand enabled by DERs and algorithms for real-time grid management. However, while these innovations suggest potential benefits of the sharing economy for the electric energy sector, there are important access and equity considerations to be addressed. In a future where corporations and wealthy neighborhoods shift toward community microgrids, less wealthy and powerful energy consumers could suffer negative consequences. If a subset of energy consumers invests in their own microgrid's reliable distribution and generation infrastructure, they are no longer effectively investing in the reliability and efficiency of the whole electrical energy system. Such a trend in consumer behavior would effectively create islands of energy resilience in a sea of energy vulnerability.

11.8 POLICY CONSIDERATIONS

In the future, in much the same way that sharing economy platforms such as Airbnb have simplified the process of contracting with an independent short-term lodging provider, electricity sharing has the potential to radically change how electricity consumers interact and behave. Indications of the future impacts can already be observed in the form of smart devices such as thermostats, operated by third-party platforms, that optimize their demand based upon real-time energy markets.

In earlier chapters, authors have discussed how the rise of the sharing economy in some sectors may increase consumption without improving sustainability. However, in the case of energy sharing, we anticipate a different trajectory that does not lead to increased consumption of fossil fuels. In part, this is because energy sharing is connected with a larger transformation toward renewable energy and a reduced carbon footprint.

The other benefits of *utility control, consumer choice,* and *peer-to-peer energy* system innovations primarily involve the reduced cost of energy generation and delivery. These reduced costs and impacts could theoretically result in an increase in energy consumption, but due to the price inelasticity mentioned earlier, we do not expect energy sharing to significantly impact energy consumption rates. That is, while reducing the price of lodging (for example, with the growth of Airbnb) may lead to more travel, energy consumption is unlikely to increase appreciably as the cost of energy goes down, particularly in developed economies (US Energy Information Administration, 2021). Any future increases in electricity consumption will instead likely be driven by increased adoption of electric vehicles and heat pumps as opposed to the specific influence of the sharing economy on energy. Finally, even with the rise of smart metering, demand response, and time-of-use pricing, there is relatively limited transparency in energy pricing. For example, the average consumer will most likely not be aware of the cost of running their dishwasher. This is due to the traditional monthly electricity billing cycle, temporally separating the saliency of the energy costs from the energy consumption occasions. New real-time IoT devices bring the potential to better synchronize consumption and costs; however, care must be taken to not overload users with too much information in real-time.

The potential societal benefits of a transition toward peer-to-peer and shared grid energy systems include improved efficiency, an increased share of renewable energy production, and more consumer engagement. In addition, these new mechanisms for local control and management provide individuals, households, and communities with more economic and political power as well as electrical power. Thus, increased energy sharing can be understood as a pathway toward realizing the goals of the energy democracy movement. Originating from trade union activism, energy democracy focuses on restructuring the political, economic, and social makeup of the energy system by transitioning to renewables while establishing democratic energy decision-making processes, equitable access to energy and energy-ownership for marginalized groups, and widely distributed and renewable energy resources (Sweeney 2012; Burke and Stephens 2018).

However, while sharing economy innovations enable consumers to have more say in where and how their electricity is produced, there are possible negative consequences associated with a transition to a shared grid and associated "energy democratization" (Stephens et al 2015). Increased development of community microgrid systems could potentially lead to greater inequality in access to reliable and affordable electric energy. The traditional electric grid doesn't just provide electric energy, it provides electric energy *reliability*. That reliability is critical to economic productivity and, in some cases, social wellbeing. If the transformation underway in the electric energy sector does in fact represent a death spiral of the utility business model, the result could be that only wealthy energy consumers could afford to have reliable community microgrids, and fewer resources would go toward maintaining the grid. This could lead to a decrease in energy reliability for consumers who do not have access or cannot afford to participate in microgrid systems. One possible solution would be to increase public investment in shared grids for communities who may not otherwise have access to emerging energy sharing systems. This may in practice resemble the move in recent decades toward public–private partnerships that support charter schools in low-income communities (Koirala et al., 2016).

Another way that energy sharing is tied to disruption and transformation in the electric energy sector is through altering the geographic distribution of energy generation sites (Stephens 2019). Historically, power generation occurred near coal reserves or at hydroelectric facilities. With increased local solar- and wind-powered electricity generation, preferred sites for power generation are changing and power lines built for transmission over long distances are no longer optimally placed, leading to increased potential for congestion. However, building new transmission lines is exceedingly expensive. There is a market opportunity to invest in reducing energy consumption demand. For example, it is cheaper to give away smart thermostats and selectively adjust them automatically during peak demand times than it is to build a new transmission line. This example points to just one of the ways that new technologies and changing social and economic priorities may transform the electrical energy sector.

11.9 CONCLUSIONS

As the pace of transformation in electrical energy generation and distribution systems continues to accelerate, the possibilities for innovative ways to "share" electricity are rapidly evolving. This chapter has reviewed this dynamic landscape and provided a taxonomy to characterize different modes of energy sharing. There is a transition underway away from legacy systems with high levels of utility control and toward new opportunities for prosumer engagement, peer-to-peer sharing, and ultimately in the direction of fully integrated sharing of all aspects of electricity generation and grid management. In this transition from utility control, to prosumer engagement, to peer-to-peer sharing, toward a decentralized market structure and integrated end-to-end management energy and assets, we recognize a possible end of the traditional utility business model. As third-party platforms for energy sharing and technologies enabling local renewable energy generation, storage, and supply and demand management systems emerge, we anticipate that the traditional integrated power supply and grid management roles of utilities may shrink across many regions.

In addition to a rise in prosumers, who are both energy users and energy generators, future energy sharing could also lead to a growing number of passive electricity consumers who are integrated into community microgrids. We anticipate that prosumers, currently primarily homeowners who own private renewable energy generation infrastructure, will increasingly be outnumbered by energy consumers whose energy purchasing decisions are regulated by smart devices. For example, a customer who wants to charge their electric vehicle at their home will have their default charging algorithm set to only charge when electricity is most readily available or cheapest.

Previous research on energy sharing has focused on technological innovation and prosumer behavior, including both empirical case studies and theoretical analyses. This research provides a valuable foundation for future studies. There is a need for more research on policy mechanisms to promote and regulate sharing in real-world energy systems. Barriers to redesigning the current energy system include current regulations and policies, public awareness and acceptance of new technologies, and established corporations' resistance to change, which can lead to manipulation of markets and disinformation campaigns that question the legitimacy and reliability of alternative energy systems. There is also need for more social science research on how sharing could contribute to more inclusive energy systems including opening up opportunities for women, people of color, and indigenous people who have been historically excluded from energy sector jobs and economic empowerment through energy systems (Allen et al., 2019).

Government and regulatory bodies have an important role to play in facilitating a transition to increased electrical energy sharing. Policy makers could, for example, establish incentive programs in the form of subsidies for new energy sharing enterprises entering the market, and punitive measures such as a carbon tax or pollution charges for fossil fuel-based energy systems. By enacting policy measures such as these and providing an environment that supports fair competition, government regulatory bodies can facilitate increased energy sharing systems that balance the goals of energy efficiency, sustainability, resilience, and equity.

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12

Shared Last Mile Delivery

Current Trends and Future Opportunities

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12.1 INTRODUCTION

Last mile delivery is the movement of products from a warehouse or store to their final delivery points, most commonly residential locations. One of the largest and growing components of last mile delivery operations is parcel delivery. The total volume of the parcel delivery market in the United States was 14.8 billion packages in 2018 [1], with the United Parcel Service (UPS) having the largest market share at 5.2 billion shipped packages [2].

E-commerce is a major contributor to the global parcel delivery market and is one of the fastest growing business sectors in the world. Retail e-commerce revenue is expected to rise to $6.5 trillion in the world and to $565 billion in the United States by 2023 [3, 4]. The number of packages shipped increases along with revenue growth. Amazon alone, which accounts for about 49 percent of all e-commerce in the United States [5], shipped more than 5 billion items to its Prime customers in 2017 [6] and delivered more than 3.5 billion packages through its own delivery network in 2019, almost half of its total number of shipped packages [2]. The size of the last mile delivery market increases rapidly as the share of e-commerce in the whole retail industry continues to grow and new contributors to last mile logistics activities, such as food and grocery deliveries, that rely on the same last mile infrastructure emerge. It is thus a vital matter for many businesses to manage last mile operations efficiently.

Last mile delivery related costs are estimated to reach up to 53 percent of total delivery costs [7]. There are several factors that make last mile delivery operations challenging and more expensive than the other parts of the delivery journey. One factor is that last mile delivery generally takes place within urban areas where the speed limit is lower and there is more traffic congestion. Hence more vehicles are required to deliver parcels by their due time. Furthermore, while multiple and cheaper transportation modes, such as those using railroads and waterways, are usually available for intercity logistics, mostly the only available mode for last mile delivery in an urban area is road transportation.

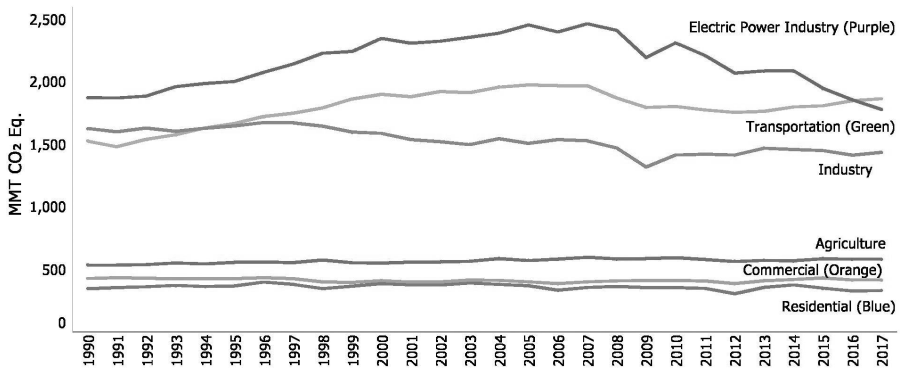

FIGURE 12.1 U.S. greenhouse gas emissions allocated to economic sectors ($MMT\ CO_2$ Eq.) [9].

Meanwhile, the size and number of urban areas also keep growing. By 2030 the number of megacities, which are cities with a population of 10 million or more, is expected to rise to 41 [8]. High population density in cities leads to increased transportation activity and high emissions, as more people and packages travel. In 2017, the transportation sector was the largest contributor to greenhouse gas emissions production by generating 28.9 percent of greenhouse gas emissions in the United States [9]; Figure 12.1 compares sectors with high emissions.

In general, objectives regarding increasing efficiency and reducing negative externalities may contradict each other. Furthermore, unexpected externalities, such as due to changing consumer behavior, may result from policy and/or operational changes leading to outcomes that are the exact opposites of the originally intended ones. For example, traffic congestion and emissions, two negative externalities of last mile delivery, are among the major concerns of city administrations, because they reduce residents' quality of life. Shared last mile delivery attempts to make the logistics operations in urban areas more efficient and also is thought to have the potential to reduce negative externalities such as emissions by reducing the number of vehicles in traffic and by converting deliveries performed by trucks to crowdsourced cars since cars produce less emissions than trucks. However detailed analysis of some of these sharing-based last mile logistics systems have shown that opposite impacts might occur under certain city and service system characteristics. It is observed that in a subset of last mile logistics systems using crowdsourced drivers increases congestion and emissions because the small carriage capacity of cars ends up increasing the number of vehicles required and the deadheaded distance to deliver all packages [10]. Therefore, these systems and the characteristics of the environment they exist in must be analyzed comprehensively and designed and operationalized in a way that creates a win-win-win outcome for businesses, customers, and the society.

There are different applications of crowdsourcing and sharing economy practices in last mile delivery. Since they differ from conventional business models they introduce new system characteristics to be considered in both practice and research. In this chapter, we briefly introduce the existing and potential sharing economy business models in last mile delivery, and discuss the aspects that distinguish them and make their operations more complex to manage.

12.1.1 *History of E-Commerce*

Home shopping existed before the Internet was widely used by the public. People could buy products via phone calls. They could choose a product they saw in catalogs or TV or newspaper advertisements and order it by calling the number given. In 1994, around 98 million consumers made $60 billion worth of home shopping purchases, and almost all of the purchases was ordered through phone calls [11].

The history of e-commerce transactions and online bookstores goes back to as early as 1991 and 1992 when Computer Literacy Bookstores and Book Stacks Unlimited started selling books online through email and their websites [12]. The first item sold online through a secure and encrypted system using a credit card was made possible by Dan Kohn, a 21-year-old entrepreneur. It was the compact disc "Ten Summoners' Tales" by the rock musician Sting and was sold through the website of Net Market Company of Nashua [13]. The transaction took place on August 11, 1994, and it was important enough to be featured in the *New York Times* the next day [14]. In 1995, Amazon started as an online bookstore [15] and eBay (starting as AuctionWeb) was established as an online auction and shopping website [16].

Since 1995, many online shopping websites have opened. The revenue from e-commerce continues to grow as the number of people who use the Internet grows as shown in Figures 12.2(a) and 12.2(b). The only period e-commerce retail revenue did not grow significantly was 2008–2009 due to the 2008 financial crisis (see the GDP growth in Figure 12.2(c)). It is clear, by comparison of Figures 12.2(a) and 12.2(c), that even a recession could not bring a sustained halt to the growth of e-commerce sales; in fact, in terms of percentage of total US retail, online retail grew during the recession [17].

12.1.2 *History of Algorithmic Research for Optimizing Last Mile Delivery Operations*

One of the earliest challenges of last mile delivery operations was faced by traveling salesmen, as they had to determine the order of visitation of potential customers' homes or towns, often taking into account the products that they carried and the expected demand at each location. Peddlers have existed for more than 2000 years [21]. After loading products, such as toiletries, clothing, and accessories, on their pack animals, or in vehicles in recent times, they travelled in one trip to several towns and villages to sell them. Both for the peddlers and the modern travelling salesman, efficiency often is equal to minimizing the cost of travel, which usually

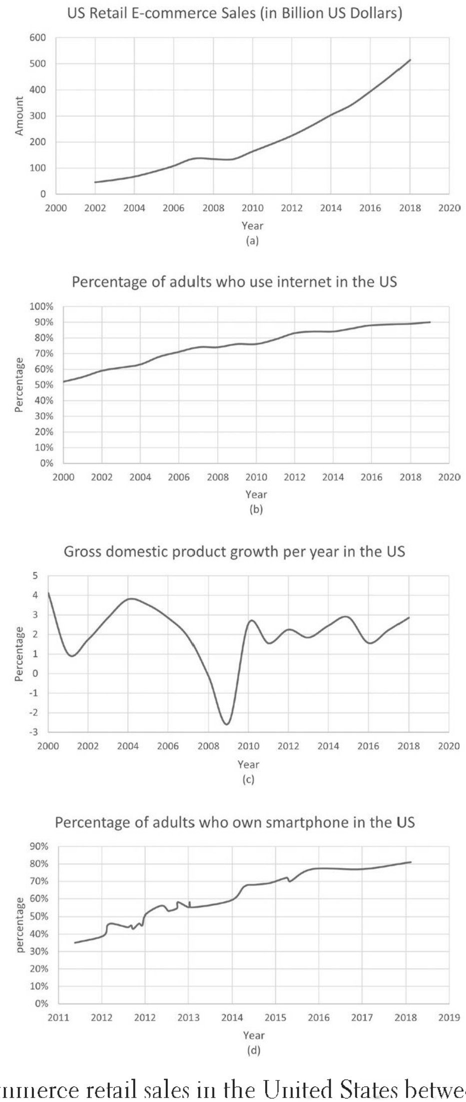

FIGURE 12.2 (a) E-commerce retail sales in the United States between 2002 and 2018 [17], (b) percentage of adults who use the Internet in the United States between 2000 and 2018 [18], (c) GDP growth in the United States between 2000 and 2018 [19], and (d) the number of mobile device owners in the United States between 2012 and 2018 [20] (d)

incorporates multiple components, such as energy and vehicle depreciation costs that are all a function of the total distance travelled.

The famous Traveling Salesman Problem (TSP) aims to optimize a traveling salesman's route. The objective of TSP is to find the sequence of customers or towns to be visited which has the minimum travel cost. The sequence must begin and end at the same location and each location must be visited exactly once. The earliest known mention of the problem is in a handbook titled "The Traveling Salesman – how he should be and what he has to do to get orders and be sure of happy success in his business" published in 1832 [22]. The first known work on the problem by a mathematician goes back to Menger's work in 1930 [23], after which the attention of many mathematicians was drawn to the problem [24], especially after the 1954 seminal work of Dantzig, Fulkerson, and Johnson [25], as discussed in [26–31]. Many variations of the problem have also been developed [32]. Nowadays, TSP is a well-studied problem among researchers and continues to attract the energies of both mathematicians and practitioners alike due to its complex and interesting theoretical nature and its applicability in a wide variety of real-world problems. The methods developed to solve TSP are the fundamental methods for solving many combinatorial optimization problems that aim to find the optimal solution in a countable set of solutions.

TSP was later generalized into the Vehicle Routing Problem (VRP), which first appeared in a paper by Dantzig and Ramser in 1959 [33] and is the most common form of modeling last mile delivery optimization problems. The objective of the VRP is to find the minimum cost assignment of orders to a fleet of homogeneous vehicles and delivery routes for each vehicle starting from the depot and ending at the depot. Since 1959, an immensely rich literature has been established for VRP models and the development of exact, approximation, and heuristic algorithms to solve them (see [34–41] for some of the early major works).

Many variants of VRP have been introduced over the years (see [42] for a detailed history) to reflect the changing and complex characteristics of real-world delivery operations. The most important VRP variants are obtained by changing or relaxing some of the assumptions such as considering multiple depots, a heterogeneous fleet of vehicles, allowing both pickup and delivery at the destination locations, adding time-dependent costs, or removing the requirement for a vehicle to return to the depot. Furthermore, new constraints such as delivery (or pickup) time windows and load-balancing for all vehicles can be added to the problem. Finally, one can use different objective functions, such as minimizing fuel costs, minimizing emissions, and a combination of different goals to produce variants of the VRP. Mostly, these new variants of the VRP are proposed and then studied by researchers as a result of novel needs emerging from the markets by the development of new technologies or changing customer requests. For example, time windows, which are the time frame when a pickup or delivery operation must take place, are important in same day delivery; in crowdsourced delivery models, heterogenous vehicles must be considered, as drivers may have different cars; and time-dependent costs are common in urban mobility where the time to travel from one point to another point may drastically change depending on the time of day.

12.2 SHARING ECONOMY MODELS IN LAST MILE DELIVERY

Digital platforms enable the interaction among different participants who supply or demand a set of services or products. Generally, sharing platforms themselves do not offer the services or products, but only match the available supply and demand. Matching as a service has been around for more than three millennia [43]. However, large scale and rapid matching of supply and demand became available with the pervasiveness of the Internet and smartphones. The Internet enabled the exponential growth of digital platform economy businesses, since it lowered the entry barrier by not requiring a large-scale initial investment in hard assets. Especially after the 2008 financial crisis, a wide variety of online platforms started services such as DoorDash, Uber, TaskRabbit, and AirBnB. The growth of online platforms was also accelerated as smartphones became widespread and the development of mobile technologies and applications accelerated (Figure 12.2d).

Currently in shared last mile delivery, many businesses operate with different sharing models. In the following, we categorize different business models that currently exist or are being discussed as options for the near future.

12.2.1 *Crowdsourced Delivery*

Crowdsourced delivery platforms do not perform shipments with their own dedicated vehicle fleets or professional drivers. Individual drivers join these platforms as independent contractors, commonly after a security background check, and deliver the packages to customers using their own vehicles. In many platforms, crowdsourced drivers have different levels of flexibility in choosing when to start and stop working.

The landscape of last mile delivery platforms evolved over time. Different platforms, past and present, such as Deliv, GoShare, Instacart, GrubHub, and Postmates, provide last mile delivery using crowdsourced drivers for different types of products such as parcels, groceries, and meals. Furthermore, while some platforms focus on delivery of one type of product, others deliver multiple types. The type of product delivered impacts the constraints of service. For example, some groceries must be carried in cold boxes to prevent spoilage and must be delivered rapidly, while parcel delivery may have a longer delivery time period and can be heavier or bulkier.

Sharing economy delivery platforms also differ in terms of how they match delivery orders and drivers. Some platforms post the delivery orders with origin, destination, and earnings information. Drivers login to these platforms, check the posted orders, and can select the orders that they would like to complete. Other platforms perform the matching themselves given the availability of the drivers and time windows of the orders. They assign the orders to drivers so as to maximize the platform's profit. Afterwards, drivers can choose to accept the order or refuse it. Furthermore, some of these platforms only make the assignment and leave the delivery sequence up to drivers, while others generate efficient delivery routes and ask drivers to follow these routes. All of these supply–demand matching strategies, complemented with different pricing mechanisms, create digital marketplaces with different characteristics and externalities.

It is commonly believed that crowdsourced drivers provide greater flexibility for delivery companies compared to a dedicated fleet of vehicles, because the driver pool can be adjusted to meet service demand dynamically and with lower costs. However, since crowdsourced drivers are currently not full-time employees, they usually are less stable and predictable, which introduces a high level of uncertainty in workforce and capacity planning. Additionally, crowdsourced driver performance is generally observed to be worse compared to delivery employees of the platform, as the latter have more experience with the business and its customers.[1] Reputation[2] mechanisms and other incentives are designed to encourage crowdsourced drivers to display more stable behavior and deliver services with an eye towards higher customer satisfaction.

From an optimization perspective, the crowdsourced delivery problem builds upon the rich body of VRP literature; see [44] for an overview. In addition, recent studies have focused on the optimization of crowdsourced delivery systems, the challenge of finding the right balance with respect to the above-mentioned criteria, and the design of appropriate incentives [45, 46–48]. However, many questions related to market design and comprehensive optimization of crowdsourced delivery platforms, including externalities, still remain open.

12.2.2 *Shared Urban Distribution Centers*

Urban distribution centers are facilities that are designed and built close to city centers to efficiently handle warehousing operations, such as loading and unloading trucks and sorting packages, as well as cross-docking operations. Their objective is to reduce last mile delivery mileage and fuel consumption and benefit from economies of scale by pooling deliveries into larger vehicles at the urban distribution centers. While it is generally believed that delivery operations using urban distribution centers benefit both delivery companies by reducing their costs and the general public by reducing pollution and traffic congestion, comprehensive analyses of these systems sometimes point to a net negative impact depending on the characteristics of the demand and the urban area.[3]

In operational models that use a *shared* urban distribution center, larger trucks bring packages from different companies' warehouses to an urban distribution center. After sorting the packages according to their destinations, packages are loaded to usually smaller vehicles and delivered to customers. At this stage, as an additional benefit of shared distribution centers, orders from multiple companies can be delivered by the same vehicle. Urban distribution centers have multiple docks to load and unload the delivery trucks which reduces the truck queue as the operations can

1 Also see Chapter 6.
2 Also see Chapter 5.
3 Also see Chapter 3.

be completed in parallel. Also, these docks complete loading and unloading operations faster than most brick-and-mortar stores, as they are designed for this purpose.

Furthermore, sharing might occur at different levels among companies in the urban distribution centers. They can share only the floor of the building which would increase the space utilization and could reduce the energy consumption, as heating, air conditioning, and lighting could be achieved more efficiently. The participating companies can also share some or all of the operations mentioned earlier. This would further increase the benefits, as the idleness of the shared machinery and equipment would be reduced. Additionally, a collaboration could be formed among the delivery companies, so that the deliveries of different companies could be pooled together, and better routes could be formed in terms of cost efficiency, traffic congestion, and emission production.

On the other hand, convincing e-commerce and/or delivery companies to participate in an urban distribution center is a challenge. The competition among these companies may prevent them from joining a collaborative system. They must be assured that benefits will be greater than costs. Several related problems regarding stable sharing of distribution centers, such as costing, space allocation, and delivery scheduling are discussed in [49–51].

12.2.3 *Pickup Lockers*

Pickup lockers are secure delivery locations similar to post office (PO) boxes. Generally, however PO boxes are rented for a long time period, whereas lockers are assigned to deliveries for a short time, mostly up to a few days. For this reason, lockers are typically shared by customers. Companies, such as GoLocker, Neopost, and Amazon Locker, currently utilize pickup or product return lockers in their last mile delivery operations.

To use locker delivery service, a customer would choose a pickup location as the delivery address. The delivery company ships the package to this pickup location. When the package is placed into a locker, the customer receives a one-time passcode that is used to open the locker which contains the order. After the customer picks up the packages, the locker is assigned to other deliveries.

Pickup lockers provide benefits for both delivery companies and customers. For customers, a locker station is a secure place to receive their packages in case they do not have a safe area, such as a lobby, in their building. Also, customers do not have to wait at home for delivery since they can pick up their packages from the locker anytime they want. For delivery companies, the locker delivery may reduce costs, since multiple deliveries are expected to be consolidated if their destination is the same locker location. Additionally, drivers avoid delivery problems, such as a wrong address, since the lockers are at known locations.

Pickup locker stations must be designed so that they are an attractive option for consumers. For example, the station must be user friendly and close to areas that customers visit frequently. Additionally, incentivizing customers, for example by providing discounts to encourage consumers to use the service, may increase both the cost and environmental benefits. Designing incentive schemes that consider several factors, such as demand and geographical area characteristics, for each customer dynamically may amplify these benefits. Hence system-wide analysis of all benefits and costs for these shared locker model must be made carefully to inform its design and operations. Comparatively, this area in last mile delivery systems has been studied less completely (see, for example, [52–54]).

12.2.4 *Autonomous Vehicles*

Autonomous vehicles (AVs) including self-driving cars, automated guided vehicles (AGVs), and unmanned aerial vehicles (drones) may release a big potential in last mile delivery operations. There are several AV brands that are working to produce autonomous vehicles that can follow a given route without human input along the way or be guided by an operator in a semi-automated manner. Currently no AVs are fully autonomous, because such vehicles still require human supervision to prevent accidents when unexpected events occur.

Development and commercial availability of fully autonomous vehicles in the future will open up the possibility for owners of AVs both to make personal use of them and share them with delivery companies. A future scenario could include people going to work with their AVs and then, while they are at work, allowing those AVs to be used by last mile delivery platforms. In a more advanced scenario, AVs could communicate and choose their paths so that traffic congestion could be reduced. Such future sharing of AVs can significantly reduce the idle hours of vehicles sitting in parking lots, while also benefiting the public and environment, as fewer vehicles would be required to achieve both urban mobility and freight transport.

Similar to AV sharing, and in the much nearer future, drones could be shared between their owners and delivery companies. When owners are not using their drones, they can lend them to make deliveries. Currently, one of the limitations of personal drones is their small size, which constrains delivery capacity and allows only small parcels to delivered. Also, personal drones currently have batteries that are much smaller compared to commercial drones, thus reducing their delivery radius. This poses a significant problem especially in cities with tall buildings, where drones cannot fly in a straight line.

Autonomous vehicles can transport packages between locations, but a system to load and unload packages to and from AVs is also required in a last mile logistics operation. An automated system to handle loading to different brands of vehicles, as might be the case in a shared AV system, might be hard to develop in the near future. Additionally, customers might need to be present for delivery, as there will be no one to pick up a package from the AV and deliver it to them. A customer picking up a wrong package can cause significant problems. Therefore, the safest approach currently could be distributing packages one at a time on an AV, which would increase inefficiency and potentially the resulting energy use and pollution of the operations. Incorporating both system optimality and energy usage in operational models may help mitigate the side effects of using autonomous vehicles (see [55].

12.2.5 *Public Transportation for Package Delivery*

In most cities public transportation network capacities are designed to handle a significant portion of the rush hour commuter needs. However, this causes the public transportation network to have a high idle capacity during long stretches of the day. This idle capacity during low volume hours could be used for last mile delivery, which in turn would reduce the number of vehicles in traffic, especially in the most congested parts of the cities. For example, instead of sending additional vehicles to downtown areas to pick up or deliver packages, last mile delivery operations could utilize the existing public transportation networks in similar ways as described in several studies [56–59]. Synergistic usage of public transport for package delivery could also produce extra revenue for the public transportation authority of an urban area, which in turn can be invested in infrastructure, benefitting the general population.

Public transportation vehicles, such as buses, trams and subways, are designed to carry people and not packages. To use them to deliver packages, operational strategies must be developed and required tools must be deployed at the stops for loading and unloading operations. This would require a high initial installation cost. Furthermore, loading and unloading operations would increase time spent at stops, thereby extending travel times. A small tail car designated for carrying packages that can be automatically and quickly removed and replaced at specific stations is a possibility for carrying packages in and out of highly congested areas using public transportation. Additionally, not all customers might be willing to come to pick up their orders. Therefore, a system to distribute packages from the stops to customers' houses could complement such a system. An alternative approach, that may be ideal for certain types of customers and packages, could be to combine public transport of packages with delivery lockers at metro stations. This way customers could pick up their packages at their local stations, perhaps at the end of the day on their way home.

12.3 SHARING ECONOMY PLATFORMS VS. CONVENTIONAL BUSINESS MODELS

Sharing platforms and conventional last mile delivery businesses differ in several ways, including workforce, competition, structure of their corresponding markets, and the externalities that may arise as a result of their operations. In this section we discuss these differences.

12.3.1 *Workforce*

Conventional delivery companies have dedicated and professional drivers to deliver packages. Since these drivers are traditionally also full-time employees, they have certain benefits which may include health insurance, paid sick leave, and retirement plans. In crowdsourced delivery businesses, generally drivers do not have such benefits, as they are categorized as independent contractors and not as employees, which continues to be a subject of many heated debates and regulatory initiatives from a labor perspective [60].[4]

From an operational perspective, although professional drivers have responsibilities regarding the use of the instruments and vehicles given to them, their employers take care of the cost and planning of insurance and maintenance of these instruments and vehicles. However, crowdsourced drivers have to manage these issues because they use their own equipment and vehicles.

Furthermore, traditional delivery companies have well-established procedures for making deliveries. The decisions on package sorting, loading, and delivery routing are mostly made by specialized professionals or software packages following established procedures. In these traditional business models, drivers have little freedom or flexibility on how to perform these operational processes. Their work shifts may also not be as flexible. In contrast, crowdsourced drivers working as independent contractors are thought to have more freedom of choice on these operational issues. Depending on the platform, they can decide when to work, which deliveries to accept, and how to route their journey. While there appears to be more freedom for an independent contractor, in many situations these drivers' actions are also restricted through rules or incentive mechanisms. For example, drivers might be held responsible for late or missed deliveries if they occur because of drivers' actions. In some cases, the flexibilities given to crowdsourced drivers are increasing as platform companies are reacting to recent regulatory efforts and trying to fortify the often-blurred boundary between the definition of a worker and an independent contractor [61].

In traditional delivery companies, the fluctuation in the workforce on a given day is very limited, as drivers must inform their employers in advance if they cannot work on a day and this does not occur frequently. As a result, the delivery capacity on a given day is known in advance, which allows for better operational planning of deliveries. However, crowdsourced drivers may choose not to work and do not even have to inform the company in advance. These conditions create a high degree of uncertainty, which leads to higher operational costs.

12.3.2 *Competition*

Traditional businesses mostly compete with others in the same business sector. For example, parcel delivery companies compete with other parcel delivery businesses

[4] Also see Chapter 6.

and not with taxi companies. However, crowdsourced last mile delivery companies must compete with crowdsourced urban mobility companies as well as other crowdsourced delivery companies, because drivers can choose to work for any of these businesses as independent contractors. Drivers can check multiple platforms at the same time while sitting in their cars and pick the offer with the best payment and/or work conditions from all the platforms they have joined. Drivers can simply switch from a parcel delivery platform to a ride-sharing platform as soon as they complete an order.

Although payment is an important factor for drivers in choosing among platforms, there are other factors to be considered. A driver might be indifferent to small changes in earnings depending on other features of the platforms. For example, if a driver prefers to socialize while driving, it is more likely that they will choose a mobility platform even though a delivery platform might be offering higher earnings. Level of freedom of choice (orders being assigned by the platform vs ability to choose orders), pressure from the platform (receiving frequent calls/texts to induce fast delivery), and incentives offered by the platform are among possible factors that might impact drivers' decisions.

The factors that impact drivers' choice of platform and their performance must be explored. These factors are important as they impact the loyalty of a driver to a platform and their dedication to providing quality service to the customers of the platform. Additionally, incentive schemes for the drivers can be developed. The incentives can be customized for each driver according to their individual preferences. Individualized incentives can improve drivers' job performance and happiness.

Most platforms do not offer employment benefits to crowdsourced drivers. However, recently Deliv started to offer full time benefits, such as retirement plans and health coverage, to its drivers in California [62]. While this decision by Deliv was taken partly in anticipation of CA AB5 regulation [60], Deliv also believed that converting to a full-time employee model might improve service quality and reduce operational costs as well as attract and keep high-performing drivers since offering these benefits provides a bargaining leverage for drivers against other platforms. In a similar recent move, Uber announced that it will consider paying healthcare benefits to workers proportionate to the number of hours they work [63].

Alternatively, multiple platforms might collaborate instead of competing with each other. For example, a mobility and a delivery platform can collaborate to share their driver pool, and the platform with low demand can transfer some of its drivers to the other one with high demand. However, formation of such collaborations must be regulated and watched carefully in order to prevent the emergence of monopolies or trusts and to ensure drivers are not harmed as a result.

12.3.3 *Market Structure*

In order to survive in the harshly competitive environment, platforms need to have a certain level of demand and supply in their systems and a continuous dynamic balance between the two must be kept. Dynamic matching of supply and demand in sharing platforms has been a very active research area in recent years [45, 64–66]. For crowdsourced delivery platforms, if there are not enough drivers at any given time, the orders in the systems will end up not being delivered on time or get canceled, increasing the risk of customers switching to another platform. On the other hand, if there are not enough orders in the system, drivers will not have enough work to do resulting in low earnings that incentivize them to switch to another platform.

Combined with the dynamic competition for labor, having to match supply to demand dynamically leads platforms to develop complex pricing policies. Reducing service prices is an effective method for competing for demand. However, this contributes to the major problem of unprofitability experienced by most platform-based businesses [67, 68]. Moreover, if the platform lowers prices too much, its drivers might switch to other platforms. This might in turn result in unsatisfied customers who might also leave. On the other hand, surge pricing, in which prices are increased at times of high demand and low supply, could instigate gaming behavior by the drivers (such as turning their apps off to generate "low supply"). Setting the prices to achieve an equilibrium for both supply and demand is a very challenging problem. While the gold standard in two-sided markets is to develop a dynamic pricing policy that balances supply and demand and drives desired customer and driver behaviors, the adaptive behavior of stakeholders and the continuously changing environment make this a moving target. Additionally, in principle, establishing good and clear communication with both sides of the market about the nature of the pricing policies might provide further benefits, as behaviors of customers and drivers can be shifted to a desired setting.

12.3.4 *Social and Economic Externalities*

Shared delivery platforms have the potential to reduce negative externalities, such as pollution and congestion. They can reduce the number of vehicles operating or the distance travelled. For example, the use of urban distribution centers can reduce distance travelled by increasing truck capacity utilization and integrating public transportation. Similarly, freight transportation networks can reduce the number of vehicles in traffic, especially in congested areas of the city.

However, simple implementations that do not consider all impacts and that lack necessary adjustments to the local needs of urban areas have led shared delivery systems to produce negative externalities in recent years [69]. For example, as discussed previously, crowdsourced delivery cars could be expected to reduce pollution and congestion because they produce less emissions than delivery trucks and delivery trucks are required to return to company parking lots, thereby increasing the distances driven. However, cars are smaller and cannot deliver as many items as trucks. Therefore, more cars are required to complete all deliveries than trucks, and this in turn may produce just as much or more congestion and pollution.

Innovative solutions and strategies are required to reduce the potential negative externalities of shared delivery systems (see [69, 70] for the literature on such strategies).

For instance, self-driving cars (that might also be electric) and drones can be used for deliveries (or mobility) when they are not used by their owners. This might reduce the number of vehicles in a city which can lighten the traffic congestion and pollution. However, some people might buy autonomous cars only to produce revenue for themselves. Such a pattern may increase both congestion and pollution in a city.[5]

12.4 CONCLUSION

Crowdsourcing and shared delivery platforms are among possible solutions which might help to reduce the externalities. They can reduce traffic congestion and pollution by decreasing miles travelled and the number of vehicles in the traffic. Moreover, they can provide additional income opportunities and improve the sense of community. On the other hand, large-scale sharing platforms are relatively new, growing with the speed of internet and mobile technologies. They have many differences with classical business models because they require a level of collaboration of participants to provide benefits for all involved parties. As a result, many questions arise on how to implement and operate these platforms.

To achieve significant benefits from the shared last mile delivery applications for the society, environment, and participating companies, each business model must be analyzed as a system, considering all of its unique set of challenges and impacts. The analyses should take all stakeholders, such as employees, city administrations, and residents, and the interactions among them into account. Additionally, multiple business models should be assessed together. For example, public transportation can be used to bring packages to urban distribution centers from a company's warehouse, and after the sorting operations, they can be delivered to customers by crowdsourced drivers. Although creating and maintaining such a large collaboration among multiple companies would be very complex, this kind of synergy can amplify the overall benefits in the last mile delivery ecosystem.

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13

Future Themes in the Sharing Economy

Babak Heydari, Ozlem Ergun, Rashmi Dyal-Chand, and Yakov Bart

One of our goals in this volume has been to demonstrate that interdisciplinary, convergent research and analysis are indispensable to the ideal of optimizing for a more equitable, democratic, sustainable, and just sharing economy of the future. The contributions to this volume are thus central to our demonstration because they epitomize this ideal by drawing scholars from different disciplines into conversations about the most fundamental questions and challenges related to reengineering the sharing economy. But these contributions have also provided important information about some of the answers to key questions that must be addressed as we move forward. In this concluding chapter, we draw from the rich analyses undertaken by our contributors to outline important substantive lessons that can contribute to a framework for reengineering the sharing economy.

In particular, we focus on five core dimensions that are central to optimizing for a just sharing economy: understanding socioeconomic externalities; pursuing resilience; charting more just and systems-oriented business directions; defining the future of work; and prioritizing access and equity. Our effort in this chapter is more modest than to provide detailed conclusions about the relevance of any of these dimensions. Rather, it is to highlight the multiple ways in which the analyses throughout this volume intersect with these dimensions. As we describe, we believe that the centrality of each of these dimensions is itself an important lesson about the future of the sharing economy. Additionally, these dimensions convey significant information about the values that must be prioritized in the next generation of sharing economy platforms. Finally, and crucially, they help to highlight key questions that remain for future research and exploration.

13.1 SOCIOECONOMIC EXTERNALITIES

Digital platforms are becoming more integrated into our daily lives, collectively adding tens of millions of new users every year. As multiple chapters in this volume have discussed, however, the effects of these platforms go far beyond their users. Most platforms indirectly impact the socioeconomic wellbeing of people in many ways.

These indirect effects are often referred to as externalities, and given their broad scale and scope, it has been a major research effort to understand, measure, and regulate them. Such externalities have also fueled public debate since the early days of sharing economy platforms. In important respects, the analyses in this volume push beyond the current frontiers of research about socioeconomic externalities.

For example, the two chapters on urban mobility companies investigate the socioeconomic externalities of sharing platforms in urban contexts, and in doing so, they provide important clues to solving complicated puzzles about the hidden effects of the shared mobility industry. As Behroozi's chapter shows, despite initial promises that ride-sharing services could reduce urban traffic congestion, this is not always the case. In practice, ridesharing can even increase congestion for a number of reasons, including by substituting for public transportation in some cities. Evidence suggests that some of these concerns can be addressed if the industry moves from car-hailing to ride-pooling. However, moving to ride-pooling often requires an array of incentive mechanisms and technical design considerations that have heretofore been less well-charted, as Koutsopoulos, Ma, and Zahedi discuss in Chapter 9.

Chapter 10, by O'Brien, Heydari, and Ke, is similarly illuminating in discussing lodging, where debates over the consequences of short-term rental platforms on the quality of urban neighborhood life are especially vociferous. As the authors argue, strong penetration of short-term rentals enabled by platforms such as Airbnb can have an array of socioeconomic consequences at neighborhood levels, since such penetration increases the influx of nonlocal people to the neighborhoods and results in different – positive and negative – social and economic consequences. Such consequences could mean higher local rents due to decreased real estate supply or higher quality of local services caused by increased local competition. At the same time these platforms can have longer-term effects, because a high level of short-term rental penetration can poke holes in the social fabric of a neighborhood and disrupt its social organization over time.

The analyses in these and other chapters contribute to two broader insights about socioeconomic externalities in the sharing economy. While discussion of externalities has always been integrated into the literature on sharing economy platforms and multisided markets, most of the focus has been on network externalities and on some economic externalities such as the effect of these platforms on employment and traditional businesses. One of the insights gained from the analyses in this book is that we must define externalities more broadly and integrate this broader definition into designing the technical and regulatory elements of these systems. Indeed, this is part of the agenda for reengineering the sharing economy. As Heydari argues in Chapter 2, the broader definition of externalities expands the range of stakeholders who are affected by sharing platforms to include local residents and businesses, potential second- and third-tier businesses that could emerge in the ecosystem created by a sharing platform, and even other sharing platforms, given the possibility of interplatform interaction across different platforms that provide similar or complementary services.

In addition, much of the debate about socioeconomic externalities has been shaped by anecdotes and opinions that are often rooted in too much optimism or pessimism towards sharing platforms. While there are cases where a particular positive or negative externality of a platform outweighs the rest of the consequences, the reality about most types of socioeconomic externalities is more complex than what these anecdote-based debates suggest. This book highlights that assessing the overall impact of sharing platforms on a given socioeconomic factor (such as traffic congestion, the environment and carbon emissions, and neighborhood economic and criminal activities) depends on understanding the tradeoffs among competing factors through which platforms can either benefit or harm that factor. The relative weight of these competing factors depends on certain design and regulatory parameters on the one hand and the time horizon of the analysis (short-term versus long-term) on the other. Further, evaluating trade-offs requires us to learn the causal mechanisms by which platform parameters are associated with socioeconomic externalities.

As Heydari's chapter discusses, such a methodology requires steps such as quantifying the effects of these platforms in the short term and long term, determining different stakeholders and soliciting direct or indirect inputs from them, and establishing methods to aggregate inputs from different stakeholders. Moreover, given the importance of identifying different causal mechanisms, the methodology can benefit from combining empirical studies with analytical modeling. Ultimately, outputs of these models can contribute to designing externally imposed regulations, as described by Dyal-Chand in Chapter 7, as well as internal governance mechanisms designed by platform companies.

The chapters in this volume inspire future research in socioeconomic externalities on three vital areas. An initial step in identifying the impacts and mechanisms of socioeconomic externalities will be to improve sociotechnical modeling methodologies, which will allow empirical identification to be integrated with system-level simulation. Second, even when we can model and quantify various types of externalities, design and policy decisions are influenced by how we weigh and rank them. Considering platforms' algorithmic nature, this can be challenging, especially since rankings and weights must be updated dynamically. Last but not least, these models need to identify lever points that platform designers and regulators can utilize in order to govern socioeconomic externalities.

13.2 RESILIENCE

As several chapters have observed, some digital platforms serve the function of modern critical infrastructure in many parts of the developed world. This fact, laid bare by the COVID-19 pandemic, is a startling indication of the extent to which the sharing economy has transformed modern living for many of us. It is a fact that requires us to comprehensively reevaluate the forms, functions, and values that inhere in the sharing economy today. This reality also means that it is necessary to examine the resilience of sharing platforms, just as we do with other critical infrastructures. The resilience considerations of sharing platforms require us to ask two overarching questions. As is standard practice in considering the resilience of traditional infrastructures, we must examine how resilient sharing platforms are in response to unexpected disruptions. In addition and moving beyond standard practice for other forms of critical infrastructure, we must consider how these platforms can affect the resilience of other socioeconomic activities.

The COVID-19 pandemic served as a giant stress test for the resilience of many industries, social and economic institutions, and sociotechnical systems. Digital platforms can be credited for contributing positively to the resilience of pandemic life in much of the developed world by facilitating quick transitions to working at home, online shopping, and virtual socializing. Such quick transitions were enabled by a number of factors, such as preestablished logistics infrastructures for companies such as Amazon and Wayfair. Another enabler was the quick repurposing of platform capacities. For example, Uber quickly moved resources from Uber Ride Sharing, for which demand was plummeting, to Uber Eat for which demand was skyrocketing.

As the pandemic revealed, several inherent characteristics of sharing economy platforms make it possible for such platforms to respond quickly to sharp changes in demand level, thus contributing to the overall resilience of the broader ecosystem for the type of services they provide. Consider the mobility industry as an example. First, because mobility platforms do not own the underlying assets (namely cars), they are nimbler in changing the supply level by updating the participation rate on the supply side of the platform. These changes are possible within a feasible range, determined in the short term by the existing pool of agents on the supply side (namely, active drivers), but can grow or shrink in the longer term depending on the overall conditions of the platform ecosystem. Second and as a mechanism to reap the benefits of the first factor, sharing platforms can use dynamic incentives, often in the form of dynamic pricing, to close possible gaps that emerge between the supply and demand levels. Finally, the digital and on-demand nature of many of these platforms means that these platforms can quickly estimate sudden changes on their different sides and buy more time to react to those changes. In Chapter 12 Duman, Ergun, and Behroozi discuss some of these factors in the context of the last mile delivery problem, which is considered a major logistical bottleneck in implementing resilient and sustainable e-commerce systems.

Despite the positive contributions of sharing economy platforms to the overall resilience of essential services, several chapters in this volume raise important concerns about the potential negative impacts of these platforms on infrastructure resilience, especially in the future as we become more dependent on them. As the chapters on mobility discuss, mobility platforms can shift some of the demands from public transportation systems to ride-sharing services, resulting in further reductions of available investment budgets in public infrastructures. From a resilience perspective, this is not necessarily concerning as long as the platform-based systems can provide a continuation of widespread affordable service, especially in the aftermath of a major disruption. However, such access is not guaranteed, given the asset-free nature of many sharing platforms on the one hand, and on the other hand their relationship with their workers, as Schor and Vallas discuss in Chapter 6. Both these factors put much of the supply-side management at the mercy of short-term incentives offered by the platforms, which might fail under extreme circumstances.

Relatedly, it is important to understand that, like most resilient systems, the mechanisms that help these platforms to be adaptive to sudden changes can only contribute to resilience up to certain levels. These same mechanisms can become ineffective, and even counterproductive, once the changes in supply and demand go above a certain level. For example, dynamic pricing can result in unacceptable surge prices in the face of a sudden rise in demand. Importantly, too much decrease in the level of supply, in the case of a drop in demand, means that the platform reduces its geospatial coverage and consequently its on-demand nature. For ride-sharing platforms, this means that the average wait time for each passenger will increase because of the low number of drivers, resulting in dissatisfaction on the passenger side. Such dissatisfaction can lead passengers to pursue other options and lower the demand, which in turn lowers the supply, as discussed by Koutsopoulos, Ma, and Zahedi in Chapter 9). This downward spiral, similar to what is often known as the Wild Goose Chase phenomenon, can make platform systems nonresilient. By contrast, public transportation demonstrates a more linear resilience behavior – at least in the short and medium term – in response to demand changes. As Heydari argues in Chapter 2, public–private partnerships between sharing platforms and public infrastructures can address some of these concerns by including resilience considerations in their agreements governing the provision of services to passengers. These resilience-oriented partnerships can go beyond transportation infrastructure and extend to energy systems, as Kane, Allen, Si, and Stephens show in Chapter 11, focused on future energy systems.

Finally, any discussion about resilience and economic externalities is not complete without considering environmental sustainability considerations. As Eckelman and Kalmykova discuss in Chapter 3, despite initial promises about the positive role of sharing platforms on the environment, it is quite challenging to evaluate the actual sustainability orientation of sharing economy platforms. Sharing companies are highly heterogeneous in this regard and can create a wide range of unintended consequences for the environment. The authors describe a number of these unintended consequences and enumerate several back-end and front-end design opportunities for incentivizing beneficial environmental outcomes. However, research about environmental costs and benefits of peer-to-peer sharing platforms has been limited, and more studies are needed to further guide and prioritize such design opportunities.

Resilience of complex sociotechnical systems has been a topic that has attracted increasing interest from several academic communities. Resilience in these system types is the result of a combination of top-down and bottom-up responses at different levels and by various actors, including the synergistic role of policy design on the side of the regulators, behavioral change on the side of human agents, and repurposing of existing capacity and technological adaptation on the side of businesses. Studying resilience in sharing economy platforms can not only prepare us for future disruptions but can also teach us important lessons about multilevel, synergistic responses at the system level that are useful for the broader context of complex sociotechnical systems. We hope the chapters in this book will inspire new thinking about a range of crucial questions regarding system resilience, especially in the wake of the COVID-19 experience. For example, how can we identify and characterize existing capacities in sharing platforms that can be quickly and efficiently repurposed and reallocated in the face of major disruptions? How might we create more synergy between top-down responses (including policy and business decisions) and the behavioral changes that often act as bottom-up adaptation mechanisms in the face of a disruption? How can we create scenario-study models that incorporate these levels of system responses and that can be used both to identify the trade-offs of resilience decisions and to communicate them to the key stakeholders? And finally, how can we better integrate the adaptability aspects of platform-based systems with the objectives of public decisions – such as through public–private partnerships – to better steer the direction of a system's response towards the public good?

13.3 FUTURE BUSINESS DIRECTIONS

The focus of this volume has been both to provide a systemic perspective on sharing economy platforms and to discuss design and governance issues at the intersection of engineering, regulation, and operations. This is in contrast and complementary to recent books that look at the sharing economy from the perspective of the firm making key business decisions. The recent focus on the firm's perspective is not surprising, since the trends that gave rise to the modern sharing economy (which are examined in the Introduction to this book) have been associated with substantial new value creation over the last decade. Hundreds of market-based platforms continue to take advantage of growing algorithmic and data capabilities coupled with rapidly advancing technologies to allocate access to goods and expertise in such a way as to keep transaction costs to a minimum while in many cases utilizing available capacities of physical assets as fully as possible. Collectively, these features make sharing economy platforms unique from a business perspective. Although this volume's focus has been elsewhere, a number of chapters in this volume have raised important business implications that may serve as catalysts for future research in this field.

First, this book makes a case for the possibility of bringing greater shareability to a range of platform services. For example, Chapter 9 observes that on-demand mobility services currently provide very few shared rides, and the authors present models and recommendations designed to improve sharing in these services. Sharing economy models are discussed in Chapter 12 as a way to solve the challenging problem of last-mile deliveries in e-commerce. Similarly, Chapter 11 discusses the possibility of using sharing economy models in energy systems.

Second, several chapters emphasize that establishing and maintaining trust is essential for the operation of sharing economy businesses. Tadelis, in Chapter 5, argues this could be accomplished by designing appropriate feedback mechanisms. Additionally, privacy is becoming a top concern for users of platform-based businesses, and as discussed in Chapter 4, it is important to understand the privacy calculus of platform users in order to identify potential trade-offs associated with privacy protection measures and other business metrics.

Third, several chapters in this volume highlight ongoing concerns about business competition in the sharing economy. For example, looking back at how this sector grew over the past decade, there seems to be a wide gap between the multibillion-dollar valuations of platform companies like Uber and their lackluster profitability. This gap is often attributed to the power of strong network effects, as discussed in Chapter 2, which create entry barriers and effectively lock in users once the platform company succeeds in attracting many of them during the initial growth spurt. The lock-in problem has been typically discussed in the context of competition among online social networks, where it arises due to embedded positive direct network effect (for example, the more of your friends use a social network site, the higher your value of using it). Leading online social networks, such as Facebook and LinkedIn, have pursued this strategy to establish a sustainable competitive advantage. Thus, it is important to gain a better understanding of how various components of switching costs may reduce competition among sharing economy platforms. Reduced competition may result from several factors, including the cross-side network effects, possible multihoming (users joining multiple platforms at the same time), and myopic decisions on the part of users. A great deal more analytical and empirical research about these nuanced factors is needed to better understand concerns about sharing platform competition.

Fourth, on the operational side, the on-demand service delivery promise of sharing economy platforms, together with a less predictable crowd-sourced contractor resource structure for performing the services, can lead firms to maintain excessive capacities. Perhaps surprisingly, such high (and costly) capacities often correspond to low utilization of resources, contrary to common claims made by sharing economy platforms. An example of this can be seen in ride-sharing platforms: They encourage many drivers to join and be active on the platform app but impose on those drivers to spend a significant amount of time waiting for fares. Another example can be seen in the last-mile delivery context, as discussed in Chapter 12. More research is required to understand these unexpected phenomena on the operational side of platforms.

More broadly, over a decade has passed since most sharing economy leaders started their businesses, and major industry changes have followed the COVID-19 pandemic, thereby raising the possibility that it is time to reassess some of the business assumptions that have been widely and, for the most part, silently accepted in the sharing economy industry. For instance, it has been suggested that one of the factors driving sharing economy growth is the shift from ownership to use among millennials. However, we have seen much evidence of the opposite trend during the COVID-19 pandemic. In response to rising demand, the average price of used cars increased by more than 40 percent in less than two years from the start of the pandemic.[1] Meanwhile, millennials significantly contributed to the real estate market boom in 2020–2021.[2] It remains to be seen whether these recent trends are temporary and could be fully explained by supply chain disruptions or whether these are harbingers of long-term structural changes that present a serious challenge for sharing economy platforms.

Finally, we emphasized in the Introduction to this book that most business decisions cannot be divorced from platform governance decisions for sharing economy companies. While this is true for all businesses, governance decisions are crucial for the business success of sharing economy companies for many reasons. These reasons include regulatory compliance, safety imperatives, and resilience and environmental concerns. Therefore, we expect more research to be conducted on integrated modeling and analysis of business and governance decisions in different platform types, allowing public policy stakeholders to better assess regulatory environments and possible trade-offs.

13.4 THE FUTURE OF WORK

The workplace has undergone dramatic changes in recent decades as a result of numerous disruptive forces including globalization and automation. As multiple chapters in this volume discuss, sharing economy platforms are the most recent and rapidly accelerating disruptive force on the structure of work, with both intended and unintended consequences. For example, while digital platforms have made remote work possible during the COVID-19 pandemic, gig-workers employed by many sharing economy platforms have precarious working conditions, as described by Schor and Vallas in Chapter 6. These circumstances have fueled a fierce debate on the employment status of platform economy workers and on the future of work in general. Although some sharing economy platforms have existed for over a decade

1 Preston, B. (2020). How to buy a used car in this tough market. *Consumer Reports*, www.consumerreports.org/buying-a-car/when-to-buy-a-used-car-a6584238157/.

2 Peterson, D. M. (2021). Millennials will drive home prices up for years to come. *Barron's*, www.barrons.com/articles/housing-boom-millennials-home-prices-51635498001.

and research on platform-based work has grown rapidly[3,4,5] it remains unclear how platform jobs affect the quality of employment, whether workers are exposed to risk with potentially adverse effects, and how platform workers view their position as independent contractors. The future of work is thus a key dimension that must be prioritized in any serious effort to reengineer the sharing economy.

Almost all sharing economy platforms have two core characteristics. First, they use Internet-based digital technology and algorithms to mediate transactions between buyers and sellers of goods and services. Second, they define themselves not as employers, but simply as providers of information systems that "match" independent contractors with potential customers or clients – an important economic and legal shift that redefines the nature of employment and that externalizes many financial and legal risks. In turn, many of these risks have been imposed on the workers themselves. As Chapter 12 on last-mile delivery and Chapters 8 and 9 on mobility discuss, crowdsourced independent-contractors help platforms to achieve greater operational flexibility to provide on-demand services, agilely matching supply to demand with minimal risk to the firm. While many on the platform side argue that this flexibility provides the necessary competitive advantage to firms and flexible working hours to workers, it also introduces a significant level of uncertainty for all actors involved in the operational environment.

The challenges of the platform economy impose unforeseen costs on platform firms themselves, which often struggle to scale up their business models in sustainable fashion. As the chapters on labor, urban mobility and last-mile delivery discuss, one major challenge that businesses face flows directly from their use of the independent contractor model. Firms cannot simply impose work schedules on workers, since freedom over working hours constitutes an important selling point for the recruitment of workers. As a direct consequence, firms encounter heightened levels of uncertainty about staffing levels, which are often vital to their business success. Moreover, since platform workers must assume responsibility for many operational costs and risks, they exhibit extremely high levels of turnover, which imposes substantial costs on platform firms in the forms of bonuses, marketing campaigns, and promises of minimum levels of earnings. Dynamics such as these mean that gig-workers can be less reliable (for example, by not showing up on time) and less experienced at the task at hand (for example, by not knowing the details of doing a delivery at a customer location), thereby forcing firms to increase their supply buffers in order to ensure a given service level in their operations. These problems

3 Rosenblat, A. & Stark, L. (2016). Algorithmic labor and information asymmetries: A case study of Uber's drivers. *International Journal of Communication*, 10, 27. https://ijoc.org/index.php/ijoc/article/view/4892

4 Frenken, K. & Schor, J. (2017). Putting the sharing economy into perspective. *Environmental Innovation and Societal Transitions*, 23, 3–10. https://doi.org/10.1016/j.eist.2017.01.003

5 Schor, J. B. & Attwood-Charles, W. (2017). The "sharing" economy: Labor, inequality, and social connection on for-profit platforms. *Sociology Compass*, 11(8), e12493. https://doi.org/10.1111/soc4.12493

can jeopardize firm viability. They reveal that firms have yet to develop sustainable models for the governance and control of the workforce on whose labor they rely.

Workers participating in the sharing platform economy also face distinctive challenges that differ from those of "traditional" paid employees (as described in Chapter 6). Many workers are attracted to platform work by the possibility of more autonomy over work schedules and greater freedom from supervision. However, the terms of their employment may be obscure. For example, transportation workers must "accept" jobs without knowledge of the destinations. From the perspective of the gig-worker, on top of not having the benefits granted to an employee, this type of work arrangement generates significant anxiety from not knowing the actual income that an intended number of work hours will generate. In addition, gig-workers must satisfy the conditions of reputational management systems in order to avoid "de-activation," even though such conditions often are unknown to them (as described in Chapter 5).

Another clear danger for workers is that the expansion of platform-based work may open up significant gaps in the social safety net, since platforms seldom provide access to health or retirement insurance and platform workers are ineligible for protections under labor standards and minimum wage laws. Collective action is the traditional approach to balancing these information, economic, and social asymmetries, either through formal labor unions or through informal information sharing. Because platform workers typically are contractors, and not employees, however, they are limited in their ability to unionize. In addition, in traditional workplaces, informal worker collectives result from conversations "around the water cooler." However, in the sharing economy, which lacks a physical workplace, these conversations come at a greater cost and often are relegated to online forums. Thus, one of the main questions for comprehensive reengineering of the sharing economy is the question of how to determine the optimal conditions of work and the regulatory actions and protection that need to be taken to ensure those conditions, as discussed in Chapter 7 on regulation and Chapter 6 on labor and work.

Urban and state governments, too, face unforeseen challenges from the platform revolution. Since platforms represent new forms of business for which decades-old regulations were not designed,[6] platforms can often operate in an unregulated space, free of the dictates that constrain their more traditional competitors. Typically, city governments lack the most basic information about platform firm operations, even though the latter have major consequences for the transportation, housing, and employment systems on which the public relies.

More generally, the sharing economy has generated important gaps in the flow of information that is vital to the interests of workers, governments, and firms. For example, large-scale proprietary information generated by ride-hailing platforms

[6] Robinson, H. C. (2017). Making a digital working class – Uber drivers in Boston. 2016–2017. https://dspace.mit.edu/handle/1721.1/113946

such as Lyft is valuable. As a result, firms rarely share such information with regulators, who could use it to better understand the effect of the firm on the public. Nor do firms share such information with workers, who could use it to make career and daily employment decisions. Ironically, firms themselves suffer from information gaps, since they typically lack access to information about the long-term well-being of the workers who provide the lion's share of their service. As some of our contributors have discussed, new research methodologies can help produce, disseminate, analyze, and share information previously unavailable about the sharing economy, which in turn should help improve market efficiencies, reduce labor market uncertainty, and support proactive regulatory structures, thereby strengthening the entire sharing economy ecosystem.

The multiple observations in this volume about the nature of work in the sharing economy teach us a crucial lesson: Comprehensive optimization of work conditions by platform owners, workers, and regulators should be one of the core concerns of reengineering the sharing economy. Currently, platform owners optimize for efficiency, growth, and profit through the design of their matching and pricing algorithms. Government regulators optimize for the public good through regulations. Workers, as suggested by Hall and Krueger (2018)[7] and Schor et al. (2020),[8] currently optimize for both income and flexibility. However, it is not clear if each stakeholder optimizing myopically without a systems perspective of the entire ecosystem can possibly achieve the desired outcomes (see Chapter 2).

Looking ahead to the prospect of reengineering the sharing economy, there remain important open questions for all stakeholders related to the future of work. From the perspective of the firm, many sharing economy platform companies struggle to be profitable even after operating for years with significant market shares, raising questions about the sustainability of the business model as it concerns firms' relationship with their workforce. This relationship impacts several aspects of a firm's profitability including how it recruits, maintains, and pays its workforce and how the firm's operational efficiency is affected by issues such as workers' hours, dependability, and professionalism. In turn, workers are low-paid and lack meaningful control over working conditions and data (see Chapters 5 and 6). Finally, regulatory authorities have thus far had little success at regulating the underlying business activity and service delivery that sharing platforms make possible, in turn limiting their ability to constrain negative effects on the public good, including the future of work (see Chapter 7). While this limited regulatory success is partially due to the strong lobbying efforts of sharing economy firms, such as in the case of the

7 Hall, J. V. & Krueger, A. B. (2018). An analysis of the labor market for Uber's driver-partners in the United States. *ILR Review*, 71(3), 705–732. https://doi.org/10.1177/0019793917717222

8 Schor, J. B., Attwood-Charles, W., Cansoy, M., Ladegaard, I., & Wengronowitz, R. (2020). Dependence and precarity in the platform economy. *Theory and Society*, 49(5–6), 833–861. https://doi.org/10.1007/s11186-020-09408-y

ballot defeat of Proposition 22 in California (discussed in Chapter 6), in other cases it is due to the challenge of anticipating the externalities that will be caused by the regulation itself. In this complex ecosystem, regulatory and other actions targeting part of the system may broadly impact consumer behavior or workforce dynamics in unintended ways, potentially causing more harm than good, as discussed in Chapter 4. This observation emphasizes the point by Duman, Ergun, and Behroozi (Chapter 12) as well as Heydari (Chapter 2) that a comprehensive analysis of the nature of work in sharing ecosystems is crucial.

13.5 EQUITY AND ACCESS

Although this volume is by no means the first to emphasize the significance of equity considerations in the sharing economy, it does resoundingly affirm equity's centrality. Indeed, equity is a core theme in many of the analyses contributed by our authors, though regularly only implicitly so. These analyses provide rich detail about the range of equity-related harms and benefits that have occurred in sharing economy markets. They also provide significant information and inspiration for creating a more equitable sharing economy. Before reviewing the lessons learned from this volume about equity, it is important to consider how equity is defined – and how it manifests – in the sharing economy.

Plainly, one crucial vein of concern and analysis that invokes equity considerations relates to race and racial relations. Because the focus of this book is the American sharing economy, analysis of racial equity in the sharing economy could not be a more pressing matter. As Dyal-Chand observes in Chapter 7, the COVID-19 pandemic is not the only pandemic that has plagued the United States for many months now. Racial violence has also reemerged as a crisis that demands cross-disciplinary analysis and response. Not surprisingly then, concerns about racial equity surface throughout this volume. Schor and Vallas describe the emergence of a "third, implicitly racialized employment status," between independent contractor and employee – a status that is both unequal and "substandard" in the level of protections and value that it affords workers who have it. Dyal-Chand discusses the dawning recognition among those who study the sharing economy that at least some proprietors of sharing platforms seem to be developing their businesses in a direction that capitalizes on the racist results produced by their algorithms. More implicitly, both Chapters 10 and 11 raise troubling questions about the racialized effects of sharing innovations intended for (often commendable) purposes such as providing greater access to goods and services within neighborhoods and the democratization of energy production and control.

Issues of equity and equality also arise with respect to gender, disability, and other identity categories. Research on whether sharing economy platforms discriminate on the basis of gender has only scratched the surface, and this is reflected in the contributions to this volume. Yet it is also apparent that many of the questions raised by the research on disparate racial impact also necessitate a robust research agenda concerning other disparate effects. These effects will no doubt be different from the effects of racism within the sharing economy, but the research on race in the sharing economy can provide helpful clues to guide additional research.

This volume also overwhelmingly makes the case that equity within the sharing economy is defined by level of income and wealth. For example, Heydari's proposal of a sociotechnical examination of the many positive and negative externalities produced by sharing platforms provides an analytical perspective that reveals the hidden burdens and benefits that depend partly on the wealth of sharing economy participants. Focusing their analytical lens on the increasingly ubiquitous mobility industry, Koutsopoulos, Ma, and Zahedi provide nuanced information about the differential impact of ride-sharing innovations in the first generation of mobility platforms. While their attention is on reducing congestion, increasing sustainability, and improving the profitability of mobility companies, the detailed innovations they propose also provide a template for achieving more equitable access to mobility platforms by consumers with lower incomes and less access to traditional goods and services such as privately owned cars and taxis.

The contributions in this volume additionally make clear that equity concerns exist on both the demand and supply sides of sharing platforms. On the demand side, the analyses by Koutsopoulos, Ma, and Zahedi as well as O'Brien, Heydari, and Ke provide deep empirical insights into how access to first-generation sharing platforms can vary for consumers by neighborhood, income, and other demographics. Dyal-Chand describes the proliferating literature on the genderized and racialized consumer harms wrought by first-generation sharing platforms. Kane, Allen, Si, and Stephens raise similar concerns in the new frontier of energy sharing. As the discussion by Lambillotte and Bart suggests, such fundamental concerns as privacy may intersect in significant ways with the axis of equity.

On the supply side, Schor and Vallas raise deeply troubling questions about the future of equitable work, especially for the sharing economy workers who rely on platform jobs as their primary source of income. Such concerns are amplified when considered in contexts such as last mile delivery (see Chapter 12) and the development of clean energy systems (see Chapter 11). These chapters provide the detailed examples for the conclusion reached by Heydari and Dyal-Chand in their chapters that sharing platforms have been able to develop in a regulatory environment that does not constrain platform proprietors in their treatment of those who provide goods and services through those platforms.

The analyses in this book thus present a vexing puzzle: On the one hand, sharing economy platforms maximize opportunities for maintaining anonymity and for sharing the value of expensive goods and services. Through technology, such platforms reduce the costs of market entry and exit by making it easy and cheap to provide – and also to access – goods and services. They significantly increase access to information at a very low cost. In short, the sharing economy should be a means of equalizing access to an enormous range of markets. Yet, on the other hand, many of these very platforms have innovated in ways that allow proprietors and suppliers to differentiate – and outright discriminate – on the basis of race, gender, disability, income, and other characteristics. In so doing, these platforms have *limited* access to sharing economy participation on the basis of criteria that should have been rendered invisible and irrelevant by platform technology. They have regularly contributed to inequity rather than increasing equity.

While this volume has contributed to the conversation about equity by providing important empirical and interdisciplinary evidence of this puzzling phenomenon, it has also contributed to a basic diagnosis. As the scholars in this volume have described from a range of disciplinary perspectives, the proprietors of sharing economy platforms innovate in directions that optimize for their priorities. The first generation of sharing economy platforms have overwhelmingly optimized for fast growth, and more broadly, profit. In the course of doing so, they have produced a range of positive and negative externalities, some of them startling. These externalities teach us important lessons about the multiple impacts of the sharing economy – and its *potential* for achieving equity among other things. Yet, realizing this potential requires more deliberate and concerted action. In short, the current state of the sharing economy demands a rebalancing in the direction of greater equity. Whether by choice, by mandate, or by some combination of the two, such a rebalancing can only occur if platform proprietors optimize for equity in addition to growth and profit.

Moreover, the diagnosis that emerges from this volume makes clear that the problem of inequity in the sharing economy is deeply systemic in nature. Currently, market design, industry practices, and law all provide ample space for sharing platform proprietors to make their own choices about goals, priorities, and innovations, including those that increase inequity. For example, the design of sharing platforms provides ample opportunities to innovate new forms of business transactions that capitalize on reputation and trust. As Tadelis describes, such innovations are exciting and disruptive, allowing a broad range of participants in the sharing economy to rely on new forms of information and new business methods. Transparent rating systems allow suppliers of services on sharing platforms to develop good will rapidly and efficaciously, as compared to traditional businesses. Yet, as other contributors point out, these very forms of market design also can reduce equity by eliminating anonymity and thereby reinstating the ability to discriminate on the basis of race, geography, wealth, and other criteria. Industry practices can exacerbate such effects. By leveraging just such design mechanisms, sharing platforms can use surge pricing and other methods to take advantage of unequal access by consumers. As Schor and Vallas discuss, they can also increase the precarity of low-wage workers who depend on sharing platforms for meaningful income.

Currently also, as the chapters by Heydari, Dyal-Chand, and others discuss, law creates ample space for innovation in market design and industry behavior without systemic analysis of the connection between such behavior and equity considerations. Powerful intellectual property rights, contracts of adhesion, weak labor and employment laws, piecemeal and reactive regulations, and lack of political will or even direction in protecting widespread access to sharing platforms at times combine to nurture and even valorize disruption at the expense of necessary protections.

Crucially, the contributions in this volume have supplemented these diagnostic insights by enhancing our understanding of a range of possible solutions to the problem of rising inequity in the sharing economy. One of the most important messages from the volume as a whole is that, because of the multiple sources for inequitable development and operation within the sharing economy, the solutions must also be cross-disciplinary. To examine the potential of cross-disciplinary solutions to address inequity in the sharing economy, consider one set of solutions that has come to the fore in this volume, and indeed that invokes the title of this volume. Specifically, consider the potential that some of the necessary *regulations* of the sharing economy may be best imposed by means of the *engineering* of the platforms. In other words, the concept of "regulation by design," which has been the subject of much scholarship in the privacy domain, may also be a valuable form of regulation for the purpose of prioritizing equity.[9]

As the analyses in this volume suggest, the incorporation of regulation into the design of sharing platforms would require at least two indispensable ingredients. First, a certain level of what has been described as "self-regulation" would be required. Self-regulation might originate in the design choices made by businesses within a sector that choose to maximize value for different stakeholders, beyond profit, growth, or efficiency. For example, recognizing its role as a necessary component of the transportation infrastructure (especially during crises or other periods when public transportation is disrupted), a ride-sharing company could choose a more socially responsible pricing structure that would reduce or at least stabilize prices during times of crises, instead compensating for this lost opportunity by charging higher prices in business districts or other geographic regions where riders could expect to be subsidized by their employers or would have incomes high enough to support paying higher prices. Just as some platforms have already marketed their products and services on the basis of their greater contributions to environmental sustainability (see Chapter 3), or consumer safety,[10] such a business could distinguish itself in the market on such grounds.

In addition, government would have an important role in developing and maintaining this kind of self-regulation. In the ride-sharing pricing example just provided, it is possible that the hypothetical company could achieve market success by means

9 For an authoritative treatment of this subject in the privacy domain, see Woodrow Hartzog's recent book, *Privacy's Blueprint*. Harvard University Press.

10 RideAustin, www.rideaustin.com, and Safr, www.gosafr.com, are two examples in the mobility platform context.

of this combination of social responsibility and pricing differentiation, and it is even possible that it could begin a "race to the top," rousing other companies to explore the benefits (and costs) of fulfilling their function as a necessary part of an urban transportation infrastructure. However, given the many apparent incentives toward monopolization, it is likely that such moves would need to be encouraged by governmental involvement. Fortunately, there already exist numerous regulatory models from which regulators could draw. One interesting model is the development of "certificates of trust," which could originate either within an industry or with a governmental agency.[11] Another example could be for regulators to lead the development of an industry-wide code of conduct for platform design. Another would be to provide design guidelines such as those issued by regulatory agencies to ensure compliance with the Americans with Disability Act and similar federal and state laws.[12] Certainly, also, it may be appropriate for regulators to at times require the incorporation of certain design standards that would optimize for one or more of these principles.

As Chapter 2 makes clear, this kind of coordination between platform design and regulatory design would require a sociotechnical approach that could account for a broad range of positive and negative externalities, design characteristics, and individual and group behaviors on both the supply and demand sides of sharing platforms. The analyses in the chapters on sharing in the neighborhood, sharing and sustainability, sharing and last-mile delivery, and sharing energy all provide vivid examples of the need for system-wide analysis in engineering self-regulatory approaches.

This, however, would be just the beginning. While such an approach to reengineering a more equitable sharing economy holds much promise, crucial questions will arise and will require interdisciplinary research and analysis. Three sets of questions seem particularly salient on the equity front. None can be answered on the basis of the research presented in this volume, though much of this research certainly lays the foundation for an ambitious forward-looking research agenda.

First, how could platforms be inspired to *choose* to self-regulate in the direction of greater equity? Given the extraordinary impetus to optimize for immediate fast growth – and the reality that many platforms have yet to achieve any meaningful profit while taking in vast amounts of venture and other private capital – how could platforms be motivated to race to the top in designing equitable industry practices?

11 Early regulation of platforms in Europe already contemplated such a model as a means of developing acceptable minimum safety and quality standards to protect consumers in such markets. Such certificates can take the form of partial self-regulation as an alternative to established permitting and licensing requirements. But they also contemplate a role for government either to substitute for an industry-led process or to facilitate it, thereby ensuring that standards would be sufficiently protective of consumers. Kristina Dervojeda et al., Accessibility based business models for peer-to-peer markets (European Commission Business Innovation Observatory, Contract No 190/PP/ENT/CIP/12/C/N03C01, 2013), https://single-market-economy.ec.europa.eu/publications/accessibility-based-business-models-peer-peer-markets_en

12 For an example, see Information and Technical Assistance on the Americans with Disabilities Act, United States Department of Justice Civil Rights Division, www.ada.gov/2010_regs.htm

This question seems particularly salient in light of the extraordinary level of social and political polarization in US society (and many other societies) today. Indeed, it is reasonable at least to wonder whether the type of "regulatory entrepreneurship" described by Pollman et al. is possible partly because of such polarization.[13] If so, then the challenge of solving the contemporary polarization in wealth depends partly on solving these other forms of polarization as well – a daunting task.

Second, while the benefits of governmental regulation to promote reengineering of a more equitable sharing economy may be apparent, it is also important to consider the costs of such regulatory interventions. One such cost could be social and political backlash, thereby leading to even greater polarization. Such a counterproductive result would be to no one's advantage. A second cost could be the potentially high level of investment required to achieve a regulatory approach that is responsive, thoughtful, and sophisticated enough to nurture industry-led design that could successfully achieve equity over the long-term. Unfortunately, our regulatory history has produced too many examples of analogous regulatory failures, despite the good intentions behind them. A third obvious cost is that regulation could delay and stunt positive industry innovations as well as profits, thereby harming the very individuals and groups, such as low-wage workers and consumers of color, that the regulations would be intended to help. These are serious concerns, and they demand careful attention going forward.

Finally, it will be important for future research and analyses of equity – and the possibility of engineering for equity – to consider the implications for sharing economy governance more broadly. All of the complicating factors just described and many others, including political and other forms of polarization and the globalized nature of the sharing economy, also complicate the prospects of stable governance. The multiple and varied examples of sharing economy platforms provide fertile ground for further research about governance. For example, as the chapters on sharing delivery systems, energy, and mobility discuss, genuinely peer-to-peer platforms have addressed a range of access and even equity issues. Heydari and Dyal-Chand both raise questions about whether these and other examples could point us toward deeper examinations of the emerging democratic principles in some sharing economy contexts.[14] Here again, the contributors to this volume have raised significant questions that deserve further research attention.

13.6 REENGINEERING SHARING: WHAT LIES AHEAD?

In addition to these core dimensions that define the challenge of reengineering a more just sharing economy, the contributions in this volume have raised a set of

[13] Pollman, E., Barry, J. M., Barney, B., Coan, A., Fox, D., Gadinis, S., … Yadav, Y. (n.d.). Regulatory entrepreneurship. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2741987

[14] This is an area in which important research has already begun, led by scholars such as Yochai Benkler.

questions that might best be described as more philosophical, epistemic, or even existential in nature. These questions present some of the most difficult and complex challenges of all. Yet we believe that it is only wise for those involved actively in reengineering the sharing economy to reflect on these questions, and in so doing, to make their best efforts to proactively address them. While we make no pretense to answer these questions, we conclude this chapter by raising two salient areas of necessary exploration.

13.6.1 *How Have Platforms Contributed to Globalization?*

The relationship between platforms and globalization is deep and diffuse. Indeed, at this stage, we can only raise more specific questions about this relationship in an effort to define its contours. On the labor side, for example, how has platform work affected patterns of migration and immigration? In what ways has platform access replicated patterns of discrimination, colonialist behavior, and nationalisms, and in what ways has it disrupted those patterns?

Some of these questions are relevant on the consumer side as well. Additional questions also arise: How have consumers benefited from accessing platforms across borders? On the other hand, in what ways have they assumed greater risk?

Finally, a number of crucial questions arise for businesses and those who govern them. For example, how have platform-based businesses responded to taxation, and more generally to other laws that depend in meaningful measure on physical location within a territory? These are just some of the many, many questions inspired by the connection between platforms and globalization.

13.6.2 *Who has the Right to Govern the Sharing Economy?*

Finally, and relatedly, one of the most vexing set of questions moving forward will no doubt concern platform governance. The diffuse, indeed globalized, nature of platforms deeply impacts the question of governance for the obvious reason that it raises foundational questions about who has the right to govern the platform economy, or any given piece of it. While this question at times feels rhetorical, especially in light of claims that the Internet is too diffuse a phenomenon to be governable, it remains imperative to search for a more substantive answer in response to such claims.

On this question, the editors of this volume have a clear normative position: As we, and many of our contributors, have expressed, we believe it is imperative to develop processes, structures, and norms that move the sharing economy in the direction of genuinely democratic governance. While such a statement is rhetorically powerful, it is also rhetorically straightforward. It will of course be much more difficult to operationalize this statement. Doing so will require serious attention to the current power imbalance between platform owners on the one hand and consumers, workers, and even regulators on the other. It will require reconsideration of intellectual property rights and other legal and market structures that perpetuate this power imbalance. Moreover, just as is the case with any political democracy, it will require vigilance and nurturing over the long term.

Yet we believe that it will be imperative to engage in just such an effort as we seek to optimize for a more just sharing economy. We hope that the analyses in this volume have provided both information and inspiration for future work in this direction.